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7.6 Combined Modelling and Appraisal Report

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7.6 Combined Modelling and Appraisal Report

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1 Introduction

1.1 Purpose of this document

1.1.1 This report forms the Combined Modelling and Appraisal (ComMA) report. The ComMA is intended to inform decision makers and stakeholders on the evidence underpinning the business case: notably how it has been developed from the initial identification of the underlying transport problems; then covering the data used in the development of the scheme traffic models, development of traffic forecasts, assessment of the impact of the scheme on traffic and the environment, and subsequently the economic appraisal of the scheme. In undertaking the assessment of the scheme, the 'without scheme', Do-Minimum (DM), is compared with the 'with scheme', Do-Something (DS), to forecast the impact the scheme would have on journey times, traffic flows, accidents, air quality, greenhouse gases and noise.

1.1.2 The ComMA is essentially intended to be an 'end of stage' report, detailing what has occurred through the Highways England Project Control Framework (PCF) stage and indicating where analysis has been refined or updated from a previous stage.

1.2 Scheme overview

1.2.1 The A417/A419 is a strategic route between Gloucester and Swindon that provides an important link between the Midlands/North and South of England. The route is an alternative to the M5/M4 route via Bristol. The section of the A417 near Birdlip, known as the 'Missing Link', forms the only section of single carriageway along the route and is located in the Cotswolds Area of Outstanding Natural Beauty (AONB).

1.2.2 In 2014, the Department for Transport (DfT) announced its five-year investment programme for making improvements to the strategic road network (SRN) across England. This scheme is one of more than 100 schemes identified as part of the first Road Investment Strategy (RIS1) 2015-2020[1]. Funding for delivery of the scheme has been confirmed within the second Road Investment Strategy (RIS2)[2], which covers the period between 2020 and 2025 and was published on 11 March 2020.

1.2.3 This scheme to upgrade this section of the A417 to dual carriageway, in a way that is sensitive to the surrounding AONB, would help unlock Gloucestershire's potential for growth, support regional plans for more homes and jobs, and improve life in local communities.

1.3 Scheme vision and objectives

1.3.1 The scheme vision is for a landscape-led highways improvement scheme that will deliver a safe and resilient free-flowing road whilst conserving and enhancing the special character of the Cotswolds AONB; reconnecting landscape and ecology; bringing about landscape, wildlife and heritage benefits, including enhanced

[1] Department for Transport (March 2015), Road Investment Strategy: 2015 to 2020, accessed 29 January 2020, https://www.gov.uk/government/publications/road-investment-strategy-for-the-2015-to-2020-road-period
[2] Department for Transport (March 2020), Road Investment Strategy: 2020 to 2025, accessed 11 March 2020, https://www.gov.uk/government/publications/road-investment-strategy-2-ris2-2020-to-2025

visitors' enjoyment of the area; improving local communities' quality of life; and contributing to the health of the economy and local businesses.

1.3.2 In order to deliver this vision, the following scheme objectives have been set:

- Safe, resilient and efficient network: to create a high-quality resilient route that helps to resolve traffic problems and achieves reliable journey times between the Thames Valley and West Midlands as well as providing appropriate connections to the local road network.
- Improving the natural environment and heritage: to maximise opportunities for landscape, historic and natural environment enhancement within the Cotswolds AONB and to reduce negative impacts of the proposed scheme on the surrounding environment.
- Community & access: to enhance the quality of life for local residents and visitors by reducing traffic intrusion and pollution, discouraging rat-running through villages and substantially improving public access for the enjoyment of the countryside.
- Supporting economic growth: to facilitate economic growth, benefit local businesses and improve prosperity by the provision of a free-flowing road giving people more reliable local and strategic journeys.

1.4 Scheme description

1.4.1 The scheme would provide 3.4 miles (5.5km) of new, rural all-purpose dual carriageway for the A417. The new dual carriageway would connect the existing A417 Brockworth bypass with the existing dual carriageway A417 south of Cowley. The new dual carriageway would be completed in-line with current trunk road design standards. The section to the west of the existing Air Balloon roundabout would follow the existing A417 corridor, but to the south and east of the Air Balloon roundabout, the corridor would be offline, away from the existing road corridor.

1.4.2 The scheme would include a new crossing near Emma's Grove for walkers, cyclists and horse riders including disabled users, which would accommodate the Cotswold Way National Trail. A new junction would be incorporated at Shab Hill, providing a link from the A417 to the A436 (towards the A40 and Oxford), and to the B4070 (for Birdlip and other local destinations).

1.4.3 A new 37m wide multi-purpose crossing would provide essential mitigation for bats and enhancement opportunity of ecology and landscape integration. The public would also further benefit as the crossing would accommodate the Gloucestershire Way and provide an improved visitor experience.

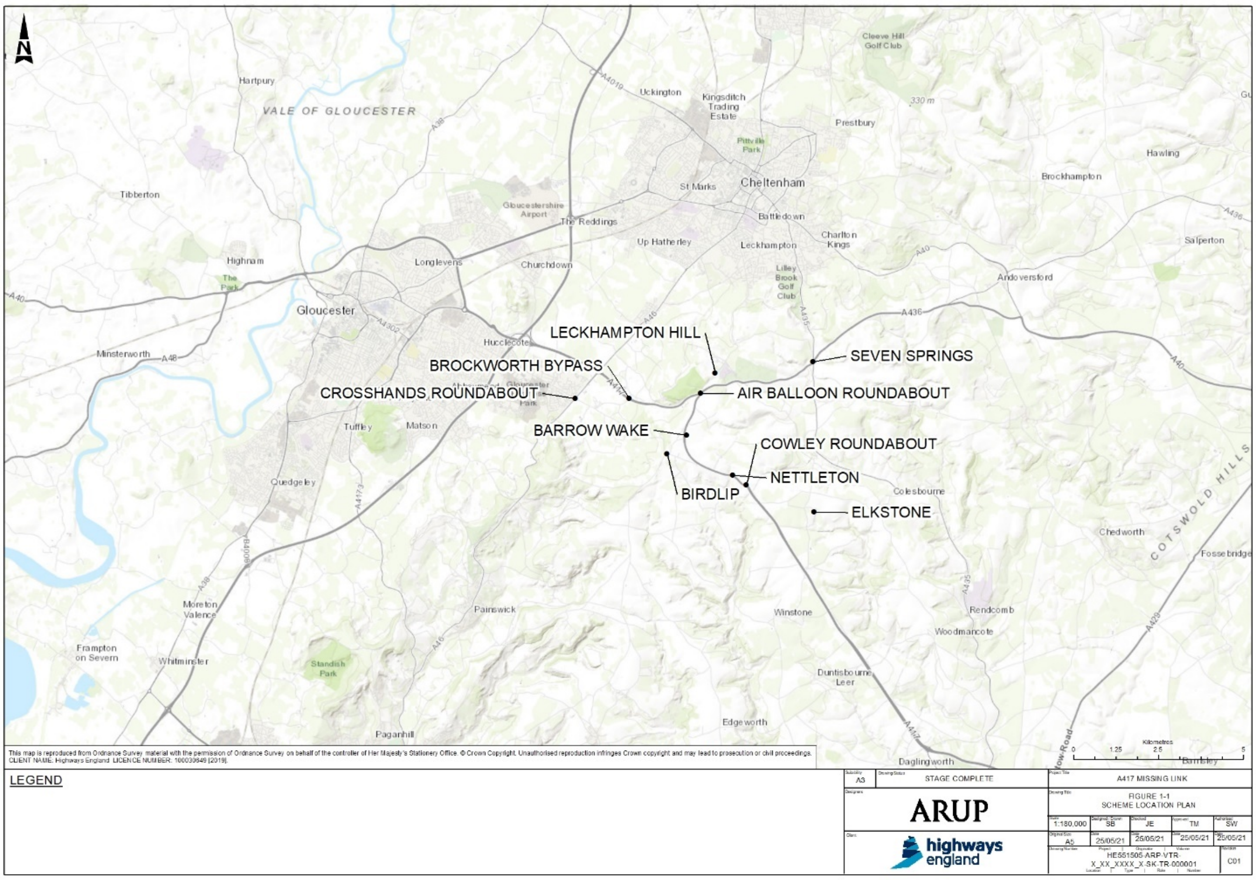
1.4.4 A new junction would be included near Cowley, replacing the existing Cowley roundabout, making use of an existing underbridge to provide access to local destinations. The use of the existing underbridge would allow for all directions of travel to be made.

1.4.5 The current A417 between the existing 'Air Balloon roundabout' and 'Cowley roundabout' would be detrunked for its entire length. Some lengths of the existing road would be converted into a route for walkers, cyclists and horse riders including disabled users. Other sections would be retained as lower-class public roads, maintaining local access for residents. Some of the route would provide Common Land.

1.5 Scheme context

1.5.1 Together, the A417 and A419 make up one of the south-west's most important road corridors, helping people to travel for work, business and leisure. They link two of the region's top growth areas, the M5 at Gloucester (junction 11A) to the M4 at Swindon (junction 15). They help south-west businesses connect with markets and opportunities in the midlands and the north, and they attract investment for Gloucestershire and its neighbours by linking them to London and the south-east.

1.5.2 Most of the A417/A419 route is dual carriageway, but there is one section that is not. Known as the A417 Missing Link, this stretch of around 3.4 miles (5.5km) of single-carriageway on the A417 between the Brockworth bypass and Cowley roundabout (see Figure 1-1) restricts the flow of traffic causing pollution and congestion. Delays of 20 minutes or more are not unusual, and nor is the sight of queuing traffic or the sound and smell of idling engines. This results in some motorists diverting onto local roads to avoid tailbacks, causing difficulties for neighbouring communities. Poor visibility and challenging gradients also contribute to the disproportionately high number of serious and fatal accidents that are seen along this stretch of road.



Source: Highways England

Figure 1-1 Scheme location plan

1.5.3 Upgrading this section of A417 to dual-carriageway, in a way that is sensitive to the surrounding Cotswold AONB, would help unlock Gloucestershire's potential for growth, support regional plans for more homes and jobs and improve life in local communities.

1.5.4 Over the years, there have been previous attempts to bring forward a scheme to upgrade or improve the A417 Missing Link across the Cotswold escarpment. For various reasons, these have never come to fruition but, in recent years, the case for improvement has become more compelling and improvements are needed to improve safety, ease congestion and pollution, and support the economy.

1.5.5 The A417 Missing Link (the scheme) is being developed in line with Highways England's PCF, as shown in Figure 1-2. The scheme is currently at PCF stage 3 (Preliminary design).

Figure 1-2 PCF stages

1.5.6 Further information on the scheme background can be found in the Scheme Assessment Report (Document Reference 7.4).

1.6 Overview of PCF stage 3 scheme traffic modelling and appraisal updates

1.6.1 The following paragraphs outline the main updates adopted at PCF stage 3 to the traffic modelling and economic appraisal of the scheme. The updates have been informed by the PCF stage 3 Analytical Requirements Report and the PCF stage 3 Appraisal Specification Report.

1.6.2 The scheme traffic model was developed using the South-West Regional Traffic Model (SWRTM) and represents an average March 2015 weekday as the base traffic model. The scheme traffic model for PCF stage 2 built on the work done at PCF stage 1, with a number of additional enhancements made to improve the performance of the scheme traffic model. The base year scheme traffic model for PCF stage 2 has been taken through to PCF stage 3 with no physical changes. The PCF stage 2 DM and DS scheme traffic models included the M4 Newport scheme, which has been removed for PCF stage 3 as in June 2019 it was announced this scheme would not proceed.

1.6.3 The scheme traffic model for PCF stage 2 reflected the design at the time of the Preferred Route Announcement. The current traffic model for the scheme is based on the design at August 2020. The differences between the two models are summarised as follows:

- realignment of the B4070 Shab Hill/Birdlip link road
- minor changes to the form of Shab Hill junction
- minor changes to the form of Cowley junction
- closure of Cowley Wood Lane for motorised traffic

1.6.4 Generalised cost parameters (pence per minute; PPM, and pence per kilometre; PPK) have been updated in all forecast year traffic models for PCF stage 3 to reflect updates in the DfT Transport Analysis Guidance (TAG).

1.6.5 The various elements of the economic appraisal of the proposed scheme have been updated to include the forecasts undertaken using the PCF stage 3 scheme traffic model. It uses the updated economic parameters issued by the DfT in the

July 2020 version of the TAG databook. The appraisal also incorporates updated scheme cost estimates, which include estimated operational and maintenance costs.

1.6.6 The assessment of accident benefits arising from the proposed scheme was updated at PCF stage 2 to account for the high number of serious and fatal accidents that occur on the existing single-carriageway section of the A417. For PCF stage 3, accidents on links and junctions have been assessed separately in Cost and Benefit to Accidents – Light Touch (COBALT) for scheme links and junctions, as well as the equivalent DM links and junctions. Elsewhere within the simulation area, accidents are assessed on links and junctions combined. This methodology provides the most accurate assessment of local conditions without the scheme and the impact of the scheme. Accident data for key links (those impacted most by the scheme) within the study area have been updated from the data used at PCF stage 2 to the most recent five years of accident data available from the DfT.

1.6.7 In addition, the assessment of monetised benefits associated with journey time reliability was undertaken at PCF stage 2 using a revised methodology that makes use of observed journey time data from TrafficMaster. Both of these approaches for appraisal have been taken forward to PCF stage 3 to ensure consistency in the calculation of the benefit cost ratio (BCR).

1.6.8 High and low growth sensitivity tests have been undertaken to assess the impact on the scheme of different background growth assumptions. In addition, a sensitivity test utilising the high carbon values has been undertaken to assess the impact of changes in the carbon value.

1.7 Analytical assurance

1.7.1 As per the scheme Analytical Requirements Report and following consideration of the risks and their likelihoods, assurance for this project under the Analytical Assurance Framework is provided to the third line of assurance.

1.7.2 Highways England's Transport Planning Group (TPG) has agreed to the approach underpinning this study and has overseen development and interpretation of its technical elements.

1.8 Purpose of this report

1.8.1 As described in section 1.1 of this report, this report sets out how the evidence underpinning the business case has been developed. This ranges from the initial identification of the underlying problem, the collection of data and the production of the supporting scheme traffic model, the forecast impacts of the scheme on traffic through to the economic appraisal.

1.9 Structure of the report

1.9.1 The remainder of the report is structured as follows:

- **Section 2 – Local transport situation** – This section summarises the existing local highway and public transport system, key demands for travel, and transport problems and their contributing factors.
- **Section 3 – Summary and review of existing data** – This section provides an overview of existing traffic data, including data that was collected and used

in PCF stage 2, which has been used to develop the scheme traffic model for PCF stage 3.

- **Section 4 – Data collection** – This section provides an overview of additional traffic data that has been collected since PCF stage 2.
- **Section 5 – Final datasets** – This section provides an overview of the full datasets used within the scheme traffic model for PCF stage 3, including discussion of checks and data manipulation undertaken.
- **Section 6 – Scheme traffic model description/specification** – This section summarises the modelling approach taken, including the geographical and temporal coverage of the scheme traffic model and an overview of the scheme traffic model system components.
- **Section 7 – Scheme traffic model development** – This section describes the network and demand model coding processes.
- **Section 8 – Scheme traffic model calibration** – This section details the scheme traffic model network and matrix calibration methodology, the location of calibration count data and the effects of Matrix Estimation.
- **Section 9 – Scheme traffic model validation** – This section describes the process of validating the base year scheme traffic model and provides a summary of the validation results.
- **Section 10 – Forecast assumptions** – This section details the approach taken in developing the future year forecast scenarios, accounting for anticipated changes to travel demand, highway network provision and travel costs.
- **Section 11 – Forecast results** – This section presents the outputs of the scheme traffic model forecasts, including an analysis of the anticipated changes in traffic and journey times as a result of the scheme. This chapter also provides the variable demand and assignment convergence statistics and an assessment of the impact of variable demand modelling on the forecasts.
- **Section 12 – Economic appraisal approach** – This section provides a description of the processes used during the economic appraisal of the scheme. The estimated scheme costs are also discussed and presented within this chapter.
- **Section 13 – Economic appraisal results** – This section presents the results of the economic appraisal, including the results for each individual element of the appraisal.
- **Section 14 – Distributional impact appraisal** – This section outlines the forecast distributional impacts of the scheme.
- **Section 15 – Sensitivity tests** – This section presents the results of the economic appraisal undertaken for the high and low growth sensitivity tests for the scheme.

1.9.2 Appendices and annexes are included to provide more detailed information where necessary.

2 Local transport situation

2.1 Introduction

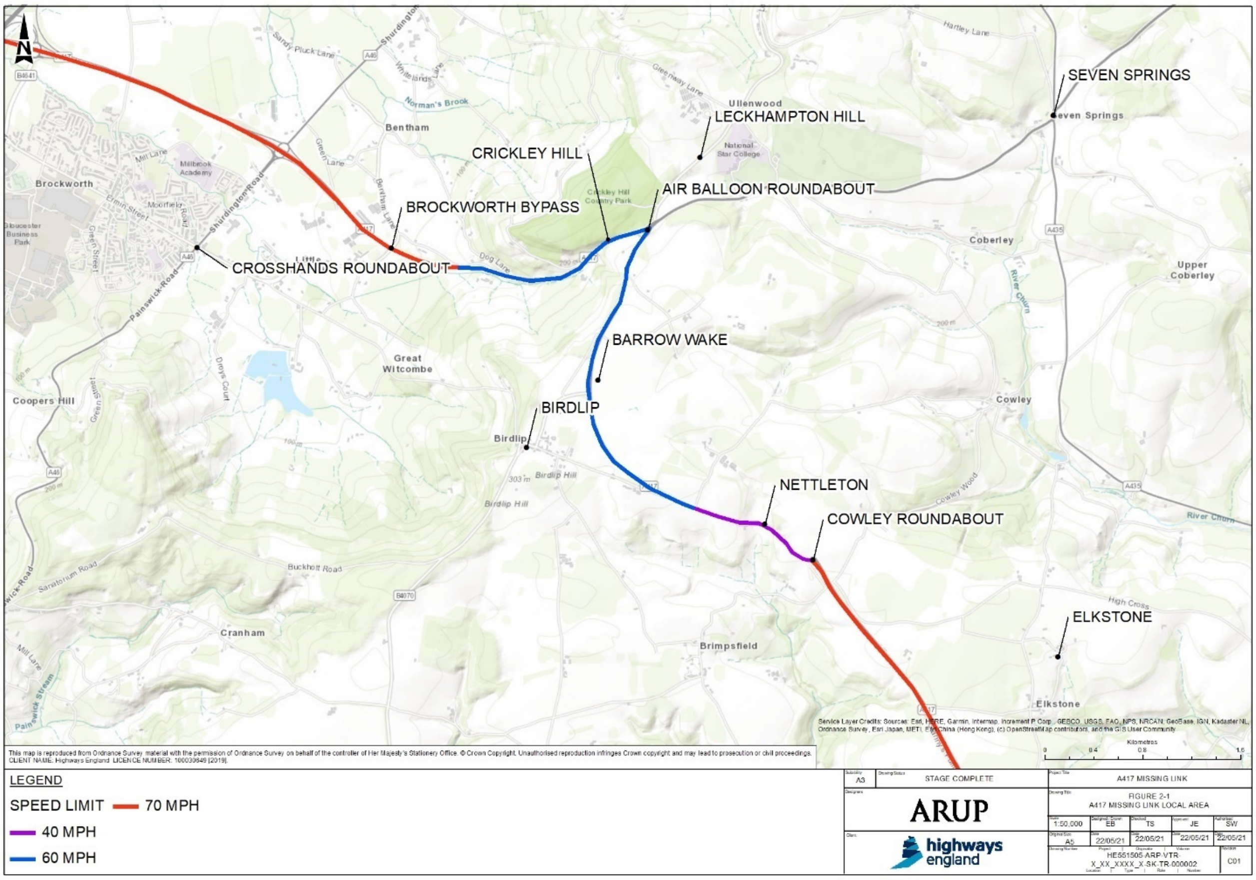
2.1.1 This section summarises the existing local highway and public transport system, key demands for travel, and transport problems and their contributing factors.

2.2 Local transport system

Highways

2.2.1 The A417/A419 route between junction 11a of the M5 and junction 15 of the M4 is part of the strategic road network (SRN).

2.2.2 The 3.4 miles (5.5km) of the Existing A417 between Brockworth bypass and Cowley roundabout is the only remaining single-carriageway section on the 32 miles (52km) length of the A417/A419 between the M5 and M4 motorways. The location of the scheme is shown in Figure 1-1 with Figure 2-1 identifying key local points of interest.



Source: Highways England

Figure 2-1 A417 Missing Link local area

2.2.3 This section of the Existing A417 crosses the Cotswolds escarpment at Crickley Hill and the alignment of the existing route does not meet current standards with steep gradients (up to 10% on Crickley Hill) present along most of the Existing A417.

2.2.4 There is a major at-grade junction with the A436 at the Air Balloon roundabout which, along with other junctions and private means of access along the route, constrain traffic flow.

2.2.5 The Existing A417 varies in lane provision and speed limit between the extents of the route proposals. Starting at the northern end, at Brockworth bypass, the existing road is as follows:

- Brockworth bypass is a dual two-lane carriageway (D2AP) section with a 70mph speed limit.
- At the foot of Crickley Hill, the dual carriageway changes to a wide single two-lane carriageway (WS2) with climbing lane with 60mph speed limit extending to the Air Balloon roundabout. This section is not compliant with current highway standards.
- Heading south from the Air Balloon roundabout, the WS2 with climbing lane continues up to Barrow Wake where the A417 changes to a dual single lane carriageway, dualled to accommodate the priority junction to Barrow Wake whilst maintaining the 60mph speed limit.
- After the junction, it reverts to a single carriageway (S2) before connecting to the original A417 alignment past Stockwell and Nettleton Bottom.
- Through Nettleton Bottom, the speed limit drops to 40mph before reverting to 60mph and the single carriageway provision continues to Cowley roundabout.
- To the south of Cowley roundabout, the A417 returns to D2AP with a 70mph speed limit.

2.2.6 As identified above, the A436 connects to the Existing A417 at the Air Balloon roundabout. The A436 is an S2 road with a speed limit of 50mph along most of its length, although there is a short section of approximately 150m on the approach to the roundabout with a 60mph limit. The A436 continues in an easterly direction and connects with the A435 at Seven Springs. The A435 runs in a north-south direction and provides an alternative to the A417 for traffic travelling between Cirencester and Cheltenham. Beyond Seven Springs, the A436 continues before connecting with the A40 around 6 miles (10km) from the Air Balloon roundabout.

2.2.7 Approximately 70m to the east of the Air Balloon roundabout, the A436 forms the major arms at a priority-controlled junction with Leckhampton Hill. Leckhampton Hill is an S2 road broadly following a north-south alignment and provides access into the south of Cheltenham from the A436 and A417.

2.2.8 Around 0.9 miles (1.5km) to the south of the Air Balloon roundabout, the Existing A417 forms a priority-controlled at-grade junction with the B4070. The B4070 is an S2 road that connects the A417 to Stroud, around 10.5 miles (17km) to the south. Less than 0.6 miles (1km) to the south of the A417, the B4070 enters Birdlip village where it forms a junction with a minor road named Birdlip Hill.

2.2.9 Birdlip Hill runs broadly parallel with the Existing A417 section on Crickley Hill before meeting the A46 at the Crosshands roundabout at Brockworth. The A46 follows a broad north-south alignment, connecting Stroud in the south to Cheltenham in the north. It forms a grade-separated junction with the A417 around 2.2 miles (3.5km) to the west of the Air Balloon roundabout.

2.2.10 To the south of Cowley roundabout, the A417 continues in a south-easterly direction towards Cirencester and, beyond that, Swindon and the M4. Around 1.9 miles (3km) to the south of Cowley roundabout, close to the Highwayman Inn, a minor road connects to the A417 at an all-movements compact grade-separated junction. This minor road connects onto the A435 in the north, via Elkstone village, and provides a route into Cheltenham that avoids the delays often seen at the Air Balloon roundabout.

Public transport

2.2.11 The railway line between Swindon and Gloucester/Cheltenham, known as the Golden Valley Line, provides a public transport option for people travelling on this corridor. Direct rail services are available between Swindon and Gloucester and Cheltenham Spa. These services generally operate with one service per hour in each direction, with journey times from Swindon of around 55 minutes to Gloucester and 70 minutes to Cheltenham Spa. The line is also used by direct services operating between Gloucester/Cheltenham and London Paddington.

2.2.12 Cheltenham Spa railway station is situated on the main line between Birmingham and Bristol, with journey times of 45 minutes and 100 minutes to each city respectively.

2.2.13 Trains between Cheltenham and Gloucester themselves are frequent, with four services an hour in each direction throughout most of the day. Journey times vary but are usually around 10 minutes.

2.2.14 There are direct bus services linking Swindon, Cirencester and Cheltenham, but not Gloucester and Swindon. The Swindon to Cheltenham (via Cirencester) services generally operates with an hourly frequency, with total journey times approaching two hours.

2.3 Key demands for travel

2.3.1 The A417/A419 is part of the strategic road network (SRN) and is one of the most important road corridors in the South-West, linking the M5 at Gloucester with the M4 at Swindon. The A417/A419 forms part of the strategic route between the south coast and the Midlands and the north-west. It helps businesses in the south-west connect with markets and opportunities in the midlands and the north and attracts investment for Gloucestershire and its neighbours by linking them to London and the south-east.

2.3.2 The A417 also represents one of the main access routes into the Cotswolds AONB.

2.3.3 Gloucester, Cheltenham and Swindon are amongst the region's top growth areas, with significant residential and employment developments proposed in these areas.

2.3.4 As well as the above strategic-type demand, the A417 is an important route for more local traffic between Cirencester in the south and Cheltenham and Gloucester in the north.

2.4 Transport problems and contributing factors

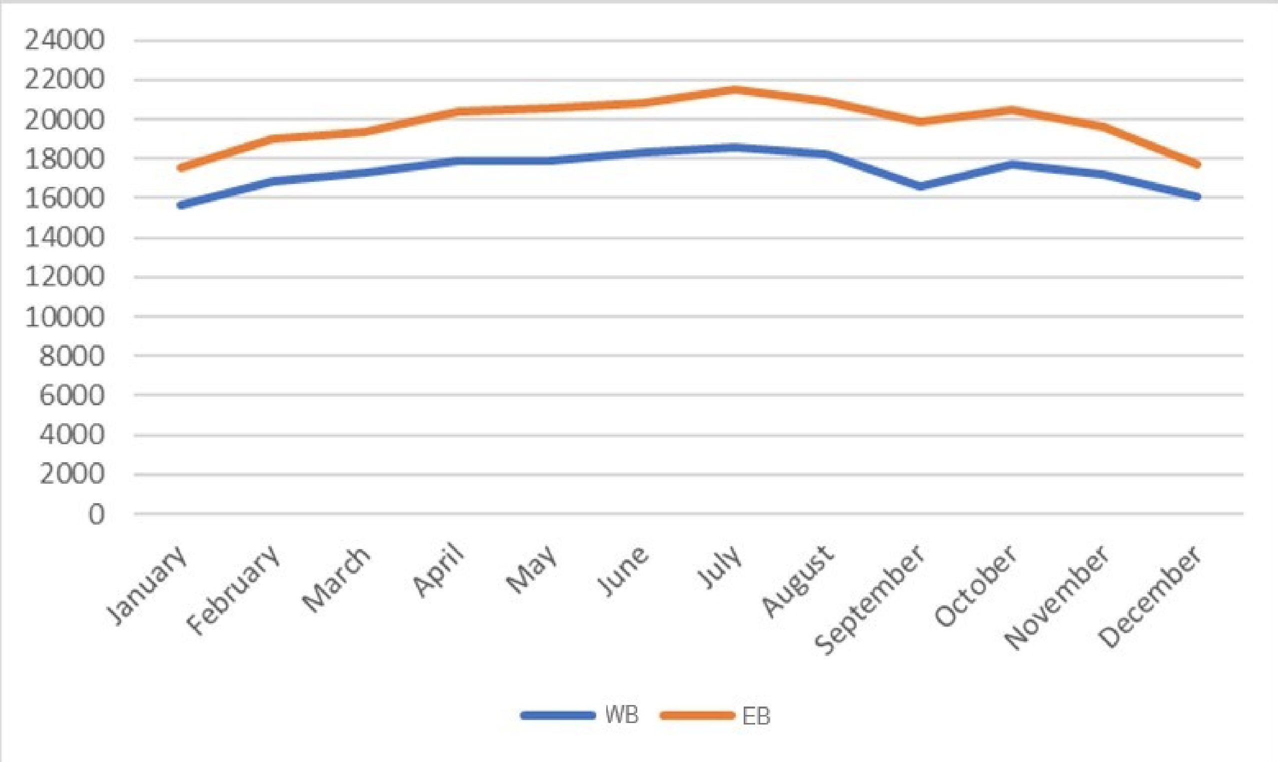
2.4.1 The Existing A417 in this area experiences high levels of congestion and poor journey time reliability. Performance is hindered by the capacity limitations on the single-carriageway sections, with limited forward visibility, steep gradients and two at-grade roundabouts restricting the flow of traffic.

2.4.2 Average daily traffic flows on the Existing A417 are around 37,000 vehicles on Crickley Hill and around 30,000 vehicles south of the Air Balloon roundabout.

These volumes are already well in excess of recommended flows for new single carriageway roads[3].

2.4.3 The Air Balloon roundabout is a key junction and a main cause of congestion in the area. The morning peak is characterised by slow moving and queuing traffic on all approaches. The Existing A417 from the south is particularly congested, with capacity on this approach restricted by its single lane approach and, despite widening to around 8.0m on entry to the roundabout, traffic turning left onto the Existing A417 towards the M5 must do so from a single lane only. Northbound traffic on this approach in the morning peak is typically slow moving from as far south as Cowley roundabout. Conditions in the evening peak are similar to the morning, except that the Existing A417 eastbound approach to the Air Balloon roundabout typically experiences fewer delays and queuing. The A436 approach to the Air Balloon also experiences delays and queues, which are an issue in the evening peak in particular.

2.4.4 Figure 2-2 shows the distribution of eastbound (EB) and westbound (WB) daily traffic volumes on the A417 Crickley Hill across the year (between November 2015 and October 2016). The data presented is the seven-day average daily flow and is derived from all days of the year (i.e. with no dates, such as school or bank holidays, excluded).



Source: Highways England

Figure 2-2 A417 Crickley Hill daily traffic flows, by direction

2.4.5 At the daily level, westbound flows on the Existing A417 in this area are typically 10-15% lower than the eastbound direction. The variation in directional flows is reflective of congestion along this section of the Existing A417. Westbound traffic on the Existing A417 experiences delays for much of the day, while eastbound

[3] DMRB

traffic typically experiences less delay, and journey times are more consistent throughout the day.

2.4.6 As a result, a number of northbound "rat-runs" are observed which are not reflected to the same degree in the southbound direction. Traffic to Cheltenham is known to divert off the A417 and travel along the local road network through the villages of Elkstone and Cockleford before joining the A435. Traffic destined for Gloucester is known to divert off the Existing A417 at Birdlip and travel along Birdlip Hill and Ermin Way through the village of Little Witcombe. Traffic rat-running through villages causes difficulties for local communities.

2.4.7 Figure 2-3 shows the hourly weekday traffic flows, by direction, in February 2016 on the A417 Crickley Hill.

Source: Highways England

Figure 2-3 A417 Crickley Hill hourly traffic flows, by direction (February 2016)

2.4.8 Figure 2-3 clearly identifies morning and evening peak periods for eastbound traffic, but the peaks for westbound traffic are far less pronounced with relatively little variation in flows in the 12-hours between 07:00 and 19:00. Peak period traffic volumes in the westbound direction are also lower than in the eastbound direction, particularly in the morning peak period. This is likely to be reflective of a lack of westbound capacity, particularly at the Air Balloon roundabout and on Crickley Hill, which restricts the volumes of traffic travelling westbound on this section of the Existing A417 throughout the day.

2.4.9 As a consequence of the high traffic flows and steep gradients even minor incidents cause considerable disruption and delay. Observations and feedback from public consultation indicate that heavy goods vehicles (HGVs) regularly break down in congested stop-start traffic on the steep hill.

2.4.10 The high volumes of traffic, poor forward visibility and challenging gradients also contribute towards a particularly poor safety record on the existing single-carriageway section of the A417.

2.4.11 In the five years to the end of June 2019, there were 42 personal injury accidents (PIAs) on the Existing A417. These accidents resulted in 8 fatalities and 21 seriously injured casualties, with a further 53 slight casualties.

2.4.12 The fatal and serious casualty rates observed on the Existing A417 are significantly higher than the national average for single-carriageway roads. This is summarised in Figure 2-4 which presents the observed casualty rates per PIA on the A417 against the national average for equivalent road types.

Source: Highways England

Figure 2-4 Number of casualties per PIA

2.4.13 Table 2-1 provides a comparison of the observed number of casualties against a national average equivalent. The national average number of casualties shown in the table are based on the same number of observed accidents (42) but assuming national average casualty rates.

Table 2-1 Casualty rates per PIA by severity – local and national comparison

	Total PIAs	Casualties			
		Fatal	Serious	Slight	Total
Observations (July 2014 – June 2019)	42	8	21	53	82
National Average	42	2	10	55	66

Source: Highways England

Notes: numbers may not sum due to rounding

3 Summary and review of existing data

3.1 Introduction

3.1.1 This section provides an overview of existing traffic data, including data that was collected and used in PCF stage 1 and PCF stage 2, which has been used to develop the scheme traffic model for PCF stage 3.

3.1.2 The section also includes the outcome of analysis of observed traffic growth between 2015 and 2019 to ascertain how traffic has changed compared to Trip End Model Presentation Programme (TEMPro) forecast traffic growth.

3.2 Data review – 2015 to 2019

Introduction

3.2.1 The scheme traffic model has a base year of March 2015. DfT TAG notes that former guidance in the Design Manual for Roads and Bridges (DMRB) had previously indicated that models based on source data more than five years old should not be used. However, TAG goes on to say that: *"This simple threshold should not be used, as there can be significant changes that would make the use of more recent data inappropriate or there may have been little change and older data may be acceptable."*

3.2.2 TAG therefore recommends that evidence should be established on the "*scale of changes to land use and demographic characteristics, transport networks and travel patterns, with more attention given to the key movements in the model internal area, and use this evidence to assess the validity of 'old' data sources and their suitability for the intended use(s) of the model."*

3.2.3 Analysis of traffic count data on the SRN and local roads between 2015 and 2019 has been undertaken to ascertain how traffic has changed in the intervening period; with observed traffic growth between 2015 and 2019 compared to TEMPro forecast traffic growth. This analysis will provide the evidence to assess the validity of data sources and their suitability for the intended use of the model.

3.2.4 The data review is set out in detail in a technical note. This technical note can be found in Appendix E of this report.

Strategic road network

3.2.5 Analysis has been undertaken using Highways England WebTRIS data for the Existing A417, A417 sites to the south and west of the scheme, and for the M5 between Junctions 10 and 12.

3.2.6 Appendix E of this report provides detailed analysis and the results of this assessment.

Local road network

3.2.7 Analysis has been undertaken using automatic traffic count (ATC) data from Gloucestershire County Council (GCC) for the A436 (Ullenwood), A435 (Rendcomb), A419 (Coates), A46 (Fiddlers Elbow) and Lobleys Drive Bridge.

3.2.8 Appendix E of this report provides detailed analysis and the results of this assessment

Summary

3.2.9 Overall, the observed traffic growth on the SRN and local road networks is considered to be comparable to TEMPro forecast traffic growth and the difference does not have a material impact on the uncertainty underlying the use of the existing scheme traffic model or the uncertainty underlying the scheme appraisal.

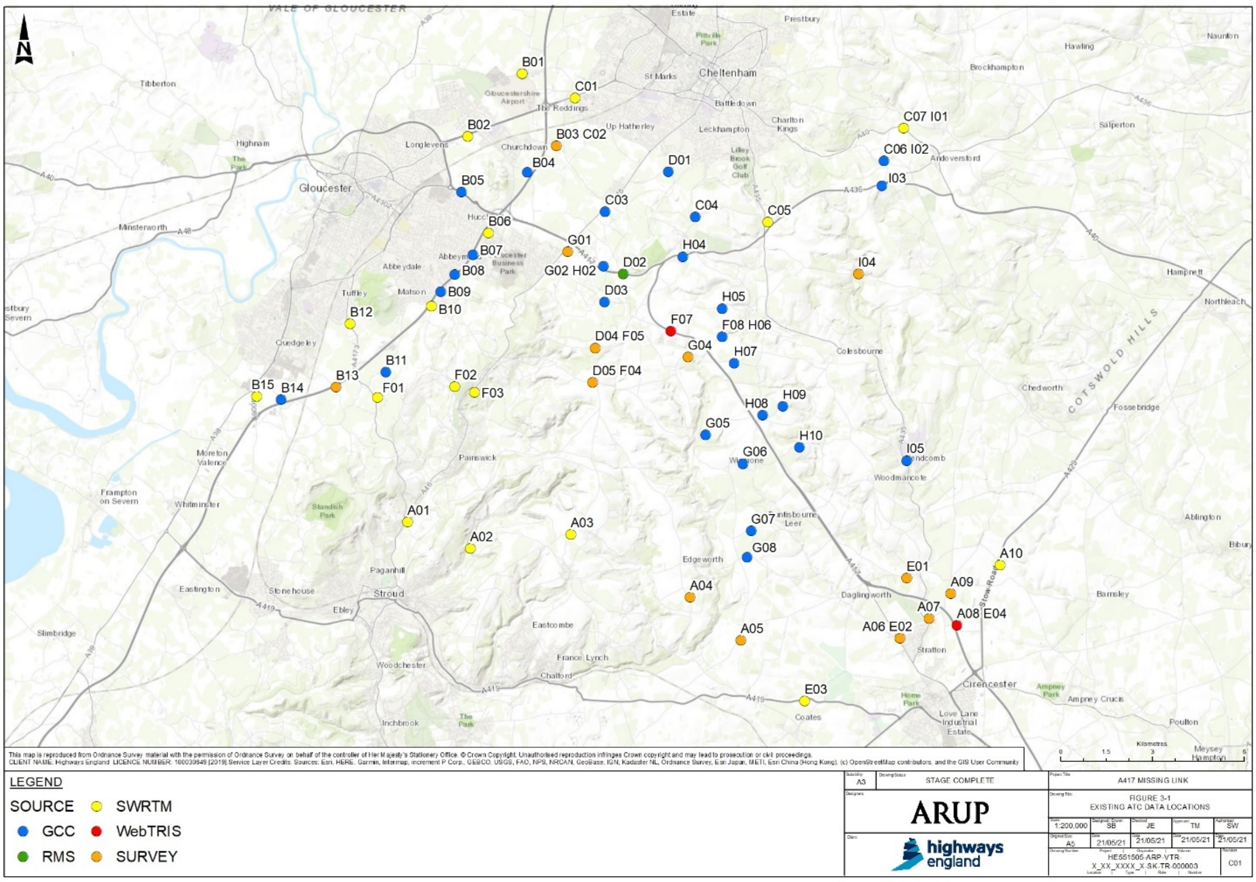
3.2.10 As such, and as agreed with Highways England's TPG, it is considered that retaining the 2015 base year is consistent with TAG and use of the existing scheme traffic model for PCF stage 3 is appropriate.

3.3 Automatic traffic count data

3.3.1 ATC data has been used in the calibration and validation of the highway assignment model and is supplementary to data previously collected for the SWRTM. The location of data used in the wider SWRTM is provided in Appendix A of this report.

3.3.2 The scheme base traffic model is intended to be representative of an average weekday in March 2015 which was the base period that SWRTM was developed to represent. Traffic survey data was therefore obtained where possible to match the base year.

3.3.3 ATC count data was obtained from the wider SWRTM and from traffic surveys from a number of sources. The location of survey data obtained is shown in Figure 3-1, with further details provided below.



Source: Highways England

Figure 3-1 Existing ATC data locations

Gloucestershire County Council

3.3.4 The location of GCC's ATC sites are detailed in Table 3-1.

Table 3-1 Existing RMS data summary

Site ref	Site description	OSGR	Survey dates
B04	Brockworth Rd over M5	388978 219133	20/02-04/03/2014
B05	A417 between Zoons and C&G rbouts	386822 218488	05/03-31/03/2015
B07	Lobleys Dr over M5	387203 216440	01/03-31/03/2015
B08	Upton Ln over M5	386606 215801	12/09-25/09/2013
B09	The Ash Path over M5	386155 215239	12/09-25/09/2013
B11	Upton Ln over M5	384361 212611	17/03-23/03/2014
B14	Haresfield Ln over M5	380937 211714	21/02-11/03/2014
C03	A46 south of jct with Badgeworth Ln	391523 217850	26/02-07/03/2014
C04	Leckhampton Hill south of Leckhampton	394466 217676	19/03-01/04/2015
C06 I02	Unnamed road through Dowdeswell	400643 219503	11/07-17/07/2016
D01	Leckhampton Ln east of Shurdington	393596 219144	01/03-31/03/2015
D03	Unnamed road west of Birdlip Hill	391498 214899	06/10-19/10/2015
F08 H06	Cowley Wood Lane	395357 213761	06/10-19/10/2015
G02 H02	Bentham Ln under A417	391467 216066	06/10-19/10/2015
G05	Unnamed road SW of Syde	394807 210559	06/10-19/10/2015
G06	Jackbarrow Rd through Winstone	396036 209617	06/10-19/10/2015
G07	Unnamed road SW of Dunt'ne Abbotts	396303 207427	06/10-19/10/2015
G08	Crabtree Ln SW of jct with Longhill Rd	396171 206566	06/10-19/10/2015
H04	A436 east of jct with Leckhampton Hill	394065 216379	01/03-31/03/2015
H05	Cowley Lane	395345 214684	06/10-19/10/2015
H07	High Cross Lane	395736 212899	06/10-19/10/2015
H08	Unnamed road south of Elkstone	396679 211202	06/10-19/10/2015
H09	Unnamed road SE of Elkstone	397339 211485	06/10-19/10/2015
H10	Unnamed road SW of Rapsgate	397870 210157	06/10-19/10/2015
I03	A436 west of jct with Gloucester Rd	400563 218696	01/03-31/03/2015
I05	A435 south of Colesbourne	401390 209719	17/03-31/03/2015

Source: Highways England

RMS (Gloucester) Ltd

3.3.5 Road Management Services (Gloucester) Ltd are the design, build, finance, operate (DBFO) contractor for the A417/A419 strategic road between the M4 at Swindon (junction 15) and the M5 at Gloucester (junction 11A). RMS Ltd provided ATC data on the A417 as detailed in Table 3-2.

Table 3-2 Existing RMS data summary

Site ref	Site description	OSGR	Survey dates
D02	A417 west of jct with A436	392120 215817	01/03-31/03/2015

Source: Highways England

SWRTM

3.3.6 ATC data from the SWRTM is detailed in Table 3-3.

Table 3-3 Existing SWRTM data summary

Site ref	Site description	OSGR	Survey dates
A01	A46 south of Pitchcombe	385059 207715	01/03-31/03/2015
A02	B4070 south of Slad	387116 206847	11/11-24/11/2015
A03	Calf Way north of jct with Stancombe Ln	390407 207306	26/11-09/12/2015
A10	A429 north of jct with Welsh Way	404426 206300	01/03-31/03/2015
B01	B4063 west of Staverton Bridge	388808 222353	01/03-31/03/2015
B02	A40 west of M5 J11	387033 220304	07/03-31/03/2015
B06	Hucclecote Rd under M5	387710 217153	01/04-30/04/2015
B10	B4073 under M5	385843 214759	11/03-31/03/2015
B12	A4173 south of Tuffley	383186 214183	01/03-31/03/2015
B15	B4008 between M5 J12 and A38	380144 211814	01/03-31/03/2015
C01	A40 east of M5 J11	390547 221553	01/03-31/03/2015
C05	A435 north of jct with A436	396841 217509	01/03-31/03/2015
C07 I01	A40 NW of Andoversford	401290 220571	01/03-31/03/2015
E03	A419 north of Coates	398046 201866	01/03-31/03/2015
F01	A4173 north of jct with Styles Ln	384088 211774	06/09-27/09/2013
F02	B4073 through Painswick Beacon	386608 212129	21/02-11/03/2014
F03	A46 east of Painswick Beacon	387247 211944	21/02-07/03/2014

Source: Highways England

Highways England WebTRIS

3.3.7 The location of ATC data from the Highways England WebTRIS system is detailed in Table 3-4.

Table 3-4 Existing WebTRIS data summary

Site ref	Site description	OSGR	Survey dates
A08 E04	A417 NE of Stratton	403019 204342	01/03-31/03/2015
F07	A417 south of jct with B4070	393774 213900	01/03-31/03/2015

Source: Highways England

2016 traffic surveys (Streetwise and GCC)

3.3.8 ATC surveys were undertaken in October and November 2016 by GCC's in-house data collection team and by Streetwise Services Ltd, who were appointed directly by GCC.

3.3.9 Traffic counts were undertaken in accordance with DfT TAG unit M1.2, in relation to the specific requirement to undertake a minimum of a two-week ATC. Traffic surveys were programmed to be carried out during neutral months, outside of school holidays and other local abnormal traffic periods.

3.3.10 The location of ATC surveys undertaken is detailed in Table 3-5.

Table 3-5 2016 ATC survey locations

Site ref	Site description	OSGR	Survey duration
A04	Dane Ln south of Edgeworth	394297 205250	31/10-13/11/2016
A05	Unnamed road NE of Sapperton	395967 203847	31/10-13/11/2016
A06 E02	Gloucester Rd, Stratton between Baunton Ln and Overley Rd	401168 203910	31/10-13/11/2016
A07	A435 between Baunton and Stratton	402113 204565	31/10-13/11/2016
A09	White Way NE of Baunton	402831 205377	31/10-13/11/2016
B03 C02	Brookfield Rd over M5	389935 219994	31/10-13/11/2016
B13	Naas Ln over M5	382729 212113	01/11-14/11/2016
D04 F05	Buckholt Rd between A46 and B4070	391193 213396	14/11-27/11/2016
D05 F04	Unnamed road east of Cranham	391120 212274	14/11-27/11/2016
E01	Welsh Way west of Perrott's Brook	401384 205888	31/10-13/11/2016
G01	A46 south of jct with A417	390298 216538	31/10-13/11/2016
G04	Unnamed road between A417 and Brimpsfield	394226 213097	31/10-13/11/2016
I04	Unnamed road west of Withington	399810 215808	01/11-14/11/2016

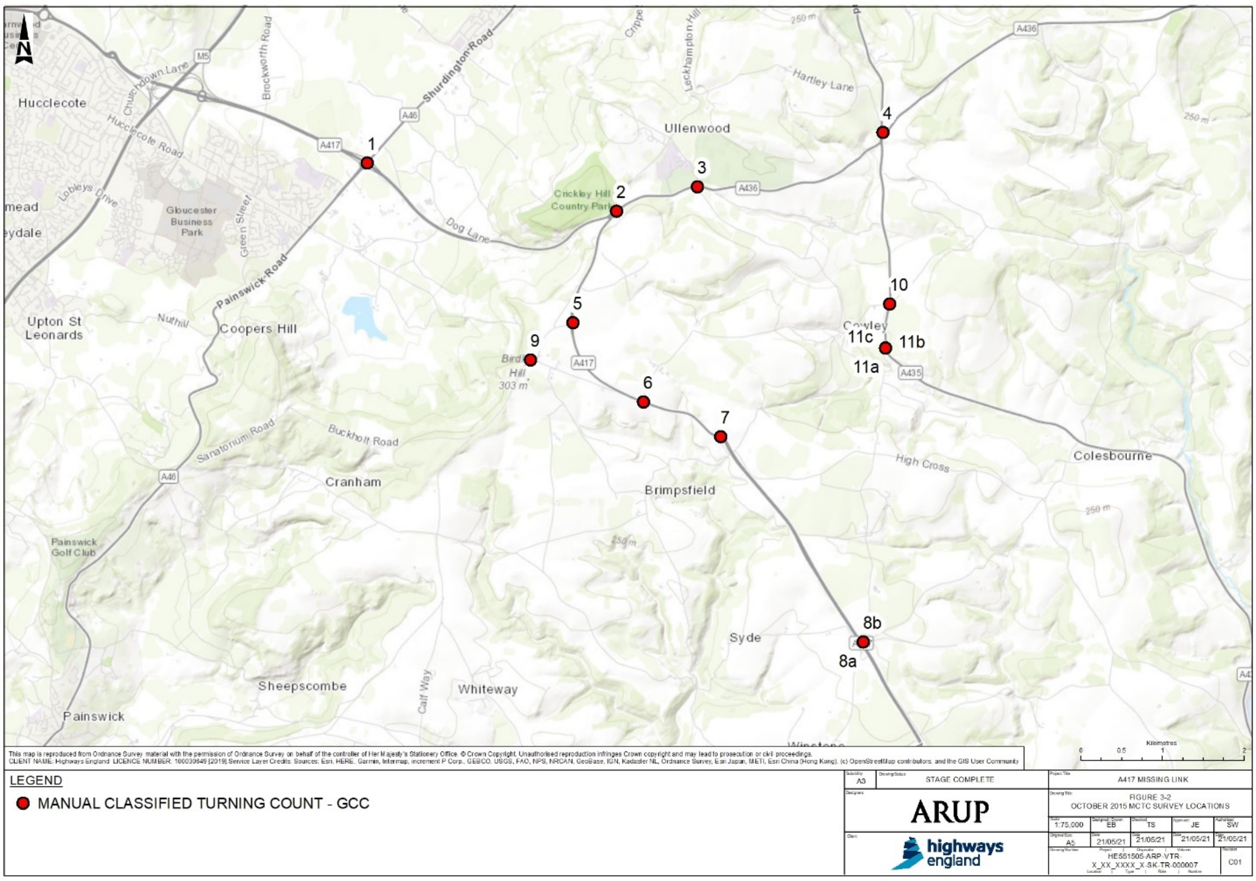
Source: Highways England

3.3.11 Other than the review of recent count data detailed in section 3.2 of this report, there was no further collation of existing ATC data during PCF stage 3.

3.4 Manual classified turning count data

3.4.1 Manual classified turning count (MCTC) data was obtained from surveys commissioned by GCC at 11 sites in October 2015. Surveys were undertaken by Nationwide Data Collection and focussed on major junctions around the scheme. The surveys were carried out for a 12-hour period between 07:00 and 19:00 on either the 14 or 15 of October 2015.

3.4.2 The location of survey data obtained is shown in Figure 3-2, with further details provided in Table 3-6.



Source: Highways England

Figure 3-2 October 2015 MCTC survey locations

Table 3-6 MCTC surveys

Survey ref	Site description	OSGR	Date of survey
1	A417/A46 Brockworth	390526 216784	14/10/2015
2	A436 Crickley Hill Country Park	393581 216195	15/10/2015
3	A436 Ullenwood Manor Lane/Main Street	394571 216491	14/10/2015
4	A436 Seven Spring	396848 217163	14/10/2015
5	A417 Birdlip	393043 214830	15/10/2015
6	A417 Roman Road	393913 213857	15/10/2015
7	A417 Watercombe	394859 213431	15/10/2015
8a	A417 Beechpike SB	396603 210911	15/10/2015
8b	A417 Beechpike NB	396603 210911	15/10/2015
9	B4070 Birdlip	392523 214368	15/10/2015
10	A435 Cowley/Cheltenham Road	396926 215056	14/10/2015
11a	A435 Cowley/Cockleford north jct	396876 214519	14/10/2015
11b	A435 Cowley/Cockleford south jct	396876 214519	14/10/2015
11c	A435 Cowley/Cockleford combined jct	396876 214519	14/10/2015

Source: Highways England

3.4.3 There was no further collation of existing MCTC data during PCF stage 3.

3.5 Journey time data

3.5.1 Data generated from the movements of global positioning system (GPS) equipped 'probe' vehicles are mapped to a representation of the road network in order to estimate average vehicle journey times across England. TrafficMaster collate this data for the whole of England and provide it to the DfT annually. This data was provided to the A417 modelling team for the entire county of Gloucestershire for the period September 2014 to August 2015.

3.5.2 Whilst the scheme traffic model base year represents traffic demand for March 2015, the TrafficMaster dataset used is from May/June 2015. This is because from April 2015 the speed limit for HGVs travelling on single and dual carriageways in England and Wales was increased. The national speed limits for HGVs over 7.5 tonnes travelling on a single-carriageway road increased from 40mph to 50mph. The speed limit for HGVs over 7.5 tonnes travelling on dual carriageways increased from 50mph to 60mph. In order to accurately forecast future vehicle journey times, data from after this change has been used. This method is consistent with that applied within the wider SWRTM.

3.5.3 The calibration and validation of journey times in the scheme base traffic model has utilised TrafficMaster data previously used in the SWRTM. This was supplemented with additional TrafficMaster data, obtained during PCF stage 1 and representing the 2015 base year of the scheme traffic model, specifically for the new local journey time routes.

3.5.4 A total of nine local journey time routes have been selected for use in validating the Simulation and Assignment of Traffic to Urban Road Network (SATURN) model, with each route split into sections by timing points corresponding to modelled nodes in the SATURN model. These local journey time routes supplement three routes used in the SWRTM, including a route along the A417/A419 between M4 J15 and Gloucester.

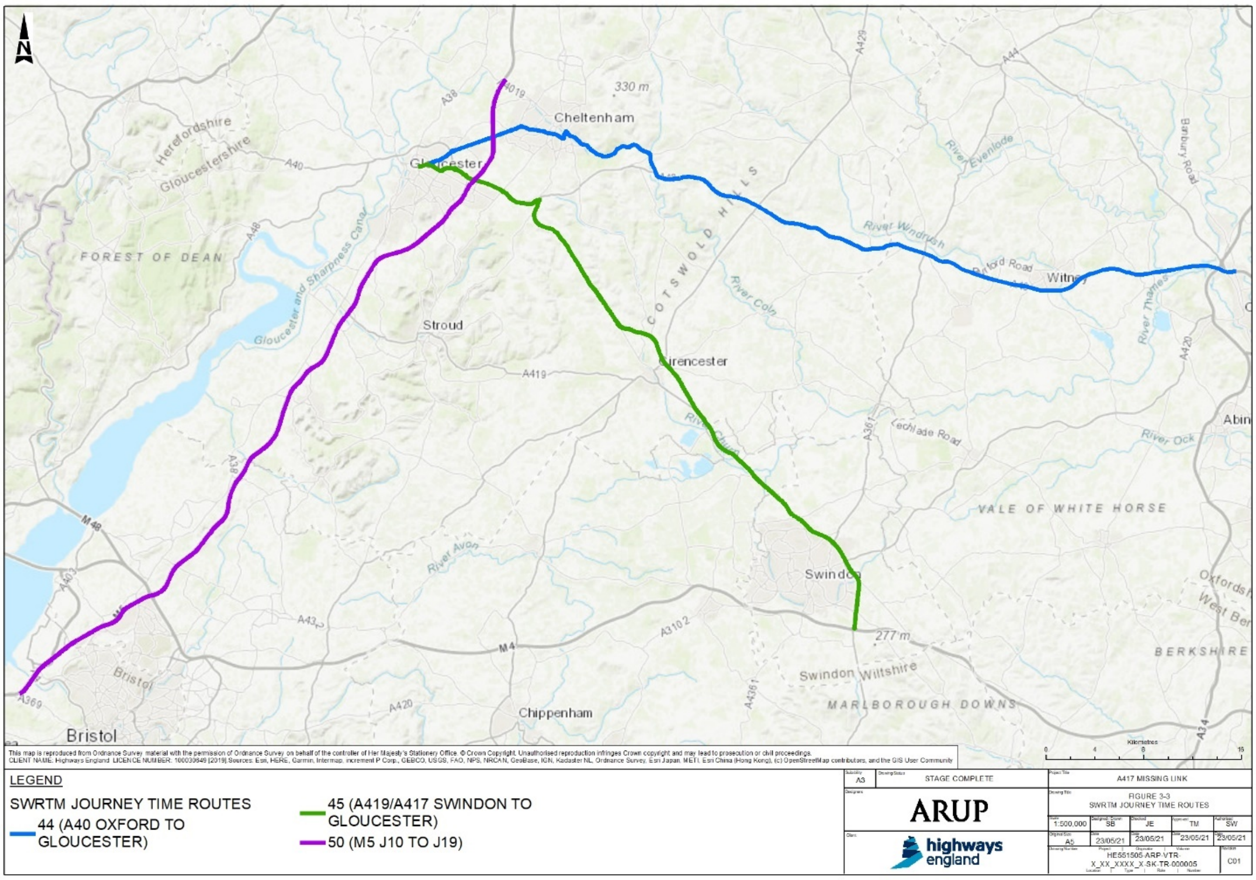
3.5.5 The journey time routes used in the PCF stage 3 appraisal are summarised in Table 3-7.

Table 3-7 Combined PCF stage 3 journey time routes

Ref.	Description
44	A40 Oxford to Gloucester
45	A419/A417 Swindon to Gloucester
50	M5 J10 to J19
101	Stroud to Cheltenham via A46
102	Stroud to Cheltenham via B4070
103	Cirencester to Cheltenham via A435, A436 and A46
104	Cirencester to Cheltenham via A417
105	Stroud to Cheltenham via A46 and A436
106	Stroud to Gloucester via local roads
107	Gloucester to Cheltenham via A436
108	Gloucester to Cheltenham via A40
109	Cirencester to Gloucester via A417

Source: Highways England

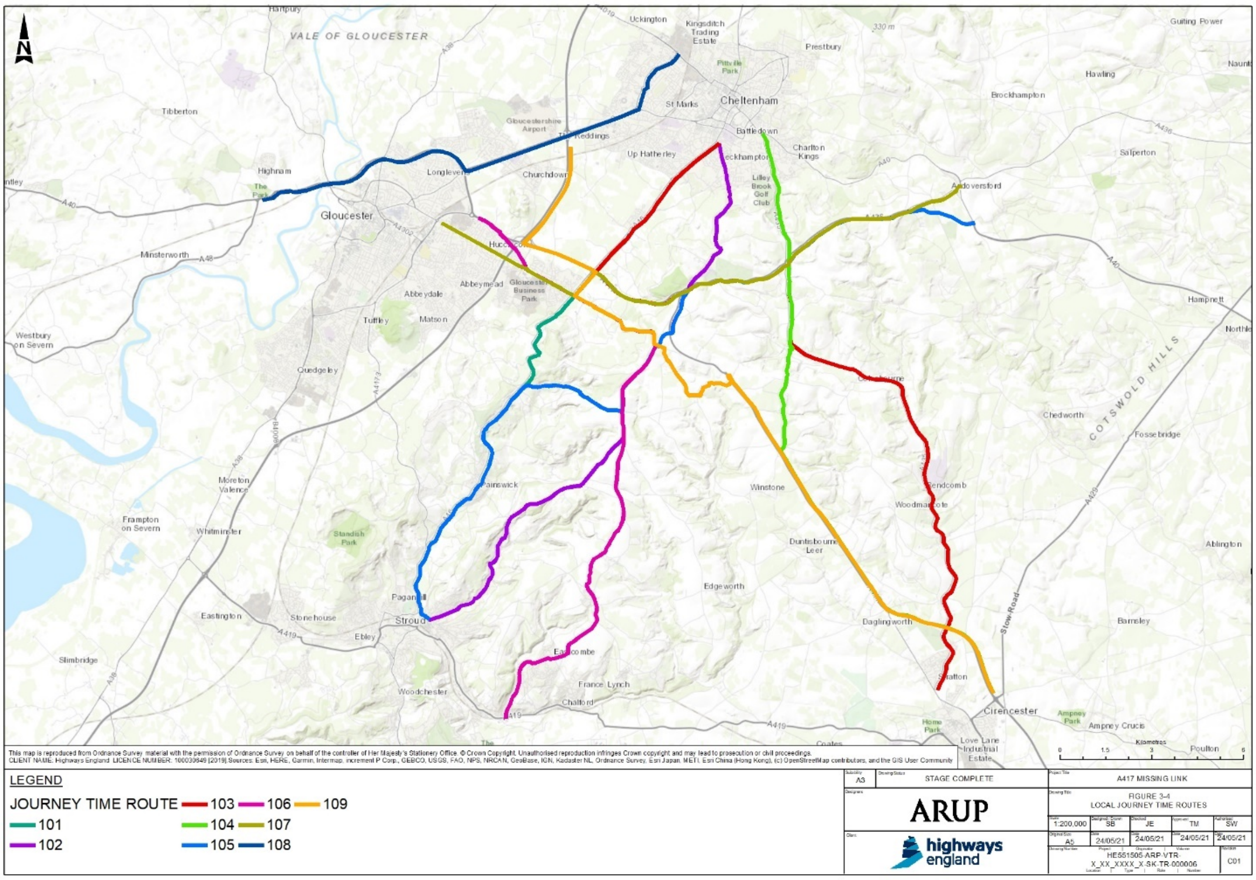
3.5.6 The original journey time routes in the SWRTM are illustrated in Figure 3-3.



Source: Highways England

Figure 3-3 SWRTM journey time routes

3.5.7 The nine local A417 journey time routes are summarised in Figure 3-4. Further detail on each of the journey time routes, including figures identifying each timing point, is provided in Appendix B of this report.

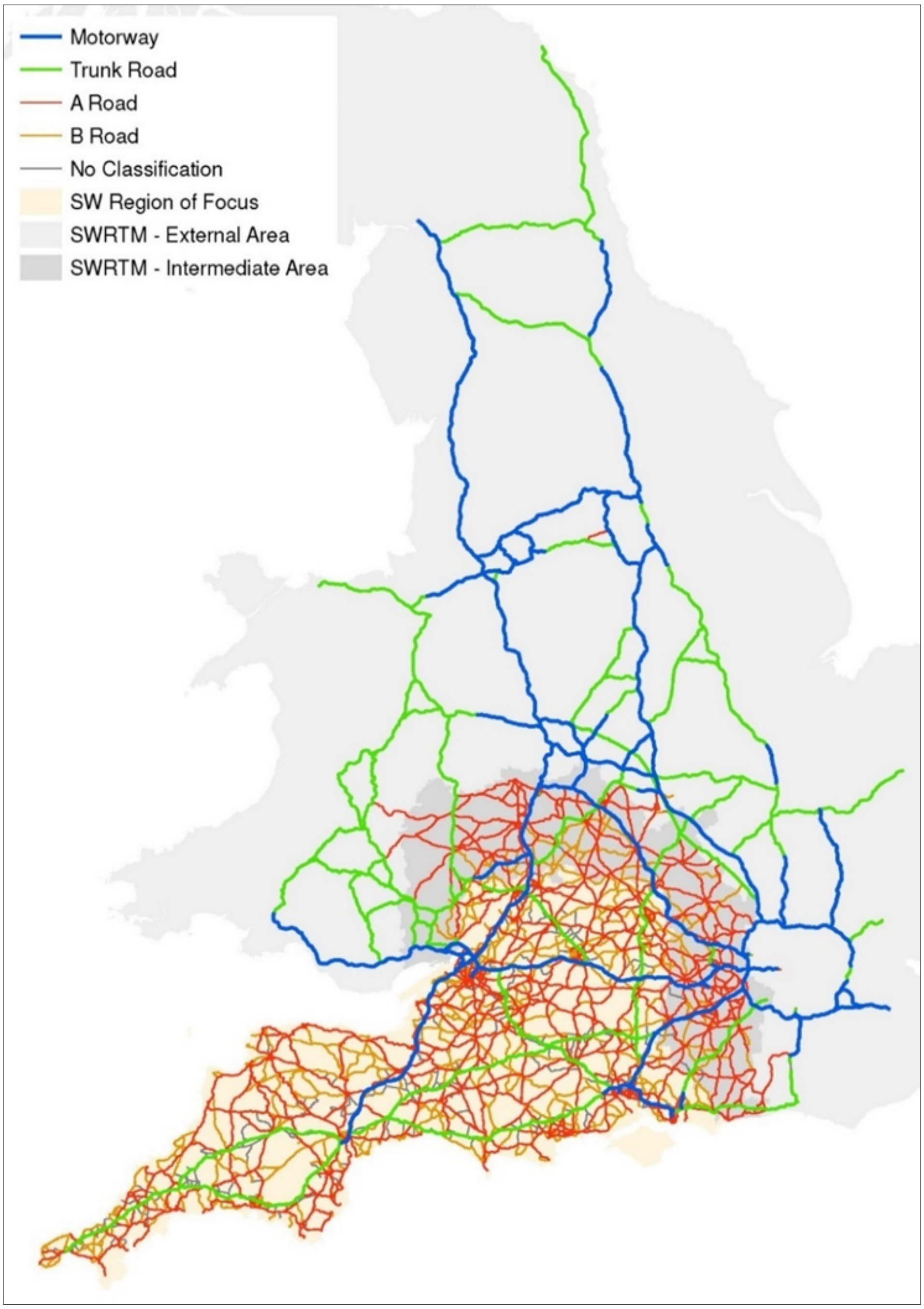


Source: Highways England

Figure 3-4 Local journey time routes

3.6 Network data

3.6.1 Network data was obtained from the PCF stage 2 scheme traffic model. The scheme traffic model for PCF stage 2 was derived from the scheme traffic model for PCF stage 1, which was in turn derived from the SWRTM. Whilst it is recognised that the regional model has undergone further development, it is not considered that subsequent amendments to the regional model required the local scheme traffic model to be rebuilt. In many respects it is in fact noted that the refinement to SWRTM in the vicinity of the scheme has primarily been driven by issues noted and addressed during the development of the PCF stage 1 scheme traffic model. Figure 3-5 identifies the SWRTM network coverage.



Source: This map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. Highways England 100030649 2016.

Figure 3-5 South-West Regional Traffic Model – network coverage

3.7 Matrix data

3.7.1 Matrix demand data for March 2015 were obtained from the SWRTM prior matrices. The SWRTM prior matrices were themselves derived from different data sources such as mobile phone data (MPD)/synthetic models, TrafficMaster, DfT's base year freight matrices (BYFM) and port and airport data.

3.7.2 Rail passenger trip matrices, which were estimated using a combination of Moira and National Rail Travel Survey (NRTS) data, were also obtained from SWRTM.

3.8 Mapping data

3.8.1 Mapping data such as a geographic information system (GIS) model networks, GIS shapefiles detailing the location of various data and an integrated transport network (ITN) were maintained from the scheme model for PCF stage 2, having originated from the SWRTM and subsequent scheme traffic model for PCF stage 1.

3.9 Operational data

3.9.1 Operational data such as signal times and geometric junction data were retained from the scheme traffic model for PCF stage 2, having originated from the SWRTM and subsequent scheme traffic model for PCF stage 1.

3.10 Accident data

3.10.1 Accident data is used in the assessment of accidents as part of the economic appraisal of the scheme.

3.10.2 At PCF stage 1, accident data for 2011 through to 2015 inclusive was obtained from the DfT. The statistics relate only to personal injury accidents on public roads that are reported to the police and subsequently recorded on the database, referred to as STATS19. In PCF stage 2 and PCF stage 3, this data was supplemented with more recent accident data, as detailed in section 4.4 of this report.

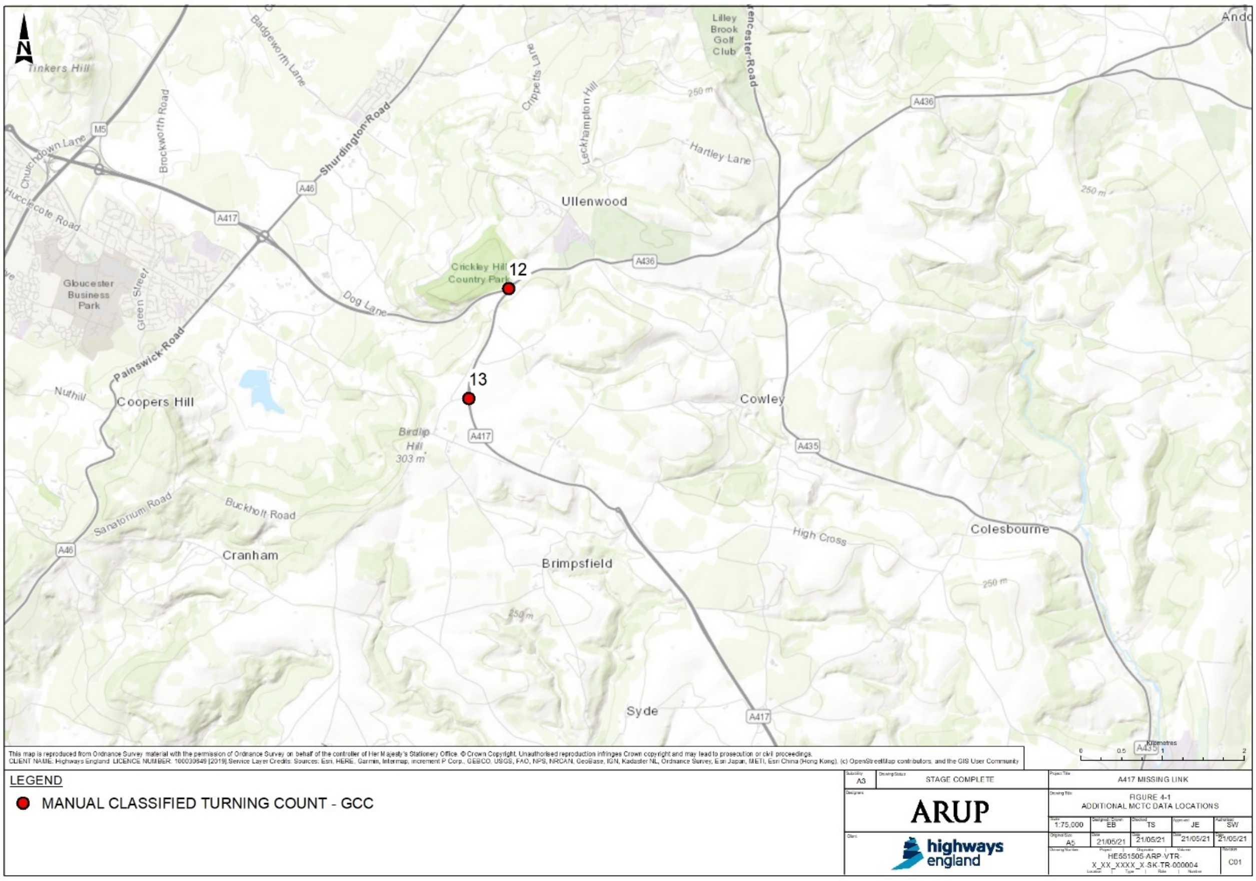
4 Data collection

4.1 Introduction

4.1.1 This section provides an overview of the additional data that has been collected through new surveys since PCF stage 1 and that was used to develop the PCF stage 2 scheme model. No additional survey data was collected during PCF stage 3.

4.2 Manual classified turning count data

4.2.1 New MCTC surveys, commissioned by GCC, were undertaken in March 2017. The location of MCTC surveys undertaken are shown in Figure 4-1, with further information shown in Table 4-1.



Source: Highways England

Figure 4-1 MCTC survey locations

Table 4-1 2017 Gloucestershire County Council MCTCs

Site ref	Site description	OSGR	Survey dates
12	Air Balloon roundabout (A417/A436/Leckhampton Hill)	393520 216139	09/03/2017
13	Birdlip Junction (A417/B4070)	393030 214793	09/03/2017

Source: Highways England

4.2.2 The additional MCTC surveys were undertaken for use during calibration and validation of the scheme traffic model for PCF stage 2; specifically to inform vehicle turning movements at these important junctions.

4.3 Operational data

4.3.1 Additional signal staging and phasing data was derived from the Central Severn Vale model. This data was used as an initial guide in the coding of signalised junctions added during the development of the scheme traffic model for PCF stage 2.

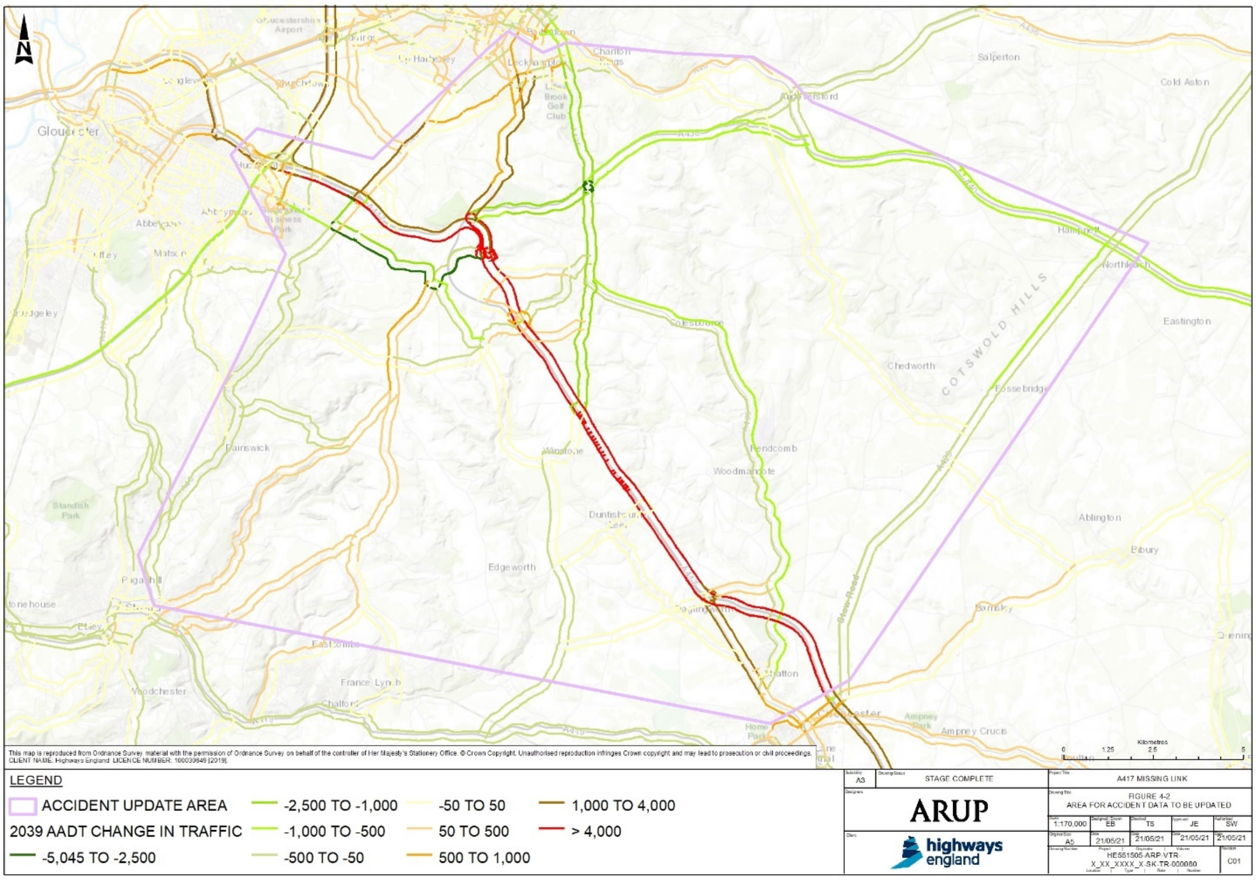
4.3.2 The locations of the additional signalised nodes are identified in Figure 7-3 within section 7 describing the scheme traffic model development.

4.4 Accident data

4.4.1 During PCF stage 2, accident data for May 2013 to April 2018 inclusive was obtained from Gloucestershire, South Gloucestershire and Wiltshire (including Swindon) highway authorities. At the time it was collated, this represented the latest available data.

4.4.2 This was further supplemented with data obtained from the DfT for 2012 to 2016 inclusive (the latest available data directly from a single source, i.e. without obtaining the data from individual authorities). This additional data was required to provide coverage for the entire accident assessment study area, which includes a small number of roads within a further five neighbouring authorities (Herefordshire, Worcestershire, Warwickshire, Oxfordshire and West Berkshire).

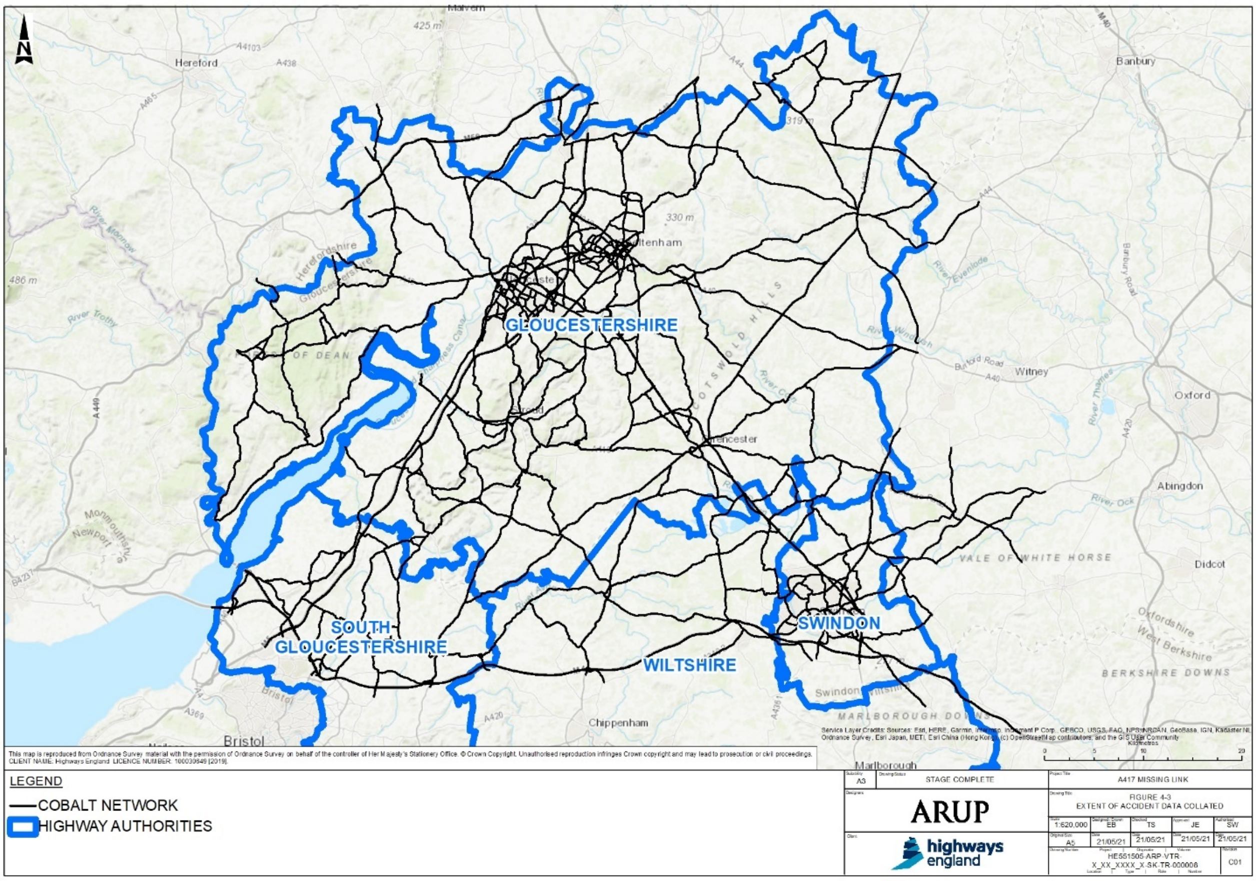
4.4.3 As agreed with Highways England's TPG during PCF stage 3, accident data for the period May 2013 to April 2018 (inclusive) has been used during PCF stage 3 for the majority of the traffic model links. For a selection of links, local to and including the scheme where changes in traffic flow as a result of the scheme are likely to be significant, accident data has been updated to include the period May 2018 to June 2019 making the five year period July 2014 to June 2019 (inclusive). These links are shown in Figure 4-2.



Source: Highways England

Figure 4-2 Area for updated accident data

4.4.4 Figure 4-3 shows the road network (in black lines) that constitutes the accident assessment study area. Accident data has been compiled for all links shown in the figure.



Source: Highways England

Figure 4-3 Extent of accident data collated

5 Final datasets

5.1 Introduction

5.1.1 This section provides an overview of the full datasets used within the PCF stage 3 scheme model, including discussion of checks and data manipulation undertaken.

5.2 Overview of full datasets

5.2.1 A summary of the existing and new data collected in support of the scheme traffic model for PCF stage 3 is provided in Table 5-1. Section references are provided where further details of each data type can be found.

Table 5-1 Overview of datasets

Data type	PCF stage 3 dataset summary	Section ref.
ATC data	Existing data at 59 sites	3.2
MCTC data	Existing data at 11 sites New data at 2 sites	3.4, 4.2
Journey time data	3 journey time routes from the SWRTM 9 local journey time routes	3.4.3
Network data	Obtained from the scheme traffic model for PCF stage 2	3.6
Matrix data	Demand data for March 2015 obtained from the scheme traffic model for PCF stage 2 prior matrices	3.7
Mapping data	Obtained from the scheme traffic model for PCF stage 2	3.8
Operational data	Obtained from the scheme traffic model for PCF stage 2	3.9, 4.3
Accident data	5 Years of data primarily 2013-2018 inclusive, however a small number of links on the fringes of the study area are 2012-2016 inclusive. Key links close to the scheme have been updated with accident data to cover the period April 2018 to June 2019, for these links accident data now covers the period July 2014 to June 2019 inclusive.	3.10, 4.4

Source: Highways England

5.3 Data checking and processing

5.3.1 The following sections of this report summarise the types of checks undertaken on data received and the steps involved in processing the data from its 'raw' form into a format suitable for use in the modelling appraisal.

Automatic traffic count data

5.3.2 All ATC data was checked to ensure its accuracy and reliability. Anomalies in the data can be caused by equipment failure, road closures, incidents, or seasonal effects. Checks included:

- Tidality – ATC flows were plotted by time and direction and inspected to ensure that the observed patterns in flow were as expected (for example, inbound; AM peak flows, outbound; PM peak flows).
- Anomalies – any recorded peaks or troughs in the data that did not follow the overall trend of the survey site were investigated and, if deemed appropriate, were removed from the dataset.

- Cross-checking with MCTC data – ATC flows are plotted and compared to plots of MCTC results from connected links, i.e. similar peaks/troughs and comparable volumes.

5.3.3 Anomalous results were rare but, when observed, these instances were corrected or removed from the dataset.

5.3.4 ATC data has been obtained from a variety of sources and therefore arrived in different formats. Following data checking and exclusion of any anomalous data, all ATC data was imported and formatted into a standardised template in which average weekday data was calculated.

5.3.5 As noted previously, the scheme base traffic model is intended to be representative of an average weekday in March 2015. Where any data collected was not from March 2015, suitable adjustments have been applied to account for seasonal differences in traffic patterns and volumes by month, and general traffic growth over time. The factors used to convert count data to March 2015 values are detailed in Table 5-2 and Table 5-3.

5.3.6 Where survey data was obtained from 2015 the applicable seasonal adjustment factor shown in Table 5-2 was applied. Similarly, for surveys undertaken during November 2016 the direct adjustment factor in Table 5-2 was applied. These factors were calculated from ATC data collected from five locations where long-term continuous monitoring data was available within the study area between January 2015 and November 2016.

Table 5-2 Weekday traffic flow – seasonal adjustment factors by month

Month	Factor
January 2015	1.08
February 2015	1.04
March 2015	1.00
April 2015	0.98
May 2015	0.97
June 2015	0.96
July 2015	0.99
August 2015	1.05
September 2015	0.97
October 2015	1.01
November 2015	0.97
December 2015	1.04
November 2016	0.97

Source: Highways England

5.3.7 Where survey data was obtained from outside of the above periods, survey data has been adjusted seasonally to March using the 2015 factors shown in Table 5-2, and annually adjusted using the factors shown in Table 5-3. The annual factors were derived using the latest version of the National Transport Model (NTM) road traffic forecasts at the time of model calibration and validation (RTF15) for the south-west region (by road type) and have been adjusted according to TEMPro for Gloucestershire county.

Table 5-3 Annual adjustment factors

Month	Strategic roads	Principal roads	Minor roads
2013	1.04	1.03	1.03
2014	1.02	1.01	1.01
2015	1.00	1.00	1.00
2016	0.98	0.99	0.99

Source: Highways England

5.3.8 From the traffic counts, average hourly traffic flows have then been derived for the following weekday time periods for use in the calibration and validation of the scheme base traffic model (described in subsequent sections):

- AM period: 07:00-10:00
- Inter-peak (IP) period: 10:00-16:00
- PM period: 16:00-19:00.

5.3.9 The off-peak period (OP) (19:00-07:00) is not subject to calibration and validation as it is simply an alternative method to factoring from modelled periods to daily levels. Therefore, there was no requirement to derive average hour count data for the OP period.

5.3.10 In a small number of cases, derived traffic counts were assigned to two adjacent modelled links, with no side road or zone connector separating them. During the matrix estimation process (see section 8), having inconsistent (i.e. non-identical) adjacent counts results in the matrix estimation procedure being unable to resolve the differences or calibrate modelled flows to two conflicting counts (a violation of Kirchoff's Law – flows in must equal flows out). In these instances, a view was taken as to the most appropriate/reliable count to maintain, and the adjacent count was adjusted accordingly.

5.3.11 The derived traffic counts are provided in Appendix C of this report.

Manual classified turning count data

5.3.12 MCTC data was checked for errors to ensure its reliability. Checks included comparison of flow profiles on individual arms against neighbouring ATC data to ensure that similar trends are observed and that the volumes recorded are comparable.

5.3.13 No anomalies were found in the MCTC data through the cross checks undertaken.

5.3.14 For each arm of the survey junctions, the average hourly traffic flow has been calculated for the following weekday time periods represented by the scheme traffic model:

- AM period: 07:00-10:00
- IP period: 10:00-16:00
- PM period: 16:00-19:00.

5.3.15 Turning counts have been aggregated into three vehicle types: cars, light goods vehicles (LGV) and other goods vehicles (OGV).

5.3.16 Where a MCTC was undertaken on the same section of road as an ATC survey, the MCTC was used to split the total traffic volumes identified from the ATC into separate vehicle categories. The correspondence of MCTC and ATC counts is summarised in Table 5-4.

Table 5-4 MCTC/ATC site correspondence

Site description	ATC count ref	MCTC count ref
A46 south of jct with Badgeworth Ln	ATC-C03	MCTC-1
Leckhampton Hill south of Leckhampton	ATC-C04	MCTC-2
A435 north of jct with A436	ATC-C05	MCTC-4
Unnamed road west of Birdlip Hill	ATC-D03	MCTC-9
A417 south of jct with B4070	ATC-F07	MCTC-6
A46 south of jct with A417	ATC-G01	MCTC-1
A436 east of jct with Leckhampton Hill	ATC-H04	MCTC-2
A436 west of jct with Gloucester Rd	ATC-I03	MCTC-4
A435 south of Colesbourne	ATC-I05	MCTC-11

Source: Highways England

5.3.17 For the remaining ATC sites that did not have a corresponding MCTC survey, an average vehicle split was applied based on the road classification. These average vehicle splits were derived from all MCTC survey arms, which were categorised as either strategic, principal or minor. This provided a sample of 10 strategic road counts, 14 principal road counts and 15 minor road counts.

5.3.18 The average vehicle splits calculated by road classification are provided in Table 5-5 to Table 5-7.

Table 5-5 Strategic road average vehicle split

Time Period	Cars	LGV	OGV
AM	75%	13%	11%
IP	72%	14%	14%
PM	84%	9%	7%
12-hour	76%	12%	11%

Source: Highways England

Table 5-6 Principal road average vehicle split

Time Period	Cars	LGV	OGV
AM	83%	12%	5%
IP	81%	13%	7%
PM	88%	10%	3%
12-hour	84%	12%	5%

Source: Highways England

Table 5-7 Minor road average vehicle split

Time Period	Cars	LGV	OGV
AM	86%	12%	2%
IP	82%	15%	3%
PM	88%	11%	1%

Time Period	Cars	LGV	OGV
12-hour	85%	12%	2%

Source: Highways England

5.3.19 At five locations no ATC count data is available. These locations are:

- F06 - B4070 south of Birdlip
- F09 - A435 north of Cockleford, east of Cowley
- G03 - B4070 north of Birdlip
- H01 - A46 north of the junction with the A417
- H03 - Leckhampton Hill north of the junction with the A436

5.3.20 At these sites, MCTC counts have been adjusted and controlled to count data from the most appropriate nearby ATC count (see paragraph 5.3.10 for adjustments made due to Kirchoff errors), or logic checks have been undertaken to ensure MCTC values are consistent with adjacent ATC counts to enable traffic volume and vehicle split to be derived from the MCTC data. For MCTC surveys used in place of ATC counts, seasonality adjustment factors have been applied to factor the data to March 2015 as detailed in section 5.3 of this report.

5.3.21 Derived traffic counts, split by vehicle type, are provided in Appendix C of this report.

Journey time data

5.3.22 Journey time data was extracted from the TrafficMaster dataset for all weekdays (excluding bank holidays) in May and June 2015 in order to be consistent with the approach adopted in the SWRTM (see paragraph 3.5.2).

5.3.23 Contained within the TrafficMaster dataset is the length of each link. The lengths of all links for which TrafficMaster data has been processed have been compared against the length in the opposite direction to ensure all required links have been processed. In addition, the link lengths have been compared to the SATURN model link lengths to ensure consistency between the two datasets. No issues were identified.

5.3.24 Once journey times had been calculated from the TrafficMaster data for each link, checks were undertaken on the derived speeds. This included identifying the minimum and maximum speeds and investigating whether the speeds appeared reasonable and whether they occurred in sensible locations. The calculated speeds on each link were also plotted in GIS to identify whether speeds appeared reasonable.

5.3.25 In a small number of very minor rural roads the number of TrafficMaster observations was considered to be too low in at least one period (a sample of less than five). In these instances, a full years' worth of weekday (excluding bank holiday) TrafficMaster data, from September 2014 to August 2015, was used to provide a more representative sample.

5.3.26 Median journey times have been calculated for the following weekday time periods represented by the scheme traffic model:

- AM period: 07:00-10:00
- IP period: 10:00-16:00
- PM period: 16:00-19:00.

5.3.27 TrafficMaster data was then associated with the SATURN links in the SWRTM network. The observed journey times along each journey time route are provided in Appendix B of this report.

Accident data

5.3.28 Accident data was mapped onto the base year COBALT network links in GIS (COBALT is the name of DfT software used for the purpose of assessing accident benefits of schemes – see sections 12 and 13). Accidents were allocated to the nearest link within 20 metres to avoid erroneously mapping any accidents that occurred on non-modelled links onto the modelled network.

5.4 Adequacy of datasets

5.4.1 The previous sections of this report have detailed the transport data used in the development of the scheme traffic model for PCF stage 3, including traffic count, journey time, network, demand, mapping, operational and accident data. Checks of the data have been undertaken and, where appropriate, suitable adjustments have been undertaken to mitigate any data shortfalls or quality issues identified. Data location checks have also been undertaken and confirm that they are appropriate. The resultant dataset is considered to form a robust basis for the development of the PCF stage 3 modelling and appraisal.

6 Scheme traffic model description/specification

6.1 Introduction

6.1.1 This section summarises the modelling approach taken in the development of the scheme traffic model for PCF stage 3, including the geographical and temporal coverage of the scheme traffic model and an overview of the scheme traffic model system components.

6.2 Highways England regional traffic models

6.2.1 Highways England have developed five regional traffic models (RTMs) to provide the basis for the development and appraisal of the Road Investment Strategy (RIS) and Road Investment Programme (RIP) schemes. The RTM base models are intended to be representative of an average weekday in March 2015.

6.2.2 The scheme is a RIS scheme within the SWRTM. The coverage of the SWRTM is illustrated in Figure 6-1, which identifies the various modelled areas that are defined below. Blue lines denote motorways and green lines denote A-roads on the Highways England SRN.

6.2.3 The SWRTM is most detailed around the former South-West government office region but this detailed area extends further east to include Oxfordshire, West Berkshire and Hampshire, or parts thereof. This area is referred to as the SWRTM region of focus (RoF). The SWRTM RoF includes all motorways, A-roads, B-roads and any minor roads that have an important role in enabling strategic traffic movements within the model. Whilst the SWRTM RoF is fully simulated in the most part, it contains 'islands' of fixed speed coding covering large urban areas.

6.2.4 Outside of the SWRTM RoF, the 'external area' is modelled as fixed speed network and does not include travel time responses to variations in flow. The network within this area is also skeletal in form, covering motorways and strategic roads.

6.2.5 The SWRTM also includes an 'intermediate area', the purpose of which is to feed the RoF, providing a transition between the external and internal areas. The intermediate area is modelled as fixed speed, but with a more detailed network compared to the external area.

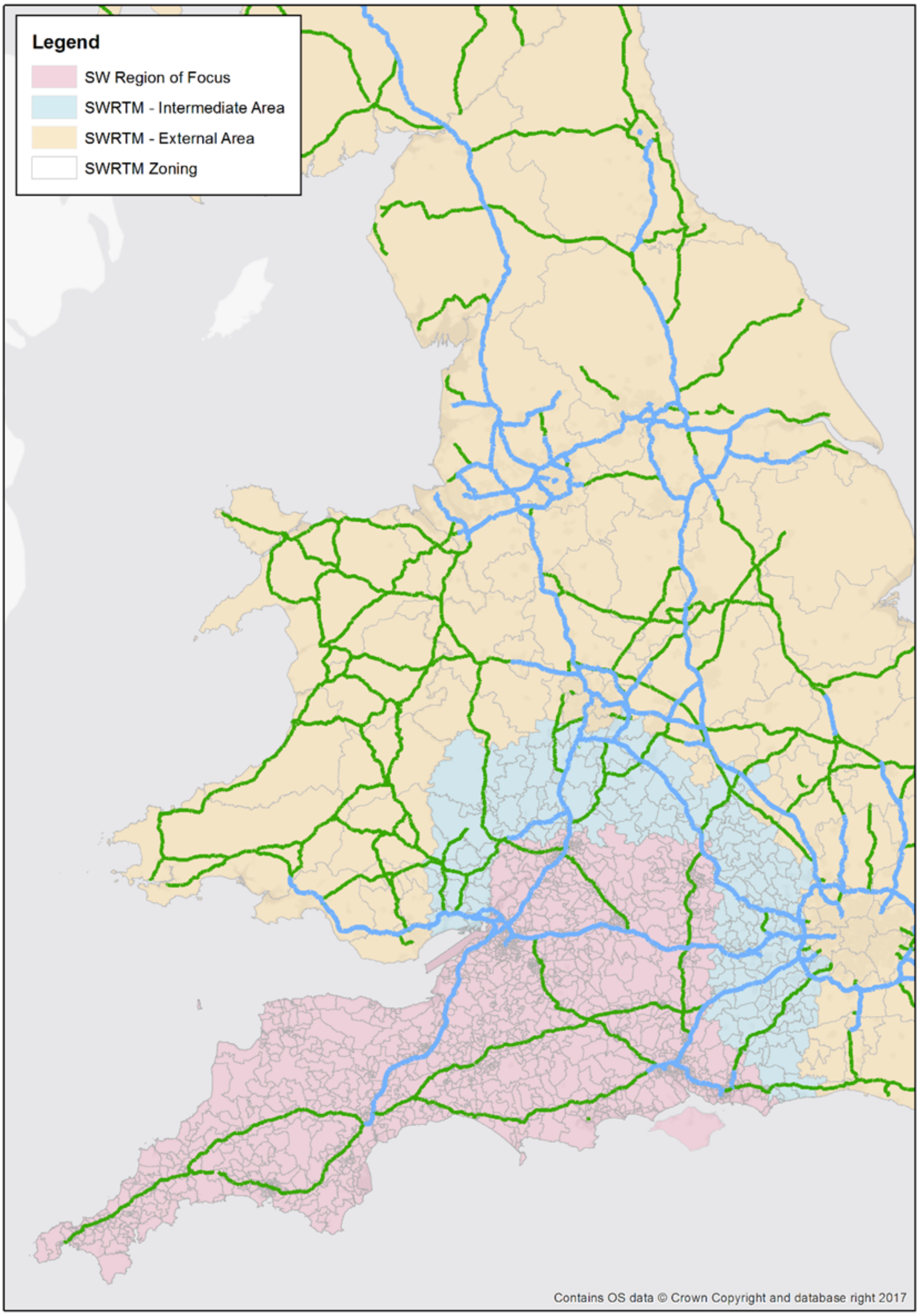


Figure 6-1 SWRTM network coverage

6.2.6 The maintenance of the SWRTM is an ongoing project but the base traffic model underwent "design freezes" at times determined by Highways England for the use of other project teams. The SWRTM base model was used as the initial basis for the scheme traffic model for PCF stage 1 and, while it is recognised that the regional traffic model has undergone further development, it was not considered that these subsequent amendments required the scheme PCF stage 2 and PCF stage 3 traffic models to be rebuilt (in many respects it is noted that the refinement to SWRTM in the vicinity of the scheme has primarily been driven by issues noted and addressed during the development of the PCF stage 1 scheme traffic model).

6.2.7 For those schemes where it was planned to use SWRTM for future appraisal work it was anticipated that the regional model would need to be adapted for each scheme. The modifications were expected to include changes to the network and matrices in the local area to better represent local traffic movements. In addition, it was expected that the model in areas remote from the local study area could be simplified, for example by converting detailed network coding into fixed speed coding.

6.3 Scheme study area

6.3.1 The scheme is expected to result in a range of local, sub regional and regional impacts and this was shown to be the case in the forecasts undertaken at PCF stage 1 and PCF stage 2.

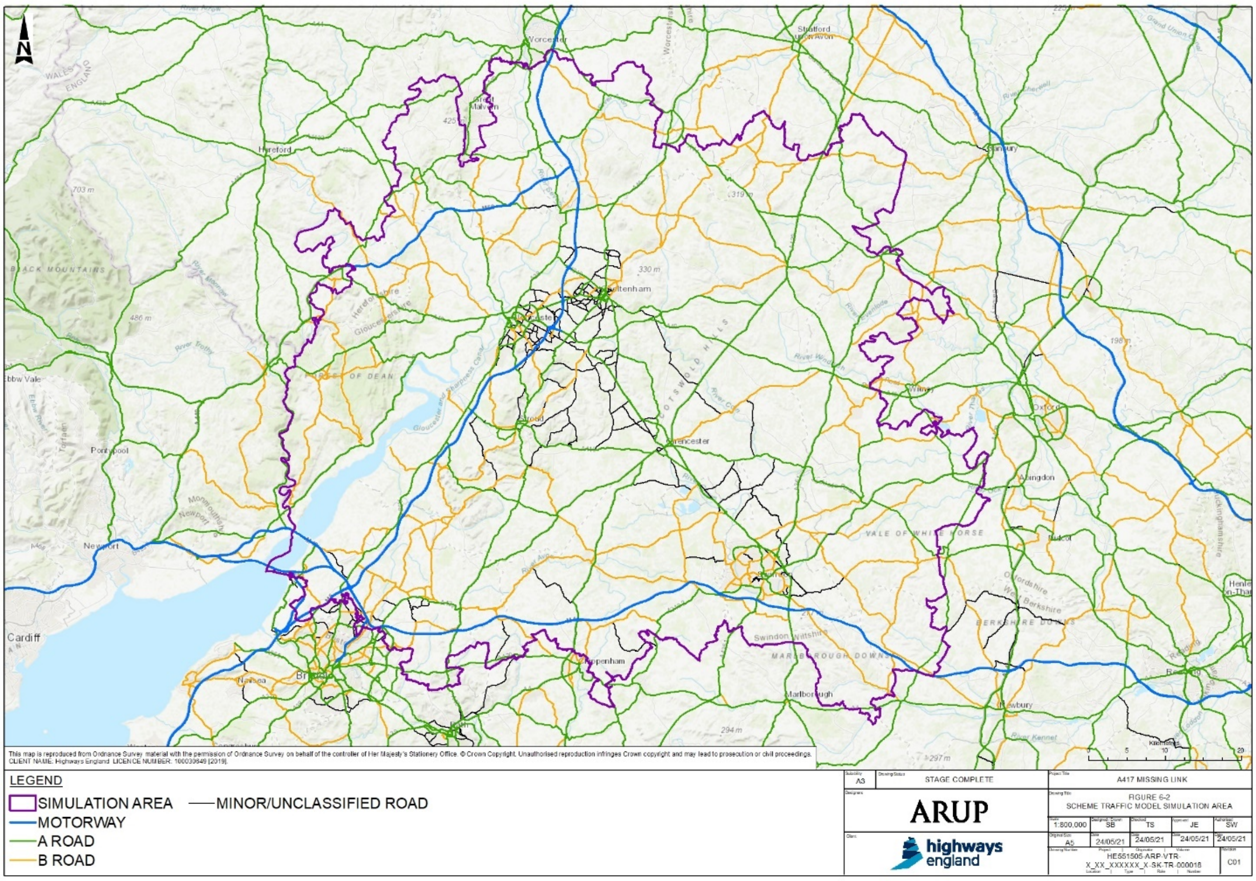
6.3.2 From the PCF stage 2 forecast assignments it was noted that, in addition to local reassignment from existing rat-runs onto the A417, the main forecast strategic effect of the scheme was reassignment onto the A417 from the long distance alternative routes of the M40/A34 and, to a lesser extent, the M5/M4.

6.3.3 Whilst the affected M4/M5 sections are included within the SWRTM RoF and were retained within the simulated area in the scheme traffic model for PCF stage 2, the length of the M40/A34 alternative route over which reassignment is anticipated to occur is primarily coded in buffer and lies outside the SWRTM RoF. At PCF stage 2, it was necessary to retain the M40/A34 route as fixed speed/buffer coding and to accept that journey time benefits arising from a reduction in traffic on this route would not be captured in the appraisal. It was considered that such benefits would only lead to marginal improvements in the economic appraisal of the scheme.

6.3.4 Due to the length of this alternative route, its relative remoteness from the main modelled area and the substantial data requirements, the M40/A34 route has not been included within the simulation network in the scheme traffic model for PCF stage 3. However, in order to improve the responsiveness of this route to changes in demand, speed flow curves have been introduced along its length (see section 7.2 of this report).

6.3.5 In light of the above, the extent of the detailed model area remains unchanged from PCF stage 2 but with the key longer distance alternative routes (M40/A34, M42 and M5 north) coded as buffer links with speed flow curves (see section 7.2 of this report).

6.3.6 Figure 6-2 illustrates the extent of the scheme traffic model simulation area for PCF stage 3.



Source: Highways England

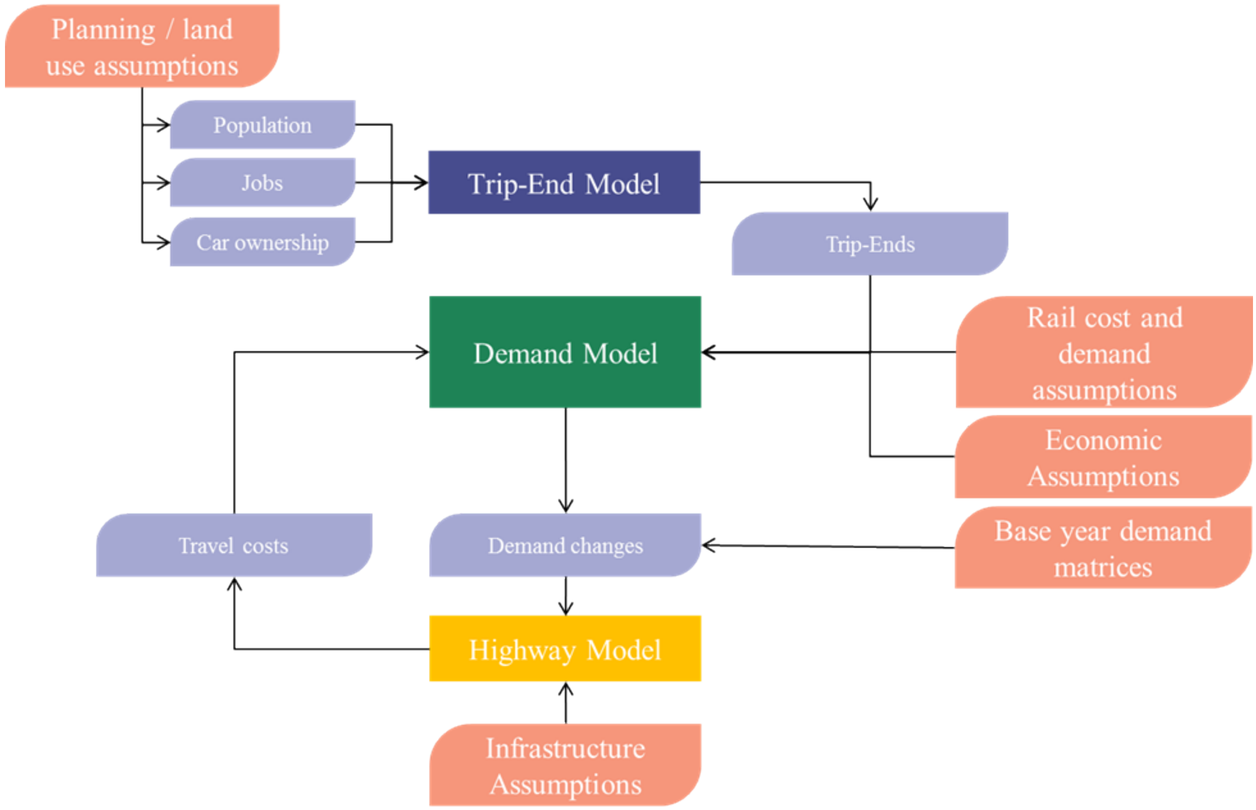
Figure 6-2 Scheme traffic model simulation area

6.3.7 As mentioned previously, the SWRTM RoF contained 'islands' of fixed speed coding covering large urban areas, which include several areas within the scheme traffic model simulation area (Swindon, Cheltenham, Gloucester, Bishops Cleeve, Stroud and Nailsworth). To better represent delay and route choice, network coding in these urban areas (with the exception of Swindon) has been enhanced to provide a more detailed representation of the highway network (see section 7.2 of this report for more information).

6.4 Overview of the modelling system

6.4.1 The model is based on the TAG approach shown in Figure 6-3, in accordance with the SWRTM modelling system. This comprises:

- trip end model – used for estimating the number of trips generated/attracted by a specific zone
- demand model – used for estimating how travellers would respond to changes in their travel costs
- highway assignment model – used for estimating travel costs and identifying the routes travellers may choose through the road network



Source: South-West Regional Transport Model, Model Validation Report, November 2016.

Figure 6-3 Regional traffic model system

6.5 Key features of the scheme traffic model

Base year

6.5.1 The scheme traffic model is representative of average weekday (Monday to Friday) traffic for March 2015.

Time periods

6.5.2 The assignment models cover a single average hour across four time-periods on a March weekday. The modelled time periods are:

- AM average hour (07:00 to 10:00)
- IP average hour (10:00 to 16:00)
- PM average hour (16:00 to 19:00)
- OP average hour (19:00 to 07:00)

6.5.3 Only the three daytime periods are subject to calibration and validation as described in later sections of this report. The OP scheme traffic model is not subject to calibration and validation as it is simply an alternative method to factoring from modelled periods to daily levels.

Segmentation

6.5.4 The following assignment vehicle and purpose classes are included in the highway and demand models:

- car – employers' business
- car – commuting

- car – other
- light goods vehicles (LGV)
- heavy goods vehicles (HGV)
- rail – employers' business
- rail – commuting
- rail – other.

6.5.5 The employers' business and other trips were also split into home-based and non-home-based purposes.

6.5.6 In accordance with the SWRTM, LGV demand is assumed to be a mix of freight and personal business trips based on the average proportions outlined in the TAG databook. HGV demand assumptions are also identical to those used in the SWRTM.

6.5.7 Rail segments are included within the demand model to allow the effects of mode choice between highway and rail to be represented in forecasting.

Software packages used

6.5.8 Various software packages were used in the development of the scheme traffic model for PCF stage 3, these are as follows:

- ArcGIS version 10.7 – for GIS analysis supporting model development
- SATURN version 11.4.07H – for highway assignment modelling
- DIADEM version 7 – for variable demand modelling
- HEIDI version 6.2 – to support the operation of DIADEM for the RTMs

6.5.9 Software used in forecasting and appraisal are identified in section 10 and section 12 respectively.

7 Scheme traffic model development

7.1 Introduction

7.1.1 This section describes the network and demand model coding processes used in the development of scheme traffic model for PCF stage 3.

7.2 Network development

7.2.1 TAG unit M3.1 explains how to design a highway assignment model and the considerations in dividing the model area into a fully modelled area (FMA) and an external area (EA). The guidance further subdivides the FMA into the area of detailed modelling and the rest of the FMA.

7.2.2 The area of detailed modelling is the area over which significant impacts of a scheme(s) would be expected to occur. This area would represent all trips with small zones, very detailed network and junction modelling. The rest of the FMA is the area over which the impacts of a scheme(s) are quite likely but relatively weak in magnitude. It would still represent all trips with junctions simulated but would have larger zones and less detailed network.

7.2.3 In the EA, scheme impacts would be very small or negligible with partial trip representation, and a skeletal network with speed/flow representation or fixed speeds for network costs.

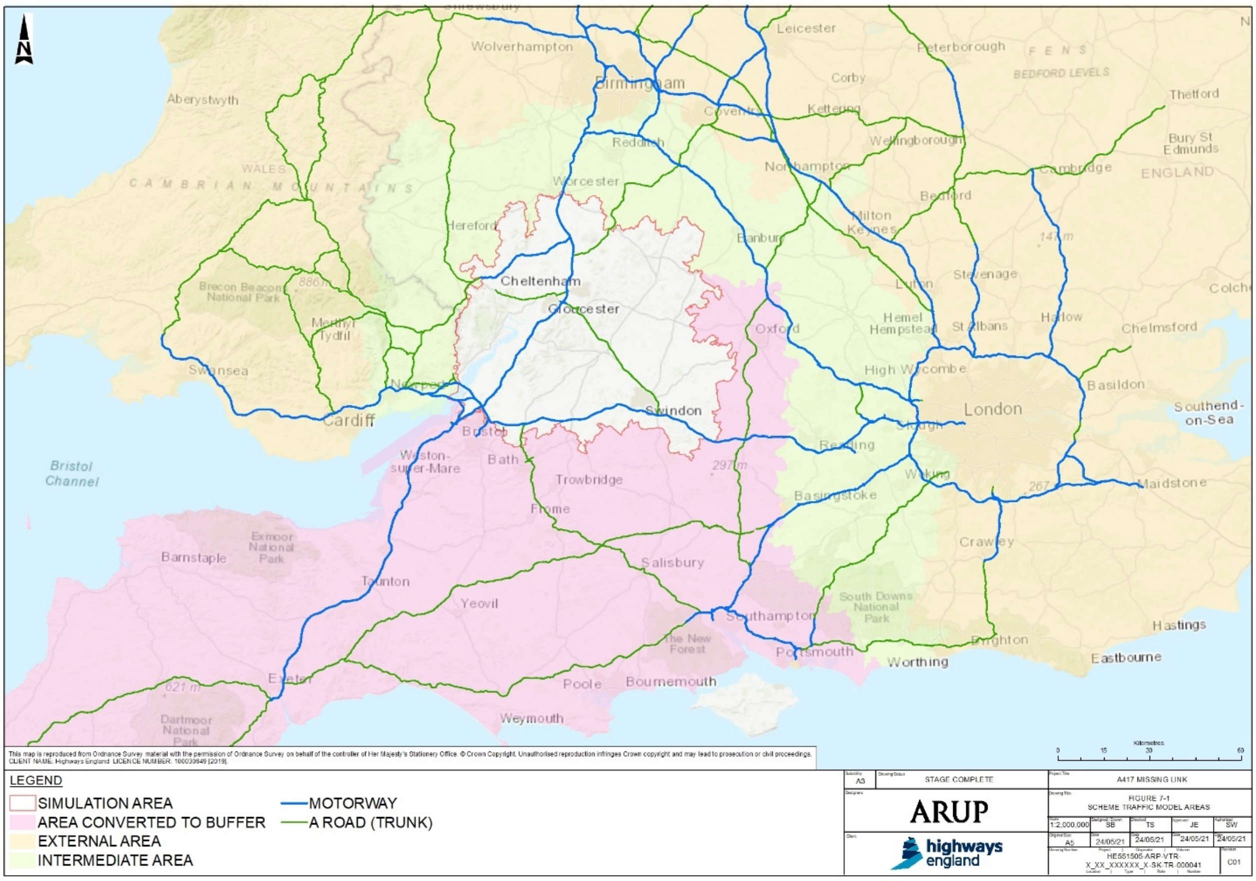
7.2.4 This is a conventional type of model design where there is a relatively small detailed area for a scheme.

7.2.5 However, the regional traffic models (RTMs) have been developed with important changes to this conventional approach recognising the modelling of a large region with a definition that is detailed for the strategic road network but not for large urban areas within the region. Thus, in the RTMs, the area which has been mostly fully simulated is referred to as the region of focus (RoF). This definition is somewhat different to a conventional FMA as it contains 'islands' of fixed speed coding covering large urban areas and, whilst most of the main road network is coded down to B class roads, for scheme appraisal a higher definition is required around the local scheme area. Therefore, in this report the reduced RoF area is generally referred to as the simulation area rather than the FMA.

7.2.6 Four main areas have been defined within the scheme traffic model as follows:

- Simulation area – this is the area over which proposed intervention has its main strategic and local impact. The network within this area consists of fully simulated links and nodes, in addition to some fixed speed links within Swindon.
- Area converted to buffer – this comprises of the network within the SWRTM RoF but outside of the scheme traffic model simulation area. This area of the network has detailed coverage as it still contains all the links, nodes and zones included in the SWRTM, but these have been converted to buffer network with fixed speeds.
- Intermediate area – this is the same as the intermediate area defined in the SWRTM. It is adjacent to the area converted to buffer and has more detailed network coverage than that of the external area.
- External area – this is the same as the external area defined in the SWRTM.

7.2.7 The scheme traffic model areas described above are shown in Figure 7-1.



Source: Highways England

Figure 7-1 Scheme traffic model areas

Network coding principles

7.2.8 The coding principles applied in the development of the RTMs are illustrated in Table 7-1. More details are available in the SWRTM Model Validation Report (MVR). The coding principles applied to the scheme traffic model for PCF stage 3 were, in the first instance, largely developed from these as outlined in the A417 PCF stage 1 Local Model Validation Report (LMVR).

Table 7-1 SWRTM network coverage

	Region of focus			SWRTM region of focus but outside A417 simulation area	SWRTM intermediate and external areas
	Area 1	Area 2	Area 3	Area 4	Area 5
Coverage	SRN roads connected to/parallel with SRN roads considered important to RIS scheme appraisal	Rural roads that are not connected to SRN	Urban areas outside the influence area of RIS schemes and the SRN network	All roads included in the SWRTM	Roads outside the region of focus (e.g. neighbouring regions, Scotland, Wales)
Level of coding	Detailed junction coding (accurate layout, sat flow, signal timing)	Template signalised junction coding Less detailed junction coding (e.g. flare lanes may not need to be considered, etc.)	Dummy nodes	Buffer network	Buffer network
Speed flow curves	Links with length greater than 0.6 miles (1km) for rural roads	Links with length greater than 0.6 miles (1km) for rural roads	No	No	No
Fixed speeds	No	No	Yes, taken from TrafficMaster JT data	Yes, taken from TrafficMaster JT data where available and from the SWRTM net speed outputs elsewhere	Yes, taken from TrafficMaster JT data

Source: Highways England

7.2.9 Most of the link speeds, link lengths and node locations in the scheme traffic model for PCF stage 3 were used directly from the scheme traffic models for PCF stage 2 and PCF stage 1 that, in turn, had come from the SWRTM.

7.2.10 Other general coding principles retained from the scheme traffic model for PCF stage 2 model include:

- Assumptions regarding passenger car units (PCUs), which are given a default length of 5.75 metres. Vehicle to PCU factors are 1.0 for all user classes, except HGVs for which one vehicle equates to 2.5 PCUs.
- Base year (2015) road tolls are treated in the same manner as in the scheme traffic model for PCF stage 1 (see PCF stage 1 LMVR for further details).

PCF stage 1 network enhancements

7.2.11 The following provides a brief overview of the enhancements made to the SWRTM network during the development of the scheme traffic model for PCF stage 1:

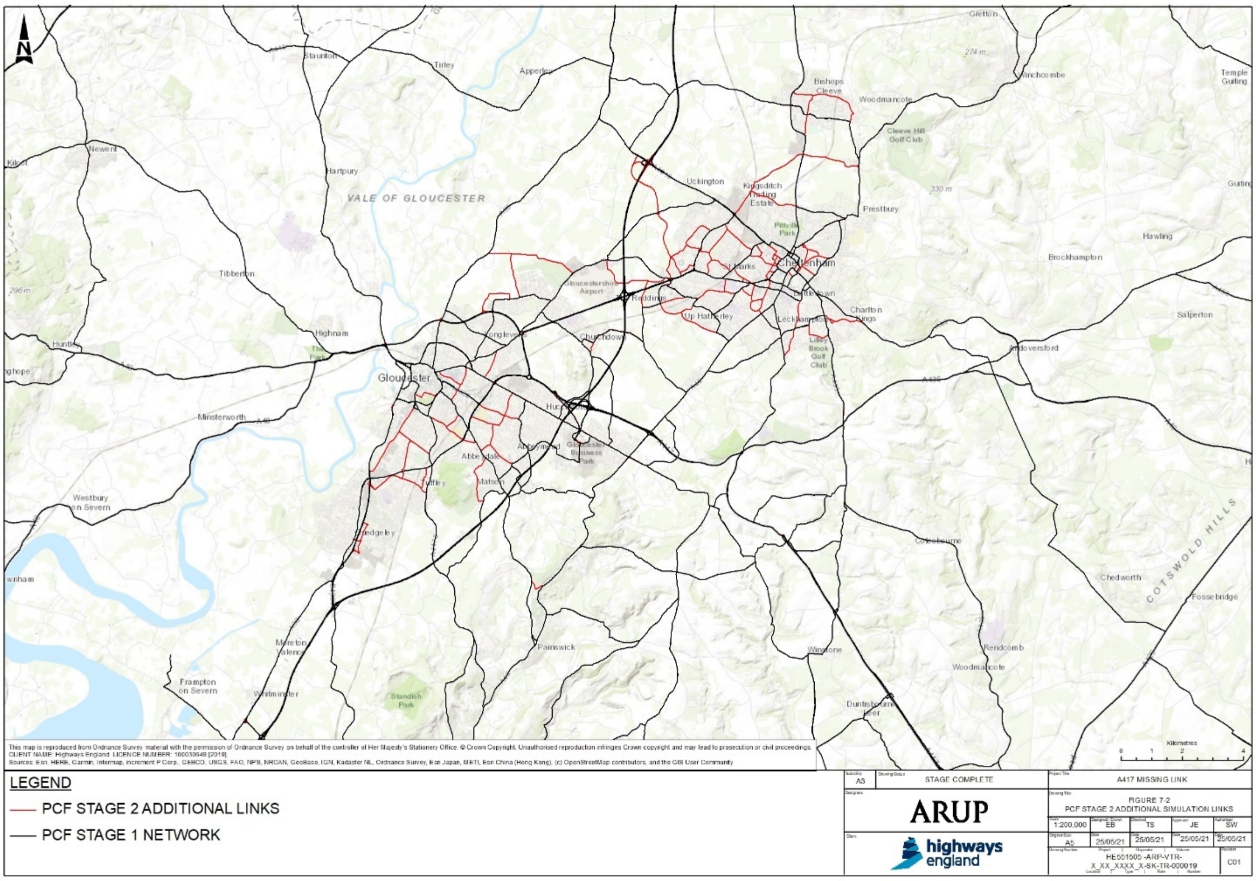
- Network anomalies identified in the SWRTM coding, such as erroneous link distances; lane/turn allocations; and saturation flows at junctions, were amended (and fed back to the RTM team for incorporation into updated versions of the SWRTM).
- Junctions represented as single nodes in the SWRTM network were enhanced by ‘exploding’ them into individual nodes. This was undertaken at the Air Balloon roundabout itself as well as other locations, such as along the A40 near Gloucester.
- Coded capacities at critical roundabout junctions were reviewed and, where required, the saturation flows and gap values were updated based on details derived from ARCADY capacity calculations.
- Coding of signalised junctions was reviewed and enhanced as required. Enhancements to traffic signal junction coding were largely focused on junctions along the A40 near Gloucester, but also included other locations, such as junctions along Ermin Street/Hucclecote Road in Gloucester, A40/A436 junctions at Andoversford and various junctions around Swindon and the M5.
- Additional network was included to provide a more detailed representation of local routes, particularly those that have been observed to be acting as alternative routes to the A417 during congested periods (e.g. Birdlip Hill, minor route via Elkstone).
- HGVs were prohibited from using additional links on which weight limits were identified.
- A new speed flow curve was created and applied to additional model links that represent minor country lanes where observed speeds are below 30kph.

7.2.12 The following sections of this report provide details on network enhancements adopted in the development of the scheme traffic model for PCF stage 2. These are subdivided into enhancements made within the model simulation and buffer areas.

PCF stage 2 network enhancements

7.2.13 To better represent delay and route choice, network coding in the scheme traffic model for PCF stage 2 has been enhanced to provide a more detailed representation of the highway network, primarily focused on the urban areas of Cheltenham and Gloucester, with enhancements also made to coding within Stroud, Nailsworth and Cirencester.

7.2.14 Nodes and links identified for inclusion in the scheme traffic model for PCF stage 2 were drawn in GIS to provide an accurate geographic representation, including link distances. The locations of the additional links, which are largely located within Cheltenham and Gloucester, are identified (in red) in Figure 7-2.



Source: Highways England

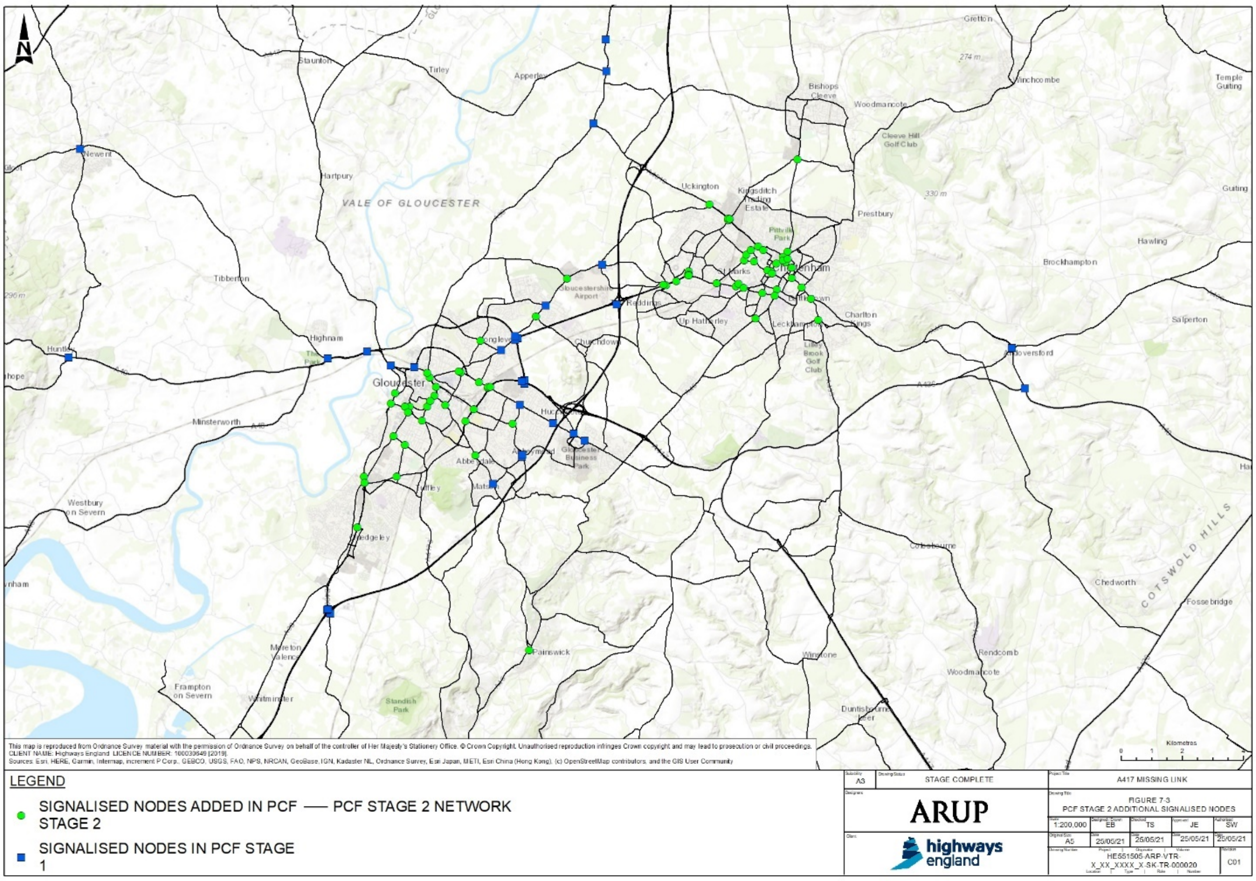
Figure 7-2 PCF stage 2 additional simulation links

7.2.15 Furthermore, as noted in 7.2.6, the SWRTM RoF contains ‘islands’ of fixed speed coding in urban areas, with the speeds derived from processed TrafficMaster journey time data (further detail provided in SWRTM MVR).

7.2.16 In the scheme traffic model for PCF stage 2 the fixed speeds urban areas of Cheltenham, Gloucester, Stroud and Nailsworth have been converted to fully simulated.

7.2.17 Additional roundabout junctions that were coded as single nodes in the scheme traffic model for PCF stage 1 were also ‘exploded’ in the manner explained in paragraph 7.2.11. This includes all roundabouts on the network within the urban areas of Cheltenham, Gloucester, Stroud and Cirencester.

7.2.18 Alongside this, 86 signalised nodes have been added to the simulation network, with staging/timings informed in the first instance by the Cheltenham and Severn Vale SATURN model. The locations of the additional signalised nodes are identified in Figure 7-3.



Source: Highways England

Figure 7-3 PCF stage 2 additional signalised nodes

Buffer areas

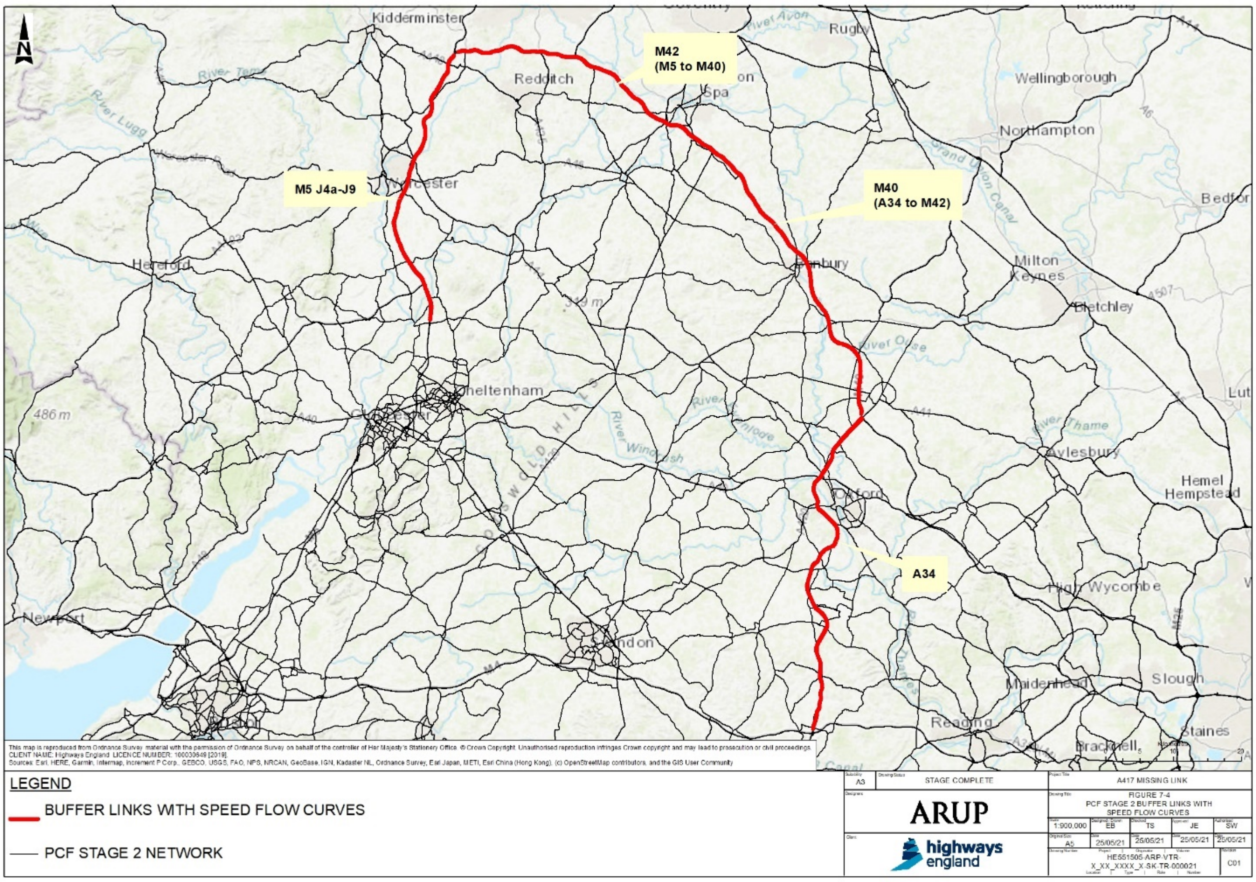
7.2.19 As explained previously, the scheme traffic model consists of a simulation area with the remainder of the scheme traffic model represented by fixed speed buffer links, which required the extension of the original SWRTM buffer area. This was done during the development of the scheme traffic model for PCF stage 1 by cordoning the required simulation area and converting the remainder of the SWRTM simulation area into buffer network. Further details on the method adopted when creating the A417 buffer area are provided in the A417 PCF stage 1 LMVR.

7.2.20 The geographical extent of the buffer area in the scheme traffic model for PCF stage 2 model remains the same as in the scheme traffic model for PCF stage 1.

7.2.21 However, to improve the responsiveness of potential alternative routes to changes in demand, speed flow curves have been allocated to the main competing strategic routes (A34, M40, M42) and also to the northern end of the M5, which were all previously coded as fixed speed in PCF stage 1.

7.2.22 In the first instance this involved allocating a default RTM speed flow curve to each link based on road type (i.e. number of lanes and speed limit). Following initial model runs, resulting model speeds on these buffer links were compared against observed speeds. In some instances, particularly further north in the West Midlands, resulting modelled speeds were notably lower than observed speeds. This was a consequence of the skeletal nature of the model network away from the main region of focus which resulted in model links carrying higher traffic flows than observed. To provide more accurate speeds, while retaining demand responsiveness, some links were allocated speed flow curves with artificially higher capacities.

7.2.23 The location of buffer links with speed flow curves in the scheme traffic model for PCF stage 2 are illustrated in Figure 7-4.



Source: Highways England

Figure 7-4 PCF stage 2 buffer links with speed flow curves

PCF stage 3 network enhancements

7.2.24 No further network enhancements were made during PCF stage 3.

7.3 Matrix development

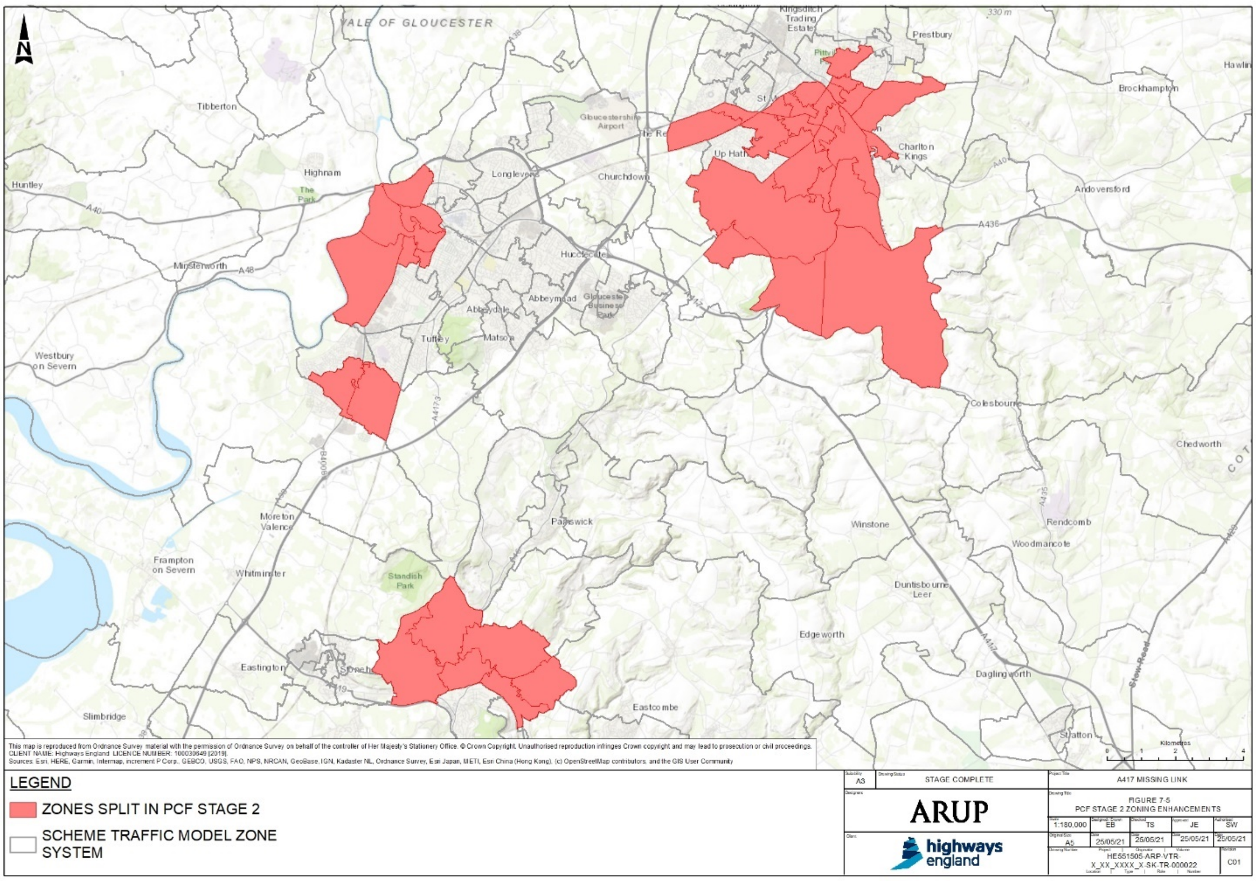
Zoning

7.3.1 The model zone structure in the SWRTM is based on aggregations of the 2011 census output areas. The zoning system was designed to be sufficiently detailed spatially to enable trips to load onto the network and follow representative routes. It has been aggregated to respect administrative boundaries so that zone-based outputs can be reported at district, county and regional levels. There are a total of 1,901 zones in the SWRTM.

7.3.2 For the scheme traffic model for PCF stage 1 the SWRTM zone system was largely retained with enhancements limited to the simulation area where some of the regional model zones were split to improve the representation of local traffic movements. In total, there were 1,914 zones in the scheme traffic model for PCF stage 1.

7.3.3 For the scheme traffic model for PCF stage 2 the zone system in the simulation area has been further disaggregated. This has been undertaken primarily around the urban areas of Cheltenham, Gloucester and Stroud. The refinements allow trip ends to be more precisely located within these areas.

7.3.4 The scheme traffic model for PCF stage 2 had 1,940 zones, an increase of 26 over the scheme traffic model for PCF stage 1 and 39 over the SWRTM. The location of the zones which have been split in PCF stage 2 are shown in Figure 7-5.



Source: Highways England

Figure 7-5 PCF stage 2 zoning enhancements

7.3.5 No further zoning amendments were made during PCF stage 3.

SWRTM prior matrices

7.3.6 The development of the SWRTM car matrices was based primarily on MPD supplied through Highways England's Trip Information System.

7.3.7 The development of the SWRTM LGV and HGV matrices were based on DfT's TrafficMaster dataset and the DfT's BYFM respectively.

7.3.8 More details on SWRTM matrix development, and associated verification tests, can be found in SWRTM MVR.

7.3.9 The scheme base traffic model for PCF stage 1 utilised the SWRTM prior matrices, which were simply disaggregated to match the refined zone system.

Scheme traffic model prior matrices for PCF stage 2

7.3.10 The scheme traffic model prior matrices for PCF stage 2 remain unchanged from the SWRTM (and PCF stage 1) matrices in terms of total trips and distribution, although, as discussed in paragraph 7.3.3 above, some local zones have been split to improve the model resolution around the urban areas of Cheltenham, Gloucester and Stroud.

7.3.11 The prior matrices have been derived by disaggregating the SWRTM prior trip matrices into the scheme traffic model for PCF stage 2 zone system, using the same approach adopted during PCF stage 1. This involved the use of 2011 Census population data to inform zone splitting factors, as follows:

- resident population – used to split the home end of home-based trips
- workplace population – used to split the non-home end of home-based work (HBW) and home-based employers' business (HBEB) trips and both ends of non-home-based employers' business (NHBEB), LGV and HGV trips
- resident and workplace population – used to split the non-home end of home-based other (HBO) trips and both ends of non-home-based other (NHBO) trips

Scheme traffic model prior matrices for PCF stage 3

7.3.12 No further changes to the prior matrices were made during PCF stage 3.

7.4 Assignment process

User and vehicle classes

7.4.1 The following assignment vehicle and purpose classes are included in the SWRTM highway models:

- car – employer's business
- car – commuting
- car – other
- light goods vehicles (LGV)
- heavy goods vehicle (HGV).

7.4.2 There is a distinct representation of seaports and airport trips in these user classes.

7.4.3 LGV demand is assumed to be a mix of freight and personal business trips based on the average proportions outlined in the TAG databook.

7.4.4 The user class structure used in the scheme traffic model was retained from the SWRTM.

Generalised cost formulation

7.4.5 Generalised cost values are calculated based on the vehicle operating costs, values of time and user class splits outlined within TAG unit A1.3.

7.4.6 Table 7-2 and Table 7-3 present the highway generalised cost coefficients used in the scheme base year traffic model for PCF stage 2 as received at PCF stage 3.

These generalised cost parameters have been taken from the July 2017 TAG databook.

7.4.7 Generalised cost parameters used in the forecast years are provided in section 10.3 of this report.

Table 7-2 Value of time assumptions – pence per minute (2010 prices, 2015 values)

		Pence per minute		
		AM	IP	PM
Car	Business	29.81	30.54	30.24
	Commuting	19.99	20.31	20.06
	Other	13.79	14.69	14.44
LGV	Work	21.78	21.78	21.78
	Non-work	15.83	15.83	15.83
	Average	21.07	21.07	21.07
HGV[2]	Other Goods Vehicles 1 (OGV1	49.19	49.19	49.19
	Other Goods Vehicles 2 (OGV2)	49.19	49.19	49.19
	Weighted average[1]	49.19	49.19	49.19

[1] A 60:40 split was assumed for all RTMs based on a review of classified count data

[2] Includes HGV multiplier (2.3) for consistency with RTM technical guidance and to reflect the fact that route choice for HGVs is not purely down to the driver's value of time

Source: TAG databook, July 2017

Table 7-3 Vehicle operating cost assumptions – pence per kilometre (2010 prices, 2015 values)

		Pence per kilometre		
		AM	IP	PM
Car	Business	12.72	12.72	12.72
	Commuting	6.28	6.28	6.28
	Other	6.28	6.28	6.28
LGV	Work	14.52	14.52	14.52
	Non-work	7.72	7.72	7.72
	Average	13.70	13.70	13.70
HGV	OGV1	12.78	12.78	12.78
	OGV2	58.08	58.08	58.08
	Weighted average[1]	47.63	47.63	47.63

[1] A 60:40 split was assumed for all RTMs based on a review of classified count data

Source: TAG databook, July 2017

Assignment model convergence

7.4.8 Assignment model convergence is measured in two ways:

- proximity to the equilibrium measured by a gap parameter

- stability, measured by changes in flows and delays

7.4.9 The criteria set out in TAG unit M3.1 (see Table 7-4) were used to assess the assignment convergence of the SATURN models. The assignment procedure used for the highway model is an interaction between an equilibrium assignment and junction delay calculations. This interaction is described below. The highway model uses an equilibrium assignment, distributing demand according to Wardrop's first principle of traffic equilibrium: *"Traffic arranges itself on networks such that the cost of travel on all routes used between each Origin/Destination pair is equal to the minimum cost of travel and all unused routes have equal or greater cost."*[4]

7.5 Model standards

Matrix verification standards

7.5.1 As part of the development of SWRTM prior matrices several verification tests were carried out to check the key aspects of the provisional mobile phone data. These include the following verification checks against independent data sources. More details on these checks can be found in the SWRTM MVR. The verification tests include:

- trip ends
- symmetry of the matrix
- trip rates
- trip distribution patterns
- trip length profile
- trip purpose allocation
- daily profile of trips
- level of vehicle flows.

Assignment convergence criteria

7.5.2 TAG unit M3.1 section 3 contains a set of convergence measures (of proximity and stability) considered acceptable for use in establishing a base highway assignment model. These measures are summarised in Table 7-4.

Table 7-4 Summary of base model convergence measures

Measure of convergence	Base model acceptable values
Delta and %GAP	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P) <1%	Four consecutive iterations greater than 98%
Percentage of links with cost change (P2) <1%	Four consecutive iterations greater than 98%

Source: DfT TAG unit M3.1 section 3 (Table 4)

7.5.3 TAG also specifies that tighter levels of convergence may be required for scheme appraisal. Therefore, the scheme base and forecast traffic models adopt a tighter set of convergence criteria. This means model convergence is achieved when at least 99.5% of links experience flow changes of less than 1% for four consecutive

[4] TAG unit M3.1 Highway Assignment Modelling, Department for Transport, May 2020.

iterations. This has been adopted in the scheme modelling so that better assignment convergence can be achieved.

7.6 Demand modelling

7.6.1 To support a major scheme such as this scheme throughout the development process and especially for economic appraisal, it is required to use variable demand modelling (VDM) in accordance with TAG unit M2. This requires a satisfactory supply model that represents the whole route travel costs as well as wide area reassignment impacts, both of which will be provided by the scheme traffic model for PCF stage 3.

Variable demand model overview

7.6.2 VDM has been undertaken using Dynamic Integrated Assignment and Demand Modelling (DIADEM) with an interface developed for use with the Regional Traffic Models, Highways England Integrated Demand Interface (HEIDI).

7.6.3 Demand model parameters were derived from realism tests on the calibrated scheme base traffic model. Table 7-5 summarises the VDM parameters/model responses and hierarchy. Further detail on the VDM approach is set out in section 11 and in section 9 of the SWRTM MVR.

Table 7-5 VDM parameters/model response and hierarchy

Parameter/setting	Data source		Notes
Segmentation			
Modelled time slices	AM 07:00-10:00, IP 10:00-16:00, PM 16:00-19:00 hours, OP 19:00-07:00		AM, IP, PM travel costs derived from average period hour calibrated assignments. OP travel costs derived from uncalibrated assignment of mobile phone data (MPD) derived OP matrix to IP network to represent free-flow conditions.
Time period factors	AM=3, IP=6, PM=3, OP=12		Simple calculation consistent across all movements and purposes as average period demand is assigned
Assigned user classes	From assignment models: Car employers' business, Car commute, Car other, Light good vehicles, Heavy good vehicles		
VDM segments	Segment	Segment ID	Fixed elements relate

Parameter/setting	Data source		Notes
	Home-based employer's business	1	to 'special zones' which include unique travel patterns that are not subject to VDM response. This may be a port or airport where 'Other' (passengers) and employer's business are not subject to VDM responses.
	Home-based commute	2	
	Home-based other	3	
	Non-home-based employers' business	4	
	Non-home-based other	5	
	Fixed – Employers business	6	
	Fixed – Commute	7	
	Fixed - Other	8	
	Light good vehicles (fixed)	9	
	Heavy good vehicles (fixed)	10	
Model parameters			
Model type	Home-based	Incremental PA	
	Non-home-based	Incremental OD	
	Goods	Fixed	
	Special generators	Fixed	
Model responses and hierarchy	(Macro) Time of day choice Mode choice Distribution		Distribution is singly constrained for employer's business and other, doubly constrained for commute.
Logit parameters: lambda, theta	Median TAG		Confirmed through realism testing (see section 9.6 of this report)
Distribution intra-zonal cost calculation	DIADEM Default values (ρ=0.5, minimum cost=5)		
Cost coefficients (value of time etc.)	TAG with distance based value of time		
Cost damping parameters and specification	Damped utility by function of distance		
Occupancy factors	TAG (and varying by distance for other trip purposes)		
Demand matrices			

Parameter/setting	Data source		Notes
Road matrices	Home-based (24hr PA)	National Trip End Model (NTEM) growth factors to calibrated base assignment matrices (split using mobile phone data (MPD) and transposed, then aggregated to 24-hour using PA outbound and return proportions)	
	Non-home-based (hourly OD)	NTEM growth factors to calibrated base assignment matrices (split using MPD)	
	Goods (hourly OD)	RTF growth factors to calibrated base assignment matrices	
	Special generators	Specific growth factors to calibrated base assignment matrices (with extraction of demand for specific zones and demand segments)	
Public transport	NTEM growth factors to base matrices (combination of Moira and NRTS assigned to demand segments)		
Cost matrices			
Reference SATURN UFS files			Extracted from SATURN road assignment.
Rail costs skims for reference and forecast	Base	Time skims provided from the RTMs	Extracted from National Rail network and then compressed to model zone system.
	Forecast		
Rail fare skims for reference and forecast	Base	In Vehicle Time Skim applied to distance-based fare function provided from the RTMs	
	Forecast		
PA data			

Parameter/setting	Data source	Notes
Outbound proportions Return proportions (by time period for each demand segment, sector movement, and mode)	DIADEM manual (from NTS) proportions applied for Employers business for all sectors. MPD derived proportions used for work and other for 7 sectors, as per SWRTM, based on origin trip ends. Proportions adjusted to reflect assignment matrix proportions with outbound/return split based on initial values for each time period.	
Tour proportions	Default values provided in DIADEM from NTS data, which are then furnessed within DIADEM application to match defined outbound and return proportions (see above).	
DIADEM parameters		
Algorithm	Fixed step length (0.5, as per base model calibration)	
Convergence	Target GAP of 0.1% for entire model and 0.2% for simulation area (sub-area)	

Source: Highways England

Demand model realism testing and convergence criteria

7.6.4 Standard TAG (unit M2) realism tests have been carried out, involving the calculation of the following out-turn demand elasticities:

- car vehicle kilometres with respect to fuel cost (matrix-based and network-based versions)
- public transport (PT) trips with respect to PT fares

7.6.5 The following tests of demand model acceptability have been applied:

- Realism testing has achieved sensible out turn elasticities.
- Are the final, calibrated, model parameters within an acceptable tolerance of the initial values (±25% if based on the TAG illustrative parameters)?

7.6.6 In relation to the demand/supply model convergence, the supply/gap measure has been adopted with a target of 0.1% as per TAG within the SWRTM RoF. In addition, a sub-area gap target (calculated for all trips that has an origin in the SWRTM RoF) of 0.2% has been adopted as per regional traffic models.

8 Scheme traffic model calibration

8.1 Introduction

8.1.1 This section details the scheme traffic model network and matrix calibration methodology, the location of calibration count data and the effects of matrix estimation (ME) carried out during PCF stage 2.

8.1.2 No further model calibration has been undertaken in PCF stage 3.

8.1.3 Journey time and count data used in calibration and validation are detailed in section 6. As per PCF stage 1, ME was carried out for the unconstrained scenario meaning no constraints are applied to the ME process. The same ME parameters as PCF stage 1 were used in all ME runs which are also constant with the SWRTM. The OP scheme traffic model is not subject to calibration and validation as it is a simple alternative method to factoring from modelled periods to daily levels.

8.1.4 Calibration and validation dashboards were produced for prior and post ME assignments. These were compared against corresponding PCF stage 1 dashboards to see whether the changes are reasonable.

8.2 Calibration and validation criteria

8.2.1 TAG unit M3.1 sets out acceptability guidelines for highway assignment models and TAG unit M2 sets out guidelines for demand models.

8.2.2 The validation of a highway assignment model includes comparisons of the following:

- assigned flows and counts totalled for each screenline or cordon, as a check on the quality of the trip matrices
- assigned flows and counts on individual links and turning movements at junctions as a check on the quality of the assignment
- modelled and observed journey times along routes, as a check on the quality of the network and the assignment

8.2.3 Turning movement validation is also an important aspect of local model development, particularly at key junctions, as it provides a good indication of the quality of the assignment.

8.2.4 For trip matrix validation, comparisons at screenline level provide information on the quality of the trip matrices. The measure used is the absolute differences between modelled flows and counts.

8.2.5 For link flow validation, the measures used are:

- the absolute differences between modelled flows and counts.
- the GEH statistic which is a form of the chi-squared statistic that incorporates both relative and absolute errors and is defined as follows.

$$GEH = \sqrt{\frac{(M-C)^2}{(0.5 \times (M+C))}}$$

where:
M is the modelled flow; and
C is the observed flow.

8.2.6 For journey time validation, the measure used is the percentage difference between modelled and observed journey times, subject to an absolute maximum difference.

8.2.7 The validation criteria and acceptability guidelines for each of these measures are presented in Table 8-1.

Table 8-1 TAG validation criteria

Criteria	Description of criteria	Acceptability guidelines
Screenline flow validation criterion and acceptability guidelines		
	Difference between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines
Link flow and turning movement validation criterion and acceptability guidelines		
1	Individual flows within100vph for flows < 700vph	>85% of cases
	Individual flows within 15% for flows 700-2700vph	
	Individual flows within 400vph for flows > 2700vph	
2	GEH < 5 for individual flows:	>85% of cases
Journey time validation criterion and acceptability guidelines		
	Modelled journey times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	>85% of routes

Source: TAG unit M3.1, Table 2

Changes due to matrix estimation

8.2.8 TAG unit M3.1 sets out measures for testing the significance of changes brought about through matrix calibration (estimation). These include the correlation of changes in cell values, trips, scale of sector to sector changes and changes in the mean and standard deviation of trip lengths as indicated in Table 8-2.

Table 8-2 Significance of matrix estimation changes

Measure	Significance criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Source: TAG unit M3.1, Table 5

8.3 Network calibration

8.3.1 During calibration, various elements of the network were reviewed following comparisons of model data against observations of traffic counts and journey times. A review of all warnings/serious warnings flagged by the software was undertaken, which included an examination of the various output files created by SATURN (i.e. .lpt, .lpn and .lpj files). Any specific issues identified during this review process were resolved through further network editing.

8.3.2 Network calibration was driven by aiming to achieve a good fit between the modelled and observed journey times and link flows/turning movements at junctions. As part of this calibration, nodes with unrealistic delays were checked and modified where necessary to achieve realistic journey times.

8.3.3 Modifications made to the network included changes to turn saturation flows, number of approaching lanes at nodes, signal timings in each time period, roundabout parameters and revisions to the link speed-flow curves/fixed speeds for achieving the observed link journey times. Such enhancements to the network coding were undertaken throughout the A417 simulation area.

8.3.4 Network calibration also involved assigning base year demand with up to an additional 40% of demand onto the developing base networks (using SATURN's 'GONZO' parameter). This 'stress test' was useful in identifying some erroneous coding in the network, which only became apparent when higher volumes of traffic were assigned. Although generally remote from the existing A417 and the scheme, once identified, these issues were corrected in the scheme base traffic model coding.

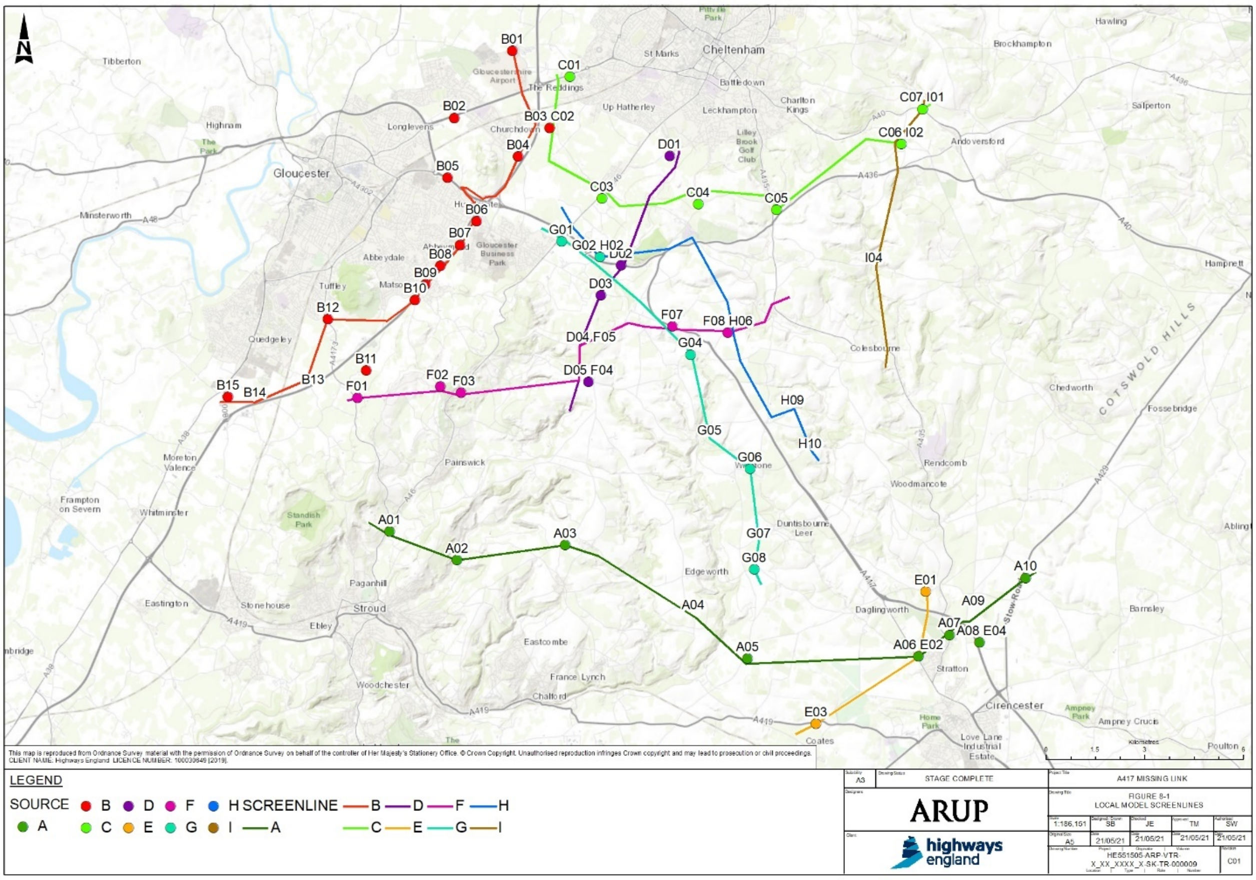
Count data used in calibration and validation

8.3.5 In validating the scheme traffic model, 20 (ten bi-directional) calibration screenlines and six (three bi-directional) validation screenlines were used (screenlines are formed by a selection of individual counts).

8.3.6 Of the calibration screenlines used, eight were taken directly from the SWRTM and form cordons around Gloucester, Cheltenham, Stroud and Cirencester.

8.3.7 The other eighteen screenlines (12 calibration and six validation) were formed from link flow data as detailed in sections 3 to 5.

8.3.8 The screenlines used in the scheme traffic model for PCF stage 2 are shown in Figure 8-1. Screenlines C, D and F were retained for validation with the others being used for calibration.



Source: Highways England

Figure 8-1 Local model screenlines

8.4 Matrix calibration

8.4.1 The prior matrix calibration and validation results for screenlines, links and journey time routes and segments are presented in Table 8-3. The screenline results from the assignment of the prior matrix are generally poor, with a significant number of screenlines and cordons failing to meet the TAG target. The link calibration and validation results are better but still fall short of the TAG criteria. The journey time route comparison shows much better results, exceeding the TAG criteria in all three time periods.

Table 8-3 Prior model calibration and validation results

	TAG criteria		AM	IP	PM
Primary screenlines within 5%	All or nearly all	Calibration	35%	30%	60%
		Validation	17%	33%	83%
		Total	31%	31%	65%
Primary links passing GEH or flow criteria	>85%	Calibration	74%	76%	71%
		Validation	79%	96%	92%
		Total	74%	79%	74%
Journey time routes within 15%	>85%		88%	100%	100%

Source: Highways England

8.4.2 These results demonstrate the need to undergo the matrix estimation process detailed in section 8.5 of this report. The results of the post-matrix estimation run are discussed in section 8.6 of this report.

8.5 Matrix estimation methodology

8.5.1 The matrix estimation (ME) procedure attempts to improve the “prior” matrix so that a better fit between the modelled flows and observations could be achieved. Matrix estimation was undertaken within SATURN using the SATPIJA and SATME2 modules and was based on counts by vehicle type (car, LGV, HGV). To ensure a reasonable level of convergence for the matrix estimation process it was run for six iterations as per PCF stage 1 and PCF stage 2.

8.5.2 XAMAX is a parameter that defines the maximum balancing factor used to limit excessive changes to the prior matrix. In PCF stage 1, a value of two was used for car and a value of five used for the LGV and HGVs. These values reflect the relative confidence in the data used to develop the demand for each of the vehicle classes. No changes were made to these values for the scheme traffic model for PCF stage 2.

8.5.3 The observed counts are input into the ME procedure where some counts are grouped into mini-screenline groups as per the SWRTM methodology. SATURN then attempts to match mini-screenlines totals for different vehicle classes.

8.5.4 The ME process was run regularly throughout the calibration stage of the scheme traffic model, each time incorporating any network and matrix changes as well as any changes to the observed counts and mini-screenline groupings.

8.5.5 As per the SWRTM and the scheme traffic model for PCF stage 1, an “unconstrained” ME run was undertaken with all trips (car, LGV and HGV) being left to change as much/little as the estimation process requires. A “constrained” ME run was also undertaken where car trips higher than 12 miles (20km) were frozen. In both the unconstrained and constrained runs, port and airport trips were frozen within the ME process.

8.5.6 The impact of the unconstrained run on the trip matrices was monitored as per the approach adopted in the SWRTM, however, the changes noted as a result of ME in the scheme traffic model were not considered to be as significant as those seen in the equivalent unconstrained regional model assignments. The overall changes noted in the scheme traffic model were broadly consistent with the blended SWRTM assignment although a slight deterioration was noted in PM peak. As a consequence, the constrained assignment and subsequent matrix blending process adopted in the SWRTM was not carried through into the final calibrated assignment for the scheme traffic model for PCF stage 2.

8.6 Monitoring matrix estimation changes

General

8.6.1 In order to understand the changes that matrix estimation had made to the prior matrix and to ensure that the effects were reasonable, it was necessary to undertake various analyses. These included regression analyses of both cell values and trip ends, comparisons of trip length distributions and comparisons of sector to sector movements.

8.6.2 Table 8-2 sets out the criteria to judge the significance of the changes brought by ME as recommended by TAG (M3.1). It is recognised that achieving all these criteria in a large area model such as this could be challenging and therefore the matrix estimation effect should not be considered against strict pass and fail criteria, but the overall model calibration/validation assessed, including the comparison against the observed journey times.

Matrix totals

8.6.3 For trips that have at least one end within the SWRTM RoF, Table 8-4 shows the trip totals before and after the application of matrix estimation. Similarly, Table 8-5 presents the differences arising from matrix estimation.

8.6.4 Changes in car and LGV matrix totals arising from ME are generally within, or close to, five percent in all time periods. Changes in HGV totals are noticeably larger, although the scale of the changes made by ME to these matrices are likely to be a reflection of the greater uncertainty associated with the HGV prior matrices, given that they are derived from the 2006 BYFM.

Table 8-4 Matrix total for trips with a trip end in the SWRTM RoF

Class	AM		IP		PM	
	Pre-ME	Post-ME	Pre-ME	Post-ME	Pre-ME	Post-ME
UC1	55,250	51,892	43,269	42,942	44,048	42,876
UC2	286,319	265,756	80,921	79,616	262,424	247,964
UC3	320,303	306,789	408,903	404,884	405,387	391,358
UC4	72,088	76,672	59,252	64,178	56,450	60,319
UC5	30,902	39,462	29,748	37,057	19,510	23,380

Source: Highways England

Table 8-5 Matrix total changes for trips with a trip end in the RoF

Class	AM		IP		PM	
	Diff	% Diff	Diff	% Diff	Diff	% Diff
UC1	-3,357	-6%	-327	-1%	-1,172	-3%
UC2	-20,563	-7%	-1,304	-2%	-14,460	-6%
UC3	-13,514	-4%	-4,020	-1%	-14,029	-3%
UC4	4,584	6%	4,926	8%	3,870	7%
UC5	8,560	28%	7,309	25%	3,870	20%

Source: Highways England

Trip length distributions

8.6.5 A comparison of trip length distribution for all trips with at least one trip end in the SWRTM RoF has been undertaken between the prior and final matrices.

8.6.6 Table 8-6 shows that the mean trip lengths are generally within, or close to, the five percent target for cars in all time periods but the standard deviation in the PM peak is less closely matched. LGVs also show a reasonable performance against the targets, with the AM period being slightly worse than the IP and PM. The results for HGVs are less convincing, although this is thought to be due to the fact that demand matrices for HGVs are based on adjustments to the 2006 BYFM matrices, which has resulted in a more 'lumpy' matrix, and it is expected that HGV trip patterns would have changed in the last 10 years.

Table 8-6 Trip length changes for trips with a trip end in the RoF

Class	AM		IP		PM	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
UC1	5.9%	6.0%	6.8%	5.3%	15.6%	12.9%
UC2	0.0%	6.4%	2.9%	5.5%	3.6%	12.3%
UC3	2.2%	6.5%	3.8%	6.0%	6.0%	13.1%
UC4	-7.5%	-9.6%	-4.1%	-3.6%	-3.1%	-1.4%
UC5	-14.1%	-8.6%	-13.6%	-6.8%	-10.3%	-4.8%
Cars	2.0%	6.5%	4.2%	5.9%	7.0%	13.5%
Total	2.4%	3.0%	3.1%	2.8%	6.2%	9.3%

Source: Highways England

Sector to sector changes

8.6.7 Analyses of sector to sector movements before and after ME are summarised in Table 8-7, with Figure 8-2 showing the spatial coverage of the sectors. To avoid large percentage differences, which represent only a small number of trips, sector to sector movements with fewer than 100 trips in the prior have been excluded from this analysis (similar to SWRTM). The GEH statistic has also been used to assess the changes between the post and prior matrices, in addition to considering the proportion of cells. The analysis shows that nearly all movements in all time periods have a GEH less than five between the prior and post estimation matrices. Around 70% of all sector to sector movements in all time periods have changed by less than 10% compared to the prior.

Table 8-7 Summary of sector to sector matrix changes

Full matrix excluding intra-zonals		No. cells with >100 trips in prior	% of cells with <5% change	Full matrix excluding intra-zonals	No. cells with >100 trips in prior
Car	AM	168	51.2%	70.2%	82.7%
	IP	175	66.9%	77.7%	92.0%
	PM	170	54.1%	69.4%	84.7%
LGV	AM	104	57.7%	72.1%	93.3%
	IP	96	63.5%	71.9%	92.7%
	PM	90	58.9%	71.1%	87.8%
HGV	AM	81	69.1%	77.8%	90.1%
	IP	80	72.5%	78.8%	91.3%
	PM	62	74.2%	82.3%	90.3%
ALL	AM	210	51.0%	67.1%	85.2%
	IP	209	58.9%	74.2%	92.3%
	PM	194	53.1%	72.7%	86.6%

Source: Highways England

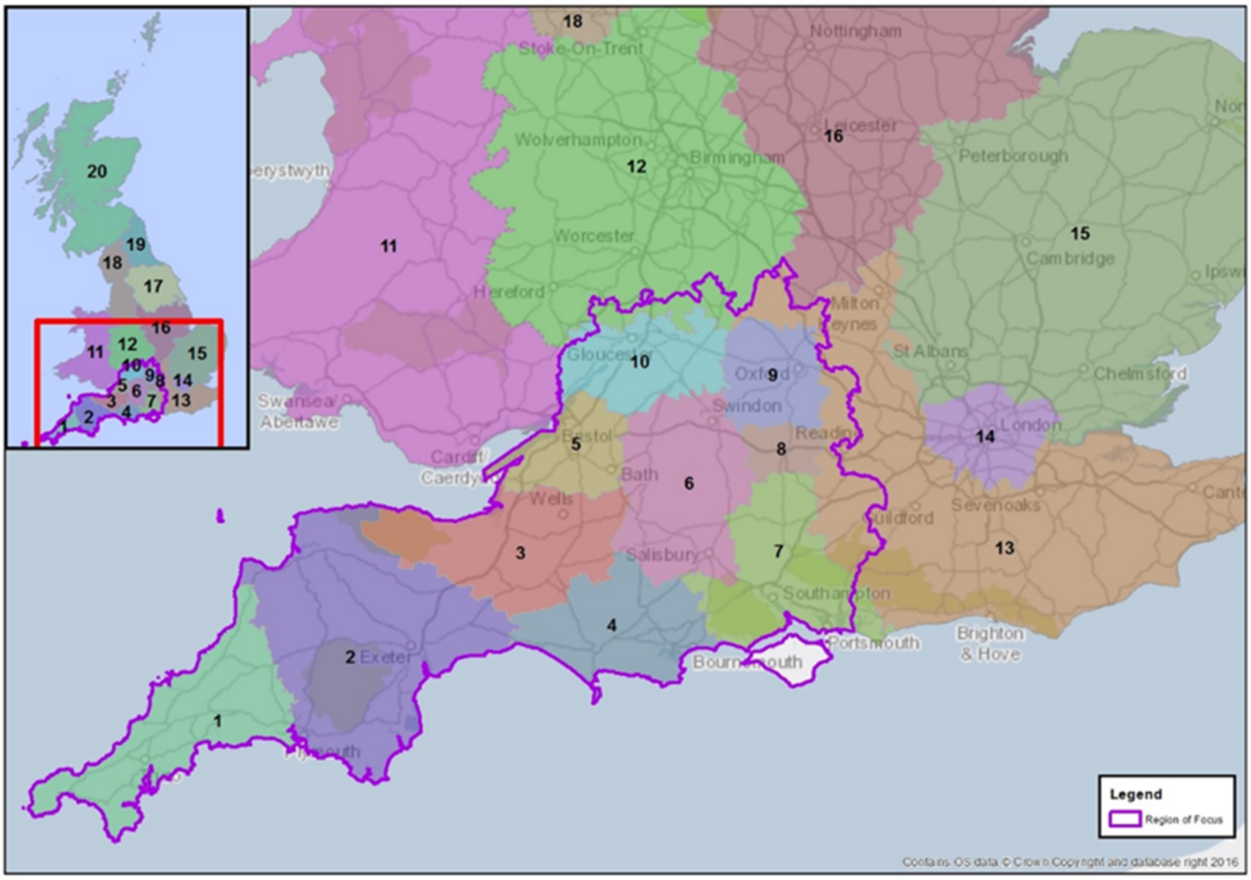


Figure 8-2 SWRTM sectors

Zonal trip ends

8.6.8 Linear regression analysis of the post and prior ME matrices have been undertaken based on the following expression: y=A+Bx. The results of these analyses are presented as the intercept and slope coefficients along with the R-squared coefficient of determination. These are shown in Table 8-8 and Table 8-9 by both origins and destinations with at least one trip end in the SWRTM RoF. The results show that while there are some variations between user classes, the effects of ME on the prior matrices are not a long way adrift of the targets. Overall, the R-squared correlation coefficient meets the target in all time periods and the intercept values are relatively close to zero. The slopes are generally close to unity, deteriorating to 0.96 in the AM and PM periods for the destination comparison and the PM period for the origin comparison. As noted from the other checks detailed above, the comparison for HGVs stands out as the least well performing segment, although this is to be expected given the inherent uncertainty in HGV trip patterns derived from the 2006 BYFM.

Table 8-8 Cell values for trip ends - origins

Origins								
AM peak								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	0.95	0.95	0.97	1.03	0.85	0.96	0.98
Intercept	Near zero	-0.44	-3.43	-2.99	1.89	7.16	-6.53	-3.48
R-squared	In excess of 0.98	0.97	0.98	0.99	0.94	0.74	0.98	0.98
IP								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	0.99	0.99	0.99	1.08	0.84	0.99	1.00
Intercept	Near zero	-0.04	-0.10	0.36	0.22	6.48	0.20	2.07
R-squared	In excess of 0.98	0.98	0.98	0.99	0.96	0.75	0.99	0.99
PM peak								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	0.95	0.93	0.96	1.09	0.90	0.95	0.96
Intercept	Near zero	0.27	0.95	0.25	-0.03	3.11	2.25	3.71
R-squared	In excess of 0.98	0.97	0.98	0.99	0.95	0.83	0.98	0.98

Source: Highways England

Table 8-9 Cell values for trip ends - destinations

Origins								
AM peak								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	0.91	0.92	0.96	1.07	0.91	0.94	0.96
Intercept	Near zero	0.47	0.56	-0.92	-0.16	6.09	0.66	3.37
R-squared	In excess of 0.98	0.97	0.98	0.99	0.95	0.76	0.98	0.98
IP								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	0.98	0.98	0.98	1.07	0.83	0.98	0.99
Intercept	Near zero	0.24	0.09	2.99	0.73	6.41	3.37	5.69
R-squared	In excess of 0.98	0.98	0.98	0.99	0.96	0.73	0.99	0.98
PM peak								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	0.96	0.95	0.96	1.03	0.82	0.95	0.96
Intercept	Near zero	0.20	-0.54	1.31	1.23	3.79	1.37	3.58
R-squared	In excess of 0.98	0.98	0.98	0.99	0.95	0.76	0.99	0.98

Source: Highways England

Zonal cell values

8.6.9 Table 8-10 shows that all user classes across all time periods have an intercept near zero when cell values for trips with a trip end in the SWRTM RoF are considered. Car user classes and LGVs meet the R^2 criteria in all three time periods. HGVs do not meet the criteria, with HGV R^2 values of 0.72. This again reflects uncertainty in the HGV trip patterns from the BYFM matrices.

Table 8-10 Cell values for trip ends with a trip end in the RoF

AM peak								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	1.01	1.00	1.00	0.98	0.77	1.01	1.00
Intercept	Near zero	0.00	0.01	0.00	0.00	0.00	0.00	0.01
R-squared	In excess of 0.98	0.98	0.99	1.00	0.98	0.72	0.98	0.99
IP								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	1.00	0.99	1.00	0.99	0.77	1.00	0.99
Intercept	Near zero	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-squared	In excess of 0.98	0.99	0.99	1.00	0.99	0.72	0.99	0.99
PM peak								
Measure	**TAG M3.1 criteria**	**EB**	**COM**	**Other**	**LGV**	**HGV**	**Cars**	**Total**
Slope	Within 0.99 and 1.01	1.01	1.00	1.00	0.98	0.77	1.01	1.00
Intercept	Near zero	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-squared	In excess of 0.98	0.98	0.99	1.00	0.98	0.72	0.98	0.99

Source: Highways England

Variable demand modelling and realism testing

8.6.10 As per SWRTM, variable demand modelling for scheme PCF stage 2 and PCF stage 3 has been developed with a DIADEM demand model (supported by a HEIDI front end), with the following attributes:

- segmentation by purpose: commute/employers’ business/other
- vehicle types: car/other
- home-based (PA)/non-home-based (OD)
- freight – fixed no VDM
- hierarchical incremental model
- model responses to frequency, time period choice, mode choice (with rail) and distribution
- use of illustrative parameter values and adjustment using realism testing
- cost damping for long distance trips
- monitoring of demand model convergence to achieve TAG criteria.

8.6.11 The SWRTM DIADEM/HEIDI set up has been used as the basis for the demand modelling for the scheme. Realism testing has been carried out with the enhanced scheme traffic model for PCF stage 2. Elasticity results derived through realism testing have been compared against SWRTM results for the same parameter values used in the models. Realism test results can be found in section 9.6 of this report.

9 Scheme traffic model validation

9.1 Introduction

9.1.1 The data not used for the ME process or for the matrix building exercise provides a set of independent validation data. A map of the validation counts along with a description of how the calibration and validation split were determined is given in section 8 of this report.

9.1.2 This section describes the process of validating the scheme base year traffic model and provides a summary of the validation results achieved for PCF stage 2.

9.1.3 No further scheme traffic model validation has been undertaken in PCF stage 3. Figures in this section have been reproduced based on the PCF stage 2 handover information but do not precisely replicate the model validation presented in the PCF stage 2 ComMA Report.

9.2 Validation – network

Ad-hoc network validation

9.2.1 Throughout the validation process, various network checks were carried out as described in section 8.2 of this report. The journey times through the network show a good match with the observed journey times from TrafficMaster which shows that the network coding is sufficiently accurate.

Examination of route choices/paths

9.2.2 Through the network calibration and validation stages, reviews of routeing within the scheme traffic model were undertaken, with focus given to routes that travel through the Air Balloon roundabout, or known rat run alternative routes. This was undertaken to ensure that adopted paths were logical and that major routes were adopted where relevant. Some representative routeings examined in this analysis are Gloucester – Oxford, Swindon – Tewkesbury, Cirencester – Cheltenham and Cirencester - Gloucester. A detailed breakdown of these paths and output is provided in Appendix D of this report.

9.2.3 The analysis indicated that, in general, the paths predicted by the scheme traffic model appeared logical. This included routes through the Air Balloon roundabout and rat-runs through Elkstone and Birdlip Hill. Routes were also compared against internet journey time sources such as Google Maps as a further check. Where localised routeing issues were identified, the network was further refined and calibrated accordingly.

9.3 Validation – matrices

Matrix comparisons

9.3.1 As stated in section 7.3 of this report, the scheme traffic model PCF stage 3 base prior matrices have been inherited from the previous PCF stages which were derived from the SWRTM prior matrices.

9.3.2 The SWRTM matrices were mainly created using mobile phone data but enhanced with synthetic trips for short journeys and for deducing trip purposes.

During the building of the SWRTM, demand comparisons were undertaken between the SWRTM demand and independent observed data sources, primarily involving the National Travel Survey (NTS) and the 2011 Census. Since the A417 PCF stage 3 matrices are derived directly from the SWRTM matrices, no further comparisons have been carried out.

9.3.3 Various analysis has been carried out on the changes produced by the matrix estimation process on the prior matrices. Details and results of these tests are given in section 8.6 of this report.

9.4 Validation – assignment

Scheme traffic model convergence

9.4.1 As noted in section 7.4 of this report, the TAG criteria displayed in Table 7-4 were used to assess the convergence of the base year highway assignment model. The key statistics for the post-matrix estimation scheme model run are given in Table 9-1 for the final four loops of each time period. The results show that the scheme traffic model is very well converged in all time periods.

Table 9-1 Assignment scheme traffic model convergence post ME

Time period	Assignment loop	%Flows	Assignment loop	%Flows
AM	31	99.6	99.4	0.00021
	32	99.6	99.6	0.00013
	33	99.7	99.8	0.0003
	34	99.6	99.6	0.00017
IP	14	99.7	99.9	0.00017
	15	99.7	99.9	0.00011
	16	99.8	99.9	0.00008
	17	99.8	99.9	0.00022
PM	44	99.8	99.7	0.00042
	45	99.8	99.5	0.00056
	46	99.6	99.3	0.00042
	47	99.8	99.6	0.00039

Source: Highways England

9.5 Scheme traffic model performance

9.5.1 The TAG validation criteria set out in section 8.2 of this report were used to assess the screenline/link flows and journey times in the scheme traffic model. Table 9-2 summarises these results.

Table 9-2 Scheme traffic model performance summary

	TAG criteria		AM	IP	PM
Screenlines within 5%	All or nearly all	Calibration	100%	100%	95%
		Validation	100%	100%	83%
		Total	100%	100%	92%
Screenlines GEH <4	(no longer included in TAG)	Calibration	100%	100%	100%
		Validation	100%	100%	100%
		Total	100%	100%	100%
Links and turns passing GEH or flow criteria	>85%	Calibration	93%	97%	94%
		Validation	96%	100%	100%
		Total	93%	97%	95%
Journey time routes within 15%	>85%		100%	100%	100%

Source: Highways England

9.5.2 The calibration and validation results of link flows and journey time routes all meet the relevant TAG criteria.

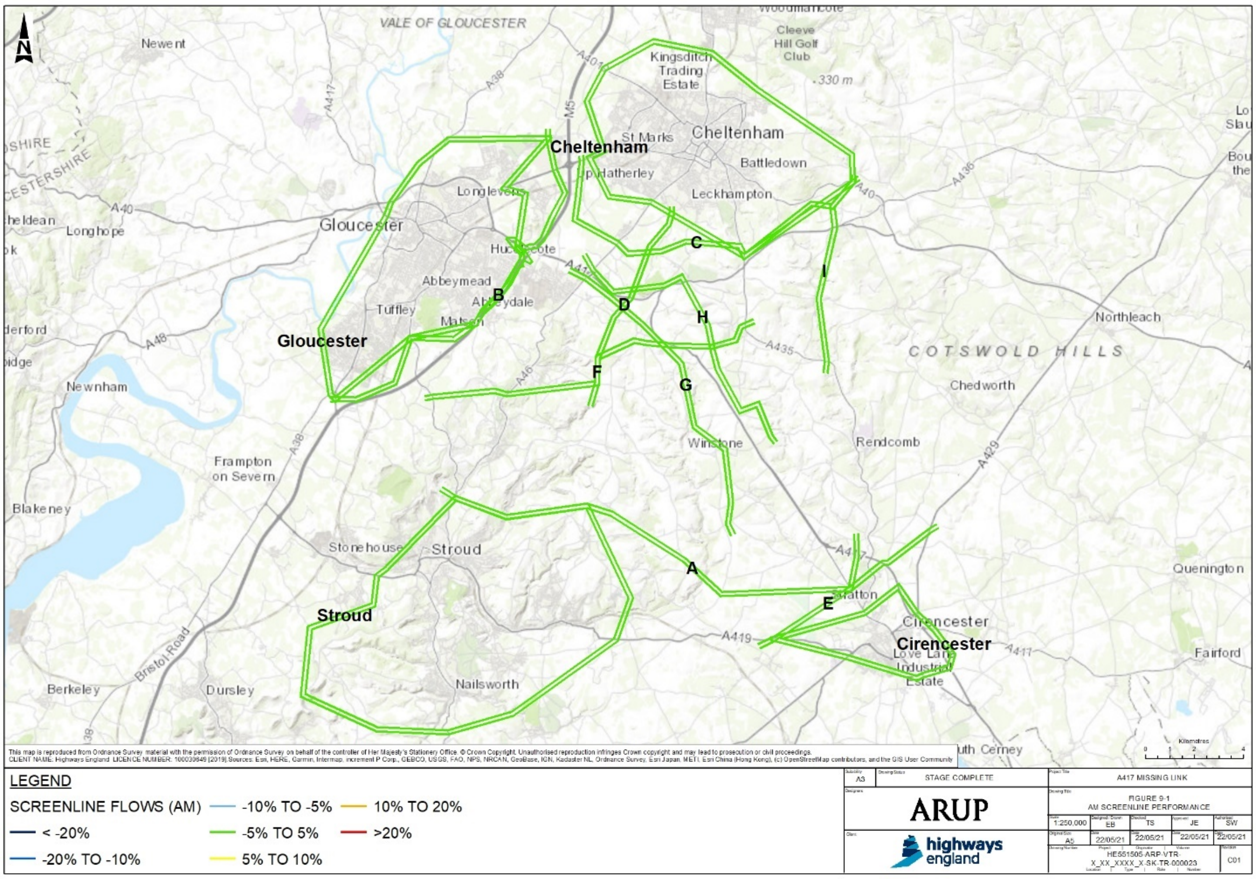
9.5.3 Modelled flows at the screenline level are within five percent of observed flows in all instances in the AM and IP periods. Only a single calibration screenline and a single validation screenline fall outside the five percent target in the PM peak, and these do so by a small amount. Modelled flows on screenlines F and G are 5.1% lower and 5.7% higher than observed flows respectively in this period, and both achieve a low GEH value (2.8 and 1.8 respectively).

9.5.4 These results represent a clear improvement on the results achieved in the scheme base traffic model for PCF stage 1, in which achieving the five percent screenline total flows target proved particularly difficult. The improvement in the PCF stage 2 screenline results reflects the additional work undertaken at PCF stage 2 and particularly the improved representation of the urban areas of Cheltenham, Gloucester, Cirencester and Stroud in the model.

Screenline performance

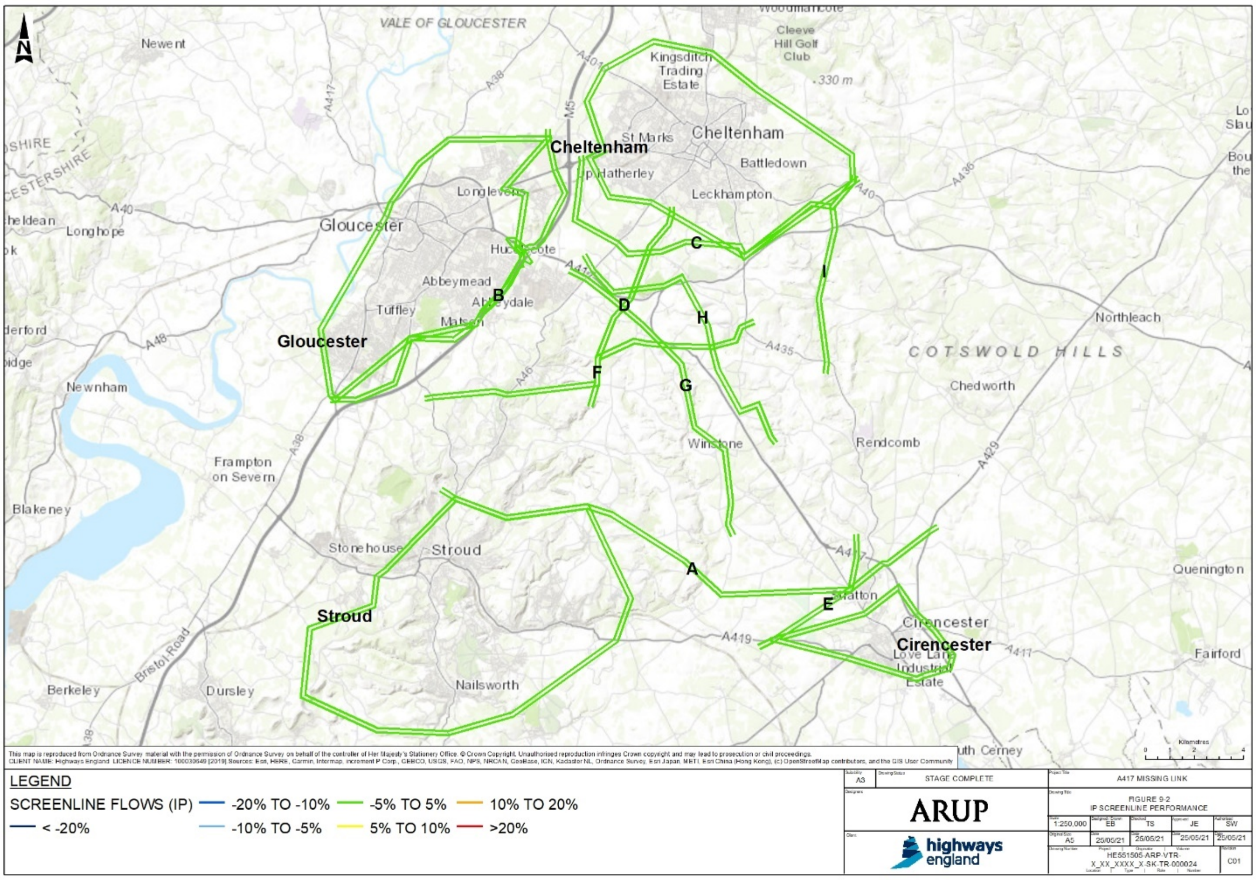
9.5.5 The screenlines used for the calibration and validation process are shown in Figure 8-1.

9.5.6 The screenline results are illustrated in Figure 9-1, Figure 9-2 and Figure 9-3.



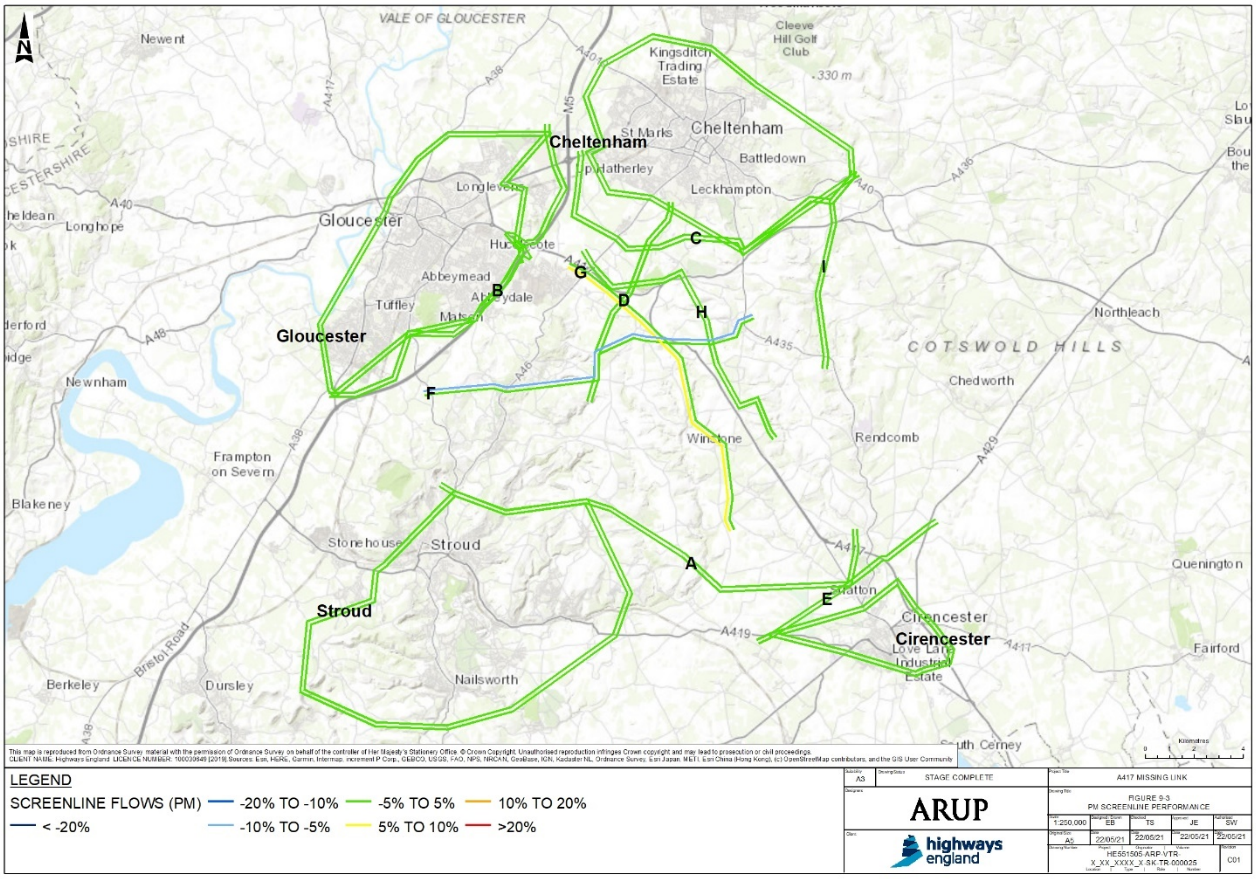
Source: Highways England

Figure 9-1 AM screenline performance



Source: Highways England

Figure 9-2 IP screenline performance



Source: Highways England

Figure 9-3 PM screenline performance

Turning count performance

9.5.7 Turning counts at key junctions have been used in the calibration of the scheme base traffic model. A comparison between the observed and modelled turning counts is summarised in Table 9-3. This shows that there is an excellent match between the observed and modelled turning movements at the key junctions.

Table 9-3 Turning counts meeting flow criteria

Junction	Site Ref.	Turns meeting flow criteria		
		AM	IP	PM
A417/A436 Air Balloon roundabout	12*	All	All	All
A417/B4070 Barrow Wake	13	All	All	All
A436/Leckhampton Hill	12*	All	All	All
A436/Seven Springs	4	All	All	All
A417/A46 Shurdington Road Interchange	1	All	All	All
B4070/Birdlip Hill (Birdlip village)	9	All	All	All

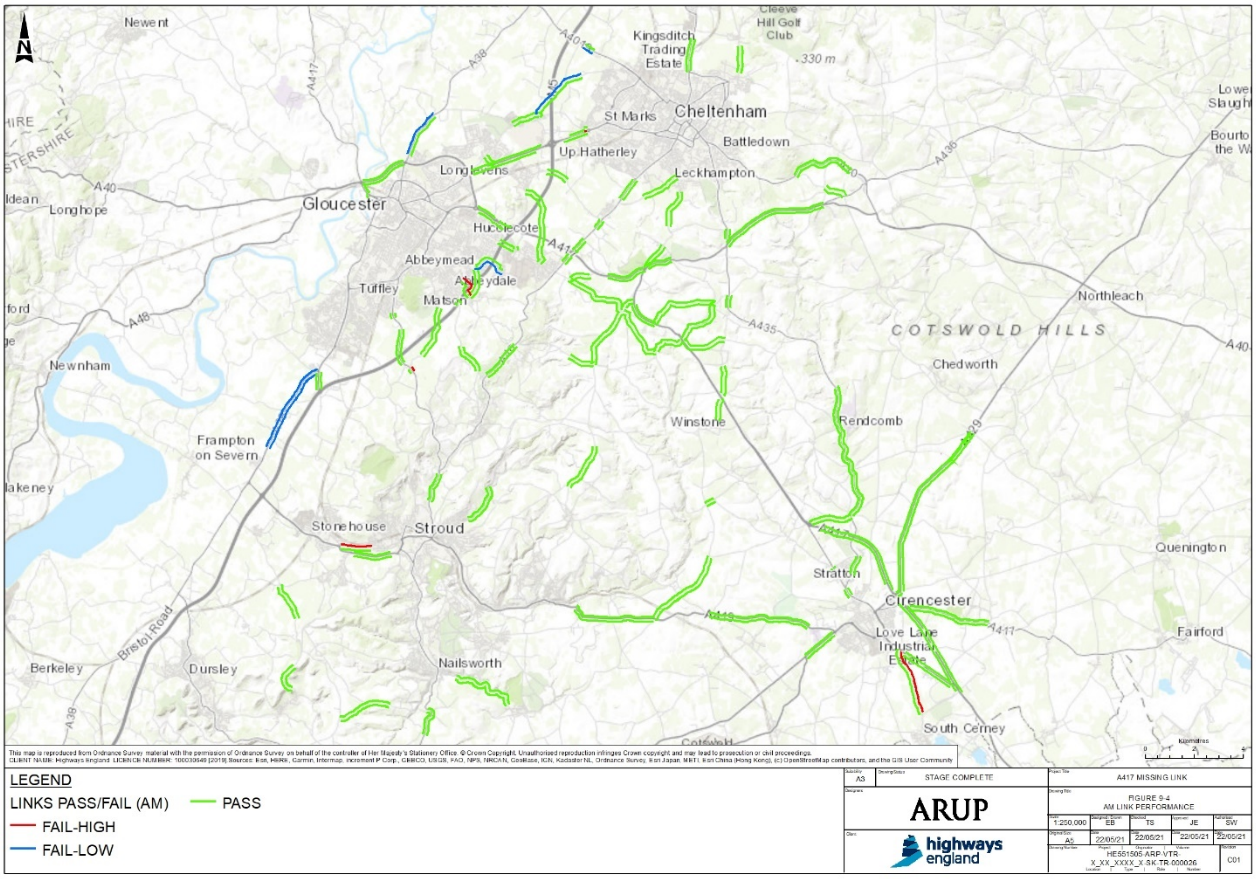
Source: Highways England

* A417/A436 Air Balloon and A417/Leckhampton Hill junctions were surveyed together as Site 12

Link performance

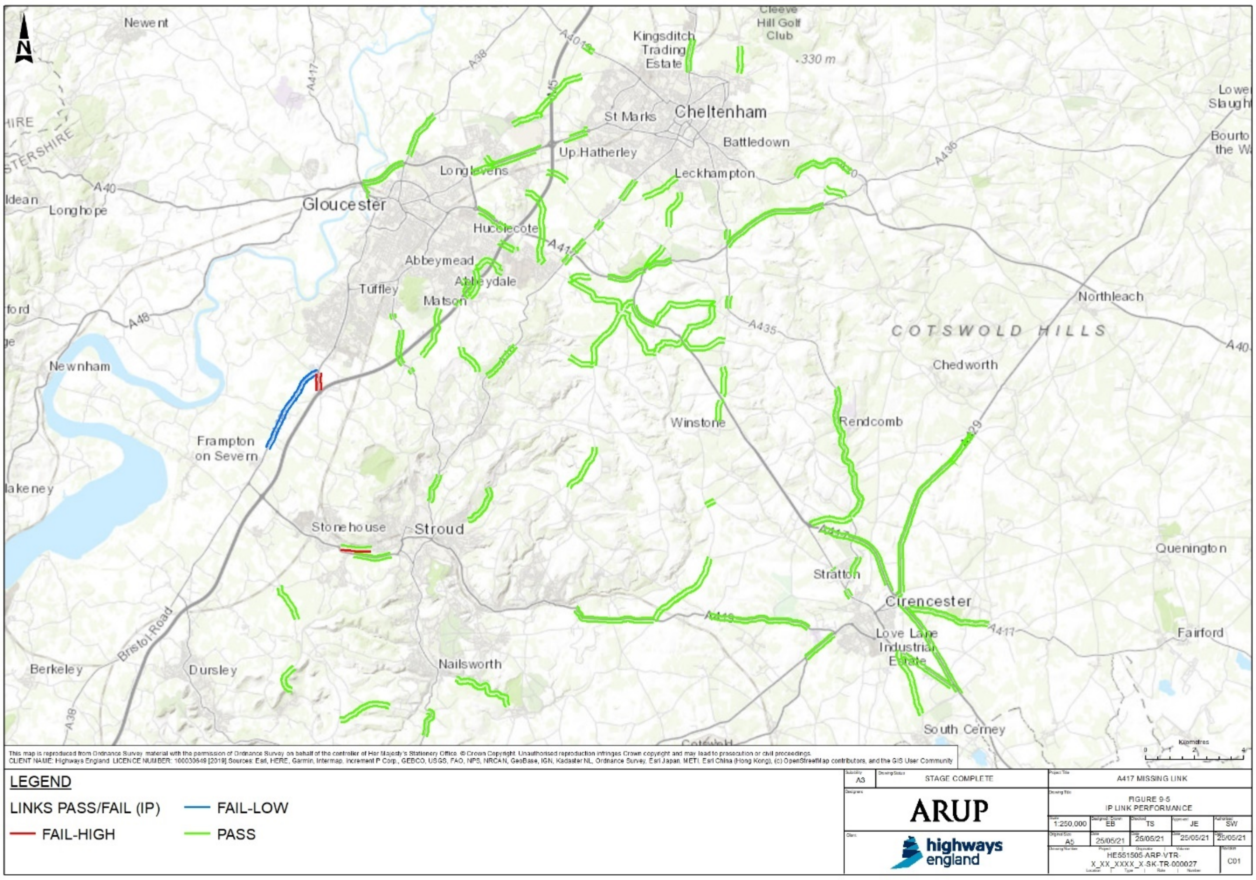
9.5.8 An analysis of individual links in the scheme traffic model was carried out, showing good results in the majority of cases, with links in the local scheme area and much of the wider area meeting the criteria in each time period. Those links that do fail are generally remote from the A417 and the location of the proposed scheme.

9.5.9 The performance of individual links is displayed in Figure 9-4, Figure 9-5 and Figure 9-6.



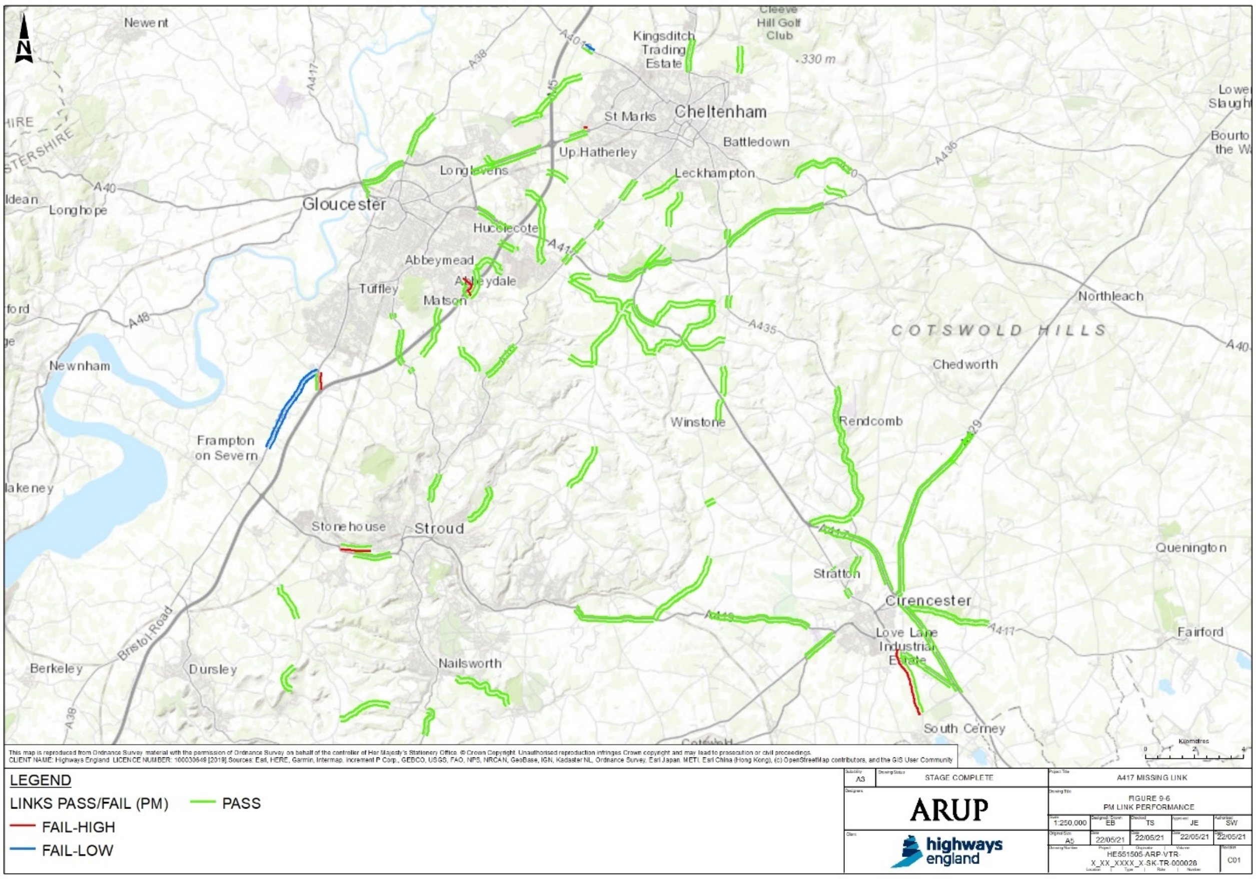
Source: Highways England

Figure 9-4 AM link performance



Source: Highways England

Figure 9-5 IP link performance

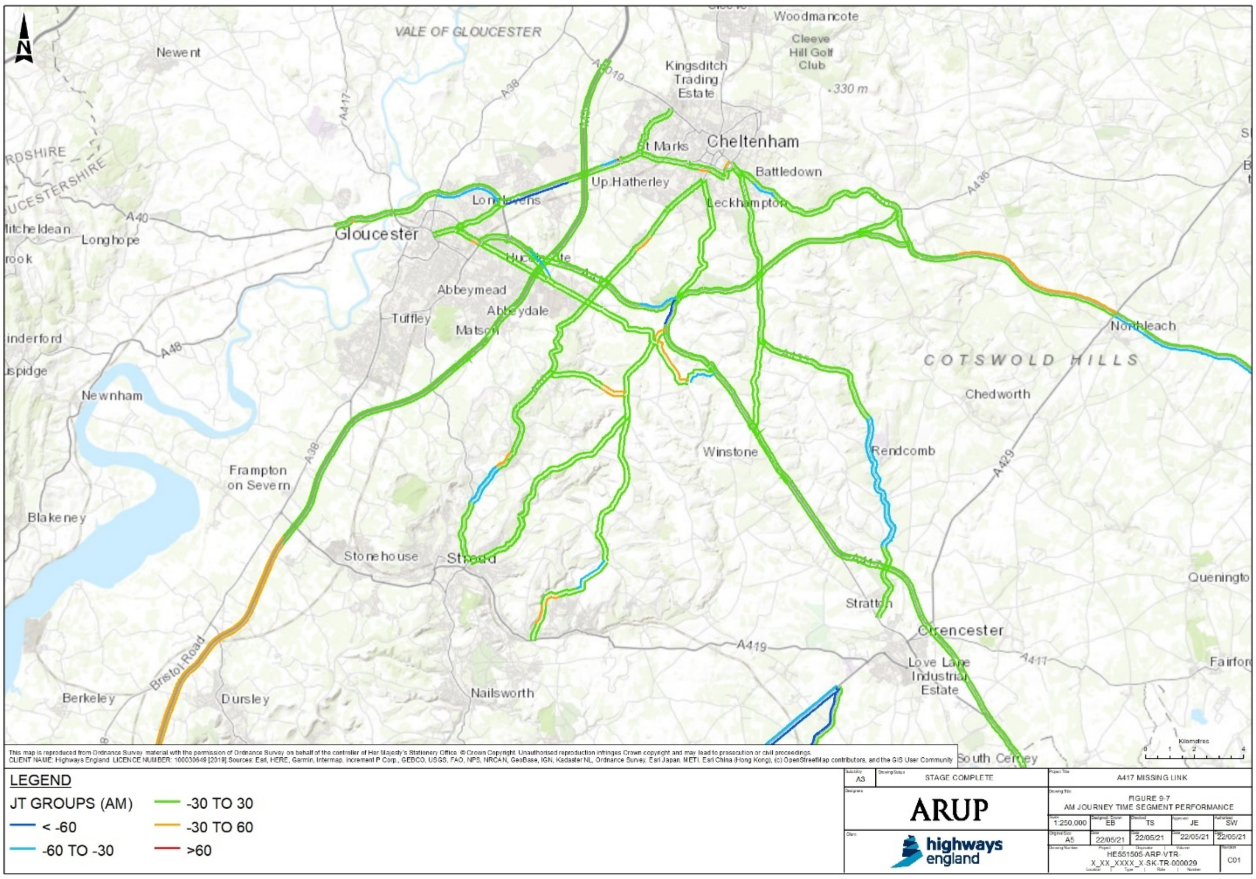


Source: Highways England

Figure 9-6 PM link performance

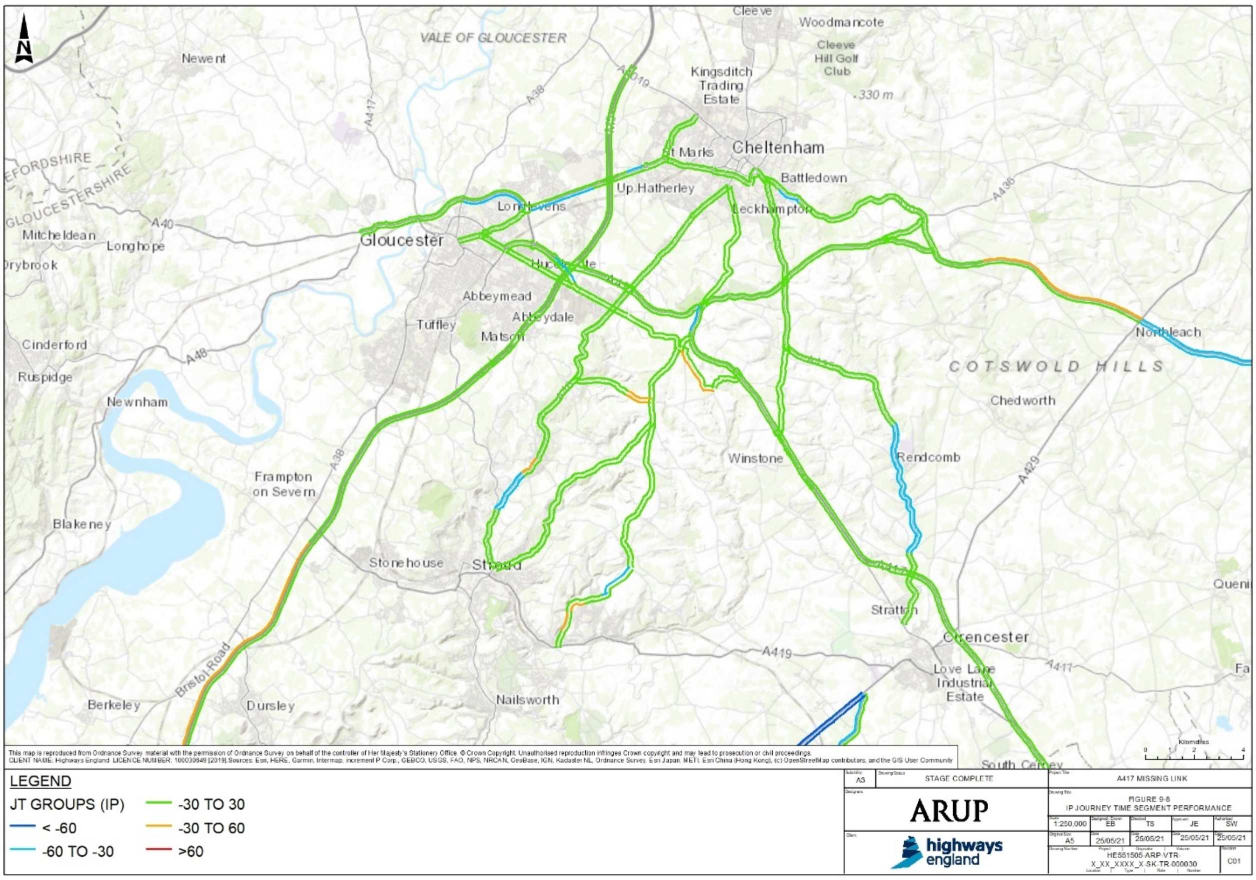
Journey time performance

9.5.10 The journey time performance of the scheme traffic model is good, with all routes in all time periods meeting the TAG criteria. The journey time segment results are displayed in Figure 9-7, Figure 9-8 and Figure 9-9, from which it can be noted that the key routes are generally closely aligned with observations. (N.B. these figures show the absolute difference in journey time in seconds for a particular segment rather than a percentage change.)



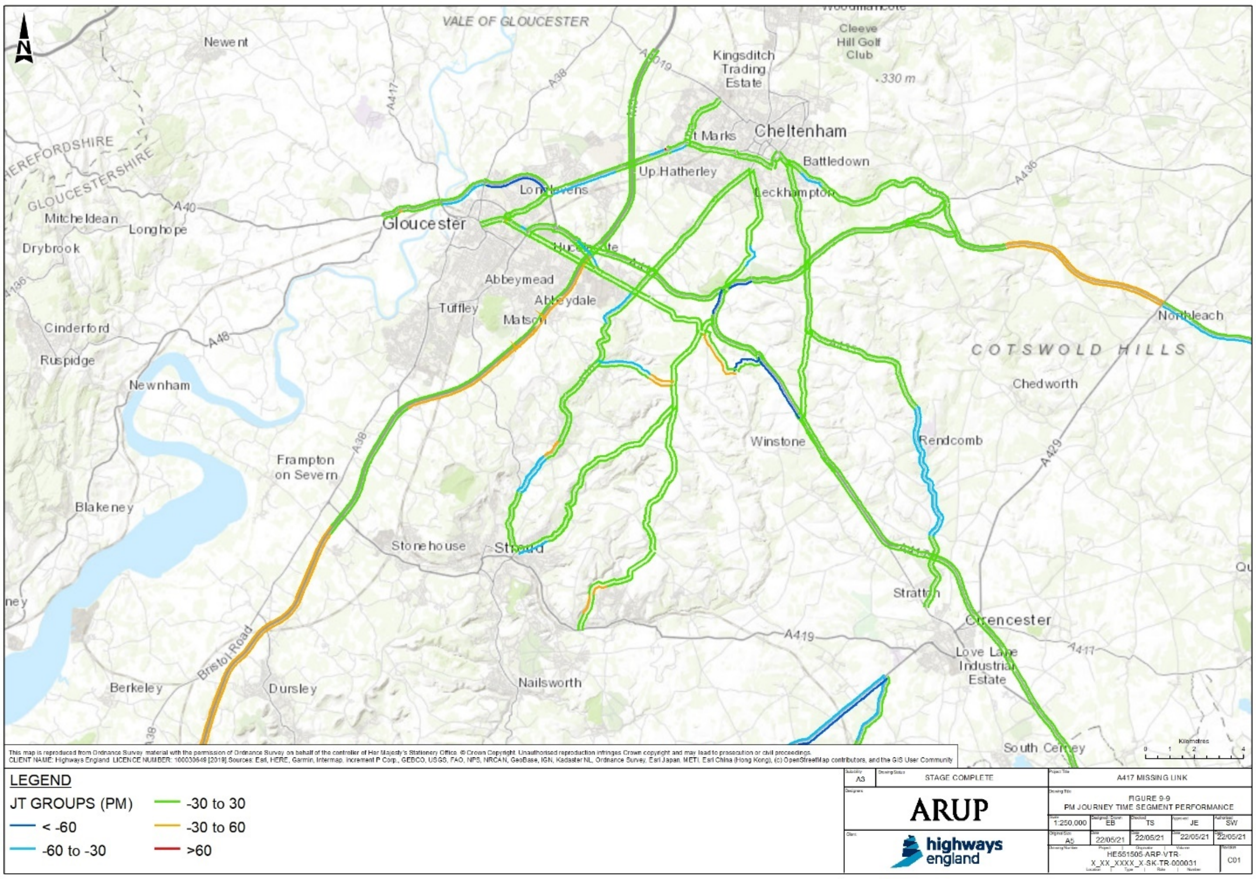
Source: Highways England

Figure 9-7 AM journey time segment performance



Source: Highways England

Figure 9-8 IP journey time segment performance



Source: Highways England

Figure 9-9 PM journey time segment performance

9.5.11 Although modelled journey times on the approaches to the Air Balloon roundabout are generally closely aligned with observations, it should be noted that modelled times on the westbound A436 approach to the roundabout are quicker than observed times by over one minute in the PM peak period. This reflects a compromise that sought to achieve a balance between journey times on the westbound A436 approach and on the Leckhampton Hill approach to the A436 (where modelled journey times are too slow by an equivalent amount). The need for this compromise arises from the way SATURN represents delays in this location, with the scheme traffic model attributing most of the A436 delays on the short approach to the roundabout, rather than distributing delays along the upstream links on the A436. It is considered that the balance that has been struck is a reasonable compromise that minimises the overall time differences on both routes combined. On balance it is considered that the impact of this discrepancy on the appraisal of the scheme is likely to be a very small or even negligible understatement of potential benefits.

9.6 Realism testing results

Fuel cost realism test results

9.6.1 A fuel cost realism test was carried out on the base year validated scheme traffic model, testing a 20% increase in fuel costs as per the approach adopted for the SWRTM. For the SWRTM a 20% increase in fuel cost was considered appropriate in order to obtain plausible results due to the size of the model.

9.6.2 The results from the test are shown in Table 9-4, and are very similar to the results calculated for the SWRTM, which are shown for reference in Table 9-5. The overall fuel cost elasticity for the scheme traffic model for PCF stage 2 of -0.39 is a slight deterioration on the result reported for the SWRTM.

Table 9-4 Scheme traffic model fuel cost elasticities

	Employers business	Commuting	Other	Total
AM	-0.34	-0.18	-0.53	-0.34
IP	-0.34	-0.25	-0.53	-0.45
PM	-0.24	-0.22	-0.50	-0.35
OP	-0.27	-0.24	-0.55	-0.39
Total	**-0.31**	**-0.22**	**-0.52**	**-0.39**

Source: Highways England

Table 9-5 SWRTM fuel cost elasticities

	Employers business	Commuting	Other	Total
AM	-0.22	-0.17	-0.55	-0.32
IP	-0.22	-0.21	-0.55	-0.43
PM	-0.20	-0.18	-0.49	-0.32
OP	-0.26	-0.24	-0.57	-0.39
Total	**-0.22**	**-0.19**	**-0.54**	**-0.37**

Source: Highways England

9.6.3 The calculated overall fuel cost elasticity (-0.39) is just outside the TAG indicated range (-0.25 to -0.35). However, there is a clear difference between the elasticities by purpose and those suggested by TAG.

- employer’s business (-0.24 to -0.34) is approximately two to three times as strong as TAG (-0.1)
- commuting (-0.18 to -0.25) is weaker than TAG (-0.3)
- other (-0.49 to -0.57) is stronger than TAG (-0.4).

9.6.4 It is important to note that TAG elasticity values are based primarily on research undertaken in 2002. Since then there have been a number of changes that are relevant to the observed fuel cost elasticities as noted below (further details are presented in the SWRTM MVR):

- car fuel efficiency improvements – 15%
- fuel pump price increase – 13%
- value of time increase – 13%
- value of time for business is distance dependent.

9.6.5 The regional traffic models concluded that if the above factors were taken into account in the derivation of the TAG elasticity values, then the final values would align much more closely with the realism test results.

Public transport fare realism test results

9.6.6 A public transport (PT) fare realism test was carried out on the base year validated scheme traffic model, testing a 20% increase in rail fares as per the approach adopted for the SWRTM.

9.6.7 The results from the test are shown in Table 9-6, and are very similar to the results calculated for the SWRTM, which are shown for reference in Table 9-7. The overall PT fare elasticity for the scheme traffic model of -0.45 is similar to the result calculated for the SWRTM and within the range recommended by TAG (-0.2 to -0.9).

Table 9-6 Scheme traffic model PT fare elasticities

	Employers business	Commuting	Other	Total
AM	-0.42	-0.22	-0.84	-0.40
IP	-0.46	-0.18	-0.82	-0.59
PM	-0.40	-0.16	-0.77	-0.40
OP	-0.42	-0.22	-0.76	-0.39
Total	**-0.43**	**-0.20**	**-0.80**	**-0.45**

Source: Highways England

Table 9-7 SWRTM PT fare elasticities

	Employers business	Commuting	Other	Total
AM	-0.42	-0.22	-0.85	-0.40
IP	-0.46	-0.19	-0.84	-0.60
PM	-0.41	-0.17	-0.79	-0.41
OP	-0.42	-0.22	-0.78	-0.40
Total	**-0.43**	**-0.20**	**-0.82**	**-0.46**

Source: Highways England

Realism test conclusions

9.6.8 The elasticities calculated for realism tests are close to those calculated for the SWRTM and are considered to be acceptable for scheme appraisal purposes.

9.7 Additional traffic data analysis and scheme base traffic model

9.7.1 As stated in section 3.2 of this report a review and comparison of traffic data between 2015 and 2019 has been undertaken on the strategic and local road network to ascertain how traffic has changed in the intervening period. This data review is set out in more detail in a technical note which is included as Appendix E of this report.

9.7.2 Overall, the observed traffic growth on the SRN and local road networks is considered to be comparable to TEMPro forecast traffic growth and the difference does not have a material impact on the uncertainty underlying the use of the existing scheme traffic model or the uncertainty underlying the scheme appraisal.

9.7.3 As such, and as agreed with Highways England’s TPG, it is considered that retaining the 2015 base year is consistent with TAG and use of the existing scheme traffic model during PCF stage 3 is appropriate.

10 Forecast assumptions

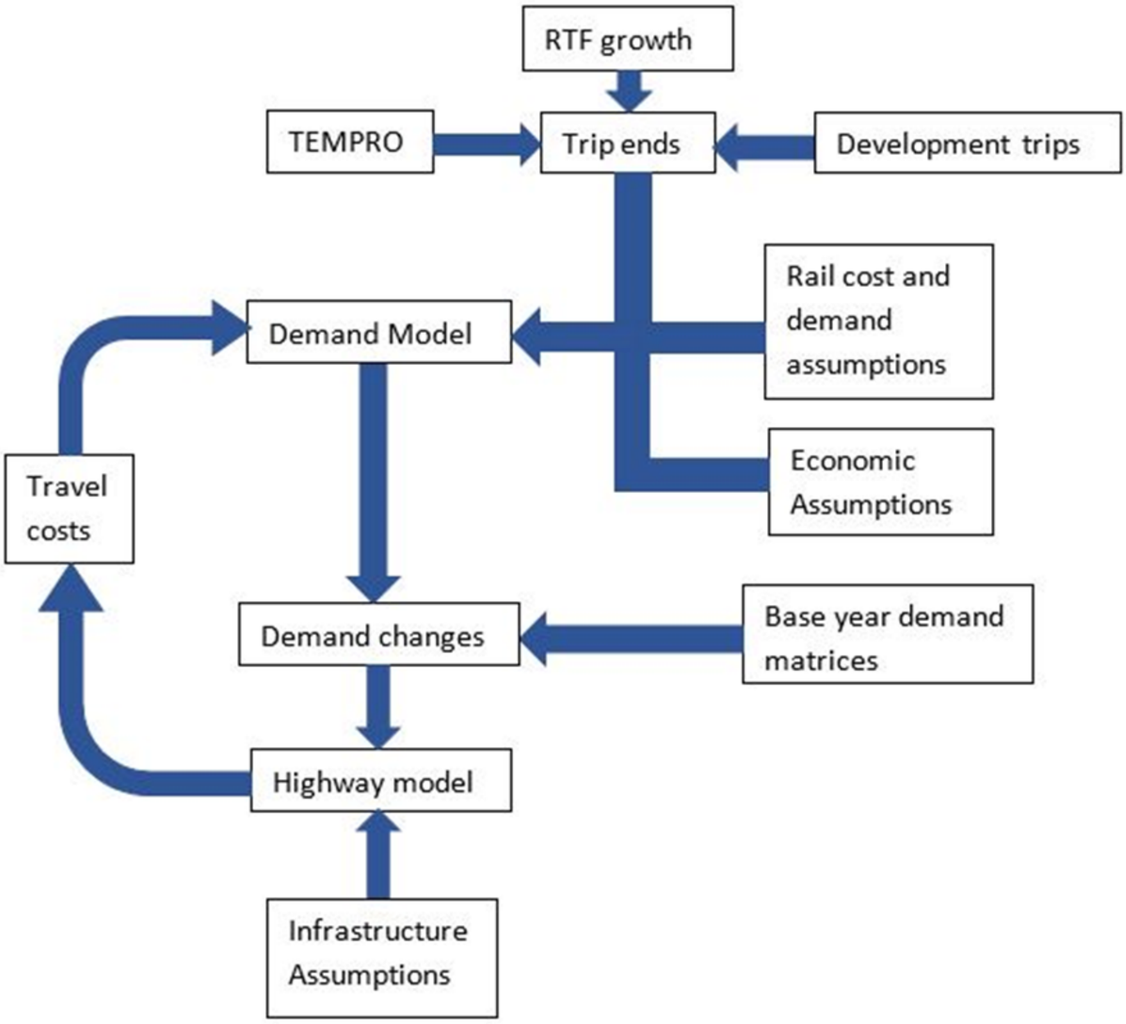
10.1 Introduction

10.1.1 This section details the approach taken during PCF stage 3 to develop the future year forecast scenarios, account for expected changes to travel demand, highway network provision and travel costs.

10.2 Forecasting approach

Overview

10.2.1 An overview of the approach adopted in the forecasting of the scheme is given in Figure 10-1.



Source: Highways England

Figure 10-1 Flowchart of forecasting process

10.2.2 The current estimated opening year for the scheme is 2026, and the scheme design year is 2041. These are later than the opening year of 2024 and design year of 2039 assessed at previous PCF stages. Demand matrices for these new forecast years have been created using HEIDI and following the process developed and set out during the previous PCF stages. Two additional forecast years, consisting of an intermediate year of 2031 and a final forecast year of 2051, have also been used to support the economic appraisal of the scheme.

10.2.3 Further information about the scheme, including a summary plan, is included within section 10.3 of this report.

10.2.4 The traffic forecasts account for future proposed residential and employment developments in the local area, as well as proposed transport network changes. The forecast scenarios comprise the following:

- a set of transport network changes
- assumptions about changes in values of time and vehicle operating costs over time
- a specific set of development assumptions
- application of National Trip End Model (NTEM) growth factors as a constraint on trip growth for cars and rail
- application of growth of freight traffic from DfT Road Traffic Forecasts 2018 (RTF18)
- application of forecast traffic growth at the primary airports and seaports within the south-west region

10.2.5 The transport supply and development assumptions have been determined through a process of identifying potential transport improvements and development proposals and undertaking an assessment of the likelihood of each of these proposals coming forward. Further details can be found in section 10.3 and section 10.5 of this report.

10.2.6 The following demand forecasts have been produced for each forecast year:

- DM forecasts – these use forecast year trip matrices and the future transport network that excludes the proposed scheme.
- DS forecasts – these use forecast year trip matrices and the future transport network changes, including the proposed scheme.

10.3 Forecast network development

Introduction

10.3.1 As part of the forecasting process, networks representing the supply and cost of transport in future years are required as a basis to assess the impact of the scheme. Future year transport supply and costs relate to changes in the transport networks, such as new transport infrastructure or changes in tolls or fares.

10.3.2 Highway networks have been produced for the DM and the DS scenarios for each of the four forecasting years (2026, 2031, 2041 and 2051). The DS scenario is based on the design at August 2020.

10.3.3 The inclusion of the scheme is the only difference between the DM and DS networks.

Transport supply uncertainty log

10.3.4 A transport supply uncertainty log has been compiled that contains the Highways England RIS[5] schemes as well as relevant local schemes identified by the local highway authority (GCC).

10.3.5 As per TAG, the transport schemes included in the DM scenarios have a likelihood of at least 'near certain' or 'more than likely', as defined by classifications set out in TAG and reproduced in Table 10-1.

Table 10-1 Transport supply certainty classification

Probability of the input	Local authority/Development scheme	Highways England	Network Rail
Near certain: The outcome would happen or there is a high probability that it would happen	Intent announced by proponent of regulatory agencies. Approved development proposals. Projects under construction.	PCF stage 4 completed, scheme entering or in PCF stage 5 (i.e. scheme consented)	Governance for Railway Investment Projects (GRIP) stage 5 completed, scheme entering or in GRIP stage 6 (i.e. scheme consented)
More than likely: The outcome is likely to happen but there is some uncertainty	Submission of planning or consent application imminent. Development application within the consent process.	PCF stage 2 completed, scheme entering or in PCF stage 3 (i.e. preferred route announced)	GRIP stage 3 completed, scheme entering or in GRIP stage 4 (i.e. single option development)
Reasonably foreseeable: The outcome may happen, but there is significant uncertainty	Identified within a development plan. Not directly associated with the transport strategy/scheme but may occur if the strategy/scheme is implemented. Development conditional upon the transport strategy/scheme proceeding. Or, a committed policy goal, subject to tests (e.g. of deliverability) whose outcomes are subject to significant uncertainty.	Scheme in PCF stage 1 or 2 (i.e. option selection)	GRIP stage 2 completed, scheme entering or in GRIP stage 3 (i.e. option selection)
Hypothetical: There is considerable uncertainty whether the outcome would ever happen	Conjecture based upon currently available information. Discussed on a conceptual basis. One of a number of possible inputs in an initial consultation process. Or, a policy aspiration.	Scheme in PCF stage 0 (i.e. major road project initiated)	Scheme in GRIP stage 1 (i.e. output definition)

Source: TAG unit M4

10.3.6 Information on the local schemes, including scheme layouts and their level of certainty, has been provided by GCC. In agreement with GCC, some major schemes that form part of the Gloucestershire Joint Core Strategy have been classified as 'more than likely', and therefore included in the DM networks,

[5] https://www.gov.uk/government/collections/road-investment-strategy

despite being at a relatively early stage in scheme development. This includes the M5 J10 ‘all movements’ scheme, the Cyber Park link road in Cheltenham and the A38 to A40 link road north of Gloucester.

10.3.7 In addition to the level of certainty, the uncertainty log identifies the estimated year of opening of each scheme, which has informed which forecast year, if any, each scheme should be included in. The transport supply uncertainty log is included in Appendix F of this report.

10.3.8 As agreed with Highways England’s TPG, the Transport Supply Uncertainty Log for PCF stage 2 opening year 2024 and design year 2039 have been used to represent PCF stage 3 opening year 2026 and design year 2041 respectively in terms of the schemes included.

10.3.9 The resulting highway schemes included in the DM scenarios are presented in Table 10-2.

10.3.10 Public transport schemes included in the scheme traffic model are as per the SWRTM reference cases and this includes High Speed Two.

Do-Minimum networks

10.3.11 The highway networks used in the DM forecasts include schemes with sufficient levels of certainty. In addition, fixed speed links within the scheme traffic model that are not directly affected by any DM schemes have been adjusted to account for forecast changes in speed/congestion using RTF18 data.

10.3.12 The DM highway schemes included in the forecast scheme traffic models are presented in Table 10-2. The DM networks includes numerous schemes that are remote from the scheme and which are unlikely to have any impact within the scheme study area. Typically, such schemes would not necessarily be included in scheme forecasts. However, given that the information on these schemes is available and compatible with the scheme traffic model, all schemes have been included in the future year forecast scheme traffic models.

Table 10-2 Do-Minimum schemes included in forecast models

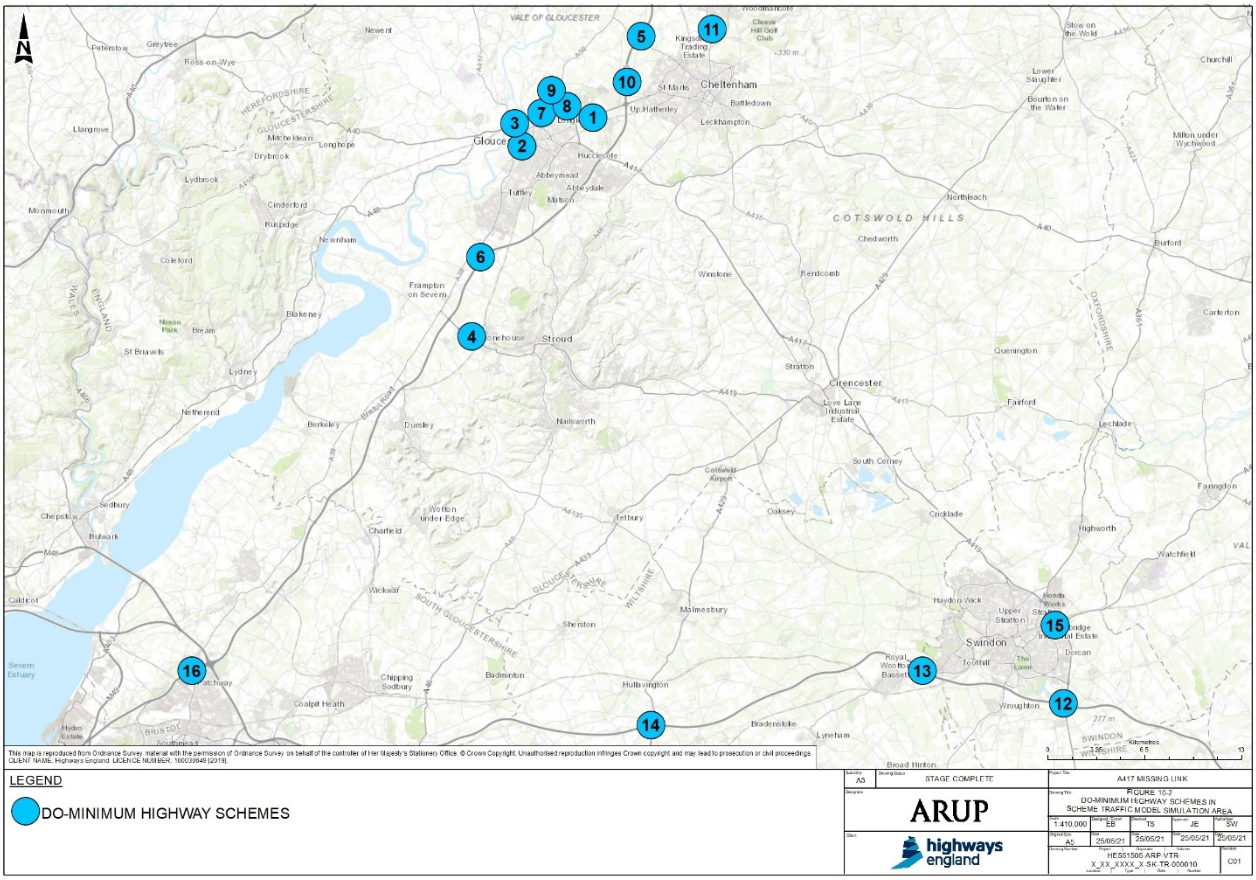
ID	Scheme	Simulation/Buffer	Forecast years
1	A40 Elmbridge Transport Scheme, Gloucester	Simulation	All
2	A430 Llanthony Rd and St Ann Way (Southwest bypass) improvement, Gloucester	Simulation	All
3	A40 Over Roundabout improvement (phase 2), Gloucester	Simulation	All
4	Improvements for A419 corridor, Stonehouse	Simulation	All
5	M5 J10 'all movements' access (including link road into Cyber Park), Gloucester	Simulation	All
6	A38 Cross Keys Roundabout	Simulation	All
7	Junction improvement A40 Longford Roundabout, Gloucester	Simulation	All
8	New A40 access roundabout (Twigworth/Innsworth)	Simulation	All
9	A38/A40 link road	Simulation	Post-2026
10	Staverton crossroads junction (B4063/B4634), Staverton	Simulation	All
11	A435/Hyde Lane/Southam Lane Signalised Junction improvements	Simulation	All

ID	Scheme	Simulation/Buffer	Forecast years
12	M4 J15	Simulation	All
13	M4 J16	Simulation	All
14	M4 J17	Simulation	All
15	A419 White Hart junction improvement, Swindon	Simulation	All
16	A38 M5 J16 to Aztec West, Almondsbury	Simulation	All
17	M5 J23 Signalisation	Buffer	All
18	M5 J23 Dunball Roundabout improvement	Buffer	All
19	M5 J24 Huntworth Roundabout improvement	Buffer	All
20	M5 J25	Buffer	All
21	M5 J30/J31 - A379 Bridge Road Widening, Exeter	Buffer	All
22	A38 Deep Lane Junction, East of Plymouth	Buffer	All
23	A380 South Devon Highway (Kingskerswell Bypass)	Buffer	All
24	A350 Chippenham Improvements	Buffer	All
25	A338 Blackwater Junction, Dorset	Buffer	All
26	A349 Dunyeat's Roundabout and Queen Anne Drive Junctions, Poole	Buffer	All
27	A349 Major Improvement, Poole	Buffer	All
28	Staplegrove, Taunton	Buffer	All
29	Northern Inner Distribution Road (NIDR), Taunton	Buffer	All
30	A34 Milton Interchange Improvement, Oxfordshire	Buffer	All
31	A34 Chilton Interchange Improvement	Buffer	All
32	A30 Temple to Higher Carblake	Buffer	All
33	M49 Avonmouth Junction	Buffer	All
34	M27 Junctions 4-11: Smart Motorways	Buffer	All
35	M3 Junctions 9-14: Smart Motorways	Buffer	All
36	M3 J2-4a	Buffer	All
37	A303 Amesbury to Berwick Down	Buffer	Post-2026
38	A303 Sparkford to Ilchester dualling	Buffer	All
39	A358 Taunton to Southfields	Buffer	All
40	M4 J3-12 SMP	Buffer	All
41	M3 Junction 2-4A	Buffer	All
42	M4 Junctions 3-12 Smart Motorways	Buffer	Post-2026
43	M23 Junctions 8-10: Smart Motorways	Buffer	All
44	M25 Junctions 10-16 Smart Motorway	Buffer	Post-2026
45	M6 Junctions 10a-13: Smart Motorway	Buffer	All
46	M5 Junctions 4a-6: Smart Motorway	Buffer	All
47	M1 Junctions 23a-25: Smart Motorway	Buffer	All
48	M1 Junctions 28-31: Smart Motorway	Buffer	All
49	M6 Junctions 13-15: Smart Motorway	Buffer	All
50	M1 Junctions 16-19: SMP	Buffer	All
51	M1 Junctions 13-16: SMP	Buffer	All
52	M6 Junctions 2-4: Smart Motorway	Buffer	All

ID	Scheme	Simulation/Buffer	Forecast years
53	A465 Gilwern to Brynmawr	Buffer	Post-2026
54	A465 Brynmawr to Tredegar	Buffer	Post-2026

Source: Highways England

10.3.13 Figure 10 2 shows those highway schemes located within the scheme traffic model simulation area.



Source: Highways England

Figure 10-2 Do-Minimum schemes in scheme traffic model simulation area

10.3.14 DM highway schemes located within the scheme traffic model simulation area have been included with appropriate node/link coding reflecting the available scheme layout drawings. These schemes have been drawn in GIS to provide geospatially accurate information, before subsequently being coded into the SATURN network. Network coding principles adopted in the scheme base traffic model have been adopted for the DM simulation schemes and largely consist of generic/default coding including saturation flows. Traffic signal timings, and green splits in particular, were initially informed from base year traffic flows and were subsequently modified following preliminary forecast scheme traffic model runs. Further details on the coding principles are provided in section 7.

10.3.15 Schemes in the buffer area, where the network is represented by fixed speed links rather than simulated junctions, have been accounted for by adjusting link speeds based on RTM forecast model runs.

10.3.16 Where a buffer scheme includes entirely new links, the revised network link structure has been implemented in the scheme traffic forecast models using coding and speeds from the SWRTM.

10.3.17 As stated above, the speeds on fixed speed links not directly affected by DM schemes have been adjusted using forecast speed changes identified in RTF18 data. Forecast speed changes from RTF18 have been applied by region, road type and time period.

10.3.18 In June 2019 it was announced that the M4 relief road scheme near Newport would not proceed. The scheme, previously classified as "more than likely/near certain" and included at PCF stage 2, has been removed from the Transport Supply Uncertainty Log and from the scheme traffic modelling for PCF stage 3.

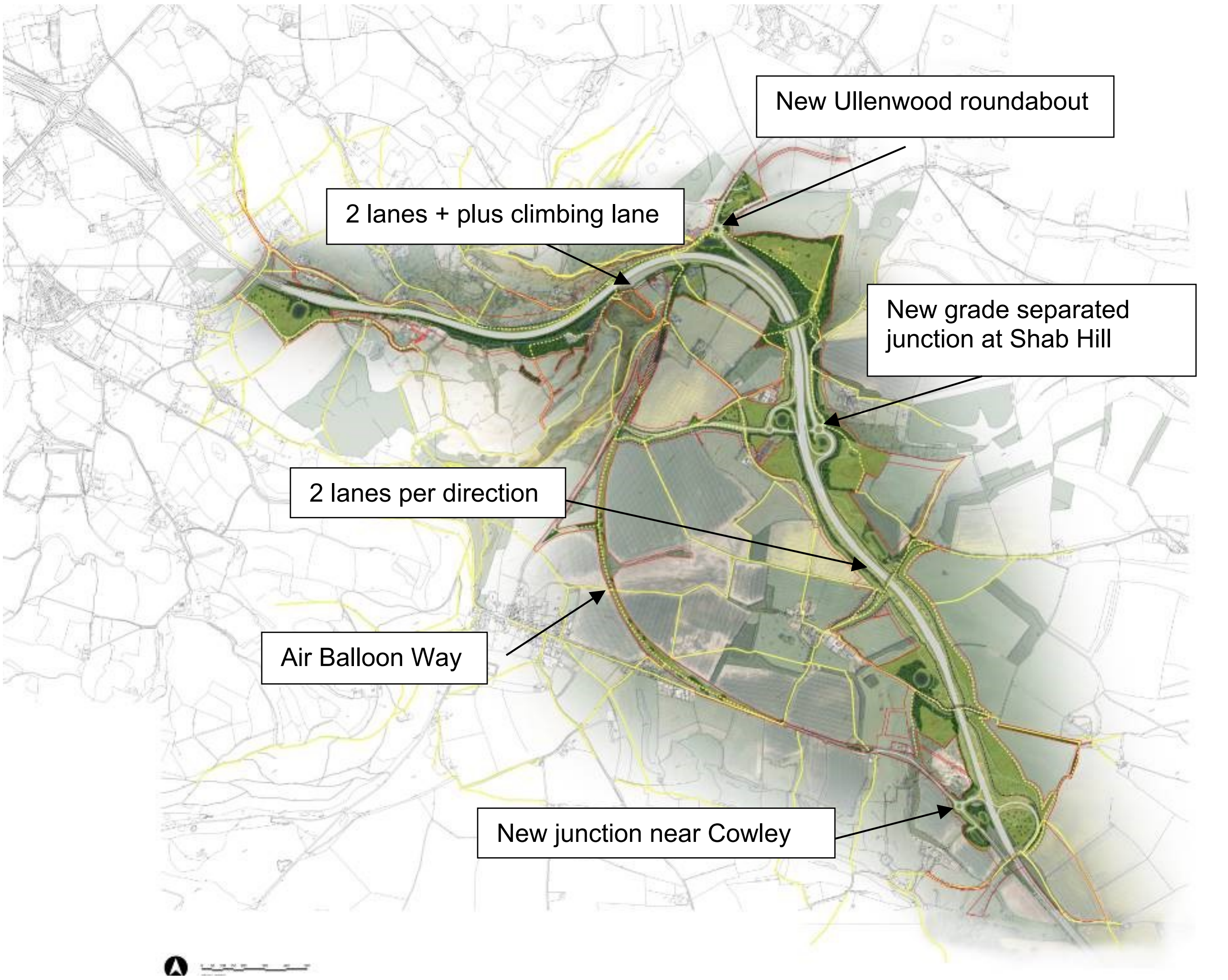
Do-Something networks

10.3.19 The DS network is based on the DM network, but also includes the scheme. As stated previously, at the current PCF stage 3, a single scheme is under consideration.

10.3.20 The route alignment and other elements of the scheme is shown in Figure 10-3. Only those aspects in relation to the highway alignment are coded into the scheme traffic model. This includes the following:

- two lanes per direction with clmibing lane for westbound traffic up Crickley Hill
- new grade separated junction at Shab Hill
- new roundabout at Ullenwood
- new roundabout near Cowley
- closure of Cowley Wood Lane to motorised vehicles

10.3.21 The plan shows the route alignment for the A417, the repurposed A417 (Air Balloon Way between the Stockwell junction and the Cotswold Way crossing the new Cotswold Way and Gloucestershire Way crossings and existing and proposed walking cycling and horse-riding routes.



Source: Highways England

Figure 10-3 Scheme alignment

10.3.22 The scheme is a surface route that provides a new dual carriageway alignment for the scheme between Crickley Hill and the existing route south of Cowley roundabout. It consists of a new dual carriageway alignment constructed to the east of the existing A417 route between the Air Balloon and Cowley roundabouts. A new grade separated junction with dumbbell roundabout arrangement, together with a new single carriageway link road, would be constructed to provide access between the new and existing A417 routes. The existing A436/Leckhampton Hill priority junction would be moved a short distance to the west to directly join the new Ullenwood roundabout.

10.3.23 To code the DS scheme into the forecast networks, the CAD drawings of the scheme were obtained and imported into GIS software. Once in the GIS software, the scheme nodes and links were drawn in GIS format, which provides a geospatially accurate representation of the schemes.

10.3.24 The networks produced in GIS were used to inform the coding of link distances and node coordinates in the SATURN networks.

10.3.25 The capacity parameters of scheme junctions have been coded based on proposed geometries and using ARCADY-based parameters. Scheme links have been assigned one of the speed-flow curves used in the SWRTM and scheme models based on the road type and speed limit/design speed.

10.3.26 The 8% gradient of the scheme will be modelled by applying time penalties to HGVs for those links impacted by the 8% gradient. This time penalty will capture decreases in speed and increases in journey times for HGVs as a result of the 8% gradient.

10.3.27 This approach has been agreed with Highways England's TPG. Full details of the methodology can be found in a technical note on 8% gradient modelling approach included as Appendix R of this report.

Travel costs

10.3.28 The reference travel costs from which all forecast scenarios have been pivoted are the validated 2015 base year assignments. The OP reference costs were obtained from assigning the base year OP matrix to the base year IP network.

10.3.29 Changes in travel costs in the opening and forecast years are to be expected due to increases in incomes and the value of time, changes in fuel costs and improvements in vehicle efficiency. Therefore, the cost assumptions of the validated scheme base year traffic models have been updated in the future year assignments.

10.3.30 Cost changes have been calculated for each forecast year and are applicable to both the DM and DS scenarios. These cost changes are set out in the following sections of this report.

Forecast assignment generalised cost parameters

10.3.31 The highway trip costs consist of time, distance and toll charges. The value of time and vehicle operating cost vary by journey purpose and also by forecast year to represent changes in fuel costs and income. Changes in fuel costs, vehicle efficiency and values of time have been taken from the TAG databook July 2020. These have been used to calculate the forecast year values of time and operating costs.

10.3.32 Table 10-3 identifies the highway generalised cost coefficients used for 2026, 2031, 2041 and 2051 in pence per minute (PPM) and pence per kilometre (PPK). The values for cars have additionally been adjusted to take account of the proportion of non-freight LGVs which gives slightly different values for each time period.

Table 10-3 Generalised cost parameters

Year	Purpose	AM		IP		PM	
		PPM	PPK	PPM	PPK	PPM	PPK
2026	Car Business	33.71	11.39	34.54	11.39	34.20	11.39
	Car Commuting	22.61	5.26	22.98	5.26	22.69	5.26
	Car Other	15.60	5.26	16.61	5.26	16.33	5.26
	LGV	24.43	13.53	24.43	13.53	24.43	13.53
	HGV	55.96	44.03	55.96	44.03	55.96	44.03
2031	Car Business	36.86	10.48	37.77	10.48	37.39	10.48
	Car Commuting	24.72	4.91	25.12	4.91	24.80	4.91
	Car Other	17.05	4.91	18.17	4.91	17.86	4.91
	LGV	26.71	13.32	26.71	13.32	26.71	13.32

Year	Purpose	AM		IP		PM	
	HGV	61.19	45.24	61.19	45.24	61.19	45.24
2041	Car Business	44.65	9.04	45.75	9.04	45.29	9.04
	Car Commuting	29.94	4.37	30.43	4.37	30.04	4.37
	Car Other	20.66	4.37	22.00	4.37	21.63	4.37
	LGV	32.36	12.87	32.36	12.87	32.36	12.87
	HGV	74.11	46.49	74.11	46.49	74.11	46.49
2051	Car Business	53.95	8.40	55.28	8.40	54.73	8.40
	Car Commuting	36.18	4.06	36.77	4.06	36.31	4.06
	Car Other	24.96	4.06	26.59	4.06	26.14	4.06
	LGV	39.10	12.49	39.10	12.49	39.10	12.49
	HGV	89.56	47.63	89.56	47.63	89.56	47.63

Source: TAG databook, July 2020

10.3.33 The PPK values for cars are expected to reduce from the opening year due to fuel efficiency improvements in cars. In addition to the assignment model generalised costs presented in Table 10-3, the generalised cost coefficients input into DIADEM are identified in Table 10-4 for cars and public transport (i.e. rail).

Table 10-4 DIADEM cost coefficients

Year	Purpose	Highway Value of time	Highway vehicle operating costs	PT Value of time
2015	Business	1,819.71	12.57	2,612.35
	Commuting	1,209.08	6.11	1,060.43
	Other	866.65	6.11	484.01
2026	Business	2,055.50	11.39	2,950.86
	Commuting	1,365.75	5.26	1,197.84
	Other	978.95	5.26	546.73
2031	Business	2,247.55	10.48	3,226.56
	Commuting	1,493.36	4.91	1,309.75
	Other	1,070.41	4.91	597.81
2041	Business	2,722.30	9.04	3,908.11
	Commuting	1,808.80	4.37	1,586.41
	Other	1,296.52	4.37	7,24.09
2051	Business	3,289.61	8.40	4,722.54
	Commuting	2,185.75	4.06	1,917.01
	Other	1,566.71	4.06	874.98

Source: TAG databook, July 2020

Toll charges

10.3.34 The toll charges on the Severn crossings have been removed in the A417 forecasts following the Government announcement that the tolls would be abolished by the end of 2018.

10.3.35 All remaining toll charges have been kept fixed in real terms (i.e. tolls would rise in line with general inflation) in accordance with the methodology adopted in the SWRTM forecasts.

Rail time and fares

10.3.36 Future year rail times and fares have been obtained from the SWRTM and re-zoned to fit the scheme traffic model. Further information on the rail inputs is available in the SWRTM MVR and forecasting report. The times and fares form an input to the VDM forecasting.

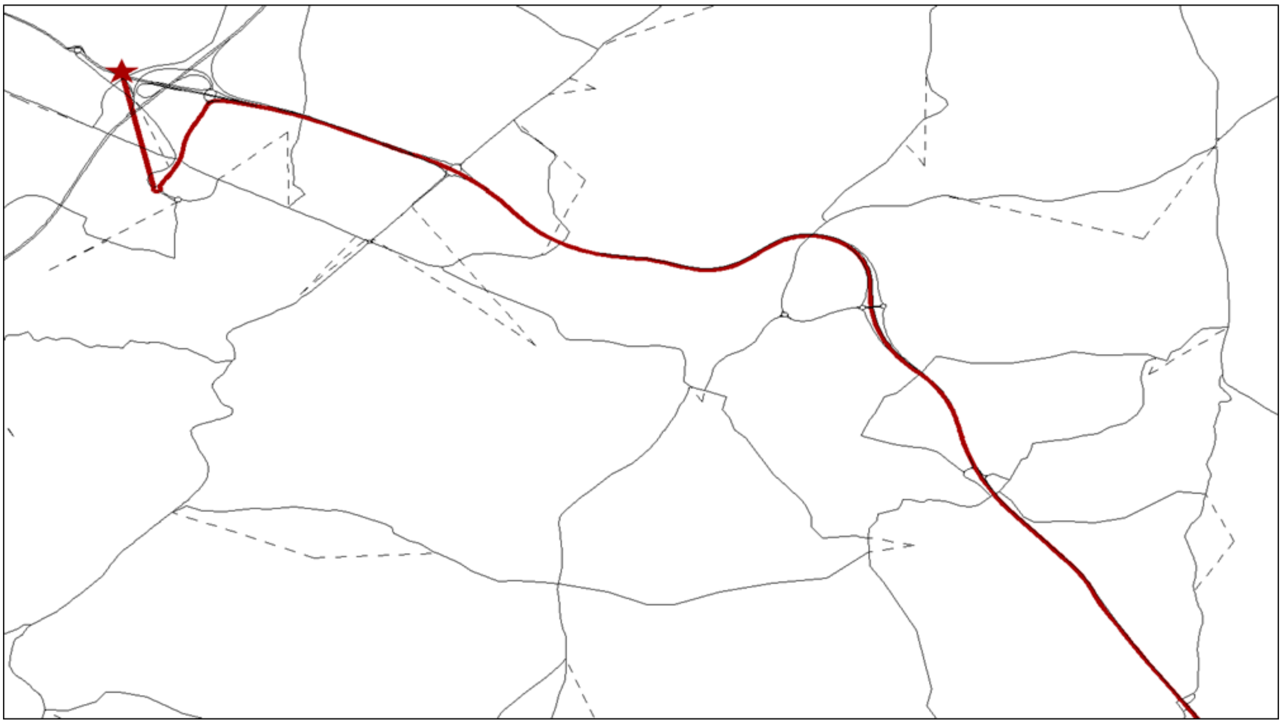
10.4 Forecast network development – calibration

Network checks

10.4.1 On completion of the preliminary forecast networks, the following reviews and checks were undertaken on the network structure during PCF stage 2:

- reviewed the completeness of the network around each scheme to ensure that the modelled and designed representations are appropriate
- reviewed modelled link lengths vs crow fly distances using SATURNs in built network checking process
- reviewed the directionality and connectivity of the proposed network changes around each scheme
- analysed traffic routeings around the DS scheme – an example of this is included in Figure 10-4, which illustrates the routeing of traffic from south of Elkstone to Churchdown Lane north of the M5 Junction 11a

10.4.2 The exercise has not been repeated during PCF stage 3.



Source: Highways England

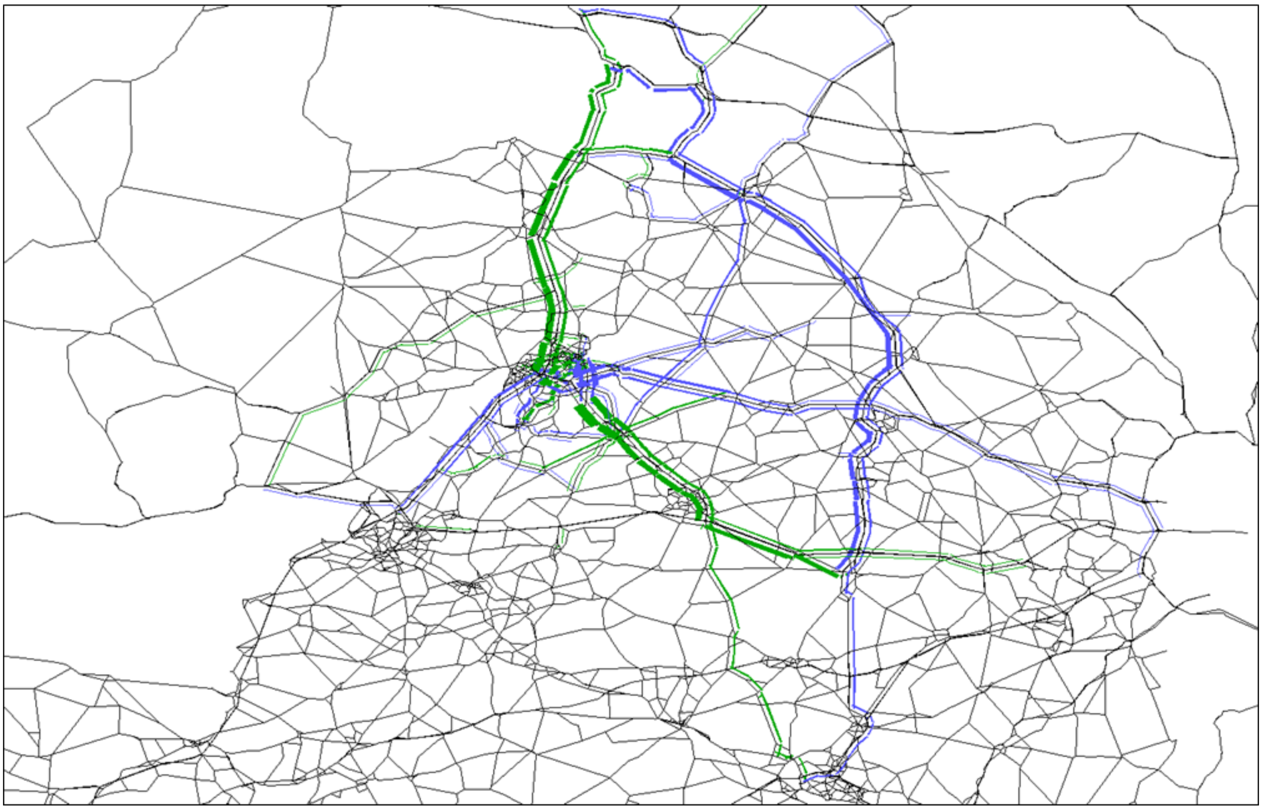
Figure 10-4 Do-Something route analysis example

Fixed demand checks

10.4.3 A further check of the coding of the scheme during PCF stage 2 involved a fixed demand assignment, whereby the base year calibrated matrices were assigned onto both the DM and DS networks. The forecast flows in the resulting DM and DS assignments were then compared.

10.4.4 An example of the differences in traffic flows between the DM and DS (in this case, the AM peak for the scheme) assignments are shown in Figure 10-5.

10.4.5 The exercise has not been repeated during PCF stage 3.



Source: Highways England

Note: Increases in flows resulting from the scheme are shown in green, with flow reductions shown in blue.

Figure 10-5 Fixed demand assignment flow difference plot example

10.4.6 The fixed demand assignments, such as the one summarised above, illustrated that changes in flows occur in expected locations, including increases in flows along the A417 and reductions on competing routes such as the M5, A34, M40 and on local rat runs. Also, unexpected changes in flows in areas remote from the scheme have not been observed. A further check of the fixed demand assignments during PCF stage 2 was undertaken by comparing network wide statistics to understand whether the impact of the scheme coding appeared in line with expectations. The total travel time, total distance and average speed from the fixed assignment scheme traffic model runs are presented in Table 10-5.

10.4.7 As the scheme is forecast to result in a reassignment of traffic from the scheme traffic model buffer area into the simulation area, the travel time and distance statistics are reported for both areas combined so that the full impact of the scheme is shown. The average network speed is reported for the simulation area only. It should be noted that the impacts compared to the DM scenario appear to be small given the scale of the units presented, which are reported across the whole scheme traffic model.

10.4.8 The exercise has not been repeated during PCF stage 3.

Table 10-5 Networkwide statistics for fixed demand assignments with base demand

	Scenario	Total travel time (pcu/hrs)	Total distance (pcu/km)	Average speed (kph)
AM	DM	953,409	76,012,324	70.1
	DS	953,286	76,013,468	70.4
IP	DM	688,703	58,759,436	73.5
	DS	688,620	58,760,105	73.8
PM	DM	906,554	73,097,667	68.1
	DS	906,420	73,098,114	68.4

Source: Highways England

10.4.9 The networkwide statistics from the fixed demand assignments are as expected, with the scheme forecast to reduce travel time compared to the DM scenario (albeit to a small degree).

10.4.10 Total travel distance is forecast to increase compared to the DM. This reflects the layout of the scheme and particularly the increased distance that traffic travelling between the A417 and the A436 is required to take.

10.4.11 The average network speed is shown to increase compared to the DM scenario in all periods, which is as expected and reflects the removal of delays on the existing single carriageway section of the A417.

Preliminary forecast demand checks

10.4.12 In addition, preliminary scheme traffic model runs using forecast future year demand were undertaken for PCF stage 3 and the assignments were checked to ensure each scheme traffic model scenario converged appropriately and that traffic flows around the A417 appeared sensible. In the same manner as the fixed demand assignments described above these checks have shown expected changes, including increases in flows along the A417 and reductions on competing routes such as the M4/M5, A34, M40 and on local rat runs.

10.5 Forecast matrix development – core scenario

Overview

10.5.1 This section summarises the approach adopted to produce demand for use in the PCF stage 3 core scenario forecasts. Traffic generated by proposed specific developments has been included in the forecast demand, which has been constrained to forecast National Trip End Model (NTEM) levels of growth at balancing area level. Forecast demand has been derived for all future years identified in section 10.1 of this report.

10.5.2 Section 10.6 of this report discusses the derivation of forecast demand for use in the high and low growth sensitivity scenarios.

Development uncertainty log

10.5.3 An uncertainty log has been developed which identifies potential major developments within the study area of the scheme traffic model and categorises them according to their likelihood in accordance with DfT TAG unit M4 'Forecasting and Uncertainty'.

10.5.4 The A417 PCF stage 1 uncertainty log was originally developed from the wider SWRTM, with proposed new developments within the local planning authorities of Cheltenham, Cotswolds, City of Gloucester, Stroud and Tewkesbury included.

10.5.5 This uncertainty log was updated for use in PCF stage 2 following liaison with GCC and using information originated from the above local planning authorities.

10.5.6 As agreed with Highways England's TPG, the Development Uncertainty Log for PCF stage 2 opening year 2024 and design year 2039 have been used to represent PCF stage 3 opening year 2026 and design year 2041 respectively in terms of the developments included. Demand for the developments included has then been created for opening year 2026 and design year 2041 in the HEIDI process outlined in section 10.2 of this report. The Development Uncertainty Log is contained in Appendix G of this report.

10.5.7 The development quantum, in terms of numbers of dwellings and jobs, was provided by the local authorities or from planning documents. Housing sites of fewer than around 20 homes have generally been excluded, unless they form a cluster with other sites which collectively total more than 20 dwellings. Where job numbers are not available, an estimated value has been calculated using job density assumptions used in the RTM forecasting and set out in Table 10-6.

Table 10-6 Job density assumptions

Land Use	Jobs per 100m² of Gross Floor Area (NIA – Net Internal Area)
B1 – General offices	10.07
B2 – Industrial and manufacturing	3.03
B8 – Storage and distribution	1.45

Source: Highways England RTM Guidance

10.5.8 The phasing for each development has been taken from information provided within planning application documentation, or in the absence of this has been assumed based on the type and scale of the development.

10.5.9 The level of certainty for each development has been assigned taking advice from GCC and in accordance with the definitions of uncertainty contained in TAG unit M4, which are reproduced in Table 10-7.

Table 10-7 Development certainty classification

Probability	Status
Near certain: The outcome would happen or there is a high probability that it would happen	Intent announced by proponent of regulatory agencies. Approved development proposals. Projects under construction.
More than likely: The outcome is likely to happen but there is some uncertainty	Submission of planning or consent application imminent. Development application within the consent process.

Probability	Status
Reasonably foreseeable: The outcome may happen, but there is significant uncertainty	Identified within a development plan. Not directly associated with the transport strategy/scheme but may occur if the strategy/scheme is implemented. Development conditional upon the transport strategy/scheme proceeding. Or, a committed policy goal, subject to tests (e.g. of deliverability) whose outcomes are subject to significant uncertainty.
Hypothetical: There is considerable uncertainty whether the outcome would ever happen	Conjecture based upon currently available information. Discussed on a conceptual basis. One of a number of possible inputs in an initial consultation process. Or, a policy aspiration.

Source: TAG unit M4

10.5.10 A total of 85 developments have been identified as being either 'Near certain' or 'More than likely' and, in accordance with TAG guidance, these are considered in more detail within the forecasts. The developments are summarised in Table 10-8 and shown in Figure 10-6, with the site IDs being consistent between the table and the figure. The quantum of developments shown in the table only include dwellings and jobs estimated to be delivered after March 2015 (the month that the scheme base year traffic model is representative of).

Table 10-8 Developments included in forecast matrices

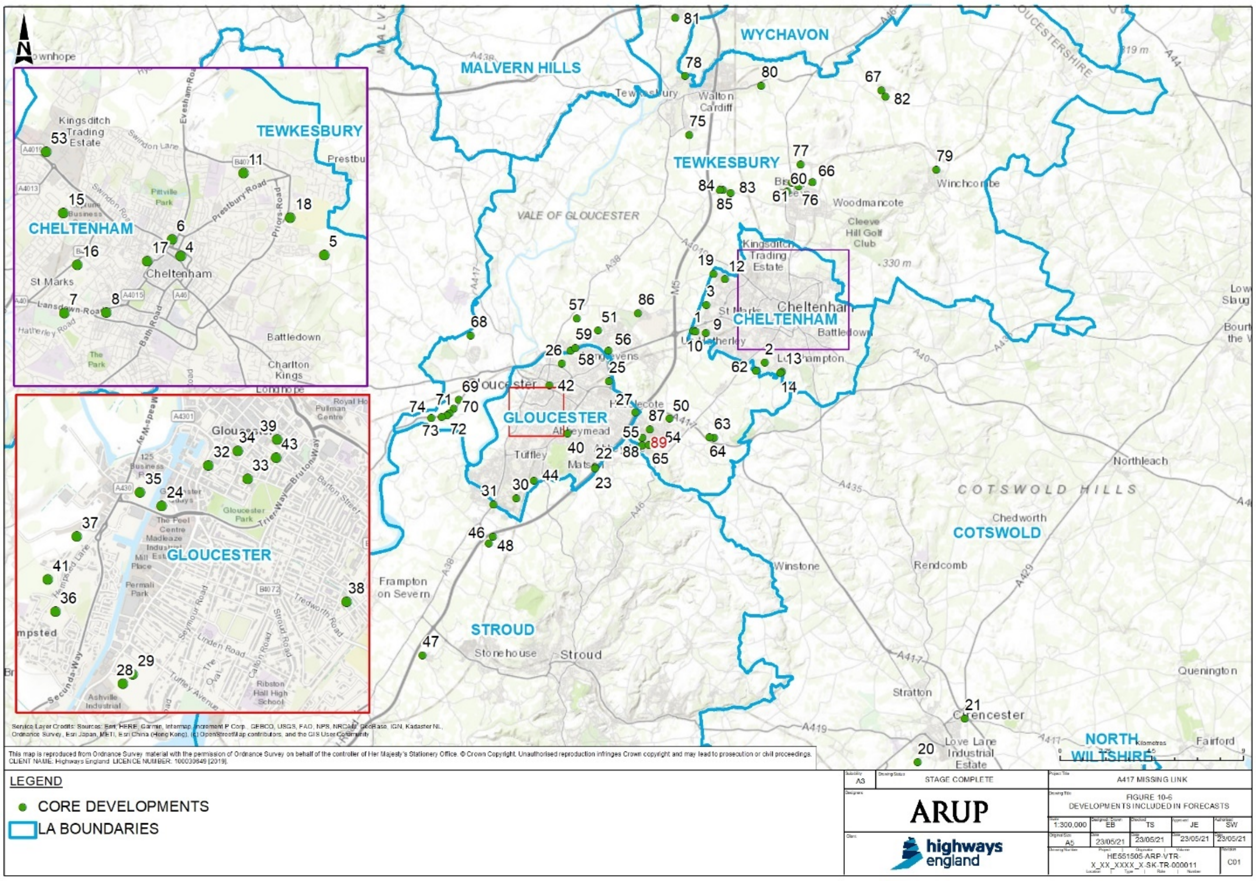
ID	Site name	Authority	Dwellings	Jobs
1	Land at North Road West and Grovefield Way Cheltenham Gloucestershire	Cheltenham	0	1,018
2	Land off Kidnappers Lane Cheltenham Gloucestershire	Cheltenham	45	0
3	Cheltenham Cyber Park	Cheltenham	1,200	7,000
4	Haines and Strange Albion Street Cheltenham Gloucestershire GL52 2RH	Cheltenham	50	0
5	GCHQ Oakley Priors Road Cheltenham Gloucestershire GL52 5AJ	Cheltenham	211	0
6	Car Park North Place Cheltenham Gloucestershire GL50 4DW	Cheltenham	143	0
7	Central Cheltenham Police Station Talbot House Lansdown Road Cheltenham Gloucestershire GL51 6QT	Cheltenham	67	0
8	Cotswold Court Lansdown Road Cheltenham Gloucestershire GL50 2JA	Cheltenham	53	0
9	Land to rear Of Nuffield Hospital Hatherley Lane Cheltenham Gloucestershire	Cheltenham	27	201
11	Land at Starvehall Farm New Barn Lane Cheltenham Gloucestershire	Cheltenham	300	0
12	Springbank Way Shopping Centre Springbank Way Cheltenham Gloucestershire	Cheltenham	34	0
13	Leckhampton Industrial Estate Leckhampton Road Cheltenham Gloucestershire GL53 0AL	Cheltenham	28	0
14	Land south of 205 Leckhampton Road Leckhampton Road Cheltenham Gloucestershire	Cheltenham	10	0

ID	Site name	Authority	Dwellings	Jobs
15	Christ College Arle Road Cheltenham Gloucestershire GL51 8LE	Cheltenham	90	0
16	Travis Perkins Gloucester Road Cheltenham Gloucestershire GL51 0SX	Cheltenham	107	0
17	John Dower House 24 Crescent Place Cheltenham Gloucestershire GL50 3RA	Cheltenham	68	0
18	Premier Products Ltd Bouncers Lane Cheltenham Gloucestershire GL52 5JD	Cheltenham	58	0
19	Phase 1 Land at Old Gloucester Road Cheltenham Gloucestershire	Cheltenham	90	0
20	Land south of Chesterton Cirencester/'Cirencester Urban Extension'	Cotswold	2,350	500
21	Kingshill Development London Road Cirencester Gloucestershire	Cotswold	100	503
22	Land south of Winnycroft Farm Corncroft Lane Gloucester GL4 6BX	Gloucester	420	0
23	Land at Winnycroft Farm Corncroft Lane Gloucester GL4 6BX	Gloucester	250	0
24	Land at Bakers Quay Llanthony Wharf and Monkmeadow Bounded by Southgate Street Llanthony St Ann Way Gloucester	Gloucester	162	0
25	Land at Barnwood Link Road Gloucester	Gloucester	0	1,031
26	Former Gloucester Academy Estcourt Close Gloucester GL1 3LR	Gloucester	90	0
27	Hucclecote Centre Churchdown Lane Gloucester GL3 3QN	Gloucester	53	0
28	Former Contract Chemicals Site Bristol Road Gloucester GL2 5BX	Gloucester	86	403
29	Former Wellman Graham St Gobain Industrial Sites Bristol Road Gloucester GL2 5BX	Gloucester	231	0
30	Land to east west of A38 And Naas Lane Quedgeley Gloucester GL2 5ZZ	Gloucester	250	0
31	Mayos Land Bristol Road Quedgeley Gloucester	Gloucester	48	0
32	Albion House 77 Southgate Street Gloucester GL1 1UB	Gloucester	22	0
33	Fitzalan House Park Road Gloucester GL1 1LZ	Gloucester	35	0
34	Former Gloscat Buildings Brunswick Road Gloucester	Gloucester	200	0
35	Land at Bakers Quay Llanthony Wharf and Monkmeadow Bounded by Southgate Street Llanthony St Ann Way Gloucester	Gloucester	340	0
36	Land east of Hempsted Lane Hempsted Lane Gloucester	Gloucester	50	0
37	Old Hempsted Fuel Depot Hempsted Lane Gloucester	Gloucester	85	0
38	Norville Optical Co Ltd Paul Street Gloucester GL1 4NY	Gloucester	63	0
39	Beatrice Webb House 75 - 81 Eastgate Street Gloucester GL1 1PN	Gloucester	27	0
40	St Aldate Church Finlay Road Gloucester GL4 6TN	Gloucester	23	0
41	Land Adj Newark Farm Hempsted Lane Gloucester GL2 5JS	Gloucester	44	0
42	Former Kwik Save 103 Northgate Street Gloucester	Gloucester	95	0

ID	Site name	Authority	Dwellings	Jobs
43	Former 1 - 3 Wellington Street Gloucester	Gloucester	22	0
44	Land South of Grange Road Gloucester	Gloucester	250	0
46	Gateway 12 Davy Way, Hardwicke, Gloucester, Gloucestershire	Stroud	0	467
47	Land north of Alkerton Road Alkerton, Eastington, Gloucestershire	Stroud	36	0
48	Land at Quedgeley Trading Estate East Haresfield Stonehouse	Stroud	0	2,149
50	Land at Perrybrook, Brockworth	Tewkesbury	1,500	540
51	Innsworth	Tewkesbury	1,300	750
53	Elms Park	Tewkesbury	4,285	4,027
54	Land to the rear of Invista Green Street Brockworth GL3 4LS	Tewkesbury	200	200
55	Nerva Meadows Plots 3200, 7400, 7520 Gloucester Business Park Brockworth	Tewkesbury	106	0
56	Parcel 3745 Cheltenham Road East Churchdown Gloucester Gloucestershire	Tewkesbury	465	0
57	Land at Tewkesbury Road Twigworth	Tewkesbury	725	0
58	Land to east of Tewkesbury Road and North of Longford Lane Longford Gloucester Gloucestershire	Tewkesbury	107	0
59	Land to east of Tewkesbury Road and North of Longford Lane Longford Gloucester Gloucestershire	Tewkesbury	197	0
60	Cleevelands Evesham Road Bishops Cleeve	Tewkesbury	550	250
61	Land to the west of Evesham Road (North Cleevelands) Evesham Road Gotherington	Tewkesbury	500	0
62	Land to the west of Farm Lane Shurdington	Tewkesbury	377	0
63	Bentham Works Bentham Lane Bentham GL51 4UT	Tewkesbury	49	0
64	Bentham Country Club Bentham Lane Bentham Cheltenham Gloucestershire GL3 4UD	Tewkesbury	39	0
65	Plot 6200 Gloucester Business Park Brockworth Gloucester Gloucestershire	Tewkesbury	0	293
66	Homelands Farm Gotherington Lane Bishops Cleeve GL52 8EN	Tewkesbury	450	50
67	Land at Beckford Road Alderton	Tewkesbury	47	0
68	Land to the west of Lassington Lane Highnam Gloucester Gloucestershire	Tewkesbury	88	0
69	Land at Hector Farm Hygrove Lane Minsterworth Gloucester Gloucestershire	Tewkesbury	9	0
70	Apple Tree Inn Main Road Minsterworth Gloucestershire GL2 8JQ	Tewkesbury	9	0
71	Pound Cottage Main Road Minsterworth Gloucestershire GL2 8JH	Tewkesbury	7	0
72	Part Parcel 3947 Main Road Minsterworth Gloucestershire	Tewkesbury	4	0
73	Part Parcel 1228 Main Road Minsterworth	Tewkesbury	6	0
74	Land adjacent to Minsterworth Village Hall Main Road Minsterworth	Tewkesbury	14	0

ID	Site name	Authority	Dwellings	Jobs
75	Part Parcel 3400 Columbine Road Walton Cardiff Tewkesbury Gloucestershire	Tewkesbury	261	0
76	Adjacent 74 Evesham Road Bishops Cleeve Cheltenham Gloucestershire	Tewkesbury	71	0
77	Parcel 7561 Malleson Road Gotherington Cheltenham Gloucestershire	Tewkesbury	50	0
78	Part Parcel 0085 Land West of Bredon Road Bredon Road Tewkesbury Gloucestershire	Tewkesbury	68	0
79	Parcel 3441 And 3629 Land Between Greet Road and Gretton Road Winchcombe	Tewkesbury	85	0
80	Land Parcels 4331 4619 And 5837 Pamington Lane Pamington Tewkesbury Gloucestershire	Tewkesbury	150	0
81	Land adjacent Cornerways High Street Twyning	Tewkesbury	58	0
82	Land east of Willow Bank Road Alderton Tewkesbury GL20 8NJ	Tewkesbury	24	0
83	Parcel 2521 & 3722 Banady Lane Stoke Orchard	Tewkesbury	45	0
84	Coal Research Establishment (CRE) Stoke Road Stoke Orchard Cheltenham Gloucestershire	Tewkesbury	38	0
85	Coal Research Establishment (CRE) Stoke Road Stoke Orchard Cheltenham Gloucestershire	Tewkesbury	100	0
86	Land on the east side of Cheltenham Road East Churchdown Gloucester Gloucestershire	Tewkesbury	0	300
87	Plot 5030 Gloucester Business Park Brockworth	Tewkesbury	27	0
88	Gloucester Business Park Brockworth Gloucester Gloucestershire	Tewkesbury	1,000	0
89	Gloucester Business Park Brockworth Gloucester Gloucestershire	Tewkesbury	0	5,882

Source: Highways England



Source: Highways England

Figure 10-6 Developments included in forecast matrices

Development trip generation

10.5.11 Trip end totals for each development were estimated using car driver trip rates (rates per dwelling and rates per job) derived from NTEM version 7.2 at local authority level. This enabled 24-hour production/attraction (PA) and origin/destination (OD) trips by period to be calculated for each development based on the quantum of development. This is consistent with an approach devised by the RTM Forecasting Consistency Group (FCG) which was implemented in regional model forecasts and also in A417 forecasting in previous PCF stages.

10.5.12 Table 10-9 identifies the 24-hour production (P) and attraction (A) trip rates per residential dwelling for the home-based demand segments. There is an implied assumption in the adopted approach that the residential end of HBEB and HBW trips does not act as an attraction and therefore these cells are zero/blank in the following table.

Table 10-9 2015 NTEM car driver trip rates per dwelling

Demand Segment	Cheltenham		Cotswold		Gloucester		Stroud		Tewkesbury	
HB	P	A	P	A	P	A	P	A	P	A
HBEB 24hr	0.057	-	0.075	-	0.059	-	0.072	-	0.070	-
HBW 24hr	0.434	-	0.441	-	0.453	-	0.461	-	0.457	-
HBO 24hr	0.644	0.099	0.768	0.105	0.667	0.101	0.758	0.106	0.737	0.105

Source: NTEM version 7.2

10.5.13 Table 10-10 presents the trip rates per job for the home-based and non-home-based segments. The trip rates presented in the table are for the full period in question (i.e. 24 hours for home-based trips and period total for non-home-based trips).

Table 10-10 2015 NTEM car driver trip rates per dwelling

Demand Segment	Cheltenham		Cotswold		Gloucester		Stroud		Tewkesbury	
HB	P	A	P	A	P	A	P	A	P	A
HBEB 24hr	-	0.044	-	0.054	-	0.051	-	0.057	-	0.054
HBW 24hr	-	0.298	-	0.362	-	0.337	-	0.366	-	0.369
HBO 24hr	-	0.460	-	0.612	-	0.503	-	0.485	-	0.355
NHB	O	D	O	D	O	D	O	D	O	D
NHBEB AM	0.011	0.010	0.013	0.013	0.012	0.012	0.013	0.014	0.013	0.013
NHBEB IP	0.036	0.035	0.046	0.044	0.040	0.041	0.045	0.047	0.042	0.043
NHBEB PM	0.011	0.010	0.013	0.013	0.013	0.012	0.013	0.014	0.012	0.013
NHBO AM	0.040	0.037	0.048	0.047	0.042	0.042	0.042	0.044	0.036	0.038
NHBO IP	0.099	0.105	0.143	0.142	0.109	0.119	0.113	0.114	0.097	0.087
NHBO PM	0.039	0.040	0.058	0.059	0.041	0.044	0.043	0.045	0.036	0.032

Source: NTEM version 7.2

10.5.14 As stated above, the trip rates were applied to each development to estimate total trip ends associated with each proposed development.

10.5.15 Each development was allocated an existing scheme traffic model zone, based on its location and proposed access points. Where appropriate, larger developments were allocated into multiple zones to provide more realistic trip loading patterns.

Development trip distribution

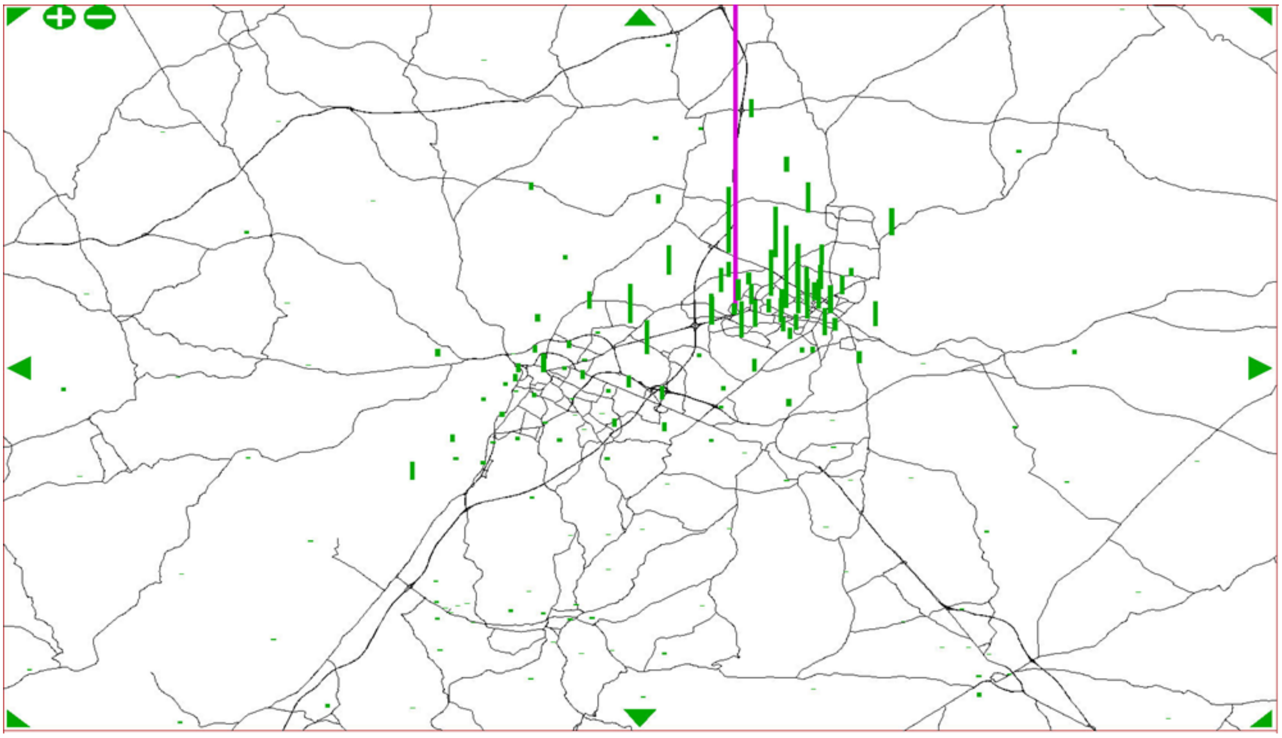
10.5.16 The development trip ends have been distributed using the Highways England Donor Distribution Tool (HEDDiT), which was developed for Highways England for use in the regional traffic models.

10.5.17 HEDDiT applies a distribution to the development trip ends based on existing distributions of selected ‘donor’ zones. The donor zones are typically local to the development and with similar land uses. The output from HEDDiT is a matrix of development trips, which are input into the scheme forecast traffic model runs. Further details on the HEDDiT software are provided in the HEDDiT User Guide document.

10.5.18 Checks of the output development matrices during PCF stage 2 showed that the input trip ends reconcile well with the output matrices, which confirms that HEDDiT has distributed all development trips.

10.5.19 In addition, trips associated with a selection of developments were analysed in SATURN during PCF stage 2 and indicated that the distribution patterns appeared sensible. An example is provided in Figure 10-7, which illustrates the origin/home locations of car commute trips to the proposed employment development at Cyber Park, Cheltenham.

10.5.20 The exercise has not been repeated during PCF stage 3.



Source: Highways England
Note: Origin/home locations are shown as green bars, while the destination/work location is shown with a magenta bar.

Figure 10-7 Home location of commute trips to Cyber Park

10.5.21 Additional examples of development distributions are included in Appendix H of this report.

National Trip End Model

10.5.22 Forecast trip ends from version 7.2 of the National Trip End Model (NTEM) were used to derive trip end growth factors at scheme traffic model zone level, via an NTEM to scheme traffic model zone correspondence list.

10.5.23 The growth factors have been derived as origin and destination factors (or production and attraction factors for home-based trips) for each of the demand segments required for input into the variable demand model.

10.5.24 The growth factors have been derived for car vehicle trips and rail trips separately and from the 2015 base years to each of the forecast years. The factors relate to car available trips only and are derived and applied at scheme traffic model zone level.

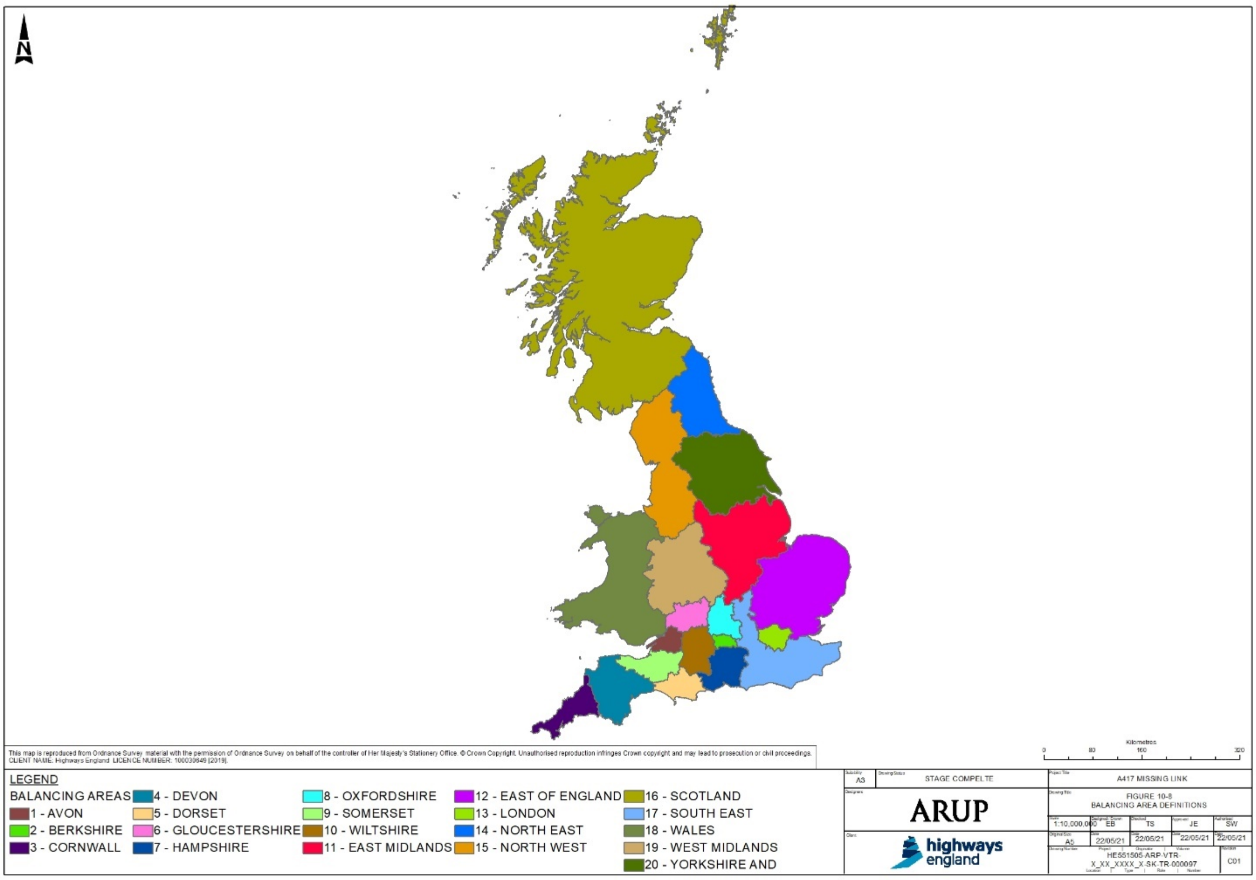
10.5.25 As stated previously, total growth has been constrained to NTEM at balancing area level. In total there are 20 balancing areas, which consist of counties within the SWRTM RoF and regions outside of this area, as summarised in Table 10-11 and Figure 10-8.

Table 10-11 Balancing area definition

Balancing area ID	Balancing area
1	Avon
2	Berkshire
3	Cornwall

Balancing area ID	Balancing area
4	Devon
5	Dorset
6	Gloucestershire
7	Hampshire
8	Oxfordshire
9	Somerset
10	Wiltshire
11	East Midlands
12	East of England
13	London
14	North-east
15	North-west
16	Scotland
17	South-east
18	Wales
19	West Midlands
20	Yorkshire and Humber

Source: Highways England



Source: Highways England

Figure 10-8 Balancing area definitions

National transport model

10.5.26 Trip end growth factors for LGVs and HGVs have been derived using RTF18 data (scenario 1), which is based on output from the DfT's National Transport Model. Unlike NTEM, which has a final forecast year of 2051, the RTF18 data only extends to 2050, so for the 2051 forecast year the growth has been extrapolated from the forecast 2045 to 2050 growth rates.

10.5.27 Table 10-12 shows the RTF18 growth factors at regional level for LGVs and HGVs. In the absence of RTF18 forecasts for Scotland, growth factors for the north-east region have been adopted as a proxy for Scotland.

Table 10-12 RTF18 LGV and HGV growth rates

	LGV				HGV			
Region	**2026**	**2031**	**2041**	**2051**	**2026**	**2031**	**2041**	**2051**
East Midlands	1.18	1.24	1.41	1.54	0.99	0.99	1.02	1.05
Eastern England	1.16	1.23	1.39	1.51	1.04	1.06	1.12	1.19
London	1.21	1.28	1.45	1.58	0.98	1.00	1.01	1.04
North-east	1.18	1.25	1.42	1.54	0.98	0.98	1.00	1.02
North-west	1.16	1.23	1.39	1.51	0.99	0.99	1.02	1.05
South-east	1.17	1.24	1.41	1.54	1.04	1.06	1.13	1.20
South-west	1.15	1.22	1.38	1.50	0.99	0.99	1.00	1.02
West Midlands	1.19	1.26	1.44	1.56	0.99	1.00	1.03	1.07
Yorks & Humber	1.17	1.24	1.41	1.53	0.99	1.00	1.03	1.07
Wales	1.17	1.23	1.40	1.53	0.99	0.99	1.02	1.04
Scotland*	1.18	1.25	1.42	1.54	0.98	0.98	1.00	1.02

Source: Regional Traffic Forecasts, 2018 (scenario 1)

* RTF18 only includes England and Wales and therefore factors for Scotland have been copied from the North East region as a proxy

Airport and ports growth

10.5.28 Future year forecast airport passenger trip matrices for car trips were produced using the same methodology used to create the base year matrices for the SWRTM, which was also adopted during PCF stage 1 and stage 2 forecasting. This utilises DfT National Air Passenger Allocation Model (NAPALM) data, which forecasts (for 2021, 2031 and 2041) the total annual air passenger trips between 455 zones and each of the four airports explicitly included within the SWRTM (Bournemouth Airport, Bristol Airport, Exeter Airport and Southampton Airport). In accordance with the methodology adopted for the RTMs, air passenger demand for 2051 was derived using DfT UK Aviation Forecasts of non-transfer air passenger growth between 2040-2050[6]. Further detail on the derivation of airport passenger trip matrices is set out in the SWRTM MVR. The future year airport passenger trips are added to the forecast demand after the application of general growth rates discussed above.

10.5.29 Forecast traffic growth at the three seaports explicitly included in the SWRTM (Bristol/Avonmouth, Portsmouth and Southampton) has been provided from the RTM Forecasting Consistency Group. This includes an assumption of zero growth

[3] UK Aviation Forecasts, DfT, August 2011

in car trips at all ports. In addition, growth in HGV trips of 1.02%, 2.23% and 2.48% per annum were assumed for Bristol, Portsmouth and Southampton respectively. An England-wide growth factor, derived from RTF18 data, for LGV traffic at the seaports was also assumed as per the RTM forecasts.

10.6 Forecast matrix development – high and low growth

10.6.1 As per TAG unit M4, uncertainty around the core scenario was tested using low and high growth sensitivity tests. These scenarios are intended to test the impact on the proposed scheme of high and low background traffic growth.

10.6.2 High and low growth reference case matrices (i.e. pre-VDM matrices) were derived by adding (or subtracting in the case of low growth) a proportion of base demand onto the future year core scenario highway and PT reference matrices. The proportion of base demand to be added/subtracted was calculated using the following:

- 2.5% x SQRT (forecast year – base year).

10.6.3 For example, the high growth scenario for 2031 has 10% of the base demand added to the future year core scenario reference matrices (2.5% x SQRT(2031-2015)).

10.6.4 Results of the economic appraisals using high and low growth demand are presented and discussed in section 15.2 of this report.

10.7 Derivation of flows/speeds for other appraisals

10.7.1 The scheme base traffic model produces traffic outputs for an average March weekday base in 2015. For the purpose of scheme appraisal, including air quality and noise assessments, the traffic forecasts are required for a range of bases, including:

- annual average daily traffic (AADT) – 24-hour daily traffic flow average for a whole 365 days in a year
- 24-hour annual average weekday traffic (AAWT) – 24-hour daily traffic flow average for all weekdays in a year
- 18-hour AAWT (06:00-00:00)
- 12-hour AAWT daytime (07:00-19:00)
- 8-hour AAWT night-time (23:00-07:00)
- 4-hour AAWT evening (19:00-23:00)

10.7.2 The 24-hour March weekday traffic flows can be compiled by adding the period total traffic flows from each time period (AM x 3 + IP x 6 + PM x 3 + OP x 12).

10.7.3 Factors with which to convert 24-hour March weekday flows to the various bases have been derived from a selection of A417 count sites provided by Highways England's DBFO contractor for the A417 route, RMS Limited. These factors, which are applied to the derived 24-hour March weekday modelled traffic flows, are identified in Table 10-13.

Table 10-13 24-hour March weekday conversion factors

Base	Factor
AADT 24-hour	0.930
AAWT 24-hour	1.000

Base	Factor
AAWT 18-hour (06:00-00:00)	0.961
AAWT 12-hour (07:00-19:00) – daytime	0.807
AAWT 8-hour (23:00-07:00) – night-time	0.097
AAWT 4-hour (19:00-23:00) – evening	0.096

Source: Highways England

10.7.4 Traffic speed information is also required for the purposes of environmental appraisal. Speed data has been compiled in accordance with LA 105 Air Quality, which provides methodologies to adjust modelled link speeds to better reflect observed speeds (known as speed pivoting) and to present speeds in banded categories or ranges (known as speed banding).

11 Forecast results

11.1 Introduction

11.1.1 This section summarises the outputs of the scheme traffic model forecasts for PCF stage 3, including an overview of the forecast impacts on traffic flows and journey times arising from the scheme. Variable demand and assignment model convergence statistics are also presented, as is a summary of the variable demand impact forecast to arise from the scheme.

11.2 Scheme traffic model convergence statistics

Demand supply convergence

11.2.1 The VDM convergence statistics for each forecast year are shown in Table 11-1. All scenarios converged after eight DIADEM loops after achieving a full model GAP lower than 0.1% and a sub area GAP lower than 0.2%.

Table 11-1 VDM convergence statistics

Year	Scenario	Full model GAP %	Sub-area GAP %	Cost (% <5%)	Flow (% <5%)	Number of loops
2026	DM	0.05%	0.12%	100.00%	100.00%	8
	DS	0.05%	0.12%	100.00%	100.00%	8
2031	DM	0.06%	0.12%	100.00%	100.00%	8
	DS	0.06%	0.12%	100.00%	100.00%	8
2041	DM	0.08%	0.12%	100.00%	100.00%	8
	DS	0.08%	0.12%	100.00%	100.00%	8
2051	DM	0.09%	0.12%	100.00%	100.00%	8
	DS	0.09%	0.12%	100.00%	100.00%	8

Source: Highways England

Post-VDM assignment scheme traffic model convergence

11.2.2 The post VDM SATURN assignment scheme traffic model convergence statistics for the core forecast scenarios are presented in Table 11-2 and Table 11-3.

Table 11-2 Assignment convergence statistics – Do-Minimum

Year	AM Peak				IP				PM Peak			
	% Gap	% Flow	% Cost	Iter.	% Gap	% Flow	% Cost	Iter.	% Gap	% Flow	% Cost	Iter.
2026	0.0002 1	99.6	99.6	42	0.0000 9	99.8	99.9	17	0.0003 7	99.6	99.4	100
2031	0.0002 9	99.8	99.5	55	0.0001 3	99.7	99.8	17	0.0006 1	99.5	99.3	64
2041	0.0003 9	99.7	99.4	39	0.0002 9	99.7	99.7	18	0.0005 6	99.7	99.1	55
2051	0.0005	99.6	99.2	47	0.0002 3	99.8	99.6	25	0.0005 1	99.7	98.8	41

Source: Highways England

Table 11-3 Assignment convergence statistics – Do-Something

Year	AM Peak				IP				PM Peak			
	% Gap	% Flow	% Cost	Iter.	% Gap	% Flow	% Cost	Iter.	% Gap	% Flow	% Cost	Iter.
2026	0.00015	99.6	99.6	71	0.00008	99.8	99.9	18	0.00077	99.6	99.5	83
2031	0.00017	99.7	99.4	50	0.00015	99.7	99.9	17	0.00037	99.6	99.4	66
2041	0.00034	99.8	99.5	45	0.00019	99.8	99.8	20	0.0021	99.7	98.9	100
2051	0.00036	99.8	99.5	45	0.00026	99.8	99.7	26	0.0015	99.7	99.1	89

Source: Highways England

11.2.3 All scheme forecast traffic model assignments satisfy the convergence criteria set out in TAG unit M3.1 (see Table 7-4).

11.2.4 The assignment model convergence 'gap' is below the recommended TAG value of 0.1% by a substantial margin (values lower than this target mean that the model has better convergence).

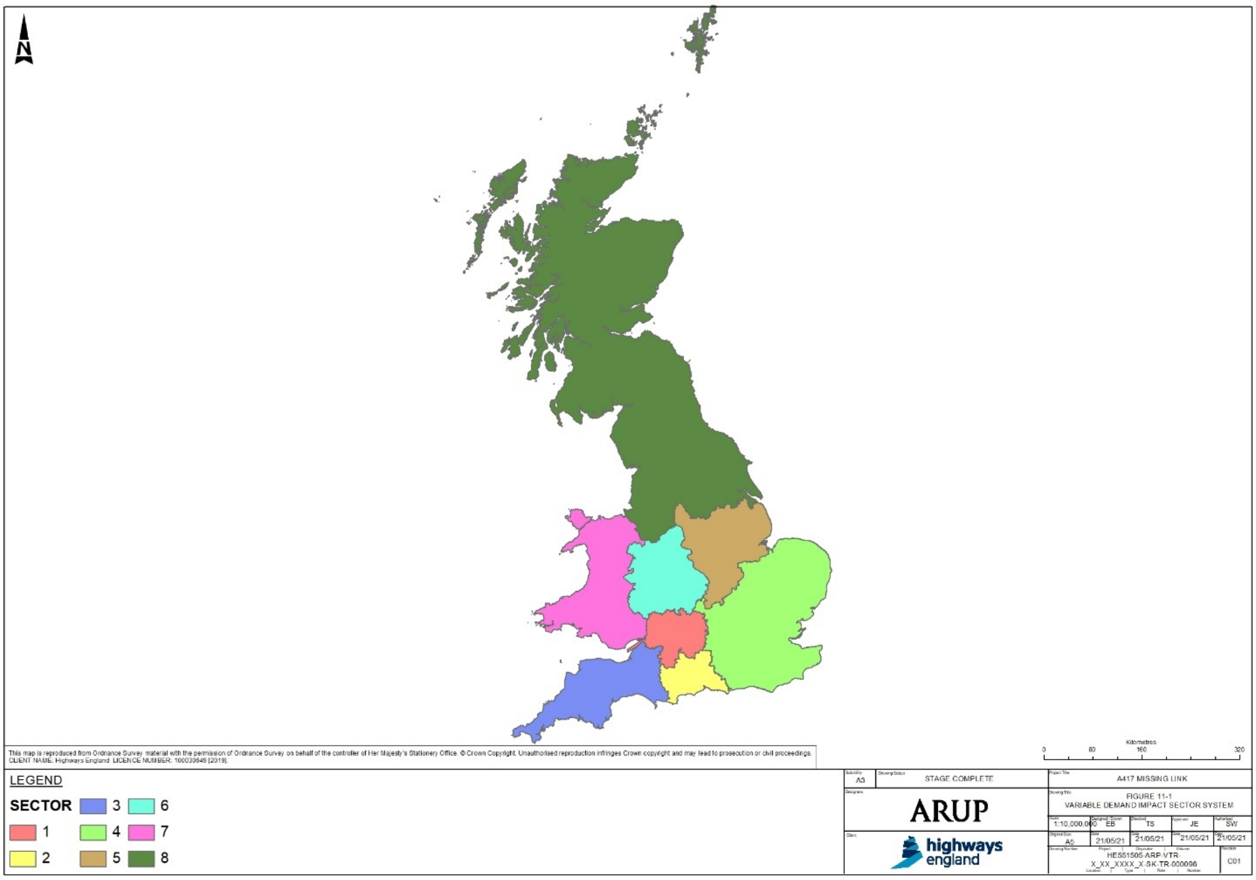
11.2.5 The measurements of flow and cost changes also exceed the TAG criteria of 98%. As discussed in paragraph 7.5.3, the scheme base and forecast traffic models have adopted a tighter set of convergence criteria. This means model convergence is achieved once at least 99.5% of links experience flow changes of less than 1% for four consecutive iterations. All scheme forecast traffic models and periods achieve these tighter criteria except for the 2031 PM peak DM (99.6%, 99.7%, 99.4%, 99.6%) and the 2041 PM peak DS model (98.7%, 99.2%, 99.0%, 99.7%) which are both close to achieving them. The slightly lower levels of convergence in these two scheme traffic models are outliers and not indicative of a poorly performing, congested model; as demonstrated by the later forecast year scheme PM traffic models, which have higher levels of demand and which all converge well within the tighter criteria. It is important to note that although the scheme 2031 PM peak DM and 2041 PM peak DS traffic models do not achieve the tightened SATURN parameters, both these scheme traffic models do achieve the convergence criteria set out in TAG unit M3.1.

11.2.6 Overall, it can be concluded that all forecast assignment scheme traffic models are very well converged and are suitable for use in the appraisal of the scheme.

11.3 Variable demand impact

11.3.1 The impacts of the variable demand model are summarised using the sector system listed and shown in Figure 11-1.

- sector 1 – main impact area of the scheme
- sector 2 – Hampshire, east Dorset and south Wiltshire
- sector 3 – Cornwall, Devon, Somerset and west Dorset
- sector 4 – London, South-East and the East of England
- sector 5 – East Midlands
- sector 6 – West Midlands
- sector 7 – Wales
- sector 8 – north and Scotland.



Source: Highways England

Figure 11-1 Variable demand impact sector system

Highway demand changes

11.3.2 The 24-hour 2026 reference highway demand is shown in Table 11-4, while Table 11-5 presents the change between the reference demand and the 2026 DM scenario.

11.3.3 Table 11-6 summarises the change between the reference demand and the 2026 DS scenario.

11.3.4 The tables show that the DM and DS have a similar redistributive pattern, with an increased number of inter sectoral highway trips compared to the reference, and a reduction in the number of intra sectoral highway trips. The overall volume of demand remains similar between each of the scenarios.

11.3.5 While not evident from the percentage differences shown in Table 11-5 and Table 11-6, the absolute reduction in intra sectoral trips, particularly in Sector 1, is slightly greater in the DS scenario than it is in the DM. Similarly, the increase in the number of longer distance trips is slightly greater in the DS scenario compared to the DM as a result of the scheme.

11.3.6 Some of the inter sectoral changes represent relatively minor absolute changes in demand but, due to the low amount of reference demand, relatively small absolute changes can result in large percentage changes. An exception to this is the relatively large absolute and percentage increase in trips to Wales (Sector 7) from Sectors 1 to 4; these increases reflect the removal of the Severn crossing toll charges, which reduces the cost for trips into Wales.

Table 11-4 24-hour reference highway demand, 2026 (000s of trips)

	1	2	3	4	5	6	7	8	Total
1	2,551	24	110	121	5	63	28	4	2,905
2	24	2,834	29	150	2	4	2	2	3,047
3	111	29	3,658	10	2	7	5	3	3,824
4	120	151	11	21,549	157	44	7	23	22,061
5	5	2	2	152	5,642	142	2	174	6,120
6	65	4	7	42	141	7,328	31	81	7,697
7	27	2	5	7	2	30	3,518	76	3,667
8	3	2	3	21	172	82	77	23,440	23,800
Total	2,905	3,048	3,824	22,052	6,121	7,700	3,670	23,802	73,123

Source: Highways England

Table 11-5 24-hour highway demand change between reference and Do-Minimum, 2026

	1	2	3	4	5	6	7	8	Total
1	-2.2%	9.9%	5.4%	6.5%	14.9%	7.4%	126.6%	35.5%	0.1%
2	9.8%	-1.0%	13.2%	11.6%	20.5%	16.6%	44.9%	32.3%	-0.1%
3	6.4%	12.9%	-0.6%	32.6%	18.8%	19.8%	87.5%	31.8%	0.0%
4	6.7%	11.6%	30.9%	0.0%	14.9%	23.7%	47.6%	37.8%	0.3%
5	14.2%	19.9%	17.7%	13.6%	-1.4%	13.5%	18.0%	20.6%	0.0%
6	6.9%	15.9%	18.4%	23.9%	14.1%	-0.7%	10.7%	15.1%	0.0%
7	69.2%	36.6%	65.2%	32.9%	19.0%	10.4%	-1.2%	12.4%	-0.1%
8	35.7%	32.4%	31.8%	39.5%	22.8%	17.5%	13.6%	-0.3%	0.0%
Total	-0.5%	-0.1%	-0.1%	0.3%	0.1%	0.0%	0.5%	0.0%	0.1%

Source: Highways England

Table 11-6 24-hour highway demand change between reference and Do-Something, 2026

	1	2	3	4	5	6	7	8	Total
1	-2.2%	10.1%	5.4%	6.6%	15.0%	7.7%	126.7%	37.1%	0.1%
2	10.0%	-1.0%	13.2%	11.6%	21.0%	20.2%	45.1%	33.2%	-0.1%
3	6.4%	12.9%	-0.6%	32.4%	18.3%	19.4%	87.5%	31.5%	0.0%
4	6.8%	11.6%	30.8%	0.0%	14.9%	24.1%	47.5%	37.8%	0.3%
5	14.3%	20.3%	17.2%	13.6%	-1.4%	13.5%	17.9%	20.6%	0.0%
6	7.2%	19.3%	18.1%	24.3%	14.1%	-0.7%	10.7%	15.1%	0.0%
7	69.2%	36.8%	65.3%	32.8%	18.9%	10.3%	-1.2%	12.4%	-0.1%
8	37.4%	33.2%	31.5%	39.5%	22.8%	17.5%	13.6%	-0.3%	0.0%
Total	-0.5%	-0.1%	-0.1%	0.3%	0.1%	0.0%	0.5%	0.0%	0.1%

Source: Highways England

Rail demand changes

11.3.7 Table 11-7 shows the reference rail (car available) demand for 2026 at the 24-hour level. Table 11-8 shows the difference between the reference demand and the DM demand, while Table 11-9 shows the difference between the reference and DS demand.

11.3.8 The changes between the reference and post VDM (i.e. DM and DS) scenarios are similar, with both the DM and DS showing a decrease in overall rail demand. This indicates that there is a mode shift from rail to highway between the reference and post VDM demand as a result of the highway schemes shown in Table 10-2 and Appendix F of this report. A similar mode shift occurs in both DM and DS scenarios, which indicates that the scheme would not result in a substantial shift from rail to highway, or vice versa.

Table 11-7 24-hour reference rail demand, 2026 (000s of trips)

	1	2	3	4	5	6	7	8	Total
1	14	1	7	13	0	2	2	1	39
2	1	30	1	22	0	0	0	0	54
3	7	1	20	5	0	0	0	0	34
4	12	22	5	1,918	15	14	2	21	2,010
5	0	0	0	16	10	5	0	7	38
6	1	0	0	14	5	93	2	6	121
7	2	0	0	3	0	2	33	2	42
8	1	0	0	23	7	6	2	203	241
Total	39	54	34	2,013	37	121	42	240	2,579

Source: Highways England

Table 11-8 24-hour rail demand change between reference and Do-Minimum, 2026

	1	2	3	4	5	6	7	8	Total
1	-6.0%	-5.3%	-5.3%	10.1%	-11.3%	-2.2%	-9.8%	-9.6%	-0.8%
2	-5.6%	-3.0%	-5.1%	-6.6%	-12.7%	-7.8%	-0.4%	-3.5%	-4.5%
3	-5.0%	-5.3%	-5.0%	-0.6%	-9.5%	-6.3%	-11.8%	-8.9%	-4.5%
4	8.0%	-7.0%	-1.8%	-4.2%	-8.5%	11.2%	7.2%	0.4%	-4.0%
5	-11.8%	-13.6%	-10.2%	-8.7%	-2.2%	2.5%	-11.6%	0.0%	-4.0%
6	-2.5%	-8.6%	-6.5%	11.1%	2.9%	-4.2%	-5.0%	-3.1%	-2.0%
7	-9.8%	-1.3%	-11.8%	11.2%	-11.3%	-5.2%	-5.6%	6.5%	-4.3%
8	-10.5%	-4.8%	-9.9%	-1.4%	1.0%	-3.7%	4.9%	3.7%	2.9%
Total	-1.6%	-4.7%	-4.8%	-4.0%	-3.6%	-2.1%	-4.6%	3.1%	-3.2%

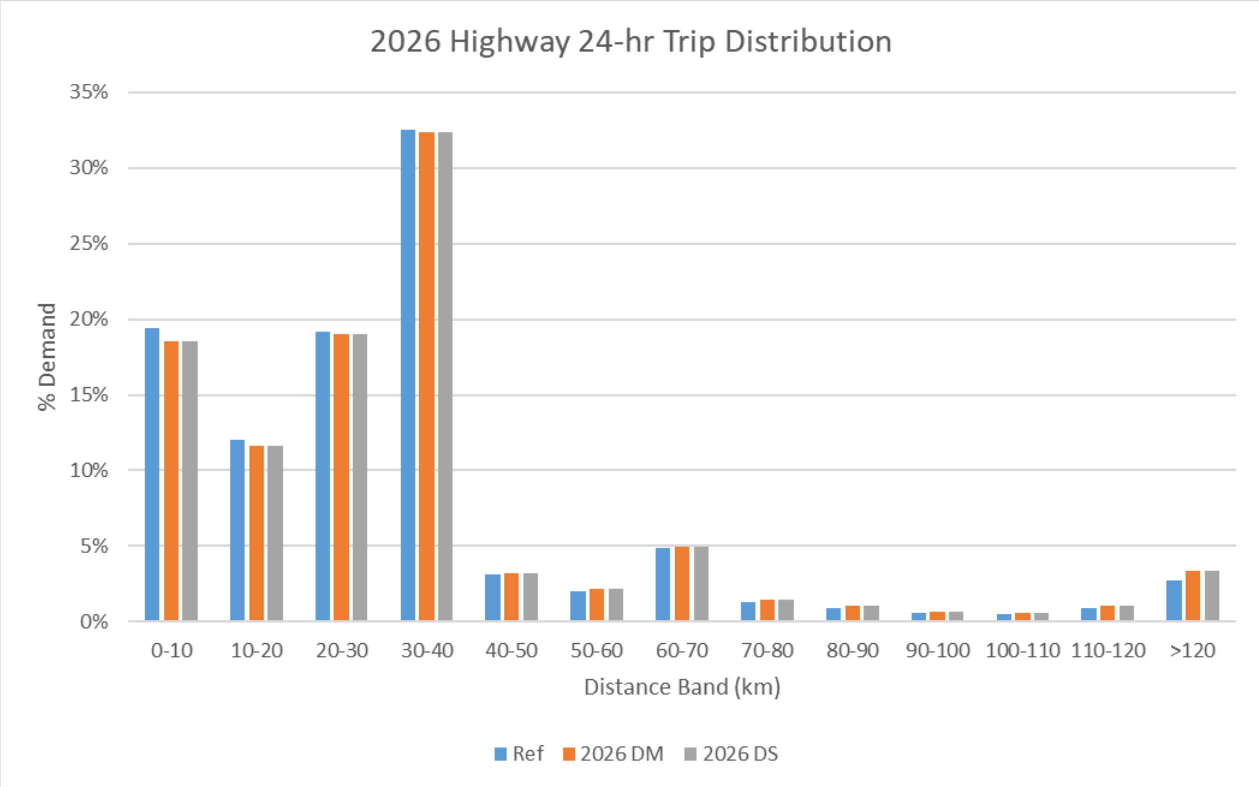
Source: Highways England

Table 11-9 24-hour rail demand change between reference and Do-Something, 2026

	1	2	3	4	5	6	7	8	Total
1	-6.1%	-5.3%	-5.4%	10.0%	-11.3%	-2.2%	-9.8%	-9.6%	-0.9%
2	-5.6%	-3.0%	-5.1%	-6.6%	-12.7%	-7.8%	-0.4%	-3.5%	-4.5%
3	-5.0%	-5.3%	-5.0%	-0.6%	-9.5%	-6.3%	-11.8%	-8.9%	-4.5%
4	7.9%	-7.0%	-1.8%	-4.2%	-8.5%	11.2%	7.2%	0.4%	-4.0%
5	-11.8%	-13.6%	-10.2%	-8.7%	-2.2%	2.5%	-11.6%	0.0%	-4.0%
6	-2.5%	-8.6%	-6.5%	11.1%	2.9%	-4.2%	-5.0%	-3.1%	-2.0%
7	-9.9%	-1.3%	-11.8%	11.2%	-11.3%	-5.2%	-5.6%	6.5%	-4.3%
8	-10.5%	-4.8%	-9.9%	-1.4%	1.0%	-3.7%	4.9%	3.7%	2.9%
Total	-1.6%	-4.7%	-4.8%	-4.0%	-3.6%	-2.1%	-4.6%	3.1%	-3.2%

Source: Highways England

11.3.9 Figure 11-2 shows the highway trip length distributions for 2026 for the reference demand and the post VDM demand for both the DM and DS scenarios. Between the reference and the forecast scenarios, there is a slight reduction in the percentage of trips in the shorter distance bands (trips 25 miles (40km) or shorter) and an increase in the longer distance bands (trips greater than 25 miles (40km)). This is likely to reflect the reduced highway costs for longer distance trips arising from the inclusion of various DM schemes and the scheme in the DS scenario. Comparison of the DM and DS scenarios shows some further slight reductions in the percentage of trips in the shorter distance bands (trips 12 miles (20km) or shorter) and slight increases in the longer distance bands (trips greater than 12 miles (20km)).



Source: Highways England

Figure 11-2 2026 Highway trip length distribution

11.4 Presentation of scheme traffic model forecasts

Scheme highway impacts – traffic flows

11.4.1 Forecast AADT flows at key locations, both near the scheme and on longer distance routes, are presented on plans included in Appendix I of this report. AADTs are shown for the DM and DS scenarios for both the 2026 opening year and the 2041 design year. The 2015 base year flows are also presented on the plans. Each of the locations on the AADT figures contained in Appendix I has been allocated a reference number (e.g. ID 6 is A417 Crickley Hill). The following sections of this report refer to these ID numbers to aid the reader.

Do-Minimum traffic impacts

11.4.2 The forecasts show that the AADT on the A417 at Crickley Hill (ID 6) is forecast to increase from 36,900 in the base scenario to 42,100 in the opening year (2026) and 48,000 in the design year (2041) in the DM scenarios. These forecasts represent increases from the base year of approximately 14% and 30% for 2026 and 2041 respectively. HGV proportions are forecast to change from 13% in the base scenario to 11% in 2026 and to 10% in 2041.

11.4.3 The AADT on the A417 immediately to the south of the Air Balloon roundabout (ID 5) is forecast to increase from 29,500 in the base scenario to 33,000 in the opening year (2026) and 37,000 in the design year (2041) in the DM scenarios. These equate to increases of 12% in 2026 and 25% in 2041 when compared to the base scenario. HGV proportions are forecast to change from 12% in the base scenario to 10% in 2026 and to 9% in 2041.

11.4.4 A lack of capacity at the Air Balloon roundabout would restrict the amount of traffic growth able to be accommodated on this section of the A417. This is reflected in the larger flow increases forecast to occur in the future DM scenarios on the A417 section south of Cowley roundabout (ID 12). At this location, flows are forecast to increase from 29,800 in the base year to 34,600 (+16%) in 2026 and to 41,200 (+38%) in 2041. HGV proportions are forecast to change from 12% in the base scenario to 10% in 2026 and to 8% in 2041.

11.4.5 These flow increases are a result of forecast increased traffic demand arising from a combination of local developments and wider NTEM growth forecasts.

Scheme traffic impacts

11.4.6 The scheme includes a new grade separated junction at Shab Hill that provides access between the new dual carriageway and the existing A417 alignment. The new junction also provides access to the B4070, A436 and Leckhampton Hill.

11.4.7 Forecast AADTs on the new dual carriageway section to the south of the new grade separated junction at Shab Hill (ID 27) are forecast to be 46,900 in 2026 and 58,200 in 2041. These are increases of 37% and 44% respectively when compared to the corresponding single carriageway section (ID 13) of the DM. HGV proportions are forecast to change from 10% to 8% in 2026 and from 8% to 7% in 2041.

11.4.8 On the Crickley Hill section (ID 6) of the new dual-carriageway AADTs are forecast to be 50,300 in 2026 and 63,000 in 2041 with the scheme. These are increases of 19% and 31% respectively when compared to the DM. HGV proportions are forecast to change from 11% to 9% in 2026 and from 10% to 8% in 2041.

11.4.9 Flows on the existing adjacent dual carriageway sections of the A417 are also forecast to increase as a result of the scheme. To the south of the A417 Elkstone junction (ID 1) AADTs are forecast to increase from 38,300 to 47,300 (+23%) between the DM and DS in 2026 and from 45,200 to 58,100 (+29%) in 2041. HGV proportions are forecast to change from 9% to 8% in 2026 and from 8% to 7% in 2041.To the west of Brockworth bypass (ID 9) AADTs are forecast to increase from 62,800 to 68,900 (+10%) between the DM and DS in 2026 and from 73,600 to 83,000 (+13%) in 2041. HGV proportions are forecast to change from 8% to 7% in 2026 and from 7% to 6% in 2041.

11.4.10 The forecast increases in traffic on the A417 in the vicinity of the scheme are a result of traffic reassigning from various alternative routes, both local and strategic, to take advantage of the improvements to the route.

11.4.11 At the local level, traffic is forecast to reassign away from existing known rat runs including via Elkstone towards Cheltenham and also via Birdlip Hill towards Gloucester.

11.4.12 On the former route, the AADT through Elkstone (ID 2) with the scheme is forecast to decrease compared to the DM from 4,100 to 1,600 (-61%) in 2026 and from 4,400 to 1,400 (-68%) in 2041. HGV proportions are forecast to change from 3% to 6% in 2026 and from 2% to 6% in 2041.

11.4.13 Comparable relative reductions as a result of the scheme are forecast to occur on the Birdlip Hill route (ID 7). AADT is forecast to decrease from 6,900 in the DM to

2,800 in the DS scenario (-59%) in 2026 and from 9,700 to 3,300 (-66%) in 2041. HGV proportions are forecast not to change in 2026 or in 2041.

11.4.14 The scheme also results in reassignment onto the A417 from strategic alternative routes. Forecast flow reductions on the M40 north of Banbury and the A34 north of Oxford, coupled with increases on the M4 east of Swindon and on the M5 north of Cheltenham and Gloucester, show that traffic is reassigning from the A34/M40 route onto the M4/A417/M5 route with the scheme in-situ.

11.4.15 AADT on the M40 between Junction 11 and Junction 12 (ID 104) is forecast to decrease by 900 vehicles in 2026 and 1,000 vehicles in 2041 with the scheme. Changes in HGV proportions are forecast to be negligible in 2026 and in 2041.

11.4.16 AADT on the M4 east of Swindon (ID 101) is forecast to be increase by 1,900 vehicles and 2,500 vehicles in 2026 and 2041 respectively with the scheme. AADT on the M5 north of the M50 (ID 105) is forecast to increase by 2,300 vehicles and 2,500 vehicles in 2026 and 2041 respectively. Changes in HGV proportions are forecast to be negligible in 2026 and in 2041 at both locations.

11.4.17 A reduction in north/south traffic is also forecast to occur on the A429 through the Cotswolds (ID 106), with AADT forecast to decrease by around 400 compared to the DM in 2026 and by around 500 in 2041. The reduction on the A429 is likely to be a result of traffic switching to the alternative A417/M5 route to/from the Midlands and the north. Changes in HGV proportions are forecast to be negligible in 2026 and in 2041.

11.4.18 The large reduction in delays at the Ullenwood roundabout encourages traffic to reassign away from the A46 and onto the B4070/Leckhampton Hill route to/from Cheltenham.

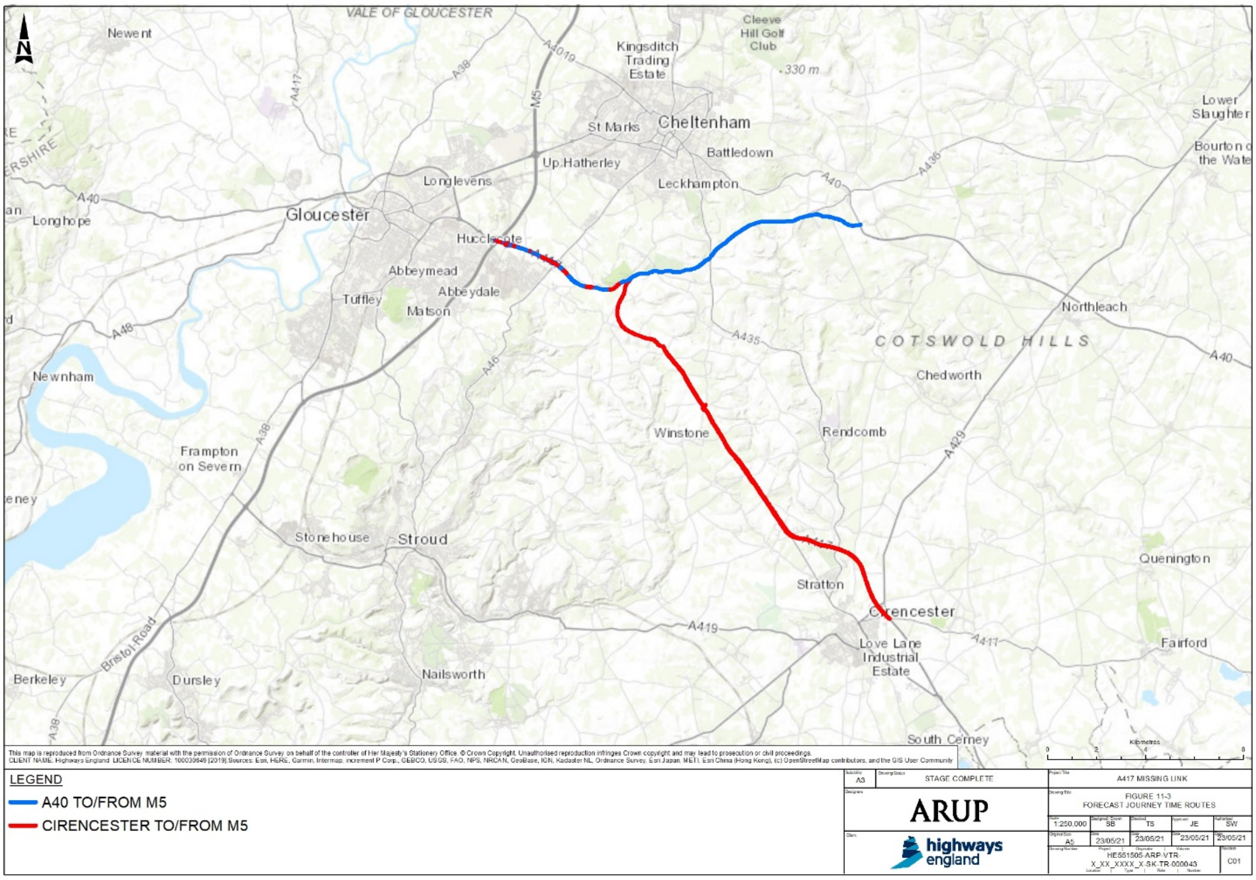
11.4.19 On the B4070 south of Birdlip (ID 14), AADT is forecast to increase by 700 (+13%) in 2026 and 1,300 (+22%) in 2041 with the scheme. On Leckhampton Hill (ID 4), AADT is forecast to increase by 2,400 (+33%) in 2026 and 3,900 (+51%) in 2041. Changes in HGV proportions are forecast to be negligible in 2026 and in 2041 at both locations.

11.4.20 AADT on the A436 to the east of the Ullenwood roundabout (ID 10) is forecast to decrease by 3,700 (-26%) in 2026 and 2,800 (-17%) in 2041 with the scheme. The forecast reductions in traffic on the A436 are a result of the increased distance for traffic travelling between the A436 and the A417. HGV proportions are forecast to remain at 9% in 2026 and reduce from 8% to 7% in in 2041.

Scheme highway impacts – journey times

11.4.21 To illustrate the impact of the scheme on forecast journey times, modelled journey times have been extracted for the following routes, which are shown in Figure 11-3:

- A417 between the A429 junction at Cirencester and the M5/A417/B4641 roundabout; and
- A40/A436 junction at Shipton to the M5/A417/B4641 roundabout.



Source: Highways England

Figure 11-3 Forecast journey time routes

11.4.22 Table 11-10 and Table 11-11 present the modelled journey times for the A417 route between Cirencester and the M5 for the westbound and eastbound directions respectively. The DS percentage differences shown are relative to the corresponding DM scenario. The DM percentage differences are relative to the 2015 Base scenario.

Table 11-10 A417 modelled journey times – Cirencester to M5 (westbound)

Year	Scenario	AM peak		IP		PM peak	
		Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.
2015	Base	17:33	N/A	17:12	N/A	18:25	N/A
2026	DM	18:19	+4%	17:55	+4%	18:55	+3%
	DS	13:33	-26%	13:21	-25%	13:49	-27%
2041	DM	19:33	+11%	19:08	+11%	20:17	+10%
	DS	14:07	-28%	13:49	-28%	14:21	-29%

Source: Highways England

Table 11-11 A417 modelled journey times – M5 to Cirencester (eastbound)

Year	Scenario	AM peak		IP		PM peak	
		Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.
2015	Base	15:38	N/A	14:42	N/A	15:03	N/A
2026	DM	17:01	+9%	15:09	+3%	15:38	+4%
	DS	13:15	-22%	12:36	-17%	12:54	-17%
2041	DM	18:45	+20%	16:09	+10%	17:13	+14%
	DS	14:12	-24%	12:58	-20%	13:38	-21%

Source: Highways England

11.4.23 The scheme is forecast to reduce journey times along the A417 in both directions compared to the DM scenarios.

11.4.24 Given the large amounts of existing delay experienced by westbound traffic, the largest journey time savings are forecast to be achieved in that direction. In the 2041 forecasts, the westbound journey times reduce by over five minutes in the AM peak and by nearly six minutes in the PM peak.

11.4.25 The journey time savings on the A417 are not as great in the eastbound direction, but still equate to more than four minutes in the AM peak and more than three minutes in the PM peak in 2041.

11.4.26 Table 11-12 and Table 11-13 present the modelled journey times for the A436/A417 route between the A436/A40 junction and the M5 for the westbound and eastbound directions respectively.

Table 11-12 A436/A417 modelled journey times – A436/A40 to M5 (westbound)

Year	Scenario	AM peak		IP		PM peak	
		Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.
2015	Base	13:37	N/A	13:21	N/A	15:18	N/A
2026	DM	14:15	+5%	13:37	+2%	16:51	+10%
	DS	14:44	+3%	14:35	+7%	15:13	-10%
2041	DM	15:25	+13%	14:45	+10%	19:01	+24%
	DS	15:10	-2%	15:03	+2%	15:56	-16%

Source: Highways England

Table 11-13 A436/A417 modelled journey times – M5 to A436/A40 (eastbound)

Year	Scenario	AM peak		IP		PM peak	
		Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.	Time (mm:ss)	% Diff.
2015	Base	13:24	N/A	12:45	N/A	12:54	N/A
2026	DM	14:21	+7%	13:02	+2%	13:22	+4%
	DS	15:03	+5%	14:25	+11%	14:44	+10%
2041	DM	16:22	+22%	13:37	+7%	14:43	+14%
	DS	16:06	-2%	14:50	+9%	15:31	+5%

Source: Highways England

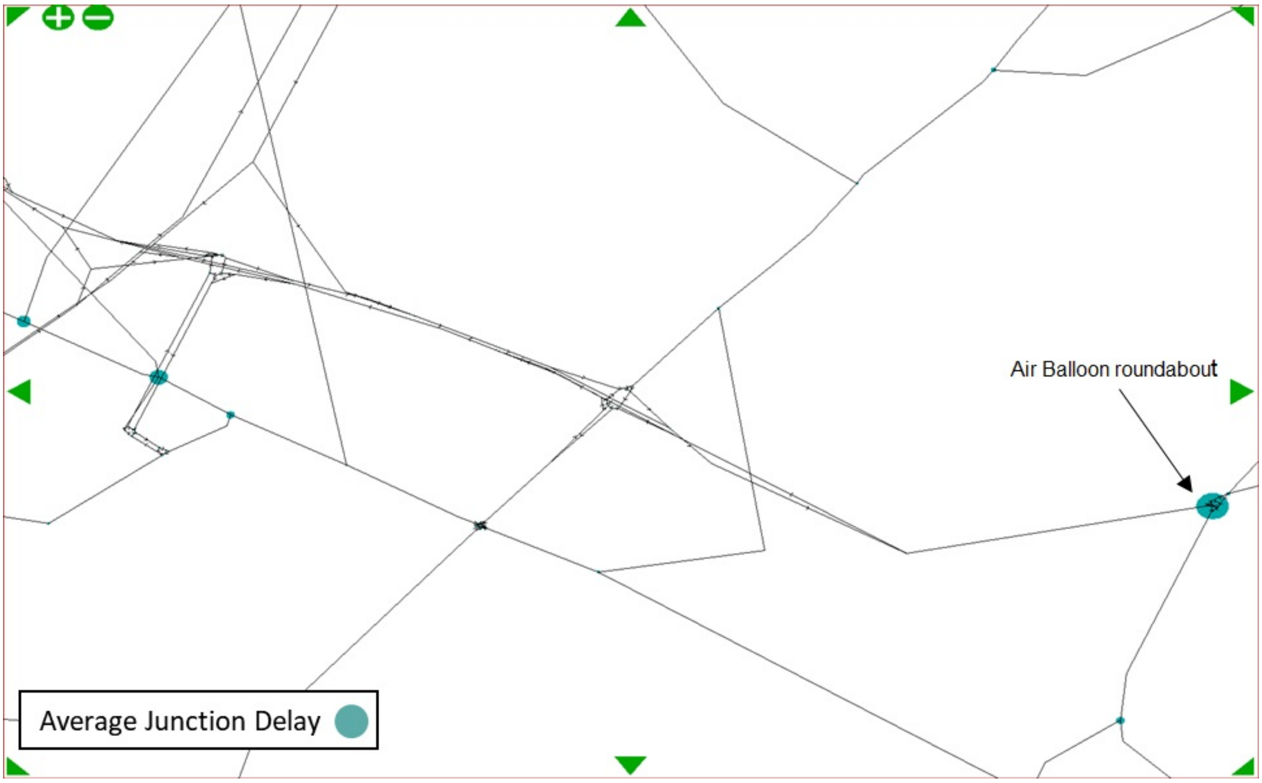
11.4.27 Westbound traffic currently experiences greater delay at the Ullenwood roundabout than the eastbound equivalent during the PM peak. Delay in other periods is comparable.

11.4.28 The scheme slightly increases journey times for the westbound A436/A40 to M5 route in the 2026 AM and IP periods as a result of the increased journey distance compared to the DM. The scheme decreases journey times for the westbound A436/A40 to M5 route in the 2026 PM peak period, despite the increase in journey distance, as a result of the decrease in delay compared to the DM. In 2041, journey times in the AM and IP periods are comparable between the DM and DS as the impact of the delay reduction with the scheme begins to be equable with the disbenefit of the increased journey distance. The scheme decreases journey times in the 2041 PM peak period by nearly three minutes.

11.4.29 Journey times for the eastbound M5 to A436/A40 route are generally forecast to increase with the scheme. This is as a result of the increased journey distance compared to the DM without the equivalent delay reductions achieved in the westbound direction. Increases in all periods are forecast to be greater in 2026 than in 2041; with journey times in the AM peak period in 2041 comparable to the DM.

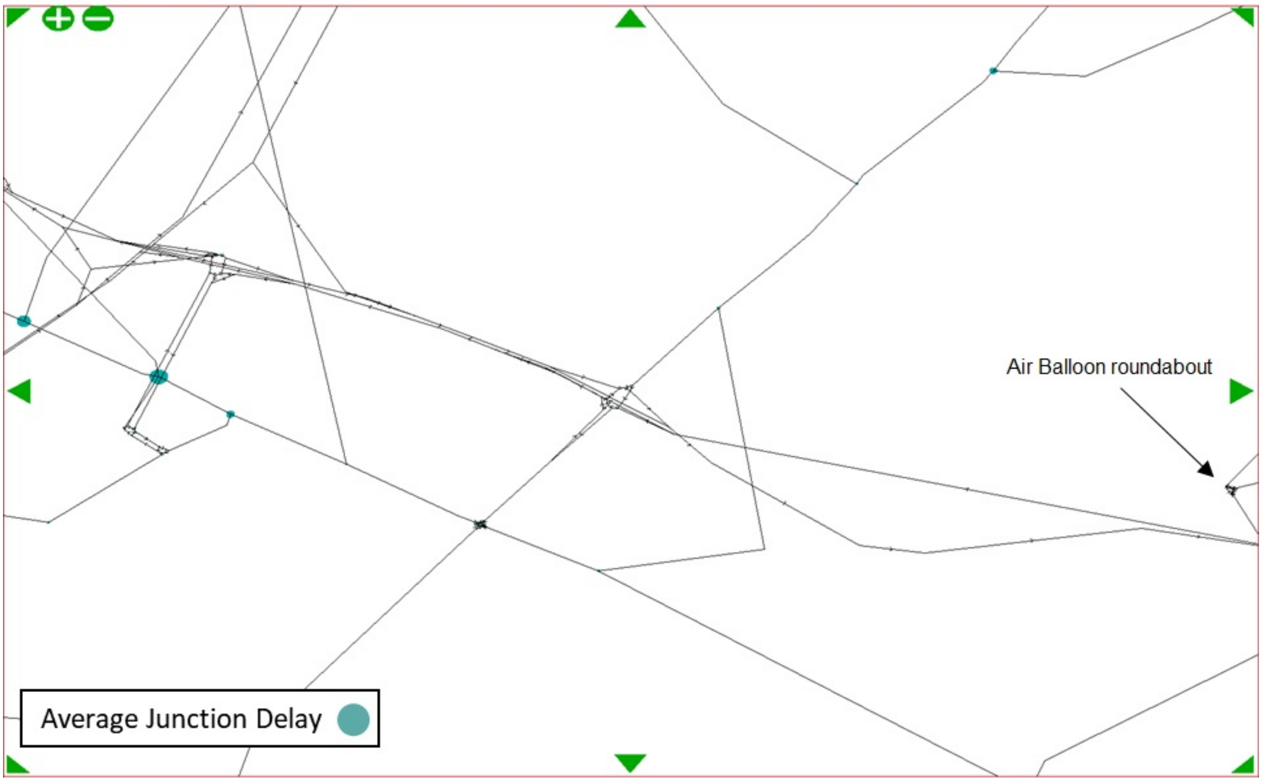
Scheme highway impacts – local delay impacts

11.4.30 Example node delay plots are presented in Figure 11-4 for the 2026 DM AM peak period and Figure 11-5 for the 2026 DS AM peak period. For reference, and to provide an indication of the scale used in the figures, the largest delay shown in Figure 11-4 is 81 seconds (on the northbound A417 entry to the Air Balloon roundabout). It should be noted that consideration of delays at nodes in isolation is likely to underestimate the total amount of delay as it does not take into account delays associated with upstream nodes or delays occurring due to overcapacity links.



Source: Highways England

Figure 11-4 Node delays for 2026 Do-Minimum AM peak



Source: Highways England

Figure 11-5 Node delays for 2026 Do-Something AM peak

11.4.31 The DM node delay plots show large delays at Air Balloon roundabout in both peak periods, with delays increasing in 2041 compared to 2026. Delays are also prevalent at signalised junctions within Gloucester in the DM plots.

11.4.32 The delay plots for the DS identify large reductions in delays that are forecast to occur at the Ullenwood roundabout. Away from the Ullenwood roundabout itself, there are no obvious locations at which the scheme is forecast to substantially change delays.

Operational assessments

11.4.33 Operational assessments, including junction capacity and merge/diverge assessments, have been undertaken for the scheme design year of 2041.

11.4.34 The assessments show that the scheme junctions are forecast to operate within capacity in the weekday peak hours. However, there are some instances in which scheme junctions are forecast to experience some delay and queuing.

11.4.35 The proposed Ullenwood roundabout is forecast to operate within capacity in the scheme design year, with some limited queuing on the A436 link road in the morning peak hour and on the A436 approach in the evening peak hour. The Shab Hill eastern roundabout is forecast to operate within capacity in the 2041 scheme design year, with some small queues and delay on all arms in both morning and evening peak hours. The Shab Hill western roundabout would work largely within capacity in the 2041 scheme design year, with some queuing on the underpass arm in the evening peak hour.

11.4.36 Merge and diverge assessments have also been undertaken for the scheme and have demonstrated that the proposed new and the existing merge and diverge arrangements are appropriate given the forecast 2041 traffic demand.

11.4.37 Full details of the assessments, including results tables, are provided in an operational assessment technical note within Appendix J of this report.

Key non-highway impacts

11.4.38 The differences in rail demand between the DM and DS scenarios are forecast to be negligible when compared at a sectoral level. This indicates that the schemes would not result in a substantial shift from highway to rail, or vice versa.

Provision of data for other appraisals

Economic assessment

11.4.39 The traffic forecasts and demand modelling form the basis of economic appraisal. More specifically, Transport User Benefit Appraisal (TUBA) software requires as inputs the following set of matrices, or ‘skims’, for each origin/destination pair:

- vehicle trips
- distance (in kilometres)
- time (hours)
- monetary charges (pence)

11.4.40 These skims are further disaggregated by user class, time period and trip purposes. Based on these trip and cost skims from the scheme DM and DS traffic models, TUBA calculates user benefits discounted to the present value year and produces results at various degrees of disaggregation and summarises the outputs.

Environmental assessment

11.4.41 The results of the scheme traffic model forecasts feed into the environmental assessments, with AADT and AAWT flows derived as per section 10.7 of this report. The speeds from the scheme traffic models are pivoted and assigned speed bands in accordance with DMRB LA 105.

11.4.42 Data provided for the environmental assessments includes, for each scheme traffic model link, definition as either a “motorway” or “non-motorway” link, the vehicle flow, percentage heavy duty vehicles (HDV), speed and speed band.

11.4.43 For air quality assessments, the data has been provided for the following time periods:

- AM peak (07:00-10:00) – average hour
- IP (10:00-16:00) – average hour
- PM peak (16:00-19:00) – average hour
- OP (19:00-07:00) – average hour
- AAWT 24 hours (00:00-24:00)
- AADT (00:00-24:00)

11.4.44 For noise assessments, the data has been provided for the following time periods:

- AAWT 18 hours (06:00-24:00)
- AAWT 12 hours (07:00-19:00)
- AAWT 4 hours (19:00-23:00)
- AAWT 8 hours (23:00-07:00)

Operational assessment

11.4.45 Peak hour forecast traffic turning movements have been extracted from the scheme traffic models at each of the scheme junctions for use in operational assessments. Details of the operational assessments are provided earlier in this section.

12 Economic appraisal approach

12.1 Introduction

12.1.1 This section provides a description of the processes used during the economic appraisal of the scheme. The estimated scheme costs are also discussed and presented within this section.

12.2 Assessment process and modelling framework

12.2.1 The DfT's TAG guidance provides a detailed methodology for quantifying a wide range of potential impacts of a transport scheme and monetising them wherever possible. The economic appraisal of the scheme has followed the guidance set out in the following TAG units:

- A1 – Cost-benefit analysis
- A2 – Economic impacts
- A3 – Environmental impacts
- A4 – Social and distributional impacts

12.2.2 Table 12-1 identifies the approach adopted to appraise the economic impacts of the scheme.

Table 12-1 Overview of economic assessments

Element	Assessment method
Transport economic appraisal	TUBA (Transport Users Benefit Appraisal) software (version 1.9.14)
Accidents	COBALT (COst and Benefit to Accidents – Light Touch) software (version 2013.02)
Journey time reliability	Comparison of observed journey time reliability (using journey time standard deviations derived from TrafficMaster data)
Construction impacts	QUADRO (QUeues And Delays at ROadworks) software (QUADRO 2020 v4.18.0.1)
Air quality	DfT's *Local Air Quality Workbook* and *Air Quality Valuation Workbook*
Noise impacts	Approach set out in TAG unit A3 chapter 2
Greenhouse gas emissions	Approach set out in TAG unit A3 chapter 4
Wider economic impacts	WITA (Wider Impacts in Transport Appraisal) software (version 2.0 beta)

Source: Highways England

12.2.3 The application of the above methods in the economic assessment of the scheme is set out in detail within section 12.4 of this report, with economic appraisal results provided in section 13 of this report.

12.2.4 The economic appraisal for the scheme has used the scheme traffic model for PCF stage 3. Details on the development of the 2015 scheme base and forecast year traffic models are provided in the preceding sections of this report.

12.2.5 As discussed previously, traffic forecasts have been prepared for an opening year for the scheme, 2026, and the scheme design year, 2041. Two additional forecast years, consisting of an intermediate year of 2031 and a final forecast year of 2051, have also been used to support the economic appraisal of the scheme.

12.2.6 Forecasts have been undertaken for the scheme and also for the DM scenario, in which the scheme is not implemented.

12.3 Estimation of costs

12.3.1 Table 12-2 summarises the costs for the scheme. The costs are in 2010 prices, undiscounted and based on the design at August 2020.

Table 12-2 Scheme cost summary (2010 prices, undiscounted)

Cost type	The scheme
Preparation	£22,751,364
Supervision	£8,793,835
Works	£217,483,913
Land	£25,678,208
Operation & maintenance	£8,329,901
TOTAL	**£283,037,220**

Source: Highways England (September 2020) and COBA manual (July 2017)

12.3.2 The expenditure profiles are based upon cost estimates for each financial year prepared in Q2 2019 prices and then inflated to outturn costs using Highways England projected construction related inflation. These costs have then been rebased to 2010 calendar year profiles for economic calculations, using the gross domestic product (GDP) deflator series as published in the TAG databook. The costs exclude all recoverable VAT and all historic costs have been removed.

12.3.3 Operation and maintenance costs are presented as net values (i.e. the costs associated with maintaining the new road(s) less the cost of maintaining the existing alignment in the DM scenario). These costs have been calculated using values included within Part 2, chapter 9 of the COBA manual (July 2017).

12.3.4 The Highways England scheme costs already make allowance for risk and contingencies. Optimism bias has therefore not been added to the costs shown. The detailed cost profiles for the scheme are included in Appendix K of this report.

12.4 Estimation of benefits

Transport user benefits

12.4.1 The DfT's economic appraisal software TUBA version 1.9.14 has been used to calculate the transport user benefits for the scheme in accordance with published DfT guidance.

12.4.2 The appraisal is based on matrices of trips and costs extracted from the scheme traffic model. From these, TUBA calculates the user benefits in travel time, vehicle operating costs for fuel and non-fuel, and charges.

12.4.3 TUBA uses the input trip and cost matrices for the four forecast years and, through a process of interpolation and extrapolation, appraises the economic benefits of the scheme for a 60-year period from scheme opening (i.e. 2026 to the end of 2085). Both the benefits, and the scheme costs, are discounted by TUBA to the present value year (2010) in accordance with TAG unit A1.1.

12.4.4 As per TAG unit A1.3 car and rail employers' business values of time are assumed to vary with distance, which is represented by a continuous function.

12.4.5 Fully converged trip matrices for each time period and assignment user class have been extracted from the traffic forecasts. Total HGV trip matrices have been split into other goods vehicles 1 (OGV1) (47%) and other goods vehicles 2 (OGV2) (53%) matrices to be consistent with the splits specified in the COBA and QUADRO manuals. The split of the LGV matrices into personal and freight trips uses the standard TAG databook proportions of 88% freight and 12% personal.

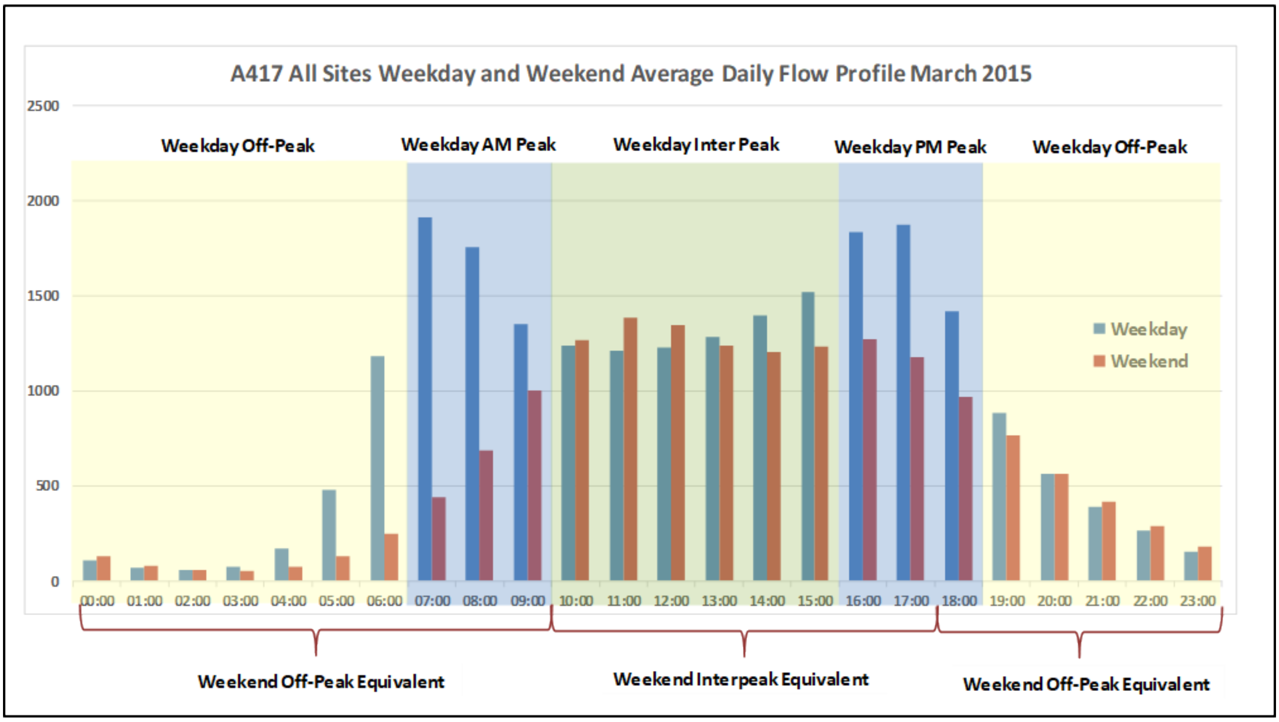
Annualisation factors

12.4.6 The scheme traffic models have been built to represent a weekday in March and include an average AM peak hour (07:00-10:00), an average IP hour (10:00-16:00), an average PM peak hour (16:00-19:00), and an average OP hour (19:00-07:00). Annualisation factors have been used to uplift the results produced for the modelled periods to represent all hours during the year as far as possible.

12.4.7 As March is not considered to be a neutral traffic month (as defined in TAG unit M1.2), a comparison has been made, using continuous ATC data, between March flows and the annual average flows with a view to deriving an adjustment factor. From this analysis it was found that the March flows were representative of the annual average with the adjustment factor being calculated as 0.995. On this basis, the March flows have been considered to be effectively neutral and therefore no adjustment has been applied in the subsequent derivation of annualisation factors.

12.4.8 Given that the modelled hours are already representative of averages over the peaks and IP periods and having demonstrated that March flows are typical of the annual average, the derivation of annualisation factors for weekdays is then relatively straightforward. Average hours are simply factored up to period totals based on the number of hours in the period (3 hours AM, 6 hours IP, 3 hours PM and 12 hours OP). Period totals are then factored up to annual totals on the basis that there are typically 253 weekdays per year (excluding bank holidays). For example, the AM average hour is factored by 3 to get a period total and then by 253 to give an annualisation factor for the AM of 759 hours per year.

12.4.9 In the absence of a weekend model for the scheme, the weekday IP and OP models have been used as a proxy. Analysis of long-term ATC data has been undertaken to identify typical weekend periods that are similar in terms of flow levels to the average IP and OP weekday hours. The comparison is presented in Figure 12-1 where the weekday and weekend flows are shown side-by-side.



Source: Highways England - Calculation TCD_040 TUBA Weekend Annualisation Factor

Figure 12-1 A417 weekday and weekend daily flow profile

12.4.10 From the analysis of weekend and weekday ATC flow data, which also included comparisons of average hourly flow over the selected periods to ensure consistency, it was considered appropriate to represent the weekend hours through a proxy of 8 weekday IP hours and 16 weekday OP hours.

12.4.11 Typically, there are 112 weekend days per year (including 8 bank holidays).

12.4.12 The annualisation factors used in the appraisal are presented in Table 12-3.

Table 12-3 Annualisation factors

Time Period	Hours in time period	Days per year	Annualisation
AM	3	253	759
IP	6	253	1518
PM	3	253	759
OP	12	253	3,036
TOTAL (Weekday)	**24**	**253**	**6,072**
Weekend (OP)	16	112	1,792
Weekend (IP)	8	112	896
TOTAL (Weekend)	**24**	**112**	**2,688**

Source: Highways England - Calculation TCD_040 TUBA Weekend Annualisation Factor

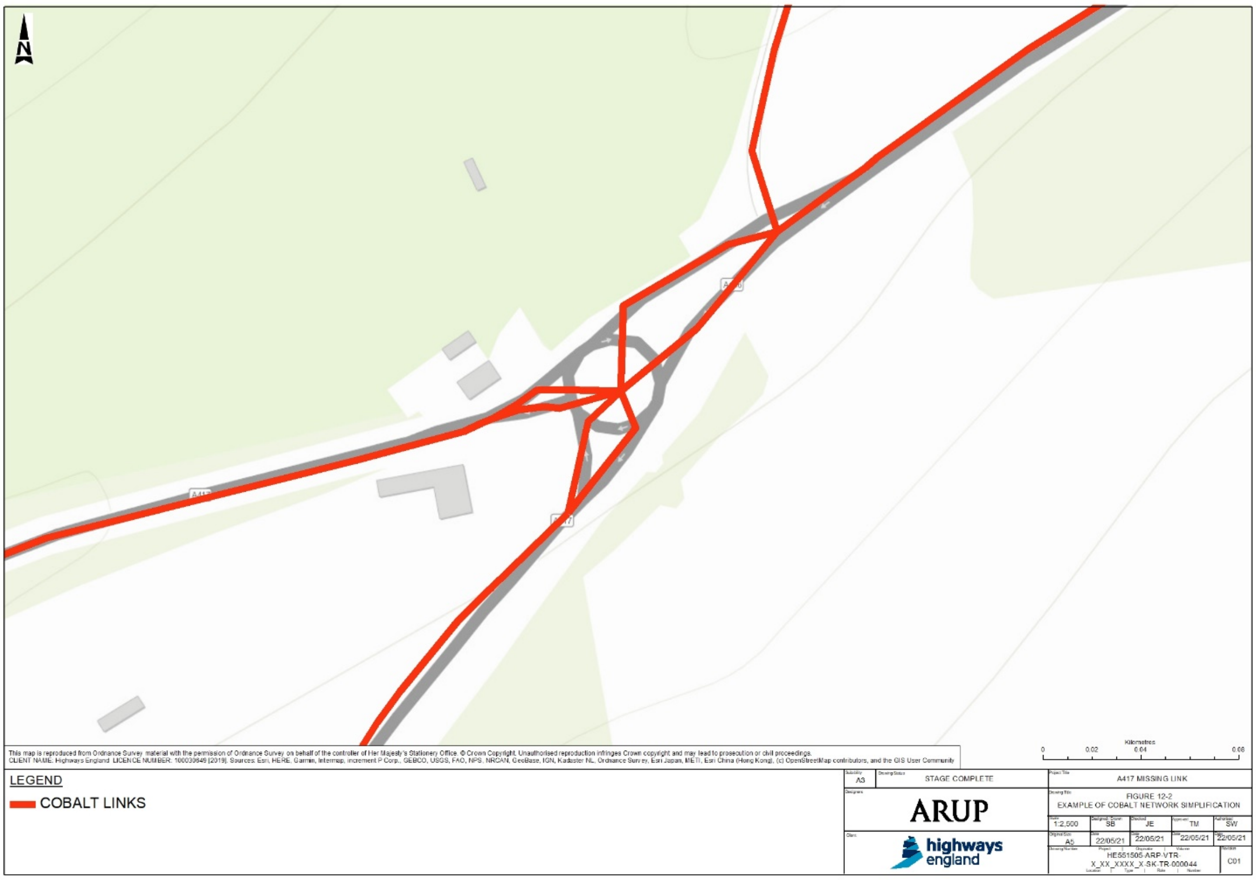
12.4.13 In TUBA the weekday and weekend OP elements were combined to give a combined OP annualisation factor of 4,828 (=3,036+1,792). Annualisation factors for the AM, IP and PM weekday periods and the weekend IP are applied individually within TUBA.

Accident benefits

12.4.14 COBALT (version 2013.02) has been used to assess the impact of the proposed scheme on accidents.

12.4.15 The COBALT approach adopted for the scheme assesses accidents on links and junctions separately for scheme links and junctions as well as the equivalent DM links and junctions. Elsewhere within the simulation area, accidents are assessed on links and junctions combined. This methodology has been agreed with Highways England's TPG and provides the most accurate assessment of local conditions without the scheme and the impact of the scheme.

12.4.16 Using the scheme base traffic model for PCF stage 3 as a starting point, a base COBALT network was prepared in GIS. To avoid the spurious allocation of observed accident data, and in keeping with COBALT guidance, the scheme traffic model highway network has been simplified in places to condense complex junction coding down to single nodes. Figure 12-2 illustrates an example of this, comparing the scheme traffic model network and COBALT networks for the Air Balloon roundabout.



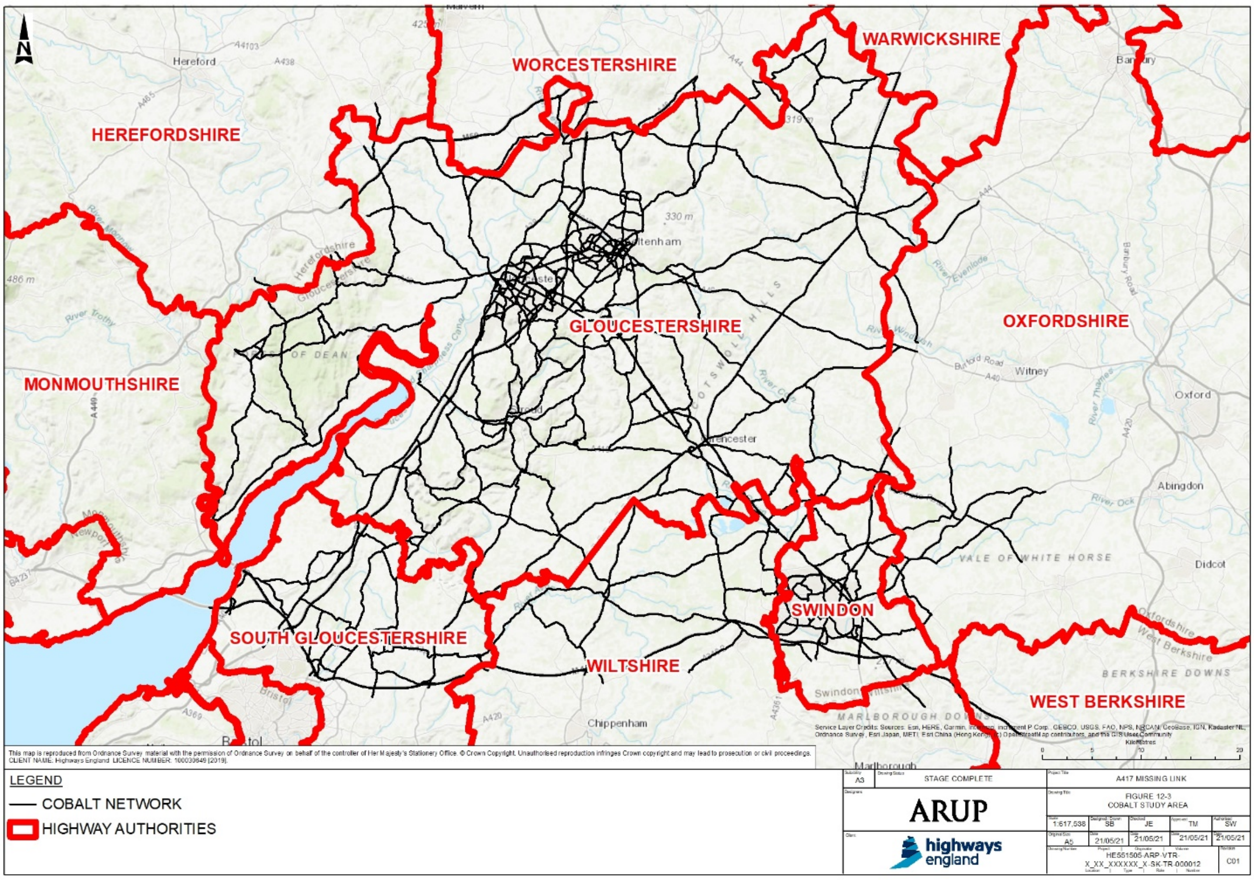
Source: Highways England

Figure 12-2 Example of COBALT network simplification

12.4.17 In addition to the simplification of complex junction coding in the SATURN networks, it was also necessary to combine SATURN links (A-B and B-A) such that a single link in COBALT (A-B) represents both directions of travel. Links were subsequently allocated a link type based on road standard, number of carriageways, width, age and presence or absence of a hard strip. The speed limit was also allocated to each link in the COBALT network.

12.4.18 Initially, accident data covering the latest full five-year period (at the time, May 2013 to April 2018) was obtained from Gloucestershire, South Gloucestershire and Wiltshire (including Swindon) highway authorities. The vast majority of the COBALT network is located within these authorities, with a handful of links encroaching into a further five neighbouring authorities (Herefordshire, Worcestershire, Warwickshire, Oxfordshire and West Berkshire), as shown in Figure 12-3. As this only affected a handful of COBALT links (less than 2%), it was considered proportionate to make use of accident data for 2012 to 2016 inclusive for these additional authorities as this was readily available from the DfT Road Safety Data website[7]. For PCF stage 3, accident data for key links (those impacted most by the scheme) within the study area have been updated from the data used at PCF stage 2 to the most recent five years of accident data available from the DfT, to include accidents for the period May 2018 to June 2019. The links where accident data was updated are shown in Figure 4-2.

12.4.19 In COBALT the range of years for input accident data is specified at link level and the software adjusts this accordingly based on the years being assessed. The use of data covering different date ranges is therefore accounted for by the software and does not introduce an inconsistency within the assessments.



Source: Highways England

Figure 12-3 COBALT study area

12.4.20 Accidents were matched to their relevant COBALT links using GIS, with any accidents that occurred on non-modelled links excluded from the analysis. The observed accident data, in combination with the 2015 base year modelled flows,

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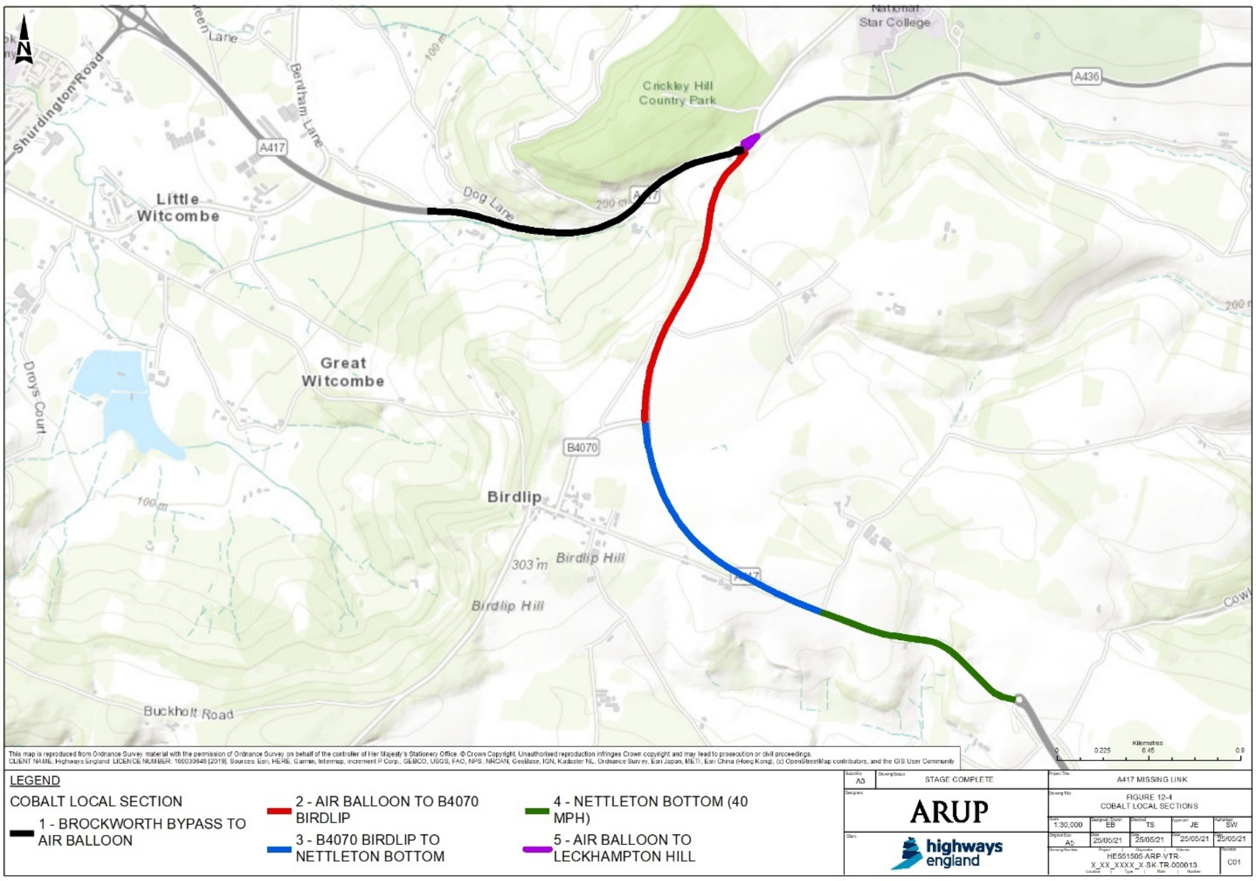
[7] Road Safety Data website https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

is used by the software to derive observed accidents rates on each of the COBALT links.

12.4.21 DM COBALT networks were prepared from the base network by modifying the structure to accommodate the relevant DM schemes. As observed accident data can only be applied to existing links, where new links were added it was necessary to allocate default accident rates (as per COBALT guidance) based on the road classification. DS networks were created from the DM networks in a similar way, with new scheme links and junctions assessed using the default TAG parameters (version 2020.1) for the relevant link and junction types.

12.4.22 Traffic flows for each scenario and year (2026, 2031, 2041 and 2051) are input into COBALT as two-way AADT flows (for link only and combined link/junction analysis; junction only analysis in COBALT requires one way entry flows).

12.4.23 To account for the high number of seriously injured and fatal casualties on the existing single carriageway sections of the A417, the assessments include the application of observed accident severity splits and casualty rates on each of the COBALT links and junctions that constitute this section of the route. A short section of the A436 between the Air Balloon roundabout and the Leckhampton Hill T-junction is also included, as this junction is replaced as part of the scheme. The local severity splits and casualty rates have been derived and applied on five sub sections of the existing single carriageway, as shown in Figure 12-4.



Source: Highways England

Figure 12-4 A417 COBALT local sections

12.4.24 The observed accident severity splits and casualty rates on each of the five sub sections are presented in Table 12-4 and Table 12-5 respectively. National average severity splits and casualty rates for single carriageway A-roads used in COBALT are presented within the tables to demonstrate the high level of serious and fatal accidents on the existing road.

Table 12-4 PIAs by severity, by A417 section (July 2014 to June 2019 inclusive)

Section	Total PIAs	Severity Proportions		
		Fatal	Serious	Slight
Brockworth bypass to Air Balloon	19	0.211	0.368	0.421
Air Balloon to B4070	12	0.083	0.250	0.667
B4070 to Nettleton Bottom	7	0.286	0.286	0.429
Nettleton Bottom (40mph)	7	0.000	0.143	0.857
Air Balloon to Leckhampton Hill	9	0.000	0.333	0.667
TOTAL	**54**	**0.130**	**0.296**	**0.574**
National Average for S2 A-roads (>40mph)	**-**	**0.034**	**0.187**	**0.779**
National Average for S2 A-roads (<=40mph)	**-**	**0.008**	**0.122**	**0.869**

Source: Highways England PCF stage 3 analysis, COBALT TAG Parameters v2020.1

Table 12-5 Casualty rates per PIA by severity, by A417 section (July 2014 to June 2019 inclusive)

Section	Total PIAs	Number of Casualties				Casualties per PIA			
		Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
Brockworth bypass to Air Balloon	19	4	11	17	**32**	0.211	0.579	0.895	**1.684**
Air Balloon to B4070	12	1	6	24	**31**	0.083	0.500	2.000	**2.583**
B4070 to Nettleton Bottom	7	3	3	5	**11**	0.429	0.429	0.714	**1.571**
Nettleton Bottom (40mph)	7	0	1	11	**12**	0.000	0.143	1.571	**1.714**
Air Balloon to Leckhampton Hill	9	0	5	14	**19**	0.000	0.556	1.556	**2.111**
TOTAL	**54**	**8**	**26**	**71**	**105**	**0.148**	**0.481**	**1.315**	**1.944**
National Average for S2 A-roads (>40mph)	47*	2*	11*	61*	**74***	0.038	0.238	1.300	1.576
National Average for S2 A-roads (<=40mph)	7*	0*	1*	8*	**9***	0.009	0.132	1.176	1.317
National Average for S2 A-roads	**54***	**2***	**12***	**69***	**83***	**-**	**-**	**-**	**-**

Source: Highways England PCF stage 3 analysis, COBALT TAG Parameters v2020.1
* National average number of casualties calculated by applying national average casualty rates by road type to number of observed accidents. Numbers may not sum due to rounding.

12.4.25 COBALT version 2013.02 does not currently have the inbuilt functionality to apply observed casualty severity splits, with the software instead applying national average splits and rates based on road type. These national average splits and rates are contained within the default parameters input file used by the software. Accounting for the high level of killed or seriously injured (KSI) casualties on the existing single carriageway section of the road therefore required the modification of the default COBALT parameters file to include the locally observed severity splits and casualty rates. Only the DM links and junctions along the existing single carriageway section use the observed severity splits and casualty rates, with all other links in the COBALT assessment using the default assumptions, based on national averages.

12.4.26 Using the input data (base year and forecast AADTs, observed accidents on each link and the severity information on the local A417 links), COBALT forecasts the number of accidents and casualties in the DM and DS scenarios over a 60-year appraisal period. The number (and severity) of accidents and casualties is monetised by the software using default costs per accident and casualty specified in TAG. By comparing the DM and DS results, the impact of the relevant scheme is identified, in terms of impacts on the number and severity of accidents and casualties as well as the economic costs.

12.4.27 The results of the COBALT assessments are presented in section 13.5 of this report.

Journey time reliability benefits

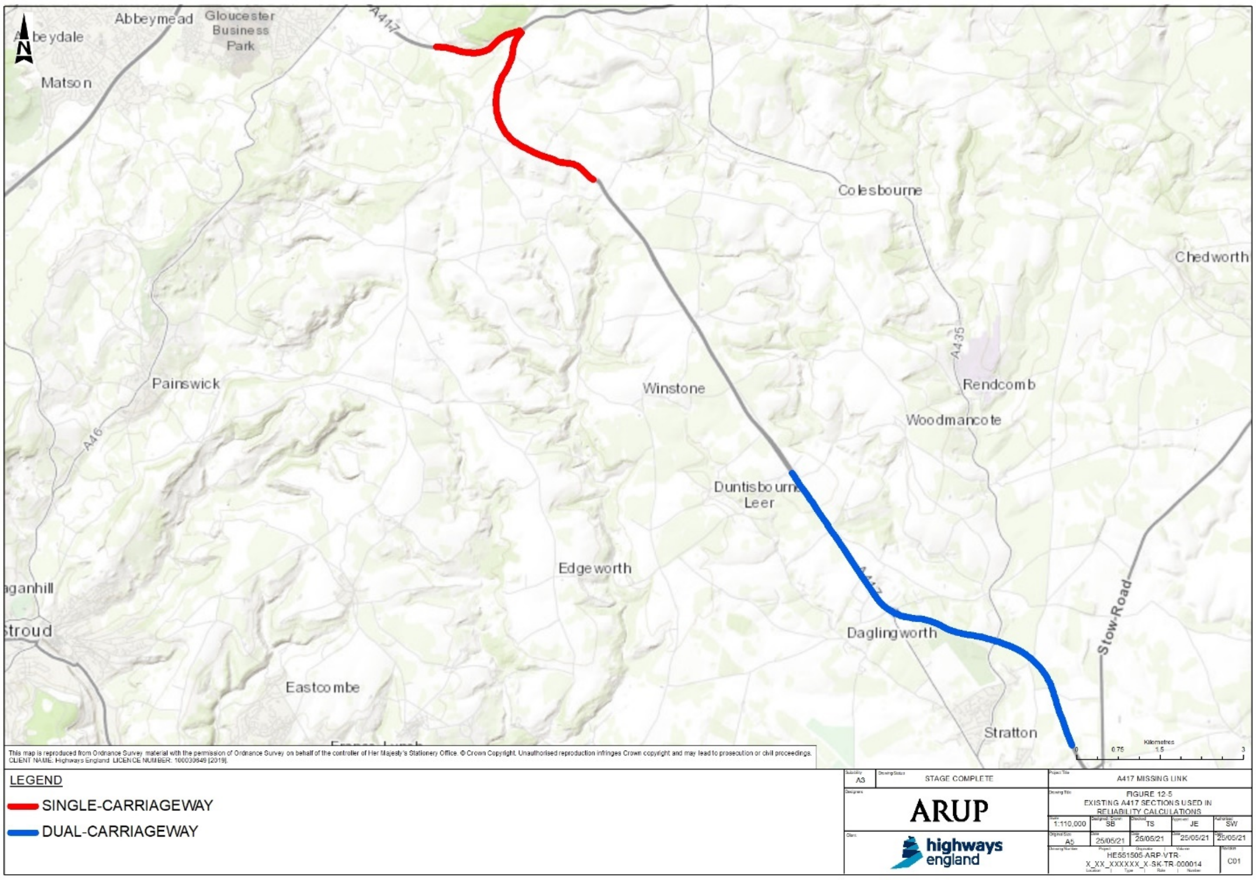
12.4.28 As defined in TAG unit A1.3, ‘reliability’ in this section refers to unpredictable variations in journey times, which could include day to day variation in congestion.

12.4.29 The existing single carriageway section of the A417, which includes at grade junctions at Air Balloon, Birdlip and Cowley, is known to experience large variations in journey times. The removal of the existing at grade junctions and provision of the new dual carriageway section would lead to improved journey time reliability along the A417 route.

12.4.30 As noted in TAG unit A1.3, there is no established approach to appraise reliability impacts for single carriageway inter urban roads such as the A417. Therefore, the methodology outlined below, which has also been adopted on other Highways England RIS schemes, has been implemented.

12.4.31 As recommended in TAG, for the purpose of assessing the impact on journey time reliability, the standard deviation of travel time has been adopted as a measure of travel time variability. The standard deviation of travel times on existing single and dual carriageway sections of the A417 has been measured using TrafficMaster data covering the period September 2014 to August 2015.

12.4.32 Figure 12-5 identifies the sections of the A417 used when calculating travel time variability for the single and dual carriageway sections. Travel time variability has been calculated in both directions separately for the existing single carriageway section. An existing section north of Cirencester was chosen as a representative dual carriageway section, as it includes a grade separated junction and is also far enough south of Cowley roundabout so as to avoid including any delays associated with the start of the single carriageway section at Nettleton Bottom.



Source: Highways England

Figure 12-5 Existing A417 sections used in reliability calculations

12.4.33 Travel time variability was identified for each weekday time period separately (AM 07:00 10:00, IP 10:00 16:00, PM 16:00 19:00 and OP 19:00 07:00), by calculating the standard deviation of journey times in seconds per km for the sections in Figure 12-5 of this report.

12.4.34 Table 12-6 presents the resulting standard deviations in journey times. Outliers have been defined as a single record in which the measured journey time (per km) is five times greater than the average for the particular time period and road type, and any such records have been removed prior to the calculation of the standard deviations. The removal of outliers is intended to ensure that delays associated with day to day variation, rather than incidents, are accounted for in the assessment.

Table 12-6 Existing journey time variability

Road type	Travel time standard deviation (sec/km)			
	AM	IP	PM	OP
Dual carriageway	5.0	3.1	2.7	4.0
Single carriageway westbound	38.6	33.2	38.2	12.9
Single carriageway eastbound	46.7	11.4	16.6	11.2

Source: Highways England

12.4.35 Substantial variations in reliability are seen between the single and dual carriageway sections of the A417, with the dual carriageway section providing minor variations in journey times during all periods of the day. Variation is also evident between the different directions of travel on the single carriageway sections, with the westbound typically less reliable than the eastbound direction. The exception to this eastbound reliability in the morning peak, which shows the greatest variation in journey times.

12.4.36 Reliability benefits are monetised by applying the 'rule of a half' method using the above standard deviations, forecast traffic flows and a forecast value of reliability (VoR) per vehicle. As recommended in TAG unit A1.3, the VoR (in £'s per hour) has been derived using TAG values of time and applying a 'reliability factor' of 0.4.

12.4.37 The methodology is outlined in the following, which is applied separately for each of the four weekday time periods:

$$Benefit = -\frac{1}{2}\Delta\sigma * (F_{DM} + F_{DS}) * VOR$$

Where:

$\Delta\sigma$	is the change in standard deviation of journey time between the DM and DS scenarios on the equivalent sections of road (seconds).
F_{DM}	is the average hourly flow (by period) on the single-carriageway section in the DM scenario.
F_{DS}	is the average hourly flow (by period) on the dual-carriageway section in the DS scenario.

12.4.38 The opening year (2026) reliability benefits are calculated by applying the annualisation factors used in TUBA (see Table 12-3) and have been discounted to 2010 using standard discounting rates. Finally, the benefits have been calculated for the full 60-year appraisal period by applying an appropriate capitalisation factor to the 2026 opening year benefits.

12.4.39 The forecast economic benefits arising from improvements to journey time reliability are set out in section 13.6 of this report.

Construction impacts

12.4.40 The construction of a scheme on the A417 would inevitably lead to disruption on the existing local road network. Roadworks during the construction phase would be expected to cause delays to traffic (due to physical presence of the works with associated speed limits and any delays caused by breakdowns or accidents occurring within the works). This would lead to impacts on travel times, vehicle operating costs, carbon emissions and accident costs.

12.4.41 To quantify the impacts of scheme construction on transport users an economic assessment has been performed with QUADRO (QUADRO 2020 v4.18.0.1)[8].

12.4.42 The assumptions used in the appraisal are based on an assessment of the traffic management arrangements that are considered to be necessary in order to construct the scheme.

12.4.43 The affected sections of existing carriageway include:

- A417 Crickley Hill (between the end of the Brockworth bypass and Air Balloon roundabout) – 1.33 miles (2.15km)
- A417 Cowley junction – 0.5 miles (0.8km)

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8 QUADRO software https://www.tamesoftware.co.uk/quadro/quadro.html

- unnamed side road at Cowley junction – 0.31 miles (0.5km)
- Leckhampton Hill – 0.62 miles (1.0km)
- A417/A436 Air Balloon roundabout
- Shab Hill junction

12.4.44 A summary of the assumed traffic management measures for construction of the scheme is provided in Table 12-7.

Table 12-7 Summary of assumed traffic management construction of the scheme

Year	Speed limit duration (months)	Reduced speed limit	Capacity	Night closures	Weekend closures	Full closures (months)
A417 Crickley Hill – 1.3 miles (2.15km) section of single-carriageway with climbing lane						
2023	3	40mph	1 lane in each direction	0	1	0
2024	12	40mph	1 lane in each direction	4	0	0
2025	10	40mph	1 lane in each direction	4	1	0
A417 Air Balloon roundabout – 0.3 miles (0.5km) section of single-carriageway with climbing lane						
2023	3	40mph	Restricted width	4	0	0
2024	12	40mph	Restricted width	0	0	0
2025	6	40mph	Restricted width	0	0	0
A436 Air Balloon roundabout – 0.3 miles (0.5km) section of single-carriageway with climbing lane						
2023	3	40mph	Restricted width	4	0	0
2024	12	40mph	Restricted width	0	0	0
2025	6	40mph	Restricted width	0	0	0
A417 Cowley roundabout – 0.5 miles (0.8km)						
2024	9	40mph	Restricted width	5	0	0
2025	10	40mph	Restricted width	4	0	0
Leckhampton Hill – 0.6 miles (1km)						
2023	3	30mph	Restricted width	0	0	0
2024	12	30mph	Restricted width	0	0	4
2025	6	30mph	Restricted width	0	0	0
Unnamed Road – 0.3 miles (0.5km)						
2024	9	30mph	Restricted width	4	0	0
2025	10	30mph	Restricted width	0	0	0
New A436 – 0.3 miles (0.5km)						
2025	6	40mph	-	0	0	0
2026	8	40mph	-	0	0	0
New A417 Crickley Hill – 2.2 miles (3.5km)						
2025	2	40mph	Contraflow on NB	0	0	0
2026	8	40mph	Contraflow on NB	0	0	0
2026	2	40mph	Contraflow on SB	0	0	0
New A417 Cowley – 1.6 miles (2km)						
2024	6	40mph	Single lane running	0	0	0
2025	8	40mph	Single lane running	0	0	0

Year	Speed limit duration (months)	Reduced speed limit	Capacity	Night closures	Weekend closures	Full closures (months)
A436 Shab Hill						
2025	-	-	-	4	0	0

Source: Highways England

Speed reduction

12.4.45 Where temporary reduced speed limits have been proposed, consideration has been given to how these would impact on the behaviour of existing traffic and the speeds that traffic currently achieve in practice.

12.4.46 QUADRO does not explicitly account for the significant junction delays at the Air Balloon roundabout or for the slowing of vehicles on the approach to Cowley roundabout. In order to realistically account for these effects an analysis of observed speeds has been undertaken using TrafficMaster data. A summary of the outcomes of this analysis is presented in Table 12-8.

Table 12-8 Observed two-way speed (flow weighted average)

Roadworks section	AM	IP	PM
A417 Crickley Hill	35 mph	44 mph	44 mph
A417 Barrow Wake	31 mph	34 mph	33 mph
A417 South of Cowley roundabout*	65 mph	64 mph	54 mph

Source: Highways England

* the observed section south of Cowley roundabout extends for several kilometres. The observed speed is therefore only partially indicative of the effects of the roundabout on traffic speeds

12.4.47 Given the observed speeds, it was assumed that the 'without works' maximum speed on Crickley Hill would be 50mph (rather than the posted 60mph). Similarly, the assumed maximum speed on the relatively short section south of Cowley roundabout was assumed to be 50mph (rather than the posted 70mph).

Diversion route

12.4.48 The assumed traffic management on the A417 includes a number of full closures during elements of the construction works. While these closures are active the existing established diversion routes for incidents on this section of the A417 would be implemented.

12.4.49 The diversion route for closures of the A417 between the A46 junction and Air Balloon roundabout is 10 miles (DBFO diversion route 2). The diversion route for the A417 between Air Balloon roundabout and Burford Road interchange is 25 miles (DBFO diversion route 3).

12.4.50 The diversion route speed-flow parameters have been calculated using the QDIV functionality within the QUADRO software package. QDIV uses length of diversion route, traffic flows and capacity to calculate the speed-flow parameters of the diversion route.

Maintenance impacts

12.4.51 A quantitative assessment of the impact of on-going routine maintenance has not been undertaken at PCF stage 3.

12.4.52 The PCF stage 3 scheme replaces the existing single carriageway section of the A417 with dual carriageway. There is therefore expected to be a reduction in the impact of routine maintenance on traffic as the additional capacity provided by the dual carriageway gives more scope to mitigate disruption to traffic during roadworks. Furthermore, it is anticipated that routine maintenance would largely be undertaken in the OP period, where possible, and so the foregone benefits of excluding this element from the appraisal would be expected to be very small in scale.

Air quality

12.4.53 An appraisal of the impact of the scheme(s) on air quality has been undertaken in accordance with TAG unit A3 chapter 3. Net present values (NPVs) have been calculated based upon local and regional changes in air quality. Roads in the scheme traffic model that meet the DMRB local and regional air quality screening criteria have been used to derive the NPVs. Changes in air quality have been appraised using the DfT's *Local Air Quality Workbook* and *Air Quality Valuation Workbook* (version July 2020)[9].

Noise impacts

12.4.54 A noise appraisal has been undertaken in accordance with TAG unit A3 chapter 2. NPVs have been calculated for changes in noise, amenity and several specific health issues. In order to derive the NPVs, calculated values for each house within the study area required independent entries in the TAG Noise Worksheets for 'with' and 'without' scheme in both opening and design years.

12.4.55 The calculation area for noise is defined by DMRB Volume 11 Section 3 Part 7 Paragraph A1.11, whilst night-time noise is considered as part of the NPV calculation in accordance with the TAG methodology (version July 2020).

Greenhouse gases

12.4.56 A greenhouse gases (GHG) appraisal has been undertaken in order to determine the carbon dioxide equivalent (CO2e) emissions for the scheme and derive the NPV of the scheme in terms of GHGs. This appraisal was undertaken based on the approach set out in TAG unit A3 chapter 4. Outputs from the scheme traffic model for PCF stage 3 were provided for the scheme. Data on vehicles flow, speed and % HDV (HDV are a sum of HGVs and buses) were available on an AADT basis for the DM and DS scenarios for the scheme. The results were input into the DfT *Greenhouse Gases Workbook* (version July 2020)[10] to generate the associated NPV for the scheme being considered.

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9 TAG environmental worksheets https://www.gov.uk/government/publications/tag-environmental-impacts-worksheets
10 TAG environmental worksheets https://www.gov.uk/government/publications/tag-environmental-impacts-worksheets

Wider economic impacts

Introduction

12.4.57 As defined in TAG unit A2.1, wider economic impacts refer to economic impacts that are additional to the standard transport user benefits assessed by TUBA software.

12.4.58 The following wider economic impacts have been included in the appraisal undertaken at PCF stage 3:

- agglomeration impacts
- labour supply impacts
- output change in imperfectly competitive markets.

12.4.59 The A417/A419 links the M5 at Gloucester with the M4 at Swindon, and forms part of the strategic route between the south coast and the midlands and the north-west. In addition to these more strategic level linkages, the A417 is also an important route for local traffic between Cirencester in the south and Cheltenham and Gloucester in the north. By removing the main bottleneck on the route, the scheme would reduce travel costs and contribute towards increased agglomeration and labour supply impacts.

Methodology

12.4.60 The wider economic impacts have been assessed using the DfT's Wider Impacts in Transport Appraisal (WITA version 2.0 beta)[11] software. WITA assesses the wider economic impacts of a scheme in accordance with the calculations and methodologies set out in TAG unit A2.1.

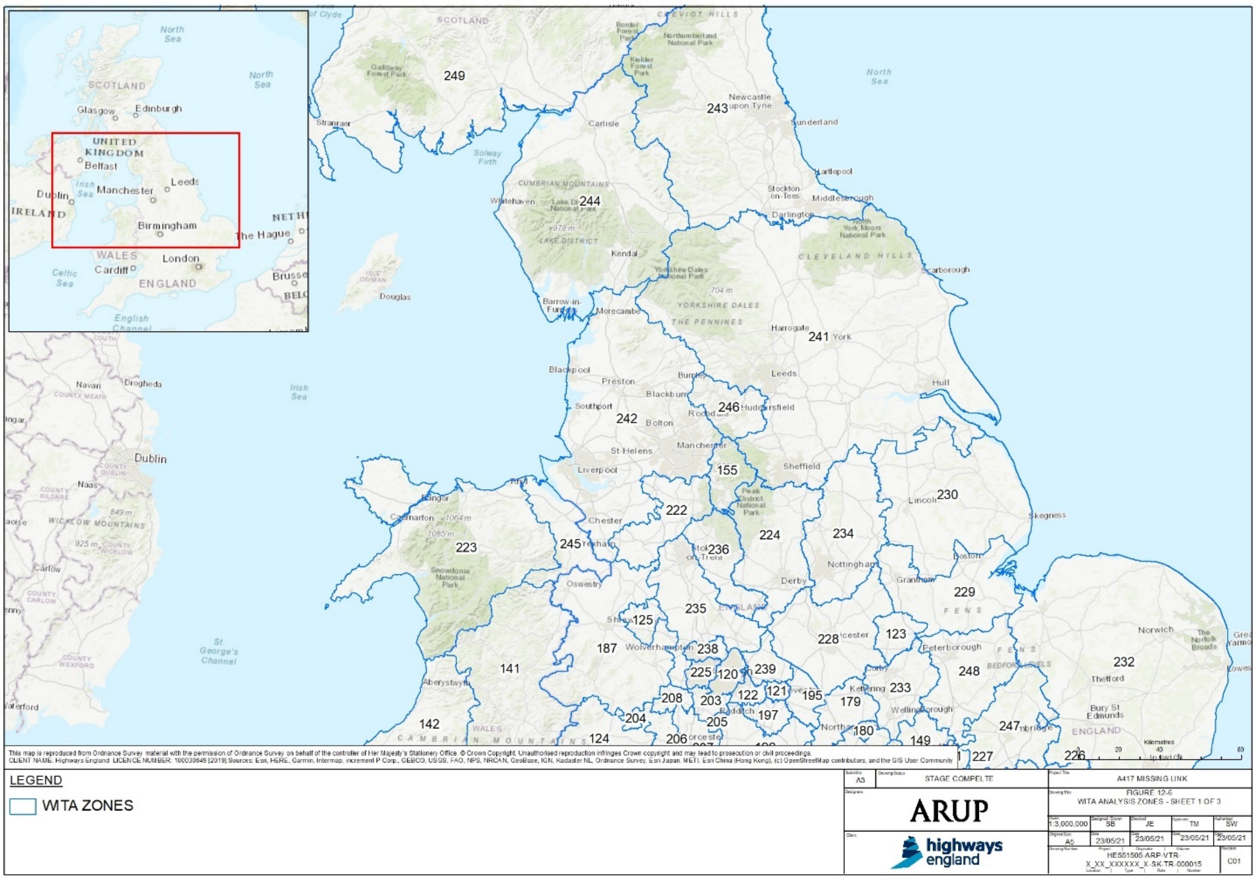
12.4.61 In this section, the assessment of wider economic impacts has only been undertaken for the core scenario, while the high and low growth sensitivity tests have been illustrated in the section 15 of this report.

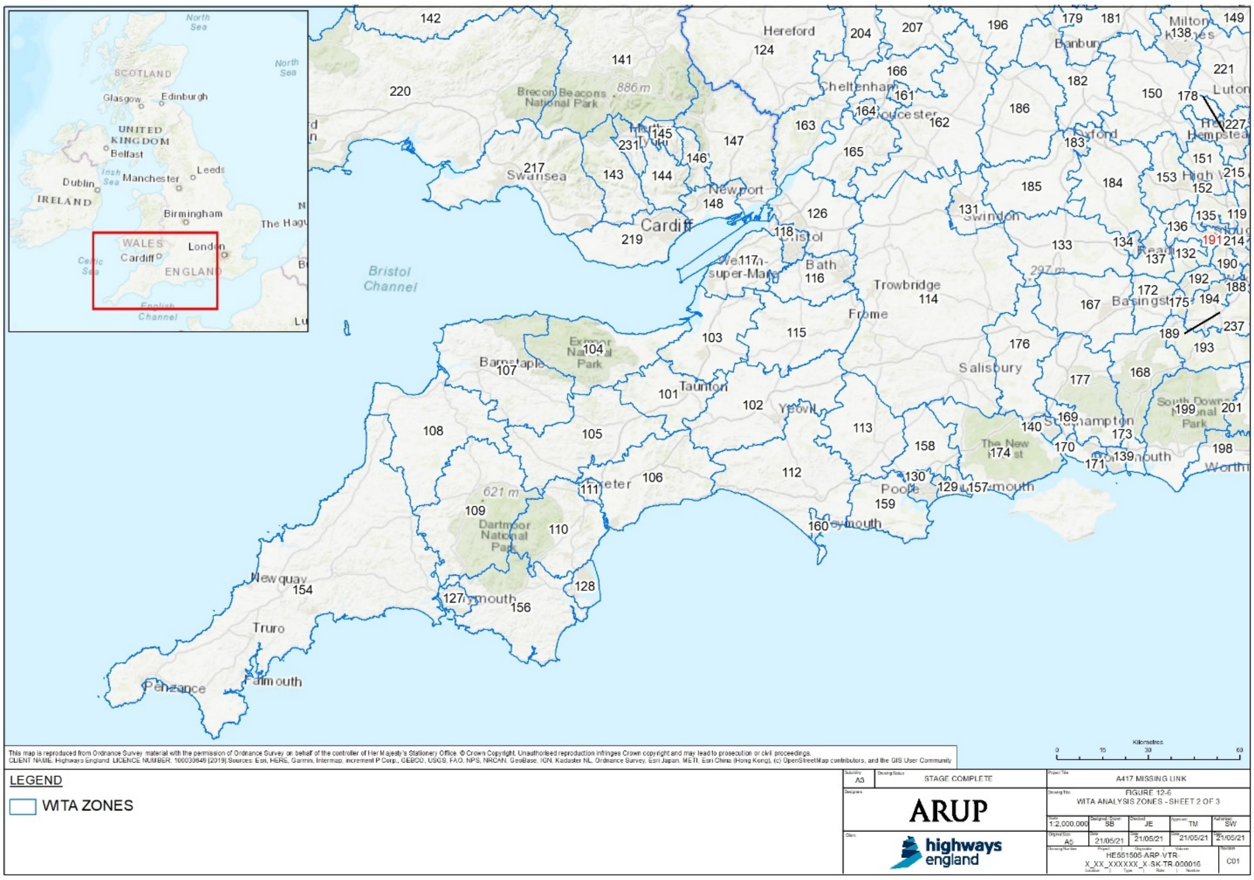
12.4.62 The wider economic appraisal is based on matrices of trips and costs extracted from the scheme traffic model for the four forecast years (2026, 2031, 2041 and 2051). Benefits calculated by WITA are then interpolated and extrapolated by the software to cover the whole 60-year appraisal period from 2026 to 2085.

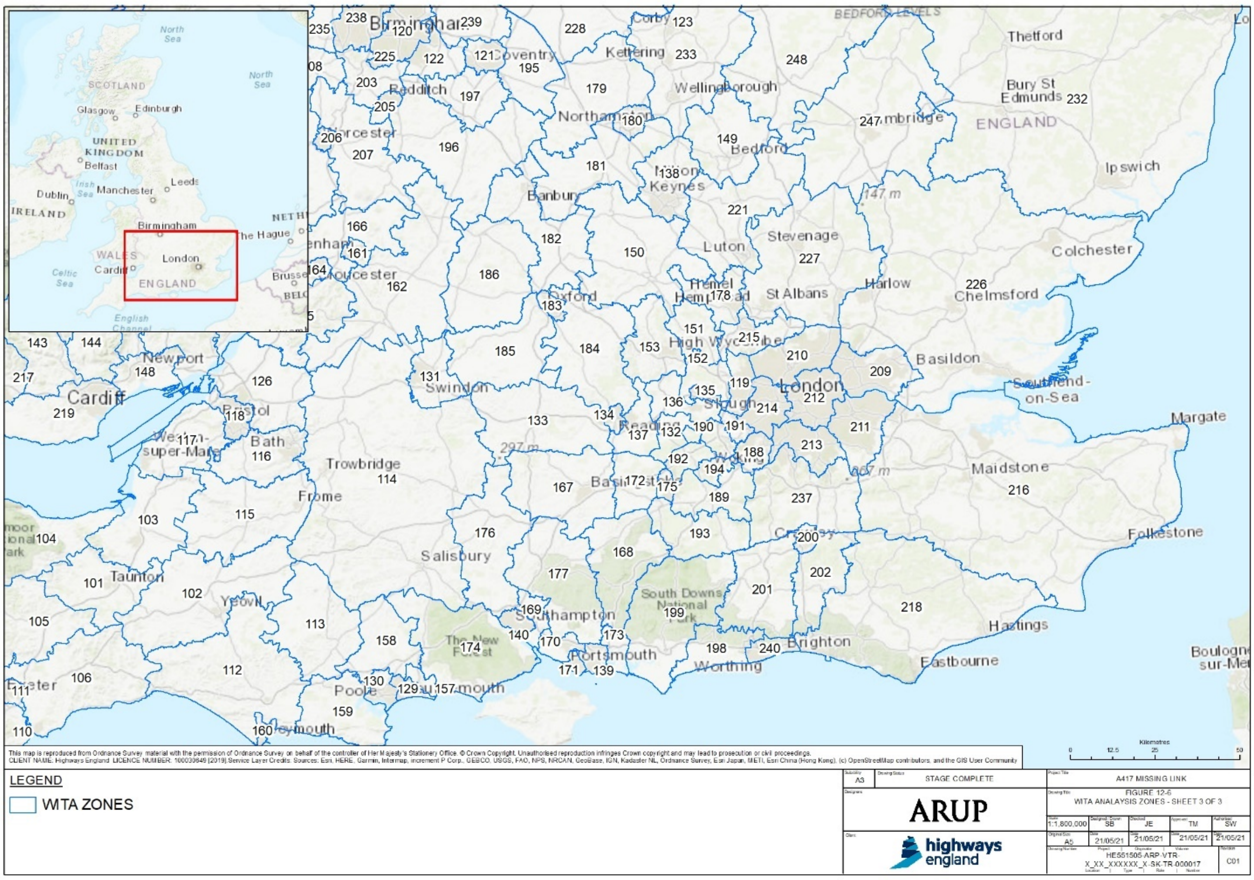
12.4.63 Wider economic impact assessments are based only on travel costs for trips related to employers' business or commute purposes. Inputs to WITA have therefore been limited to forecast trip and travel cost matrices (or skims) for just these purposes.

12.4.64 Given the extent of the scheme traffic model, which has 1,940 zones, and the limitations of the WITA software, it has been necessary to aggregate the trip and cost skims to a coarser zone system consisting of 149 zones (referred to as 'WITA analysis zones'). The calculations undertaken by WITA are done at the level of WITA analysis zones, which are summarised in Figure 12-6. The process of aggregating the scheme traffic model data involved summing the demand and calculating weighted average cost skims (time, distance and tolls) at the 149-zone level.

[11] WITA software https://tagsoftware.co.uk/WITA


LEGEND
WITA ZONES
STAGE COMPLETE
A417 MISSING LINK
FIGURE 12-6
WITA ANALYSIS ZONES - SHEET 1 OF 3
ARUP
highways england
HE551505-ARP-VTR-X_XX_XXXXXX_X-SK-TR-000015
C01


LEGEND
WITA ZONES
STAGE COMPLETE
A417 MISSING LINK
FIGURE 12-6
WITA ANALYSIS ZONES - SHEET 2 OF 3
ARUP
highways england
HE551505-ARP-VTR-X_XX_XXXXXX_X-SK-TR-000016
C01



Source: Highways England

Figure 12-6 WITA analysis zones

12.4.65 The same annualisation factors used in the TUBA assessments (see Table 12-3) have been used in WITA to uplift the results produced for the modelled periods to represent all hours during the year.

12.4.66 The local authority district level economic data (including GDP per worker across four industrial sectors, average wage per worker and the index of labour productivity) input to WITA have been derived from the TAG *Wider Impacts Dataset* (May 2019)[12]. This dataset has also been used to compile other input data, including forecast growth in GDP per worker and economic parameters.

12.4.67 Census journey to work data (2011 Census) has been applied to generate the labour supply impacts which requires a PA matrix for workers.

12.4.68 In assessing wider economic impacts, and the agglomeration impacts in particular, it is important to have confidence in the generalised travel costs extracted from the scheme traffic model. The simulation area of the scheme traffic model includes a detailed highway network and is considered to provide a good representation of travel costs. Outside of the simulation area, confidence in the representation of travel costs is reduced due to the more simplified nature of the network in these areas. Therefore, although the WITA assessments cover the whole extent of the scheme traffic model (including the external areas) only results for the simulation area are extracted and used in the economic appraisal of the scheme.

[12] WITA software https://tagsoftware.co.uk/WITA

13 Economic appraisal results

13.1 Introduction

13.1.1 This section presents the results of the economic appraisal, including the results for each individual element of the appraisal. The approach to their calculation is described in the previous section.

13.2 Analysis of monetised costs and benefits (AMCB)

13.2.1 Table 13-1 shows the AMCB which includes economic assessment results from the TUBA, COBALT, QUADRO, environmental, wider economic benefits and reliability analysis. As per TAG, all costs and benefits reported in this section are in 2010 prices, discounted to 2010. Waterfall charts, which illustrate scheme benefits and costs in a graphical form, are provided for the scheme in Appendix L of this report.

Table 13-1 Analysis of monetised costs and benefits (£000s)

Item	The scheme
Accidents (not assessed by TUBA)[1]	64,890
Roadworks (not assessed by TUBA)[2]	-17,148
Greenhouse gases (not assessed by TUBA)[3]	-39,284
Noise (not assessed by TUBA)[4]	466
Air quality (not assessed by TUBA)[5]	-3,630
Economic efficiency: consumer users (commuting)	45,357
Economic efficiency: consumer users (other)	36,484
Economic efficiency: business users and providers	173,995
Wider public finances (indirect taxation revenues)	44,691
Present value of benefits (PVB)	305,821
Broad transport budget present value of costs (PVC)	205,457
OVERALL IMPACTS	
Net present value (NPV)	100,364
Initial benefit to cost ratio (BCR)	1.49
Reliability benefits	70,502
Wider economic benefits	140,327
Adjusted BCR	2.51

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. [1] from COBALT, [2] from QUADRO, [3] TAG unit A3 chapter 4, [4] TAG unit A3 chapter 2, [5] TAG unit A3 chapter 3. Numbers may not sum due to rounding.

13.2.2 Further detail and associated discussion on the results of each individual element are set out in subsequent sub sections of this section.

13.2.3 The present value of benefits (PVB) over the 60-year appraisal period are £306 million for the scheme.

13.2.4 The scheme achieves an initial BCR of 1.49 and an adjusted BCR of 2.51 when reliability and wider economic benefits are included. The Present Value of Costs (PVC), and therefore the BCR, are calculated from costs based on the design at

August 2020. This compares to an initial BCR of 1.01 and an adjusted BCR of 1.45 at PCF stage 2.

13.2.5 Appendix M of this report contains the analysis carried out to demonstrate the reliability and robustness of the economic appraisal results.

13.3 Transport economic efficiency (TEE)

13.3.1 The results of the assessment of TUBA user benefits are shown in the TEE table of the TUBA output file, which is presented in Table 13-2.

Table 13-2 Transport economic efficiency - benefits (£000s)

Item	The scheme
Consumer – commuting user benefits	**ALL MODES**
Travel time	57,635
Vehicle operating costs	-12,279
User charges	1
During Construction & Maintenance	0
NET CONSUMER - COMMUTING BENEFITS	**45,357**
Consumer - other user benefits	**ALL MODES**
Travel time	87,368
Vehicle operating costs	-50,884
User charges	-0
During construction & maintenance	0
NET CONSUMER - OTHER BENEFITS	**36,484**
Business impacts	**ALL MODES**
Travel time	169,310
Vehicle operating costs	4,673
User charges	13
During construction & maintenance	0
Sub Total	**173,995**
Private sector provider impacts	
Revenue	0
Operating costs	0
Investment costs	0
Grant/subsidy	0
Sub Total	**0**
Other business impacts	
Developer contributions	0
NET BUSINESS IMPACT	**173,995**
TOTAL	
Present value of Transport economic Efficiency benefits (TEE)	**255,836**

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

13.3.2 The TEE table shows that over the 60-year assessment period the scheme achieves total transport economic efficiency benefits of £256 million.

13.3.3 The results of the TEE assessment show efficiency benefits for all trip purposes. As compared to consumer trips, business trips constitute the highest proportion of the reported user benefits. This is mainly due to the relatively higher value of time for business users in the economic assessment.

13.3.4 The TEE benefits arise from the improved travel times provided by the scheme. Vehicle operating costs are forecast to increase (i.e. result in disbenefits), which is primarily a result of the increase in total vehicle kilometres arising in the scheme.

Public Accounts (PA)

13.3.5 Table 13-3 presents the PA summary table in 2010 prices, discounted to 2010 (costs appear as positive numbers, while "Revenue" and "Developer Contributions" appear as negative numbers).

Table 13-3 Summary of Public Accounts - costs (£000s)

Item	The scheme
Local Government funding	**ALL MODES**
Revenue	0
Operating costs	0
Investment costs	0
Developer contributions	0
Grant/subsidy payments	0
NET IMPACT	**0**
Central Government funding: transport	**ALL MODES**
Revenue	27
Operating costs	2,522
Investment costs	202,909
Developer contributions	0
Grant/subsidy payments	0
NET IMPACT	**205,457**
Central Government funding: non-transport	
Indirect tax revenues	-44,691
TOTALS	
Broad transport budget	**205,457**
Wider public finances	**-44,691**

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

13.3.6 The impact on the broad transport budget is £205 million, while the impact on wider public finances is £45 million.

13.4 Accident benefit results

13.4.1 For the scheme, the COBALT assessment evaluates, over a 60-year appraisal period, the number of PIAs, the number of casualties and also a monetised present value cost of accidents. The results from the DS are then compared against the DM results to provide the relative saving in PIAs, casualties, and a monetised present value of accident benefits (over the 60-year appraisal period).

13.4.2 The results of the COBALT assessment for the scheme are presented in Table 13-4.

Table 13-4 Summary of accident benefit results

Accident benefits (£000s)	Number of PIAs saved	Number of casualties saved			
		Fatal	Serious	Slight	Total
64,890	-51.8	66.1	201.2	-29.4	237.9

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010.

13.4.3 The scheme is forecast to lead to a large reduction in the number of KSI casualties, with 66 fewer fatalities forecast over the 60-year appraisal period. There is forecast to be an increase in the total number of accidents and slight casualties, which is a result of the forecast increase in total traffic (vehicle kilometres) within the COBALT study area arising from the scheme.

13.4.4 The large forecast reduction in KSI equates to substantial economic benefits of £65 million.

13.4.5 Figures illustrating the location of monetised accident benefits (and disbenefits) are provided in Appendix N of this report.

13.4.6 The majority of benefits are achieved from the removal of the existing single carriageway section of the A417, which, as discussed previously, has a high incidence of serious and fatal accidents. Other benefits occur on routes on which traffic is forecast to reassign from, including the Birdlip Hill and Elkstone rat runs.

13.4.7 Disbenefits occur where forecast increases in traffic flows shown to increase accidents on the A417/A419 route.

13.5 Journey time reliability benefit results

13.5.1 As discussed in section 12.4 of this report, reliability benefits of the scheme have been estimated based on existing journey time variability along single and dual carriageway sections of the A417.

13.5.2 Table 13-5 presents the results of the journey time reliability assessment.

Table 13-5 Summary of reliability results (£000s)

Opening year reliability benefits	The scheme
AM peak	514.0
IP (includes weekday and weekend IP)	685.6
PM peak	342.9
OP (includes weekday and weekend OP)	164.4

Opening year reliability benefits	The scheme
60-year reliability benefits	**70,502**

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010

13.5.3 The results indicate that the scheme would provide significant reliability benefits of £71 million. This reflects the high levels of travel time variability currently experienced on the existing single carriageway section of the A417.

13.6 Construction delay results

13.6.1 To quantify the impacts of scheme construction on transport users, a QUADRO based economic assessment has been performed for the scheme.

13.6.2 The assessment evaluated the disbenefits due to roadworks during the construction stage of the scheme improvements. The disbenefits are a result of roadworks causing delays to traffic, leading to impacts on travel times, vehicle operating costs, carbon emissions and accident costs.

13.6.3 Table 13-6 provides a summary of QUADRO outputs for the scheme.

Table 13-6 QUADRO impacts (£000s)

Item	Monetised impact (£000s)
Consumers: user costs	
Travel time	8,930
Vehicle operating costs	968
NET CONSUMER IMPACT	**9,898**
Business users: user costs	
Travel time	6,268
Vehicle operating costs	600
Sub total	6,868
Private sector provider impacts	
Operating costs	66
NET BUSINESS IMPACT	**6,934**
Accident costs	1
Fuel carbon emission costs	652
Total non-exchequer impacts	17,485
Government funding	
Present value of costs	-337
OVERALL IMPACT	**17,148**

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Positive values in this table represent costs. Numbers may not sum due to rounding.

13.6.4 The costs of disruption due to construction estimated by QUADRO are £17.15 million. The impacts estimated by QUADRO are primarily a consequence of speed reductions implemented during construction, along with a smaller component of cost arising from a number of weekend and night-time closures on the A417.

13.7 Air quality results

13.7.1 An assessment of the air quality impacts for the scheme has been undertaken in line with TAG guidance. The monetised air quality impacts that result from the assessment are presented in Table 13-7.

Table 13-7 Monetised air quality impacts (£000s)

Item	Monetised impact
Value of change in Particulate Matter (PM2.5) concentrations	-2,456
Value of change in Nitrogen Oxide (NOx) emissions	-1,175
Total value of change in air quality	-3,630

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

13.7.2 The TAG air quality assessment concludes a negative impact for the scheme in terms of increases in PM2.5 emissions and NOx emissions. This is due to an increase in capacity in the road network and increased traffic volumes as a result of the scheme.

13.7.3 The overall outcome from the air quality assessment indicates there would be an increase of 661 tonnes in NOx emission and an increase of 85 tonnes in PM2.5 emissions over the 60-year appraisal period compared to the DM.

13.7.4 The NPV for the air quality assessment is -£3.63 million.

13.8 Noise impact results

13.8.1 An assessment of the noise impacts for the scheme has been undertaken in line with TAG guidance. The monetised noise impacts that result from the assessment are presented in Table 13-8.

Table 13-8 Monetised noise impacts (£000s)

Item	Monetised impact
Present value of noise benefits	466

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010.

13.8.2 The results from the noise assessment for the scheme show an overall benefit for the scheme with a reduction in traffic using the bypassed existing section of A417, coupled with a reduction in traffic on some minor roads contributing to the noise reduction benefits.

13.8.3 The NPV for the noise assessment is £0.466 million.

13.8.4 The result shows an overall positive benefit both in monetisation and health benefits. The number of dwellings realising higher daytime noise levels is 36, whilst by comparison, there would be 119 dwellings which would benefit from reduced daytime noise exposure. The night-time noise exposure levels would result in 24 dwellings realising higher noise levels, whilst 48 dwellings would benefit from noise reductions.

13.8.5 The majority of dwellings benefiting from noise reductions would be as a direct result of the removal of the existing A417 road between Air Balloon roundabout and Cowley junction, where the new scheme corridor moves considerably further away from these dwellings. Mitigation measures have been included to reduce the impact of the new A417 corridor upon dwellings that would realise the largest noise increases from a new traffic noise source. These are a combination of carefully considered landscaping and noise mitigation design (earth bunds and stone walls) to help reduce the spread of traffic noise along the proposed scheme corridor.

13.8.6 With the scheme in place, there would remain five noise important areas (NIAs) which lie within the affected route of the A417 scheme. Two of these NIAs and would benefit from noise reductions of between 12dB (No.1 & 2 Air Balloon Cottages) and 26dB (Castle Hill Cottage) in 2041, as a direct result of the new scheme alignment. Two further NIAs (Fernbank and Crickley Court), would benefit from noise reductions of between 3dB and 8dB(A) in 2041 as a direct result of the inclusion of proposed noise mitigation (noise barriers). NIA (Woodside House) would be removed as part of the scheme proposals. There would be three dwellings that would be eligible for noise insulation under the Noise Insulation Regulations.

13.9 Greenhouse gas results

13.9.1 The monetary value of GHG has been assessed over the 60-year appraisal period based on the approach set out in TAG unit A3 chapter 4 using forecast traffic data and the DfT Greenhouse Gases Workbook. The results are summarised in Table 13-9.

Table 13-9 Monetised greenhouse gases impacts (£000s)

Item	Monetised impact
Value of change greenhouse gases	-39,284

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010.

13.9.2 The results from the GHG assessment show an overall negative impact for the scheme. This is due to increases in traffic volumes using the A417/A419 corridor between the M5 and M4.

13.9.3 The scheme is forecast to increase GHG by 903,811 tonnes over the 60-year appraisal period compared to the DM.

13.9.4 The NPV for the greenhouse gas assessment is -£39.3 million.

13.10 Wider economic impact results

13.10.1 As discussed in section 12.4 of this report, wider economic impacts of the scheme have been assessed using DfT's WITA software.

13.10.2 Table 13-10 presents the wider economic impacts. Agglomeration and labour supply impacts are restricted to the scheme traffic model simulation area, while the benefits associated with increased output in imperfectly competitive markets, which is estimated using a 10% uplift to business user benefits, cover the entire scheme traffic model.

Table 13-10 Estimated wider economic benefits (£000s)

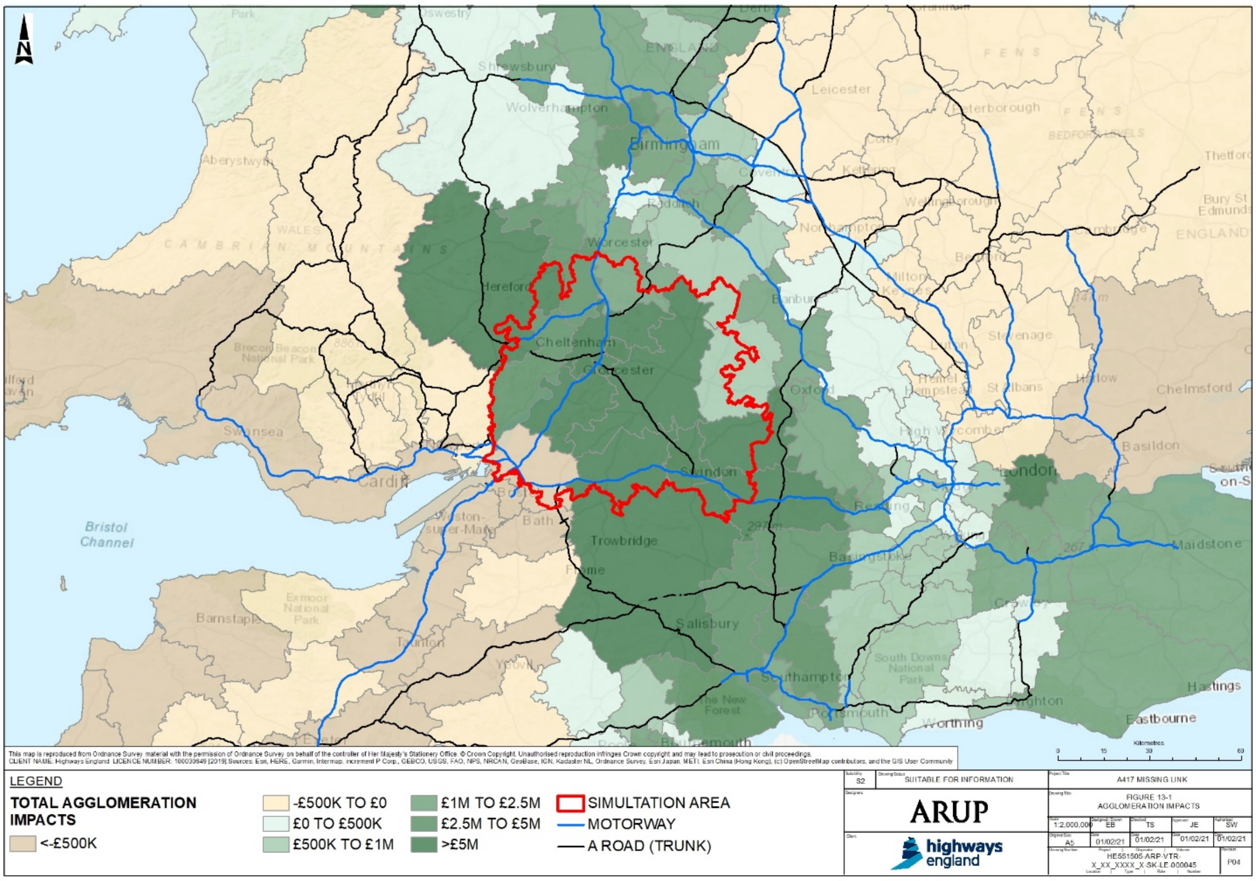
Wider economic impact category	Monetised impact
Agglomeration – manufacturing	10,196
Agglomeration – construction	8,626
Agglomeration – consumer services	23,975
Agglomeration – producer services	77,366
Agglomeration – Total	120,163
Labour supply impact	2,764
Increased output in imperfect competitive market	17,400
Total Wider Economic Impacts	140,327

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

13.10.3 The scheme is forecast to provide significant wider economic benefits, totalling £140 million.

13.10.4 The distribution of agglomeration impacts, which account for approximately 86% of the total wider economic impacts, is summarised in Figure 13-1.



Source: Highways England

Figure 13-1 Agglomeration benefits

13.10.5 As noted above, wider impacts from WITA have only been included in the economic appraisal of the scheme for zones within the scheme traffic model simulation area, where confidence in the scheme traffic model results is highest. This is considered a conservative approach and excludes significant benefits estimated by WITA to occur in adjacent areas.

13.10.6 The distribution of agglomeration impacts appears logical and generally mirrors the pattern of scheme benefits noted from TUBA. Improvements to the A417 contribute to transport user and agglomeration benefits that are aligned with the A417/A419 corridor. Conversely, but to a less marked extent, the effects of increased travel costs on the east-west A436 route that result from the scheme is also reflected in the pattern of small disbenefits in areas affected by this corridor, east and west of the scheme.

14 Distributional impact appraisal

14.1 Introduction

14.1.1 The purpose of a distributional impact (DI) appraisal is to review how impacts arising from a transport scheme differ across various social groups. This section summarises the traffic and economic impacts covered by the DI appraisal. The DI appraisal undertaken for the scheme has followed guidance set out in TAG unit A4.2.

14.1.2 A DI screening exercise has been undertaken and is reported in Appendix O of this report. The screening identified a requirement to complete detailed DI appraisal on the following indicators:

- user benefits
- noise
- air quality
- accidents
- severance
- affordability.

14.1.3 The following sections summarise the DI appraisals undertaken for user benefits, accidents and affordability with the results from the other indicators being summarised in the benefits register as noted above.

14.2 User benefits

14.2.1 In accordance with TAG u

14.2.2 nit A4.2, the distributional impacts on (non-business) road user journeys have been analysed. Impacts arising from business journeys are not included in the assessments as they are experienced by businesses and not individuals.

14.2.3 The user benefit DI analysis has been undertaken for the scheme traffic model simulation area (see Figure 6-2).

14.2.4 User benefits over the 60-year appraisal period have been extracted from TUBA outputs by origin and destination zone for every time period (weekday AM peak, weekday PM peak, weekday IP, weekday OP and weekend). These outputs have been processed and, ultimately, origin benefits have been used for the weekday AM peak, destination benefits for the weekday PM peak and an average of origin and destination benefits for the remaining periods.

14.2.5 User benefits have been processed for non-business journeys only. The methodology followed to achieve this differentiation consisted of selecting TUBA sub-modes 1 and 2 (‘car’ and ‘LGV personal’) and TUBA purposes 2 and 3 (‘home-based commuting’ and ‘home-based other’) only.

14.2.6 Income deprivation data from the 2019 Index of Multiple Deprivation (IMD) was mapped at Lower Super Output Area (LSOA) level and used to identify the distribution of incomes within the national quintiles for each scheme traffic model zone. The spatial distribution of benefits was mapped in GIS using the same geographical level as IMD data (LSOA). This allowed for the calculation of the share of population and the share of benefits for each income deprivation quintile.

14.2.7 Table 14-1 shows the summary of population benefits experienced by each income quintile of population in the study area.

Table 14-1 User benefits distributional analysis summary

	Income Quintile					Total
	<- Most Deprived Areas			Least Deprived Areas ->		
	0-20%	20-40%	40-60%	60-80%	80-100%	
Total population	83,331	104,198	211,627	276,811	321,422	997,389
Share of population	8%	10%	21%	28%	32%	100%
Total Benefits (£000s)	3,893	6,409	14,736	19,285	23,402	67,724
Share of benefits	6%	9%	22%	28%	35%	100%
Assessment	✓✓	✓✓	✓✓	✓✓	✓✓	

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010.

14.2.8 All five income quintiles experience beneficial impacts that are in line (+/-5%) with the proportion of the group in the population. Using the grading system set out in Table 8 of TAG unit A4.2, these results equate to 'moderate beneficial' impacts for each income group.

14.3 Affordability

14.3.1 Affordability DI impacts have also been analysed over the simulation area and in a manner consistent with the analysis of user benefits. Vehicle operating cost (fuel and non-fuel) impacts for consumers were analysed and mapped by LSOA. The results are summarised in Table 14-2.

Table 14-2 Affordability distributional analysis summary

	Income Quintile					Total
	<- Most Deprived Areas			Least Deprived Areas ->		
	0-20%	20-40%	40-60%	60-80%	80-100%	
Total population	83,331	104,198	211,627	276,811	321,422	997,389
Share of population	8%	10%	21%	28%	32%	100%
Total decrease in user charges (£000s)	-1,500	-1,615	-4,087	-5,662	-5,987	-18,851
Total increase in user charges (£000s)	-	-	-	-	-	-
Share of user charge decrease	8%	9%	22%	30%	32%	100%
Share of user charge increase	-	-	-	-	-	-
Assessment	✗✗	✗✗	✗✗	✗✗	✗✗	

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010.

14.3.2 All five income quintiles experience disbenefits (i.e. increased costs) that are in line (±5%) with the proportion of the group in the population and, based on the grading system set out in Table 22 of TAG unit A4.2, the impact on each group is defined as being ‘moderate adverse’.

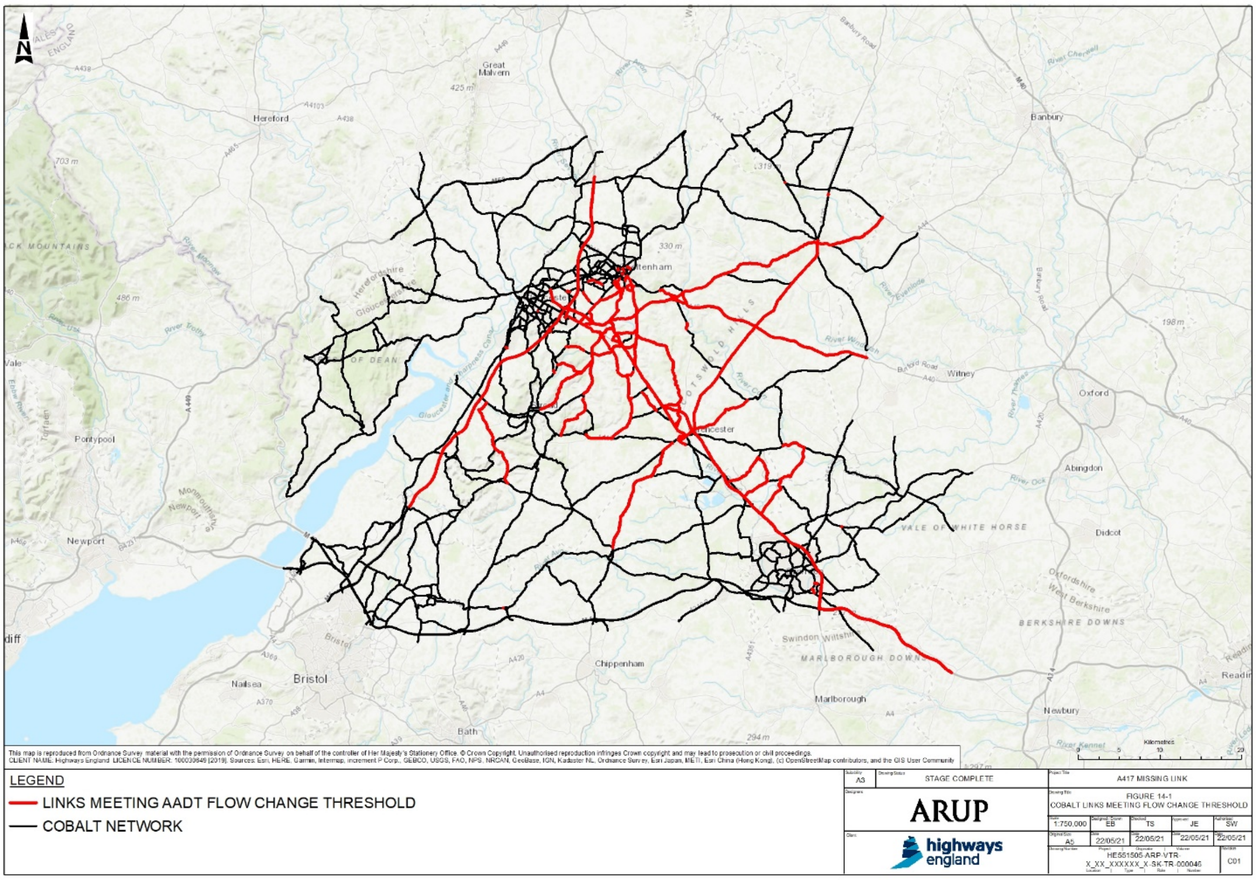
14.3.3 It should be noted that this expected overall increase in vehicle operating costs is partly driven by trip redistribution effects (i.e. users choose to travel further due to the reductions in travel time that the scheme provides, hence incurring greater vehicle operating costs). The overall increases in costs lead to the adverse impacts identified above. However, for the majority of individual existing trips, and particularly those travelling along the A417, the scheme would actually reduce vehicle operating costs as the new alignments are more direct and less congested than the current route. Therefore, at a personal level, the impact of the scheme on the affordability of existing trips is likely to be beneficial.

14.4 Accidents

14.4.1 The scheme involves a change in route alignment and traffic forecasts have identified numerous links on which changes in total traffic flows are forecast to exceed 10%. As a result, a full assessment of the distributional impact on accidents has been carried out, as outlined in TAG DI guidance.

14.4.2 Due to the short length of the majority of the 2,097 COBALT network links in the study area, most of these have been aggregated into 310 road links to conduct the accidents analysis. Links that are forecast to experience changes in total daily traffic flows due to the scheme of at least 500 vehicles or 5% have been selected and are considered within the DI accident appraisal.

14.4.3 Thirty-eight of these road links, amounting altogether to 372 COBALT network links and 515km, are forecast to experience changes in total daily traffic flows due to the scheme of at least 500 vehicles or 5% and these are shown in Figure 14-1.



Source: Highways England

Figure 14-1 COBALT links meeting traffic flow change threshold

14.4.4 Accident data for the full five-year period between 01 January 2015 to 31 December 2019 has been obtained from the DfT statistics website. Each accident has been allocated to a COBALT link and, consequently, to a larger road link. On the 38 road links meeting the five percent flow change criterion, there were a total of 1,747 accidents, which resulted in 2,474 casualties, over the five-year period. Table 14-3 shows the casualty rates[13] by vulnerable group across the 38 road links on which the flow threshold has been met. The table also contains national average casualty rates by the same vulnerable groups and an existing casualty rate comparison as defined in Table 11 of TAG unit A4.2.

[13] Defined as the number of casualties per accident as found in supplementary guidance contained within the document *DI Appraisal and HE Major Schemes V6d*

Table 14-3 Proportion of casualties by vulnerable group

Group	% of Casualties in study area	National average	Existing casualty rate
Pedestrians	10%	15%	LOW
Cyclists	14%	9%	HIGH
Motorcyclists	15%	12%	MEDIUM
Children aged under 16	11%	13%	MEDIUM
Older people aged 70+	17%	14%	MEDIUM
Young males aged 16-25	10%	15%	MEDIUM

Source: Highways England

14.4.5 Based on criteria set out in Table 11 of TAG unit A4.2, the casualty rate for pedestrians is defined as being 'low' compared to the national average. This assessment is likely to be reflective of the predominantly rural nature of the 38 road links analysed, as pedestrian flows are likely to be small compared to those in more built-up areas. On the other hand, the casualty rate for cyclists is estimated as 'high'. This may be due to the fact that the majority of the assessed road links are A- or B-roads, which cyclists use due to their importance in linking settlements, but which bear cars passing at high speeds. The casualty rates for the other four groups are classified as being 'medium' under the TAG criteria.

14.4.6 The criteria in Table 14-4, which are based on Table 11 in TAG unit A4.2, were used to assign a DI score for each link on which flows are forecast to change by at least 10%. Note that the TAG scoring criteria set out in Table 14-4 are identical for groups categorised as having either 'low' or 'medium' existing casualty rates.

Table 14-4 DI accident appraisal score matrix

Change in Traffic Flow	Existing casualty rate for vulnerable users*		
	Low	Medium	High
Significant reduction (>15% decrease)	Moderate Beneficial	Moderate Beneficial	Large Beneficial
Slight reduction (>5%, <15% decrease)	Slight Beneficial	Slight Beneficial	Moderate Beneficial
Neutral (<5% increase or decrease)	Neutral	Neutral	Neutral
Slight increase (>5%, <10% increase)	Slight Adverse	Slight Adverse	Moderate Adverse
Significant increase (>10% decrease)	Moderate Adverse	Moderate Adverse	Large Adverse

Source: Highways England

* the existing casualty rate is defined for each vulnerable group based on criteria in Table 11 TAG unit A4.2 and reported for each group in Table 14-1.

14.4.7 The link-by-link results show a vast majority of 'neutral' impacts. However, it was decided that a quantitative methodology would be the best way to determine the overall score for each vulnerable group. Therefore, an approach has been adopted whereby the total length of link in each DI score category is summed. This methodology also helps to account for the variation in road link lengths, which may have provided an inaccurate perception of reality. The values in Table 14-5, which summarises the results of the DI accident appraisal for the scheme, are therefore the total length of link in each category.

Table 14-5 Length of links (km) meeting DI score by vulnerable users

DI Accident	Vulnerable Group					
	Children (medium)	Young males (medium)	Older people (medium)	Pedestrians (low)	Cyclists (low)	Motor-cyclists (low)
Large beneficial	0	0	0	0	0	0
Moderate beneficial	0	0	0	0	0	0
Slight beneficial	0	0	0	0	0	0
Neutral	326,823	326,823	326,823	326,823	326,823	326,823
Slight adverse	29,849	14,485	14,485	0	15,364	14,485
Moderate adverse	0	15,364	15,364	29,849	14,485	15,364
Large adverse	0	0	0	0	0	0
Total	**356,672**	**356,672**	**356,672**	**356,672**	**356,672**	**356,672**
Overall score	**Neutral**	**Neutral**	**Neutral**	**Neutral**	**Neutral**	**Neutral**

Source: Highways England

14.4.8 The results are very similar for all groups, with a clear dominance of 'neutral'. Despite a small lean towards 'adverse', this is not enough to shift the overall score. On balance, the distributional impact of accidents is considered to be 'neutral'.

15 Sensitivity tests

15.1 Introduction

15.1.1 This section presents the results of the economic appraisal undertaken for the high and low growth sensitivity tests for the scheme. The methodology used to derive forecast reference demand matrices for the high and growth scenarios is outlined in section 10.6 of this report.

15.2 High and low growth

15.2.1 Table 15-1 shows the Analysis of Monetised Costs and Benefits (AMCB) for the high and low growth scenarios, alongside the equivalent values for the core scenarios for the scheme. The results of the assessment of TUBA user benefits are shown in the TEE table, which is presented in Table 15-2 for the high and low growth scenarios.

15.2.2 At PCF stage 3, the economic impacts associated with accidents, roadworks, GHG, noise and air quality have not been calculated separately for the high and low growth scenarios. Therefore, the figures in the AMCB for these elements of the appraisal are taken directly from the core scenario for the scheme.

15.2.3 The benefits (and therefore BCRs) in the sensitivity tests form a range around the central/core case and are in line with expectations, with fewer benefits in the low growth scenario and greater benefits the high growth scenario.

15.2.4 The benefits are slightly asymmetrical with a skew towards low growth (i.e. the difference between the low growth and core scenarios is greater than the difference between the high growth and core scenarios). This is likely to be a result of greater levels of congestion on adjacent parts of the network (e.g. M4 J15, M5 J11a) that would meter traffic growth along the A417/A419 route, particularly in the peak periods. This is supported to a degree by distribution of benefits across the day, with a lower proportion of benefits accrued in the peak periods in the high growth scenarios.

Table 15-1 Analysis of monetised costs and benefits (£000s) – high and low growth

Item	The scheme		
	Low	Core	High
Accidents (not assessed by TUBA)[1]	64,890		
Roadworks (not assessed by TUBA)[2]	-17,148		
Greenhouse gases (not assessed by TUBA)[3]	-39,284		
Noise (not assessed by TUBA)[4]	466		
Air quality (not assessed by TUBA)[5]	-3,630		
Economic efficiency: consumer users (commuting)	38,147	45,357	46,529
Economic efficiency: consumer users (other)	30,756	36,484	36,001
Economic efficiency: business users and providers	159,174	173,995	192,686
Wider public finances (indirect taxation revenues)	43,142	44,691	45,209
Present value of benefits (PVB)	276,513	305,821	325,719
Broad transport budget present value of costs (PVC)	**205,457**		
OVERALL IMPACTS			
Net present value (NPV)	71,056	100,364	120,262
Initial benefit to cost ratio (BCR)	**1.35**	**1.49**	**1.59**
Reliability benefits	70,502		
Wider economic benefits	142,185	140,327	137,840
Adjusted BCR	**2.38**	**2.51**	**2.60**

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. [1] from COBALT, [2] from QUADRO, [3] TAG unit A3 chapter 4, [4] TAG unit A3 chapter 2, [5] TAG unit A3 chapter 3.
BCRs in Table 15-1 are currently based on the design at August 2020.
Numbers may not sum due to rounding.
Source: Highways England

Table 15-2 Transport economic efficiency – benefits (£000s) – high and low growth

Item	The scheme		
	Low	Core	High
Consumer – commuting user benefits	**ALL MODES**	**ALL MODES**	**ALL MODES**
Travel time	48,922	57,635	60,084
Vehicle operating costs	-10,776	-12,279	-13,552
User charges	1	1	-3
During Construction & Maintenance	0	0	0
NET CONSUMER - COMMUTING BENEFITS	**38,147**	**45,357**	**46,529**
Consumer - other user benefits	**ALL MODES**	**ALL MODES**	**ALL MODES**
Travel time	77,703	87,368	90,279
Vehicle operating costs	-46,952	-50,884	-54,274
User charges	5	0	-3
During construction & maintenance	0	0	0
NET CONSUMER - OTHER BENEFITS	**30,756**	**36,484**	**36,001**
Business impacts	**ALL MODES**	**ALL MODES**	**ALL MODES**
Travel time	156,383	169,310	184,345
Vehicle operating costs	2,777	4,673	8,330
User charges	14	13	11
During construction & maintenance	0	0	0
Sub Total	**159,174**	**173,995**	**192,686**
Private sector provider impacts			
Revenue	0	0	0
Operating costs	0	0	0
Investment costs	0	0	0
Grant/subsidy	0	0	0
Sub Total	**0**	**0**	**0**
Other business impacts			
Developer contributions	0	0	0
NET BUSINESS IMPACT	**159,174**	**173,995**	**192,686**
TOTAL			
Present value of transport economic efficiency benefits (TEE)	**228,077**	**255,836**	275,216

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

Source: Highways England

15.3 Greenhouse gases high value sensitivity test

15.3.1 In addition to the traditional high and low growth sensitivity tests that are required by the DfT to assess the impact of alternative growth scenarios on the BCR there is now the requirement to assess the impact of higher carbon values on the BCR of the scheme.

15.3.2 This additional GHG sensitivity test has come about as the value placed on changes in GHG emissions are currently under review now the UK has increased its domestic and international ambitions. Accordingly, current central carbon values are likely to undervalue GHG emissions, though the scale of the undervaluation is still unclear. The potential impact of placing a higher value on GHG emissions can be illustrated by using existing high carbon values series, in addition to the prescribed central values. Her Majesty's Government are planning to review the carbon values during 2020.

15.3.3 The higher value carbon values have been applied to the scheme and when applied the disbenefit is £60.8 million over the 60-year appraisal period. When this is applied to the core growth scenario the initial BCR is 1.38, down from 1.49 and the adjusted BCR is 2.41, down from 2.51. The AMCB for this sensitivity test can be seen in Table 15-3.

Table 15-3 Analysis of monetised cost benefits (£000s) - GHG high values and core growth

Item	PCF stage	Benefits (£000s)
Accidents (not assessed by TUBA)[1]	3	64,890
Roadworks (not assessed by TUBA)[2]	3	17,148
Greenhouse gases (not assessed by TUBA)[3]	3	60,812
Noise (not assessed by TUBA)[4]	3	466
Air quality (not assessed by TUBA)[5]	3	3,630
Economic efficiency: consumer users (commuting)	3	45,357
Economic efficiency: consumer users (other)	3	36,484
Economic efficiency: business users and providers	3	173,995
Wider public finances (indirect taxation revenues)	3	44,691
Present value of benefits (PVB)	**3**	**284,293**
Broad transport budget present value of costs (PVC)	**3**	**205,457**
OVERALL IMPACTS		
Net present value (NPV)	3	78,836
Initial benefit to cost ratio (BCR)	**3**	**1.38**
Reliability benefits	3	70,502
Wider economic benefits	3	140,327
Adjusted BCR	3	**2.41**

Abbreviations List

AADT	Annual Average Daily Traffic
AAWT	Annual Average Weekly Traffic
AMCB	Analysis of Monetised Costs and Benefits
AONB	Areas of Outstanding Natural Beauty
ARCADY	Assessment of Roundabout Capacity And DelaY software
ArcGIS	Geographic Information Software
ARR	Analytical Requirements Report
ASR	Appraisal Specification Report
ATC	Automatic Traffic Count
BCR	Benefit Cost Ratio
BME	Black and Minority Ethnic
BYFM	Base Year Freight Matrices
CO2e	Carbon Dioxide Equivalent
COBA	Cost Benefit Analysis
COBALT	Cost and Benefit to Accidents – Light Touch
ComMA	Combined Modelling and Appraisal Report
CSV	Central Severn Vale
D2AP	Dual 2 Lane Carriageway
DBFO	Design Build Finance Operate
DCO	Development Consent Order
DfT	Department for Transport
DI	Distributional Impact
DIADEM	Dynamic Integrated Assignment and Demand Modelling
DM	Do Minimum
DMRB	Design Manual for Roads and Bridges
DS	Do Something
EA	External Area
FCG	Forecasting Consistency Group
FMA	Fully Modelled Area
GCC	Gloucestershire County Council
GEH	Geoffrey E Havers
GHG	Greenhouse Gases

GIS	Geographical Information System
GONZO	SATURN Parameter
GPS	Global Positioning System
GRIP	Governance for Railway Investment Projects
HBEB	Home-Based Employer's Business
HBO	Home-Based Other
HBW	Home-Based Work
HDV	Heavy Duty Vehicle
HEDDiT	Highways England Donor Distribution Tool
HEIDI	Highways England Integrated Demand Interface
HGV	Heavy Goods Vehicle
IMD	Index of Multiple Deprivation
ITN	Integrated Travel Network
JCS	Joint Core Strategy
KLUNK	SATURN Parameter
KSIs	Killed or Seriously Injured
LAD	Local Authority District
LGV	Light Goods Vehicle
LMVR	Local Model Validation Report
LSOA	Lower Super Output Area
MCTC	Manual Classified Turning Count
ME	Matrix Estimation
MMQ	Mean Max Queue
MPD	Mobile Phone Data
MVR	Model Validation Report
NAPALM	National Air Passenger Allocation Model
NDC	Nationwide Data Collection
NHBEB	Non-Home-Based Employer's Business
NHBO	Non-Home-Based Other
NIA	Noise Important Areas
NPV	Net Present Value
NRTS	National Rail Travel Survey
NTEM	National Trip End Model

NTM	National Transport Model
NTS	National Travel Survey
OD	Origin/Destination
ORPA	Other Route with Public Access
PA	Production/Attraction
PA	Public Accounts
PCF	Project Control Framework
PCU	Passenger Car Unit
PIA	Personal Injury Accident
PM	Particulate Matter
PPK	Pence Per Kilometre
PPM	Pence Per Minute
PRoW	Public Rights of Way
PT	Public Transport
PVB	Present Value of Benefits
PVC	Present Value of Costs
QDIV	Functionality within the QUADRO software package
QUADRO	QUeues and delays at ROadworks
RFC	Ratio to Flow Capacity
RIP	Road Investment Programme
RIS	Road Investment Strategy
RoF	Region of Focus
RTF15	Road Traffic Forecasts 2015
RTF18	Road Traffic Forecasts 2018
RTM	Regional Traffic Model
S2	Single Carriageway
SATURN	Simulation and Assignment of Traffic to Urban Road Networks
SQRT	Square root
SRN	Strategic Road Network
SWRTM	South West Regional Traffic Model
TAG	Transport Appraisal Guidance
TEE	Transport Economic Efficiency
TEMPro	Trip End Model Presentation Programme

TIS Trip Information System

TUBA Transport User Benefits Appraisal

VDM Variable Demand Modelling

VISSIM "microscopic multi-modal traffic flow simulation software package developed by PTV"

VoR Value of Reliability

WITA Wider Impacts of Transport Appraisal

WS2 Side Single Carriageway

Glossary

Agglomeration benefits	Wider economic benefits of the scheme that arise from improved connectivity and reduced journey times
All costs and benefits are in 2010 prices	All costs and benefits are in a 2010 price base and discounted to 2010 to provide a consistent base for comparison of costs and benefits during the scheme development and to allow ease of comparison across schemes in the United Kingdom
Annual Average Daily Traffic (AADT)	Average traffic flow for a 24-hour period across the year, this includes weekends and bank holidays
Annual Average Weekly Traffic (AAWT)	Average traffic for a 18/24-hour period across the year for weekdays only, this excludes bank holidays
Annualisation factor	A factor applied to modelled traffic flows to convert a peak hour flow or an average hour modelled flow to a number which represents all hours during a year
Base Year Freight Matrices	Origin and destination data collected by the Department of Transport for freight traffic
Benefit cost ratio	A benefit cost ratio (BCR) is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed scheme
Buffer network	The buffer network represents the highway network in the traffic model where impacts of the scheme are forecast to be minimal. The buffer area is coded in less detail and may only include key roads in and out of the model simulation area.
Capitalisation factor	The factor that accounts for changes in the value of time cost over the 60-year appraisal period
Chi-squared statistic	A statistical test to determine if there is a statistically significant difference the observed data and the modelled data

CLICKS	A traffic modelling parameter in the SATURN software. The parameter allows a specific maximum speed to be applied to a specific user class.
Coded capacities	A traffic modelling term. Each approach arm to a node (junction) in the traffic model is assigned a capacity which reflects the estimated number of vehicles (pcus) which could route through that approach arm in uncongested conditions
Convergence criteria	Criteria to assess the stability of the traffic model. These criteria demonstrate the traffic model provides stable, consistent and robust results
Cordon	A traffic modelling term. 'Cordoning' a traffic model is a process to extract a model network and trip matrix from a defined area of an existing traffic model. A 'cordon' can also be used through the model calibration/validation stage to check modelled flows against observed flows around a defined 'cordon'. For example, around a town or city.
Cost and Benefit to Accidents – Light Touch	Department for Transport software for assessing the impact a scheme will have on road traffic accidents. The assessment is calculated on a monetary basis for a 60-year appraisal period.
Development quantum	The development quantum denotes the size and type of development allocated to a site/area.
Discounted to 2010	The process of converting the monetised benefits/disbenefits over the 60-year appraisal period to a common base for comparison during the scheme development stage. Allows ease of comparison across schemes in the United Kingdom
Do-Minimum	A traffic modelling term. The 'Do Minimum' is referred to as the future year traffic model scenario that includes committed development and schemes but does not include the scheme being appraised.
Donor zones	A traffic modelling term. Used to refer to a traffic model zone which is used to replicate similar characteristics when creating a new zone. The 'donor zone' is generally located in close proximity of the new zone and have a similar land use
Do-Something	A traffic modelling term. The 'Do Something' is referred to as the future year traffic model scenario that includes committed development and schemes, but also includes the scheme being appraised.
Dummy nodes	A traffic modelling term. Used to refer to a 'node' (junction) in the traffic model. The junction coded as the 'dummy node' in the traffic model does not model junction delay.
Fuel cost elasticity	Cost elasticity measures the responsiveness of total cost to changes in output. Fuel cost elasticity refers to the percentage change in car vehicle-km with respect to the percentage change in fuel cost

GEH Statistic	A mathematical formula similar to the CHI-Squared test that compares two sets of data, in this case modelled and observed traffic flows
Generalised Costs	In transport economics, the generalised cost is the sum of the monetary and non-monetary costs of a journey.
GONZO	A traffic modelling parameter in the SATURN software. All elements in the trip matrix are factored by GONZO.
Heavy Goods Vehicle (HGV) / Heavy Duty Vehicle (HDV)	Any vehicle over 3.5 tonnes
Hierarchical incremental model	Demand model component of the Variable Demand Modelling that reflects how demand will change as costs change. Model responses are in relation to frequency, time period choice, mode choice (with rail) and distribution and these follow a hierarchy set out in TAG M2.1
Home-Base Other	A traffic modelling term. Used to define a particular type of trip in the building of the trip matrices. These are trips that start from home and return home that are related to other activities such as shopping, leisure activities etc.
Home-Based Employer's Business	A traffic modelling term. Used to define a particular type of trip in the building of the trip matrices. These trips are those which capture employer's business trips that start from home and return home
Home-Based Work	A traffic modelling term. Used to define a particular type of trip in the building of the trip matrices. These are trips that move between a person's home and place of work i.e. commuting.
Income Deprivation	One of the Index of Multiple Deprivation (IMD). The Income Deprivation Domain measures the proportion of the population in an area experiencing deprivation relating to low income.
Income Deprivation quintile	The Index of Multiple Deprivation (IMD) classifies areas into five quintiles based on relative disadvantage, with quintile 1 being the most deprived and quintile 5 being the least deprived.
Index of Multiple Deprivation (IMD)	Indices of multiple deprivation (IMD) are widely used datasets within the UK to classify the relative deprivation (essentially a measure of poverty) of small areas. Multiple components of deprivation are weighted with different strengths and compiled into a single score of deprivation.
Integrated Transport Network	Ordnance Survey GIS layer that contains the highway network and route information for Great Britain
Kirchhoff's Law	In terms of traffic modelling, Kirchoff Law states that traffic flows into a junction must equal traffic flows out of junction

KLUNK	A traffic modelling parameter in the SATURN software. This parameter defines the choice of method for variable speeds under the SATURN parameter CLICKS
Link Flow Validation	The process of comparing modelled traffic data on a section of road to observed traffic data. The difference between the modelled and observed traffic flows should be within the defined criteria as set out in TAG M3.1 to satisfy the link flow validation.
Lower Super Output Area (LSOA)	Super Output Areas (SOAs) are a set of geographical areas developed following the 2001 census, initially to facilitate the calculation of the Indices of Deprivation 2004 and subsequently for a range of additional Neighbourhood Statistics (NeSS). The aim was to produce a set of areas of consistent size, whose boundaries would not change (unlike electoral wards), suitable for the publication of data such as the Indices of Deprivation. They are an aggregation of adjacent Output Areas with similar social characteristics. Lower Layer Super Output Areas (LSOAs) typically contain 4 to 6 OAs with a population of around 1500.
Matrix Estimation Process	A traffic modelling term. A modelling process that uses observed traffic count data to refine the trip matrices to improve the fit between modelled and observed traffic data
Mean Max Queue	This is the estimated mean number of vehicles (or pcus) which have a traffic queue up to the time when the queue finally clears.
Micro-simulation model	Micro-simulation models are used to model the behaviour of individual vehicles through a network in real time and provide a 3D visualisation. Microsimulation models are used to forecast the performance of individual junctions or a combination junctions.
Mobile Phone Data	Origin and Destination data collected by the use of mobile phones
Modelled Flows	Traffic flows extracted from the scheme traffic model (base year or forecast year)
National Rail Travel Survey	A survey of passenger trips on the national rail system in Great Britain on weekdays undertaken outside of school holidays
National Transport Model	A Department for Transport model that provides the Regional Traffic Forecasts. These growth forecasts are applying to traffic models to create forecast year models
National Travel Survey	A regular household survey to monitor long-term trends in personal travel. This survey collects information on how, why, when and where people travel as well as factors affecting travel (e.g. car availability and holders of driving licences)
National Trip End Model	Department for Transport database that forecasts the growth in trip origin-destinations up to 2051
Net Present Value	The difference between the Present Value Benefits and the Present Value Costs

Node	A traffic modelling term. A 'node' is a junction coded into the traffic model. It can either form all of the junction, part of a large complex junction or can be used as a point at which the characteristic of road changes
Non-Home-Based Employer's Business	A traffic modelling term. Used to define a particular type of trip in the building of the trip matrices. These trips are those which capture employer’s business trips that start and end from somewhere other than home
Non-Home-Based Other	A traffic modelling term. Used to define a particular type of trip in the building of the trip matrices. These trips are those which capture trips that start and end from somewhere other than home for other activities such as shopping, leisure activities etc.
Observed Flows	Traffic flow data collected from traffic surveys
Operational modelling	Assessment of specific junctions using forecast traffic flows to ensure the junction design operates with limited queues and delays. Often undertaken using a micro-simulation model.
Optimism bias	Optimism bias is a form of contingency added to the overall scheme costs to allow for items such as unknown risks. The level of contingency is applied relative to the current stage of the project, i.e. optimism bias costs are removed as issues are further defined through the detailed design stage. As more issues become 'known' risks they can be estimated more accurately.
Particulate Matter 2.5	A particulate matter 2.5 micrometres or less in diameter
Passenger Car Unit	A Passenger Car Unit is a measure used primarily to assess highway capacity, for traffic modelling purposes. Different vehicles are assigned different values, according to the space they take up. Typically, a car has a value of 1; smaller vehicles will have lower values, and larger vehicles will have higher values.
Present Value of Benefits (PVB)	The total benefits/disbenefits of a scheme over the 60-year appraisal period that are expressed in 2010 prices and discounted to 2010
Present Value of Costs (PVC)	Construction/maintenance costs of the scheme over the 60-year appraisal. Costs are in 2010 prices and discounted to 2010
Priority- controlled junction	A priority junction is where one or more side arms give way to the main road.
Project Control Framework	Highways England process for managing and delivering major improvement projects
QDIV	A traffic modelling parameter in the QUADRO software for assessing the impact of scheme construction. The parameter defines diversion routes in terms of route length, traffic flows and capacity.

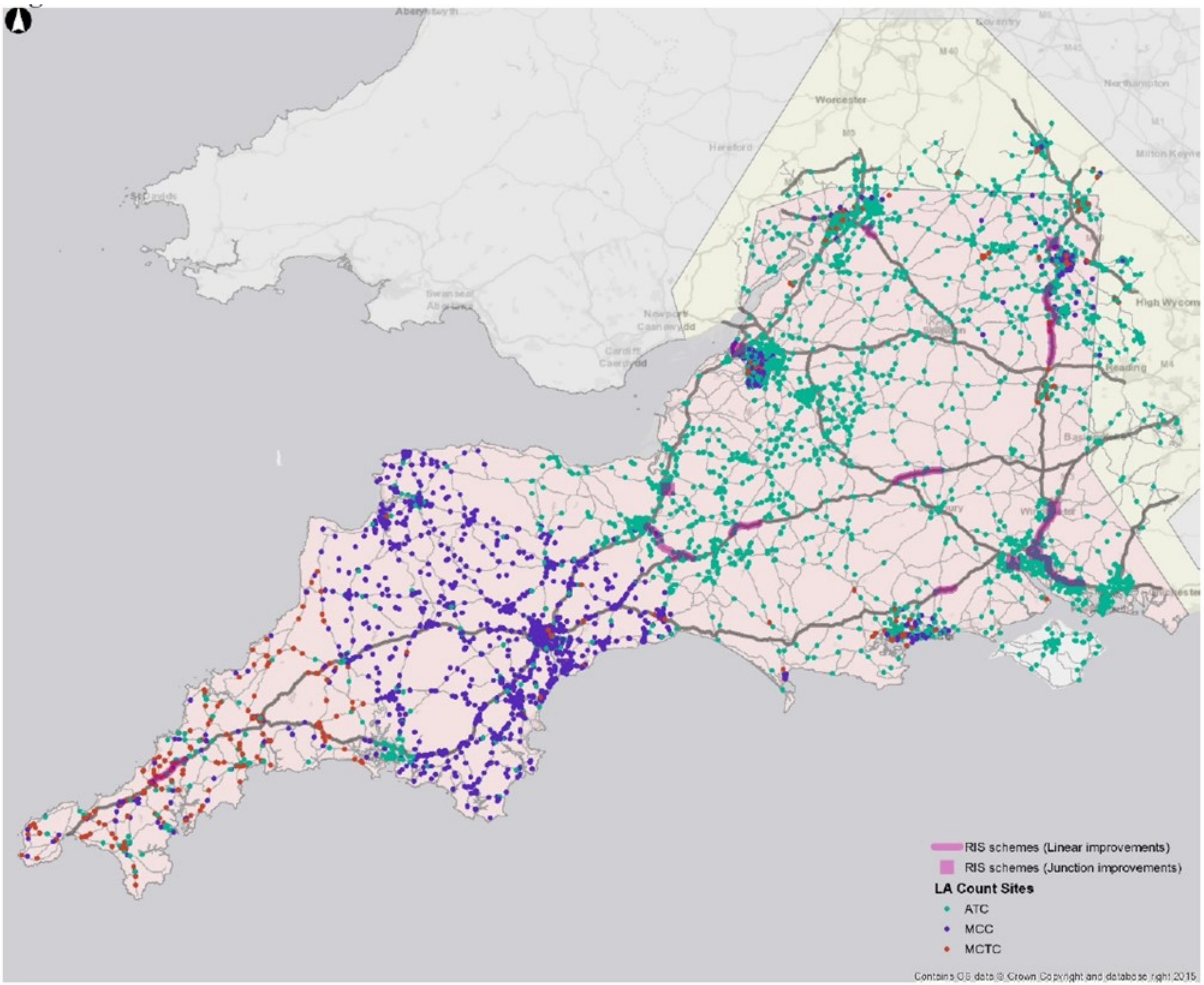
QUeues and delays at ROadworks	Department for Transport software to assessing the impact of the construction/maintenance of a scheme will have on the road network. The assessment is calculated on a monetary basis for a 60-year appraisal period.
Ratio to Flow Capacity	This is the ratio of traffic flow to the highway capacity. It is typically measured on an approach to a junction
Regional Traffic Model	Highways England have five Regional Traffic Models to cover the following regions; South West Regional Traffic Model (SWRTM) South East Regional Traffic Model (SERTM) Midlands Regional Traffic Model (MRTM) Trans-Pennine Regional Transport Model (TPSRTM) North Regional Transport Model (NRTM) These models were built by Highways England for the assessment of Road Investment Strategy and Road Investment Programme. The RTM base models are representative of an average weekday in March 2015
Road Traffic Forecasts 2015	Forecasts for traffic demand, congestion and emission for England and Wales from the DfTs National Transport Model for 2015
Road Traffic Forecasts 2018	Forecasts for traffic demand, congestion and emission for England and Wales from the DfTs National Transport Model for 2018
Rule of a Half	In terms of journey time reliability, benefits from trips that would occur anyway are calculated at their full value, benefits from trips that occur as a result of reduced costs are calculated using the 'rule of half'
SATME2	A module within the SATURN traffic modelling software for undertaking matrix estimation that tries to improve the fit between modelled and observed traffic flows be factoring individual cells of the input tip matrix
SATPIJA	A module within the SATURN traffic modelling software for undertaking matrix estimation that produces factors to apply to the matrix to improve fit between the modelled and observed traffic flows
SATURN (Simulation and Assignment of Traffic to Urban Road Networks)	Traffic modelling software that assigns traffic from a trip matrix onto a road network. The Highways England Regional Transport Models and the A417 Model use SATURN software.
Screenlines	A traffic modelling term. 'Screenlines' are defined through the model calibration/validation stage to check modelled flows against

	observed flows along a defined 'screenline'. For example, at locations where roads may cross a river or a railway line.
Sectoral highways trips	A traffic modelling term. Those trips which move within/between sectors in the traffic model. A sector is typically a group of model zones which are amalgamated to define a bigger geographical area.
Skeletal network	A traffic modelling term. These routes are included in the traffic model but with limited information.
Skims	A traffic modelling term. The process of extracting trip and travel cost matrices from the traffic model for use in the transport user benefits appraisal.
STATS19	Road Traffic Accident data collected by the Police that contains accident details
Strategic road network	The road network that Highways England has responsibility for. This includes all motorways and key A roads for which Highways England have jurisdiction.
TEMPRO (Trip End Model Presentation Programme)	Software used for viewing the forecast rates from the National Trip End Model
Tidality	In the context of transport modelling, 'tidality' refers to occurrences where traffic flow is higher in one direction compared to the other, and then this pattern reverses at other times of the day.
Traffic Model Calibration	Traffic model calibration is the process of systematically adjusting model parameters so that the model is able to reproduce the observed traffic conditions.
Traffic Model Validation	Traffic model validation is the process of establishing the credibility of a model by demonstrating its ability to replicate actual traffic patterns
TrafficMaster Data	TrafficMaster data is GPS sourced and centrally purchased by the Department for Transport. It contains data from vehicles travelling over the highway network.
Transport Appraisal Guidance	Department for Transport guidance on undertaking transport studies
Transport modelling	Traffic Modelling is undertaken to help transport decision makers – and related decision makers, e.g. land-use planners, industrial investors, public health officers – to better understand the current, the future and sometimes the past transport systems, and to make informed decisions about how to update the network.
Transport User Benefits Appraisal	Department for Transport software that calculates transport user benefits and compares these to the construction/maintenance cost of the scheme for a 60-year appraisal period

Trip Information System	A database of trip records derived from mobile phone data commissioned by Highways England
Trunk road	See Strategic Road Network
Value of Reliability	A value used to estimate the reliability benefits from the scheme, used in conjunction with the rule of a half
Value of Time	A traffic modelling term. An input to a traffic model development process to apply a cost in pence per minute which is used to calculate the most likely route a journey will take
Variable Demand Modelling	An approach for running traffic models that represents travellers' responses to changing transport costs resulting in redistribution of trips, mode choice and time period choice
Vehicle Operating Costs	A traffic modelling term. An input to a traffic model development process to apply a cost in pence per kilometre to account for the modelled cost of running a vehicle.
VISSIM	A microscopic multi-modal traffic flow simulation software package developed by PTV. See microsimulation model
Wardrop's first principle of traffic equilibrium	It states that the journey times in all routes actually used are equal and less than those that would be experienced by a single vehicle on any unused route. The traffic flows that satisfy this principle are usually referred to as "user equilibrium" (UE) flows, since each user chooses the route that is the best.
WebTRIS	A Highways England Traffic Information System for storage & dissemination of observed traffic flow & journey time data on Strategic Road Network
Wider Impacts of Transport Appraisal	Department for Transport software for assessing the impact a scheme will have on the wider economy. The assessment is calculated on a monetary basis for a 60-year appraisal period.
XAMAX	A traffic modelling parameter in the SATURN software. This parameter defines the maximum balancing factor used to limit excessive changes to the prior matrix during the matrix estimation process

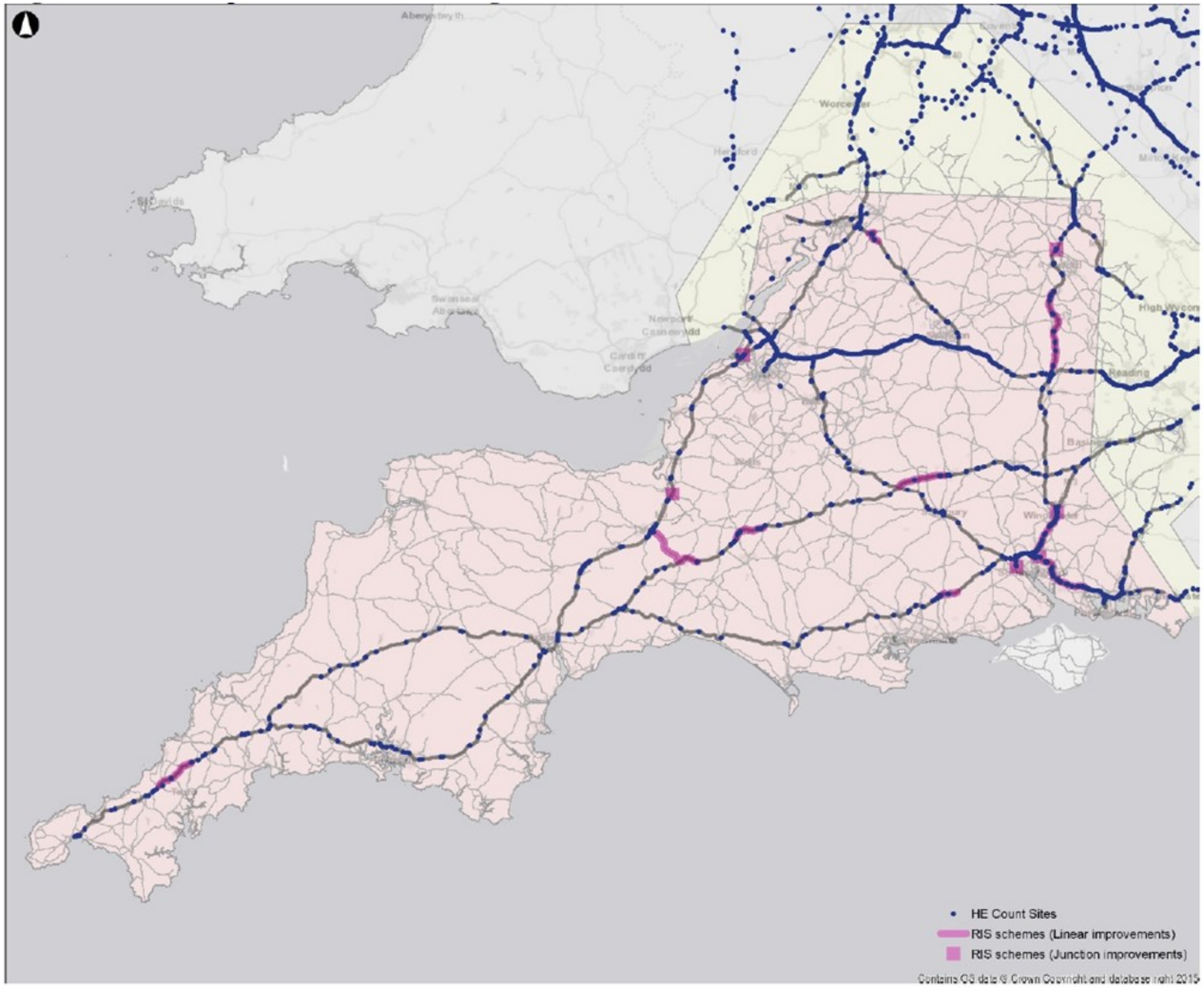
Appendices

Appendix A SWRTM traffic count data locations



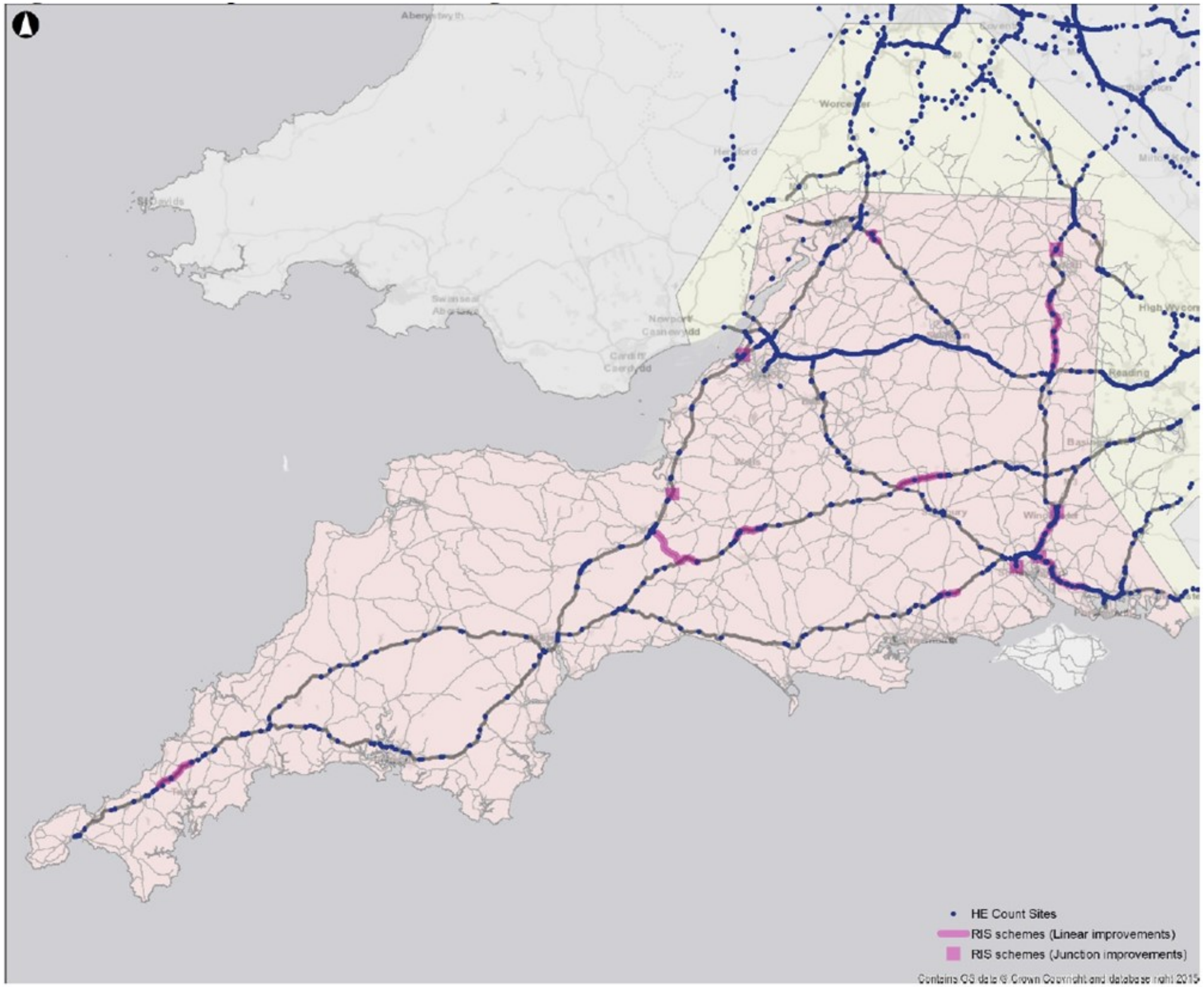
Source: Highways England South-West Regional Model Traffic Data Collection Report, version 3, 24/03/2016

Figure A-1 SWRTM local authority data



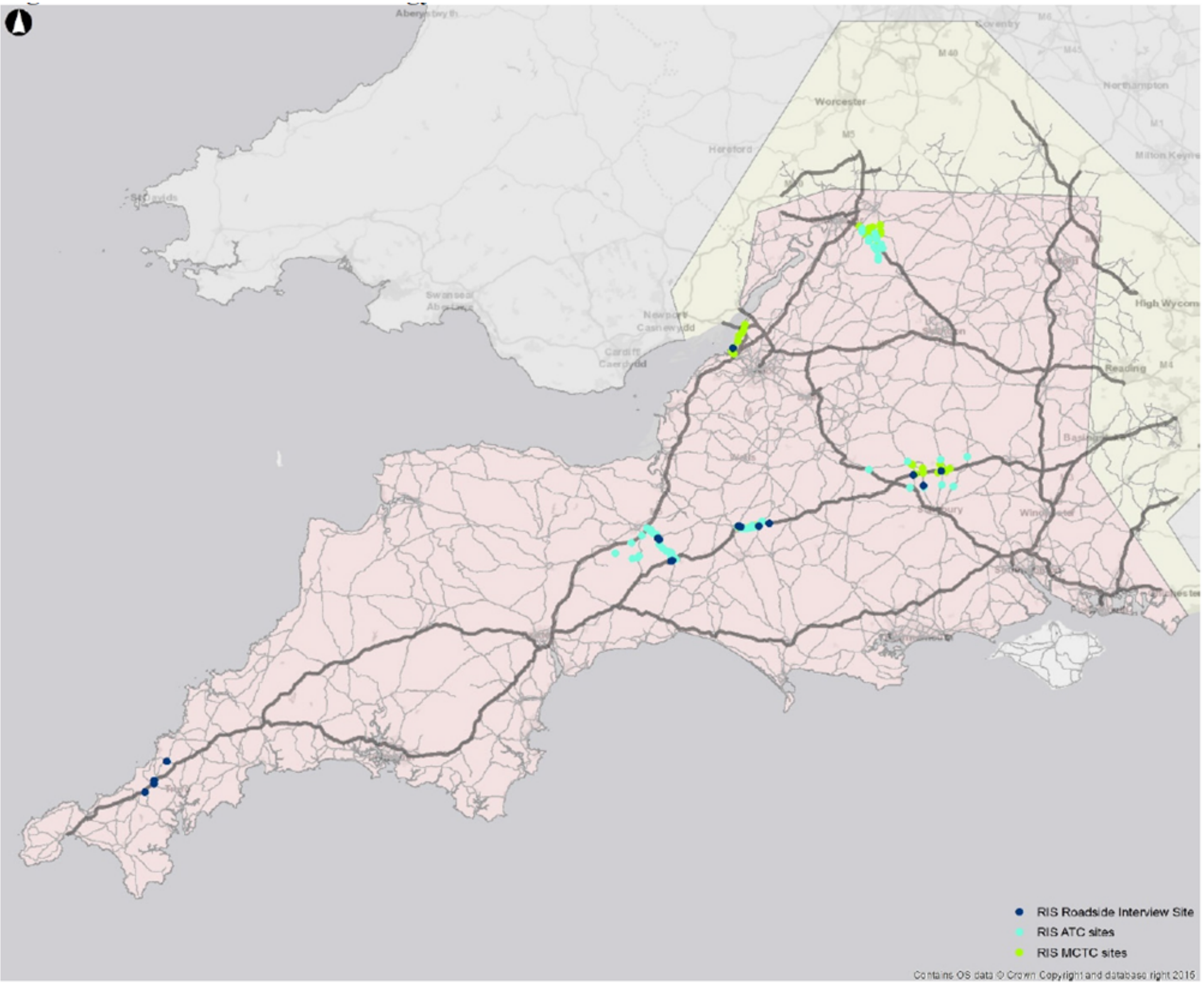
Source: Highways England South-West Regional Model Traffic Data Collection Report, version 3, 24/03/2016

Figure A-2 SWRTM TRADS permanent monitoring sites



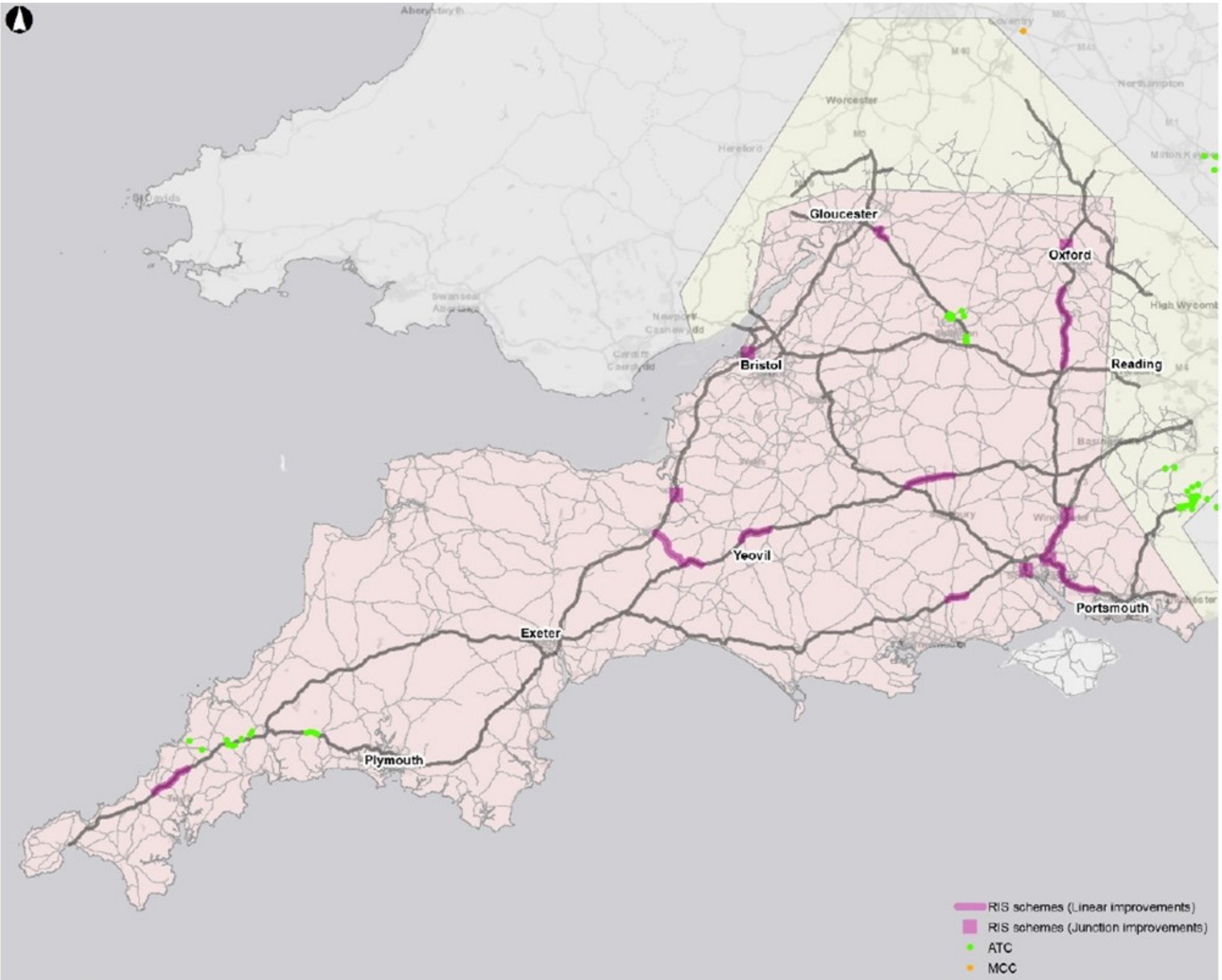
Source: Highways England South-West Regional Model Traffic Data Collection Report, version 3, 24/03/2016

Figure A-3 SWRTM DfT traffic count



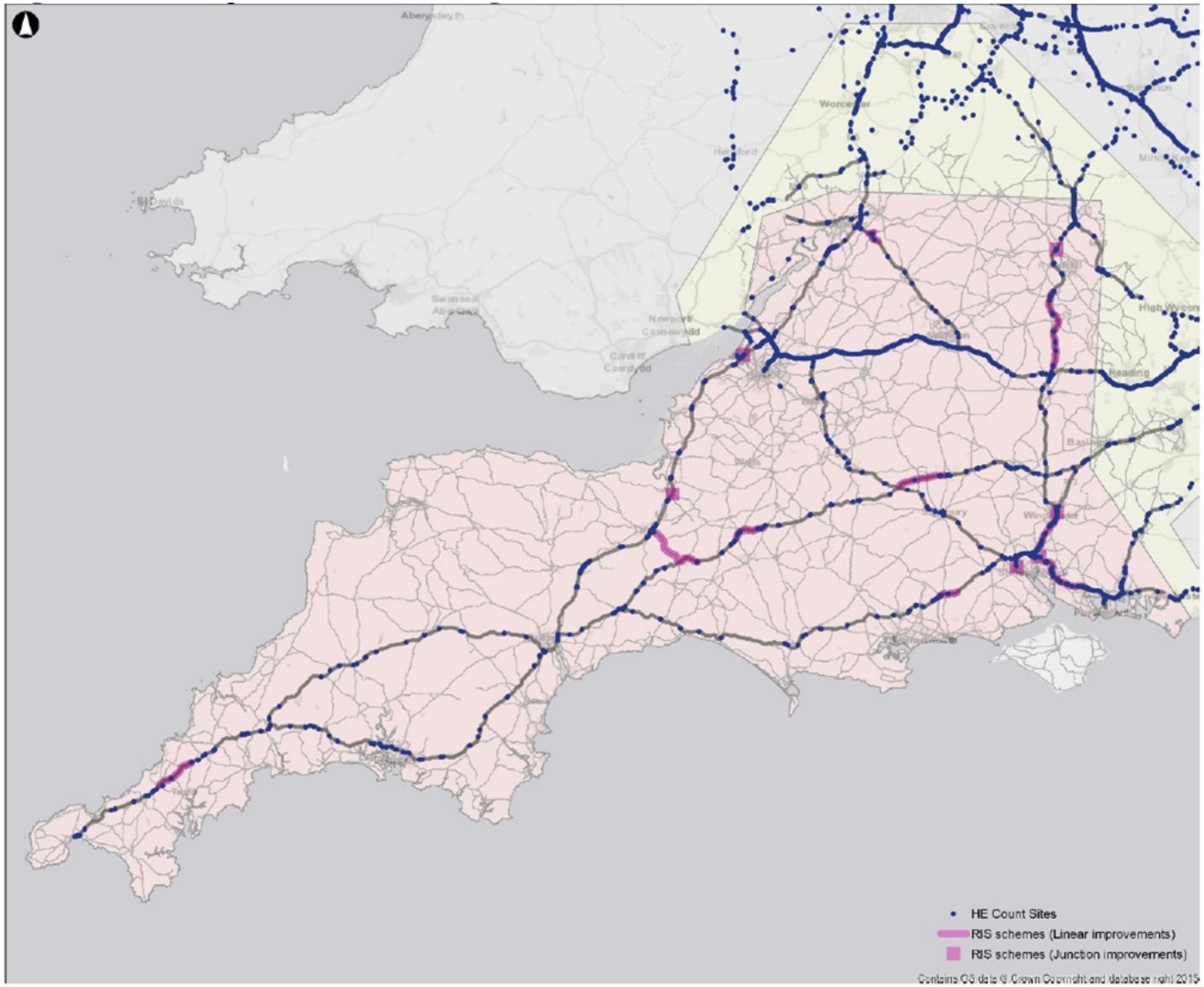
Source: Highways England South-West Regional Model Traffic Data Collection Report, Version 3, 24/03/2016

Figure A-4 SWRTM Road Investment Strategy scheme data



Source: Highways England South-West Regional Model Traffic Data Collection Report, Version 3, 24/03/2016

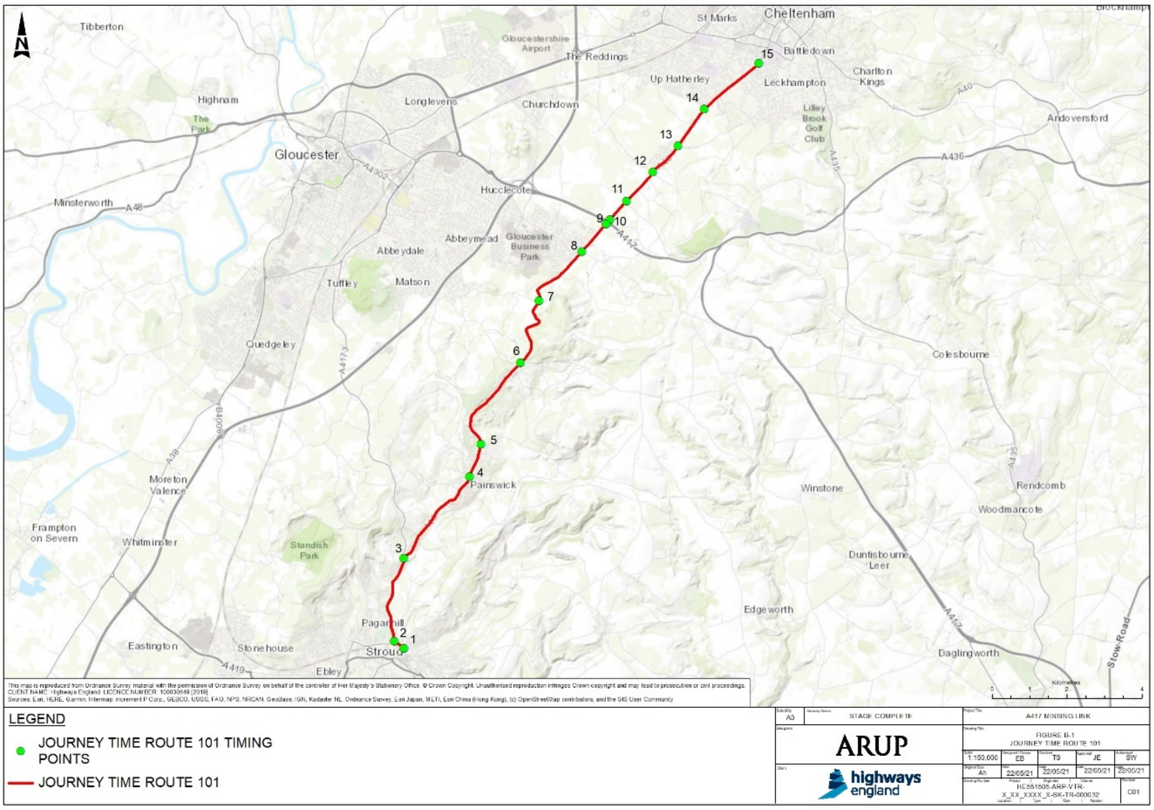
Figure A-5 SWRTM Post Opening Project Evaluation (POPE) traffic count data



Source: Highways England South-West Regional Model Traffic Data Collection Report, Version 3, 24 March 2016

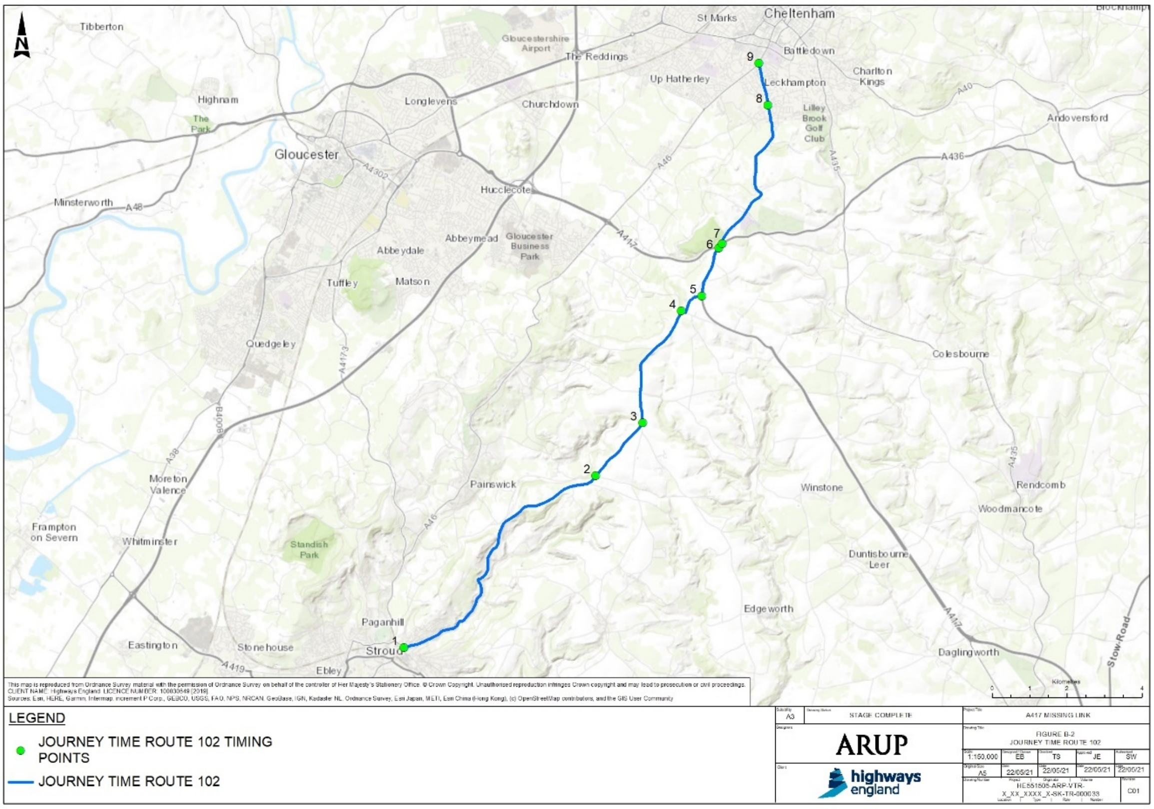
Figure A-6 SWRTM additional data collection sites

Appendix B Journey time routes and observed data



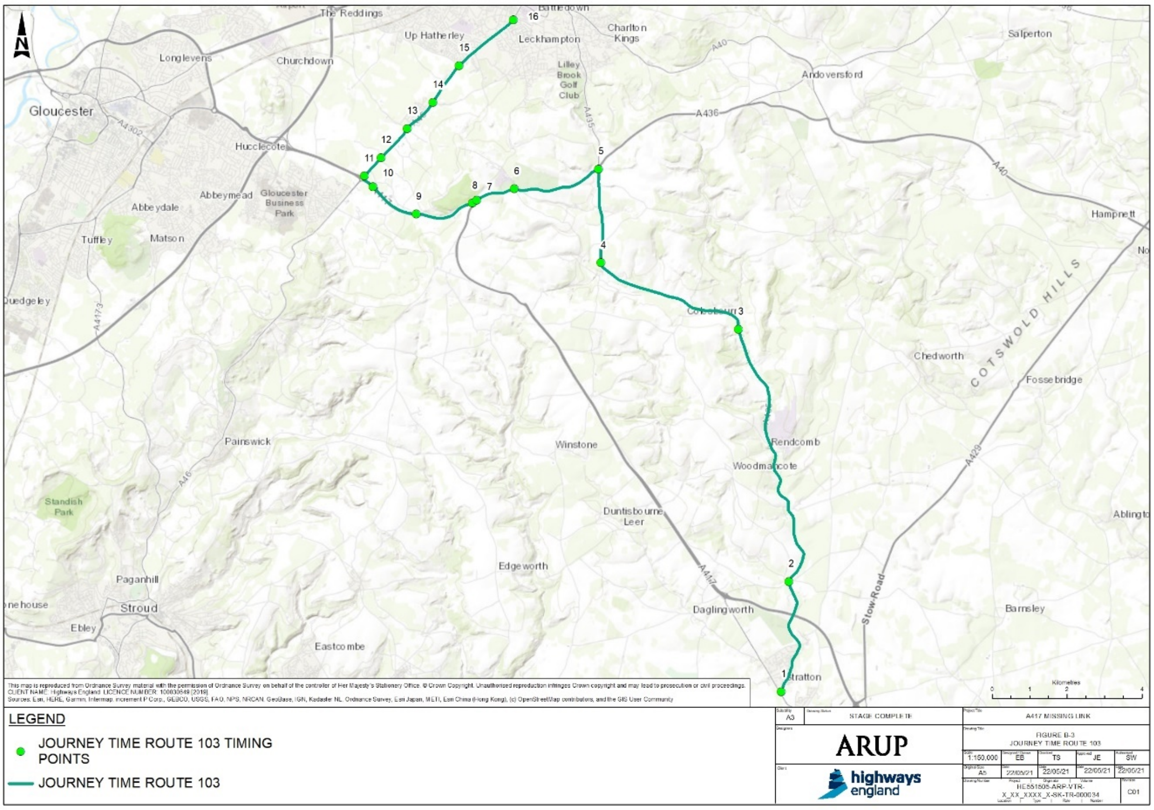
Source: Highways England

Figure B-1 Journey time route 101



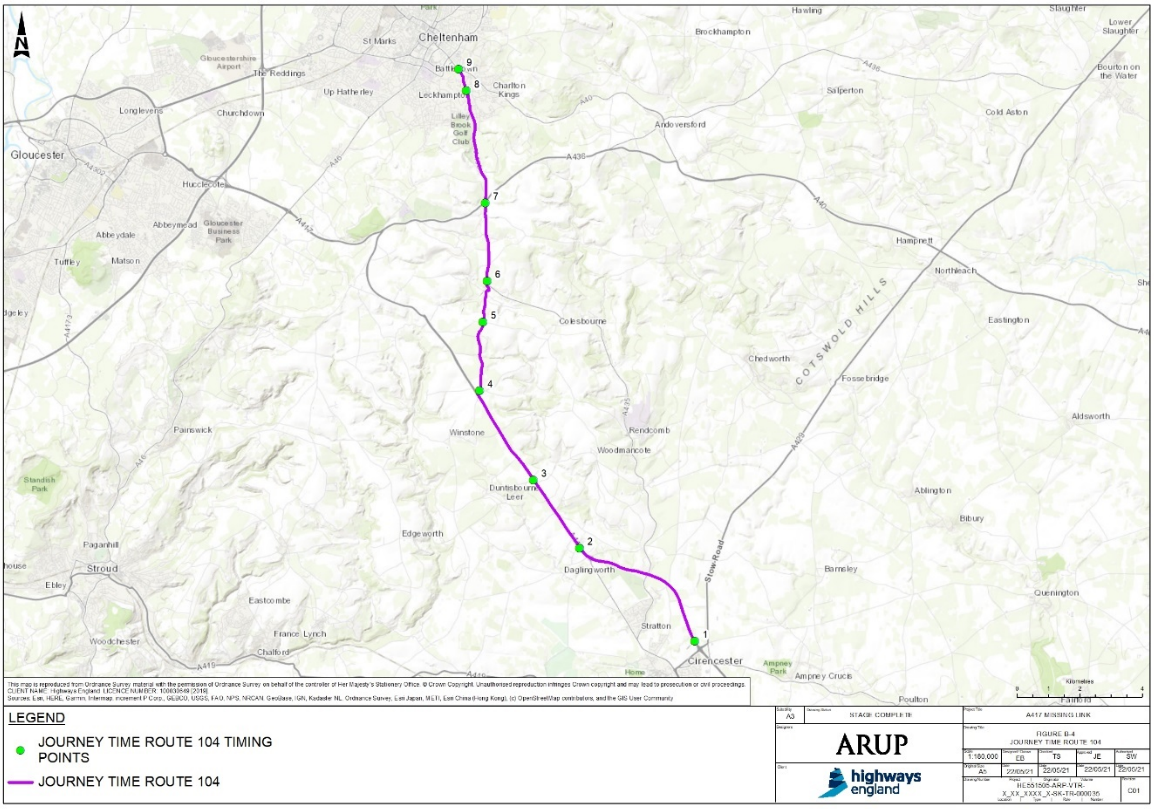
Source: Highways England

Figure B-2 Journey time route 102



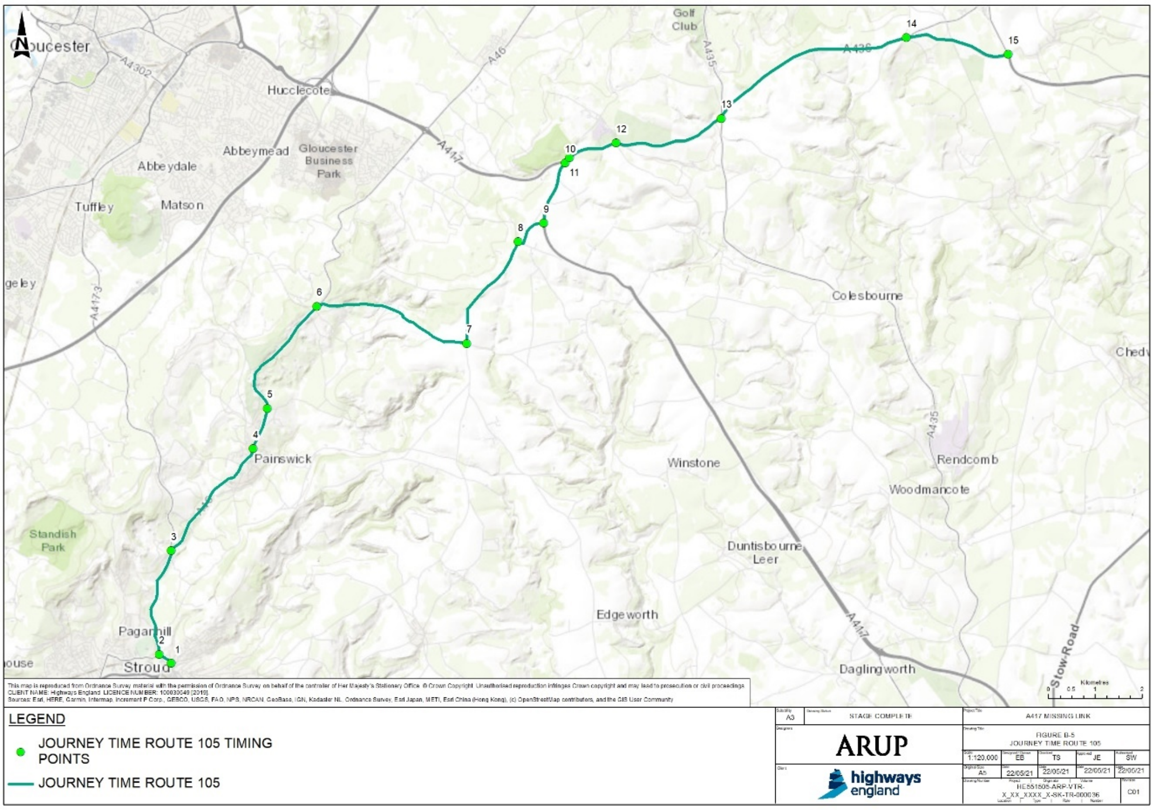
Source: Highways England

Figure B-3 Journey time route 103



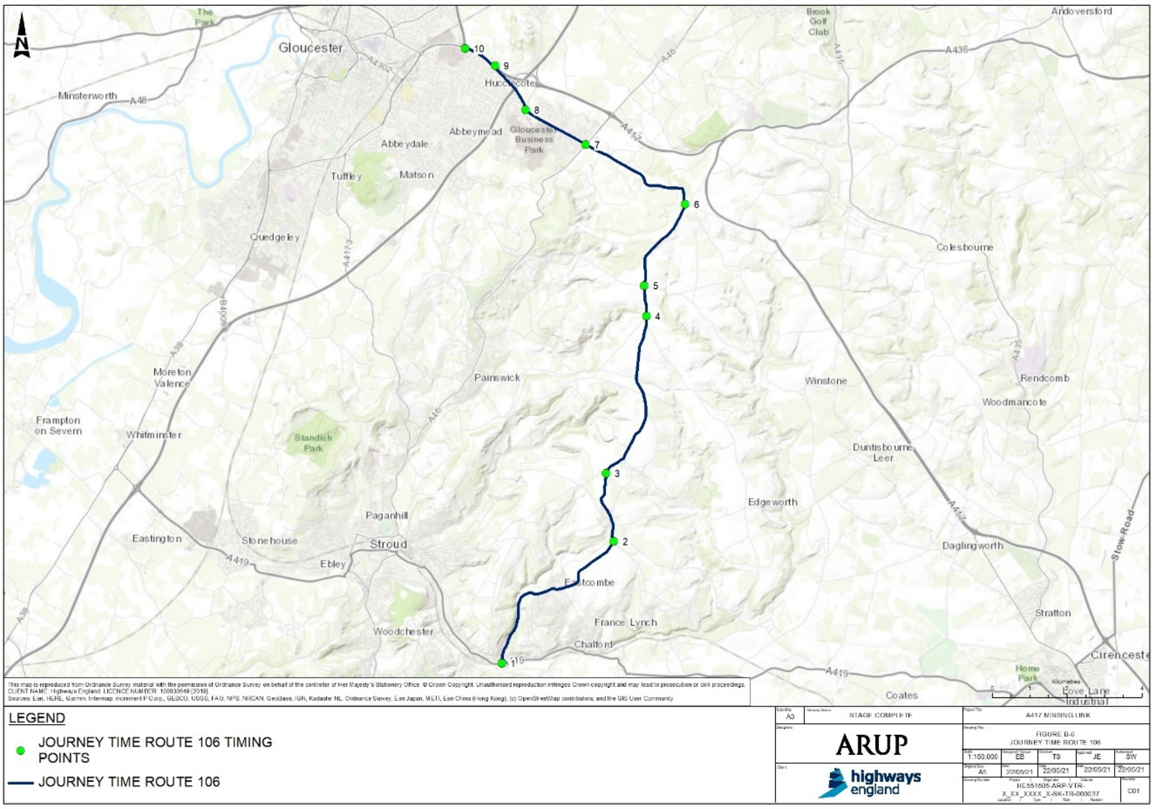
Source: Highways England

Figure B-4 Journey time route 104



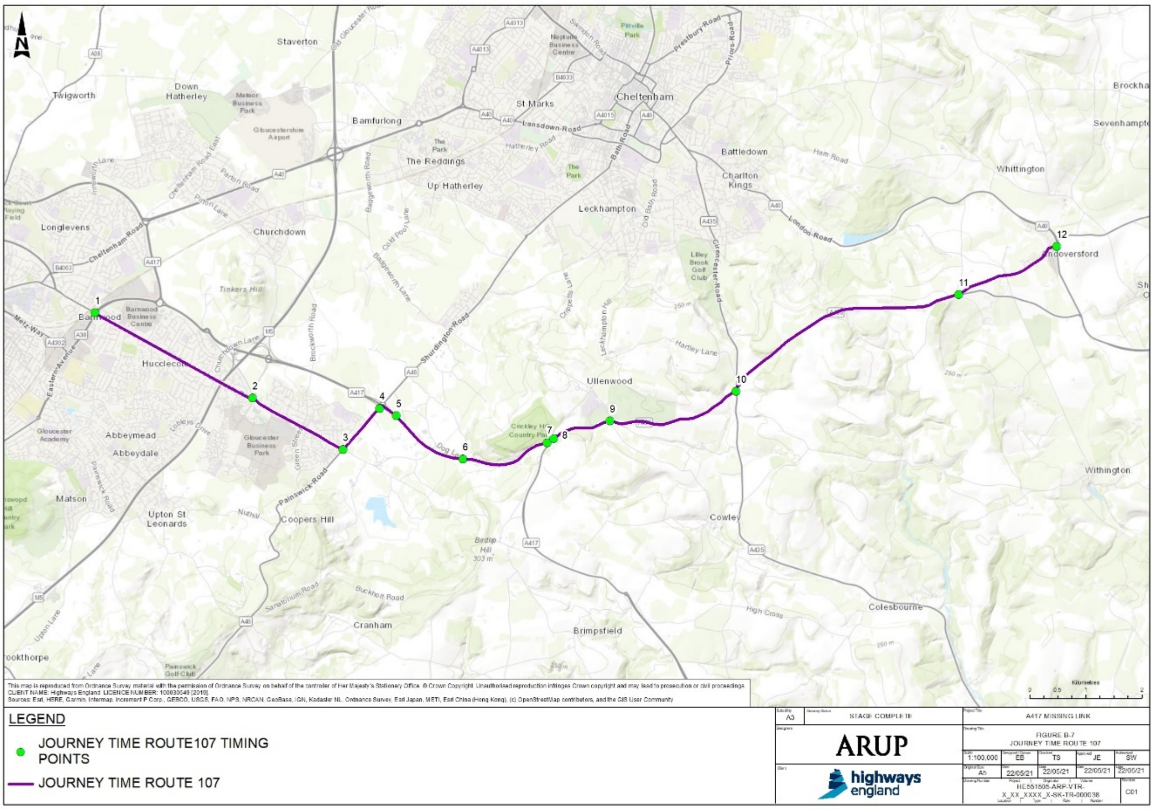
Source: Highways England

Figure B-5 Journey time route 105



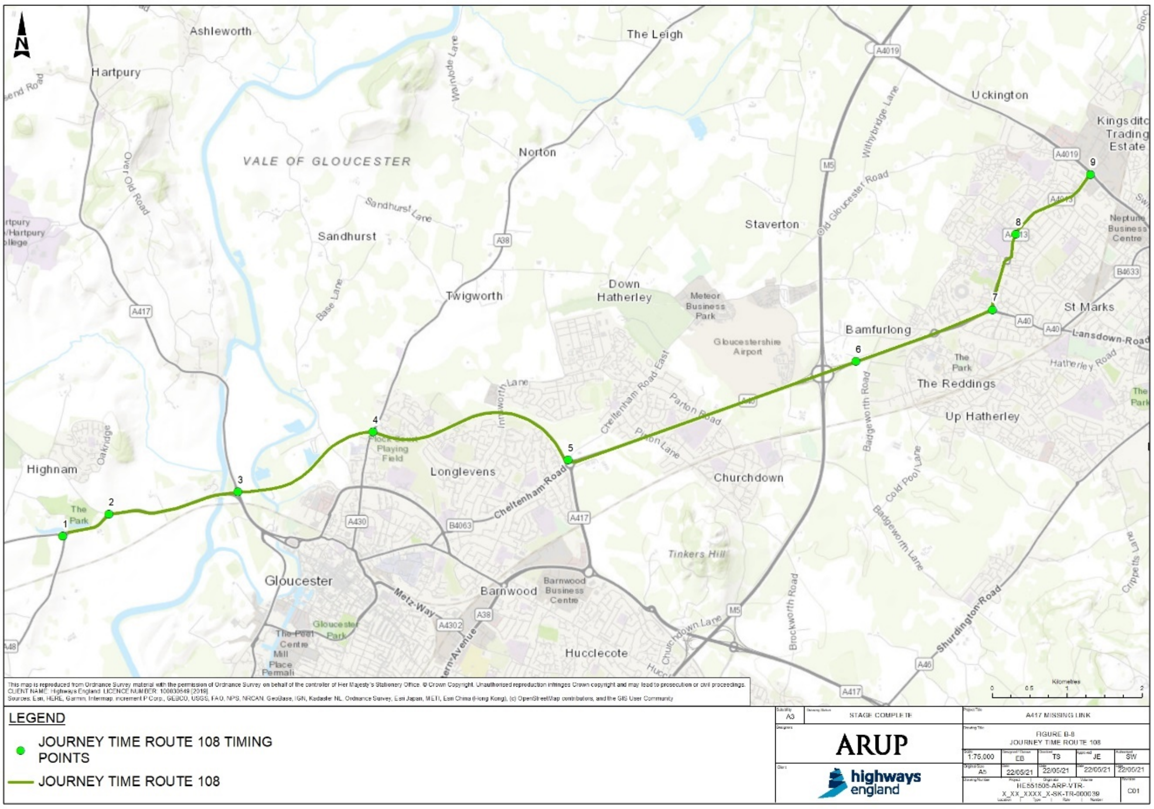
Source: Highways England

Figure B-6 Journey time route 106



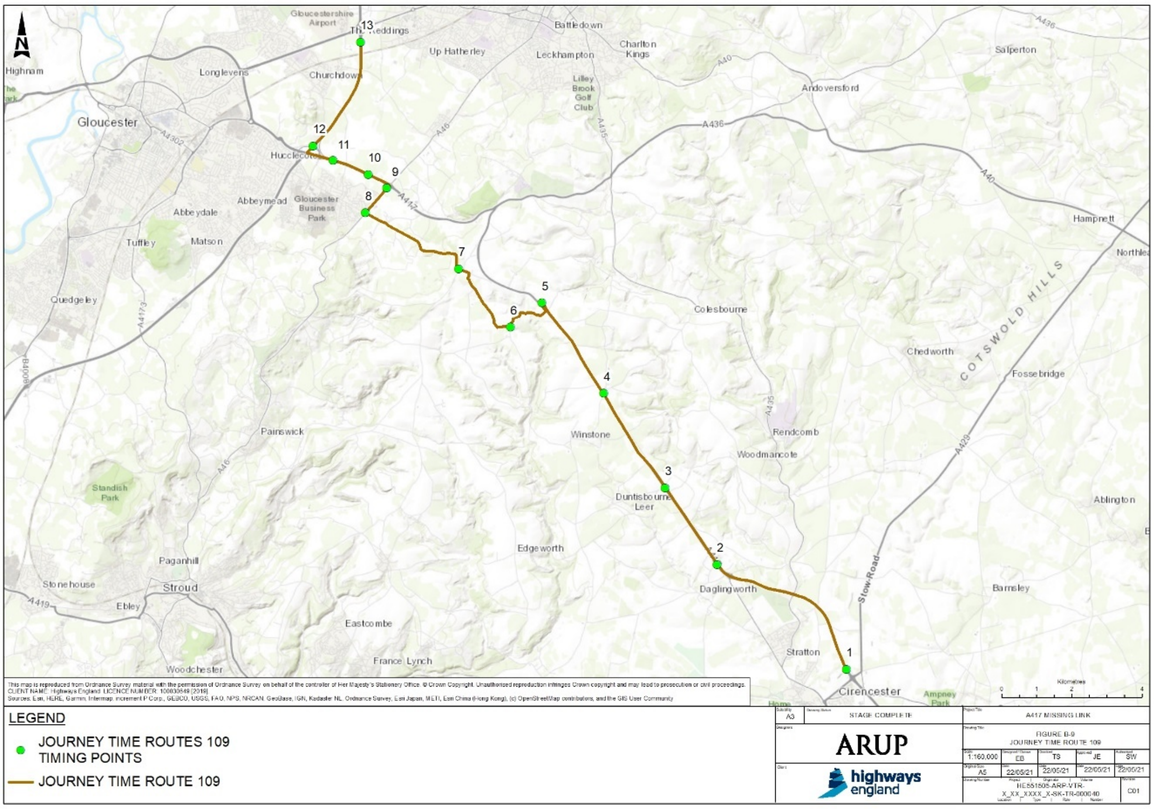
Source: Highways England

Figure B-7 Journey time route 107



Source: Highways England

Figure B-8 Journey time route 108



Source: Highways England

Figure B-9 Journey time route 109

Table B-1 Journey time route 101 - northbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	0.2	0.3	32	33	34
2	3	1.7	2.7	166	172	168
3	4	3.5	5.6	383	391	382
4	5	4.0	6.5	438	446	436
5	6	5.8	9.3	583	592	581
6	7	7.1	11.4	701	714	702
7	8	8.3	13.3	815	827	820
8	9	8.9	14.3	881	889	882
9	10	9.0	14.5	898	906	899
10	11	9.4	15.2	944	947	945
11	12	10.1	16.2	1,020	1,013	1,029
12	13	10.7	17.2	1,106	1,086	1,120
13	14	11.4	18.4	1,186	1,165	1,201
14	15	12.6	20.3	1,350	1,313	1,358

Source: Highways England

Table B-2 Journey time route 101 - southbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
15	14	1.2	1.9	144	141	156
14	13	1.9	3.1	225	218	242
13	12	2.5	4.1	307	292	344
12	11	3.2	5.1	380	361	429
11	10	3.6	5.8	426	403	479
10	9	3.7	6.0	442	420	495
9	8	4.3	7.0	504	482	558
8	7	5.5	8.9	605	585	662
7	6	6.8	11.0	726	708	783
6	5	8.6	13.8	872	857	934
5	4	9.1	14.7	931	915	994
4	3	10.9	17.6	1,176	1,141	1,244
3	2	12.4	20.0	1,318	1,286	1,385
2	1	12.6	20.3	1,357	1,322	1,429

Source: Highways England

Table B-3 Journey time route 102 - northbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	4.8	7.7	525	529	522
2	3	6.0	9.7	607	617	606
3	4	8.1	13.1	816	809	798
4	5	8.5	13.7	883	866	854
5	6	9.4	15.1	1,030	1,002	1,098
6	7	9.5	15.3	1,053	1,024	1,124
7	8	12.2	19.7	1,329	1,293	1,392
8	9	12.9	20.8	1,434	1,398	1,497

Source: Highways England

Table B-4 Journey time route 102 - southbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
9	8	0.7	1.2	106	105	108
8	7	3.4	5.5	404	393	475
7	6	3.5	5.7	430	415	508
6	5	4.4	7.1	507	478	571
5	4	4.8	7.7	564	534	628
4	3	6.9	11.1	737	709	797

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
3	2	8.1	13.1	829	802	884
2	1	12.9	20.8	1,365	1,357	1,450

Source: Highways England

Table B-5 Journey time route 103 - northbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	2.0	3.2	189	191	185
2	3	6.9	11.1	551	559	542
3	4	9.3	15.0	722	733	712
4	5	10.9	17.5	839	850	831
5	6	12.4	20.0	968	981	972
6	7	13.0	21.0	1,063	1,047	1,202
7	8	13.2	21.2	1,093	1,074	1,240
8	9	14.2	22.8	1,178	1,158	1,324
9	10	15.1	24.3	1,224	1,205	1,369
10	11	15.4	24.8	1,265	1,243	1,413
11	12	15.8	25.5	1,311	1,284	1,458
12	13	16.5	26.5	1,387	1,351	1,542
13	14	17.1	27.5	1,473	1,423	1,634
14	15	17.8	28.7	1,553	1,502	1,714
15	16	19.0	30.6	1,717	1,650	1,872

Source: Highways England

Table B-6 Journey time route 103 - southbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
16	15	1.2	1.9	144	141	156
15	14	1.9	3.1	225	218	242
14	13	2.5	4.1	307	292	344
13	12	3.2	5.1	380	361	429
12	11	3.6	5.8	426	403	479
11	10	3.8	6.1	444	422	497
10	9	4.7	7.6	496	471	545
9	8	5.7	9.2	610	548	620
8	7	5.8	9.4	627	562	635
7	6	6.5	10.4	682	617	689
6	5	8.0	12.9	812	744	818
5	4	9.6	15.4	927	859	933
4	3	12.0	19.3	1,095	1,033	1,098

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
3	2	16.9	27.2	1,455	1,398	1,453
2	1	18.9	30.4	1,638	1,584	1,639

Source: Highways England

Table B-7 Journey time route 104 - northbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	3.2	5.2	166	169	162
2	3	4.8	7.8	251	254	244
3	4	7.1	11.4	387	392	380
4	5	8.5	13.6	518	522	504
5	6	9.4	15.1	643	640	626
6	7	10.9	17.6	760	756	746
7	8	13.2	21.3	1,026	1,010	1,017
8	9	13.7	22.1	1,125	1,092	1,134

Source: Highways England

Table B-8 Journey time route 104 - southbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
9	8	0.5	0.8	76	70	85
8	7	2.8	4.5	321	310	326
7	6	4.3	7.0	436	426	442
6	5	5.3	8.5	554	546	568
5	4	6.6	10.7	683	678	701
4	3	8.8	14.2	815	805	826
3	2	10.4	16.8	898	887	906
2	1	13.7	22.0	1,065	1,053	1,066

Source: Highways England

Table B-9 Journey time route 105 - eastbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	0.2	0.3	32	33	34
2	3	1.7	2.7	166	172	168
3	4	3.5	5.6	383	391	382
4	5	4.0	6.5	438	446	436
5	6	5.8	9.3	583	592	581
6	7	8.0	12.8	837	880	897

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
7	8	9.5	15.3	1,002	1,026	1,043
8	9	9.9	16.0	1,069	1,082	1,099
9	10	10.8	17.4	1,216	1,218	1,344
10	11	10.9	17.6	1,239	1,240	1,369
11	12	11.6	18.7	1,294	1,295	1,423
12	13	13.1	21.1	1,424	1,421	1,552
13	14	15.9	25.6	1,664	1,661	1,780
14	15	17.3	27.9	1,786	1,784	1,898

Source: Highways England

Table B-10 Journey time route 105 - westbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
15	14	1.4	2.3	115	117	113
14	13	4.2	6.8	339	348	341
13	12	5.8	9.3	468	480	481
12	11	6.4	10.3	563	546	712
11	10	6.5	10.5	589	568	745
10	9	7.4	11.9	666	631	808
9	8	7.8	12.6	723	687	865
8	7	9.4	15.1	856	822	995
7	6	11.6	18.6	1,149	1,104	1,259
6	5	13.3	21.4	1,295	1,254	1,409
5	4	13.9	22.3	1,354	1,311	1,470
4	3	15.7	25.2	1,599	1,538	1,719
3	2	17.1	27.6	1,740	1,682	1,860
2	1	17.3	27.9	1,780	1,718	1,905

Source: Highways England

Table B-11 Journey time route 106 - northbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	3.2	5.1	369	362	354
2	3	4.3	7.0	524	523	515
3	4	7.3	11.7	782	793	771
4	5	7.8	12.5	826	839	816
5	6	9.4	15.1	991	985	962
6	7	11.4	18.4	1,195	1,190	1,175
7	8	12.6	20.3	1,371	1,362	1,360
8	9	13.4	21.6	1,459	1,438	1,444

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
9	10	14.0	22.6	1,525	1,502	1,509

Source: Highways England

Table B-12 Journey time route 106 - southbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
10	9	0.6	1.0	51	51	50
9	8	1.6	2.5	172	175	174
8	7	2.7	4.3	351	342	359
7	6	4.8	7.8	573	562	579
6	5	6.4	10.3	706	697	709
5	4	7.0	11.2	746	737	749
4	3	9.8	15.8	994	997	1,004
3	2	11.1	17.8	1,162	1,159	1,167
2	1	14.2	22.8	1,542	1,516	1,527

Source: Highways England

Table B-13 Journey time route 107 - eastbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	1.9	3.1	331	319	353
2	3	3.1	5.0	511	488	540
3	4	3.7	6.0	577	550	602
4	5	4.0	6.5	612	584	638
5	6	5.0	8.0	664	633	685
6	7	6.0	9.6	778	710	761
7	8	6.0	9.7	795	725	776
8	9	6.7	10.8	851	779	830
9	10	8.2	13.2	980	906	958
10	11	11.1	17.8	1,220	1,146	1,186
11	12	12.3	19.8	1,347	1,271	1,309

Source: Highways England

Table B-14 Journey time route 107 - westbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
12	11	1.2	2.0	130	130	134
11	10	4.1	6.6	354	360	362
10	9	5.6	9.0	482	492	502

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
9	8	6.3	10.1	577	558	733
8	7	6.3	10.2	608	585	771
7	6	7.3	11.8	693	669	854
6	5	8.3	13.3	738	715	899
5	4	8.5	13.6	762	738	926
4	3	9.1	14.6	824	800	989
3	2	10.3	16.5	1,000	973	1,176
2	1	12.2	19.6	1,321	1,274	1,516

Source: Highways England

Table B-15 Journey time route 108 - eastbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	0.4	0.7	51	46	51
2	3	1.6	2.5	162	145	153
3	4	2.9	4.6	277	250	259
4	5	4.7	7.5	392	367	371
5	6	7.2	11.6	550	516	514
6	7	8.5	13.6	769	690	714
7	8	9.1	14.7	887	799	844
8	9	9.9	16.0	1,031	924	1,008

Source: Highways England

Table B-16 Journey time route 108 - westbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
9	8	0.8	1.3	127	115	126
8	7	1.5	2.4	259	232	259
7	6	2.7	4.4	396	354	505
6	5	5.3	8.6	628	547	711
5	4	7.2	11.6	766	679	890
4	3	8.5	13.6	878	790	1,046
3	2	9.6	15.4	959	873	1,129
2	1	10.1	16.2	997	912	1,166

Source: Highways England

Table B-17 Journey time route 109 – northbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
1	2	3.2	5.2	166	169	162
2	3	4.8	7.8	251	254	244
3	4	6.8	11.0	353	358	346
4	5	8.8	14.2	461	470	514
5	6	9.8	15.8	650	623	667
6	7	11.4	18.3	893	820	868
7	8	13.4	21.6	1,097	1,025	1,080
8	9	14.0	22.6	1,156	1,082	1,137
9	10	14.5	23.3	1,187	1,113	1,167
10	11	15.2	24.4	1,224	1,149	1,204
11	12	16.2	26.0	1,295	1,221	1,275
12	13	18.3	29.4	1,400	1,327	1,379

Source: Highways England

Table B-18 Journey time route 109 – southbound

Timing points		Cumulative distance (miles)	Cumulative distance (km)	Cumulative journey time (seconds)		
Start	End			AM	IP	PM
13	12	1.8	2.9	95	97	94
12	11	2.6	4.2	143	145	139
11	10	3.3	5.3	184	184	178
10	9	3.7	5.9	237	226	223
9	8	4.3	6.9	299	288	287
8	7	6.4	10.3	521	508	507
7	6	8.0	12.9	720	718	747
6	5	9.0	14.5	870	878	972
5	4	10.9	17.6	977	984	1,074
4	3	13.0	21.0	1,084	1,091	1,177
3	2	14.6	23.5	1,167	1,174	1,257
2	1	17.8	28.7	1,334	1,339	1,417

Source: Highways England

Appendix C Traffic count data

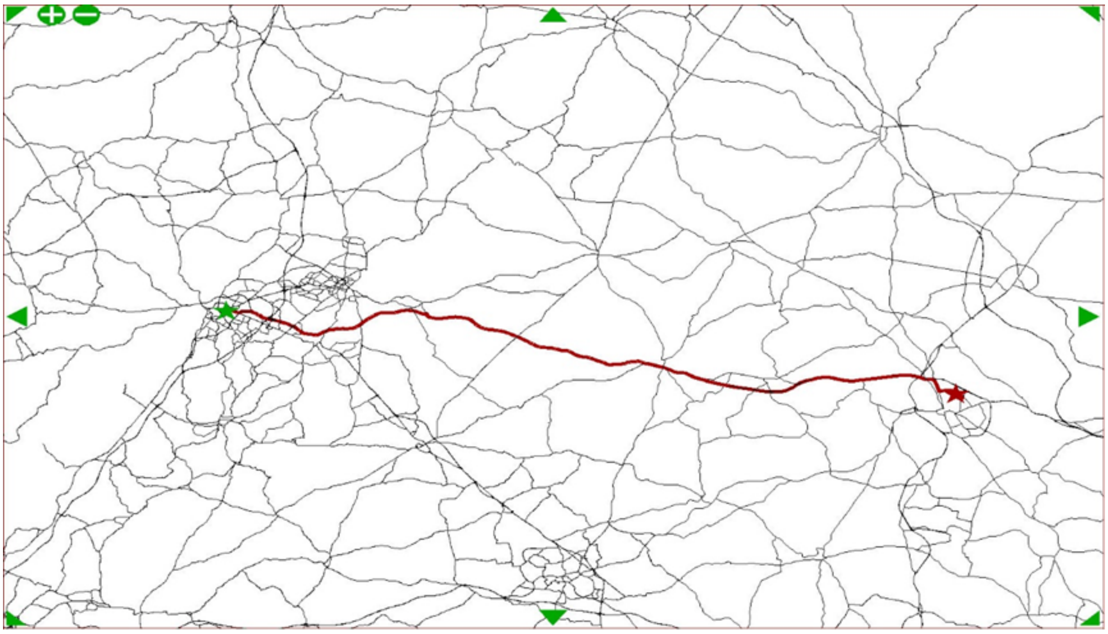
Site	Screenline Reference	Screenline Reference & Direction	Site Description	Links (ATC)	Direction	AM 7-10 Avg Car	LGV	OGV	Total Veh	Total PCU	IP 10-4 Avg Car	LGV	OGV	Total Veh	Total PCU	PM 4-7 Avg Car	LGV	OGV	Total Veh	Total PCU	12hr 7-7 Avg Car	LBV	OGV
A01	A01	A01 NB	A46 south of Pitchcombe	27384-60090	Northbound	510	75	29	614	658	364	57	31	452	498	527	59	16	602	626	443	61	26
		A01 SB		60090-27384	Southbound	487	72	28	586	627	356	56	30	442	487	525	58	16	599	623	432	60	25
A02	A02	A02 NB	B4070 south of Slad	65897-26066	Northbound	73	10	2	85	88	50	9	2	61	64	58	7	1	66	67	58	8	1
		A02 SB		26066-65897	Southbound	54	8	1	63	65	53	10	2	65	68	75	9	1	86	88	59	9	2
A03	A03	A03 NB	Calf Way north of Bisley, to the north of jct with Stancombe Ln	26001-26071	Northbound	209	29	5	243	250	92	17	4	113	118	104	13	2	119	122	125	18	3
		A03 SB		26071-26001	Southbound	104	15	2	122	125	94	17	4	115	121	184	23	3	210	215	120	18	3
A04	A04	A04 NB	Dane Ln south of Edgeworth	link not modelled	Northbound	20	3	0	23	24	11	2	0	13	14	13	2	0	15	15	14	2	0
		A04 SB		link not modelled	Southbound	12	2	0	14	15	12	2	0	14	15	23	3	0	26	27	15	2	0
A05	A05	A05 NB	Unnamed road NE of Sapperton, to the south of jct with Overley Rd	65380-26018	Northbound	53	7	1	61	63	27	5	1	33	35	41	5	1	47	48	37	5	1
		A05 SB		26018-65380	Southbound	48	7	1	56	58	29	5	1	36	37	53	7	1	61	62	40	6	1
A06	A06 E02	A06 E02 NB	Gloucester Rd, Stratton between Baunton Ln and Overley Rd	65674-26010	Northbound	139	20	3	162	167	111	20	4	135	142	163	20	3	186	190	132	19	3
		A06 E02 SB		26010-65674	Southbound	139	20	3	162	166	93	17	4	113	119	137	17	2	157	160	116	17	3
A07	A07	A07 NB	A435 between Baunton and Stratton, to the north of jct with Baunton Ln	27592-26067	Northbound	183	27	10	221	236	129	20	11	160	177	223	25	7	255	265	166	23	10
		A07 SB		26067-27592	Southbound	201	30	11	242	259	126	20	11	156	172	184	20	6	210	218	159	22	9
A08	A08 E04	A08 E04 NB	A417 NE of Stratton	65470-60540	Northbound	778	138	117	1032	1207	701	134	141	976	1187	1071	117	88	1276	1408	811	132	122
		A08 E04 SB		65471-60529	Southbound	1021	181	153	1355	1585	630	120	127	877	1067	915	100	75	1090	1202	799	130	120
A09	A09	A09 NB	White Way NE of Baunton	link not modelled	Northbound	39	5	1	45	47	36	7	1	45	47	56	7	1	64	66	42	6	1
		A09 SB		link not modelled	Southbound	58	8	1	67	69	32	6	1	39	41	47	6	1	54	55	42	6	1
A10	A10	A10 NB	A429 east of Perrott's Brook, to the north of jct with Welsh Way	60536-68010	Northbound	249	37	14	300	322	221	34	19	274	302	271	30	8	310	322	242	33	14
		A10 SB		68010-60536	Southbound	248	37	14	298	319	217	34	18	269	297	269	30	8	307	320	239	33	14
B01	B01	B01 EB	B4063 west of Staverton Bridge, north of airfield	60493-60317	Eastbound	470	66	11	547	563	353	65	14	432	453	397	49	7	453	463	397	58	10
		B01 WB		60317-60493	Westbound	409	57	10	476	490	360	66	14	441	463	485	60	8	553	565	408	60	11
B02	B02	B02 EB	A40 west of M5 J11	66709-60304	Eastbound	1141	202	171	1514	1771	791	151	159	1102	1341	1196	131	98	1425	1572	979	159	147
		B02 WB		65490-26086	Westbound	1130	200	170	1500	1754	769	147	155	1071	1303	1280	140	105	1525	1682	983	160	148
B03	B03 C02	B03 C02 EB	Brookfield Rd over M5	27531-26049	Eastbound	400	56	9	465	479	127	23	5	155	163	154	19	3	176	180	203	30	5
		B03 C02 WB		26049-27531	Westbound	142	20	3	165	171	144	26	6	176	185	375	46	6	427	437	202	30	5
B04	B04	B04 NB	Brockworth Rd over M5	65419-65417	Northbound	101	14	2	118	122	64	12	3	78	82	113	14	2	129	131	86	13	2
		B04 SB		65417-65419	Southbound	96	14	2	112	115	69	13	3	84	88	112	14	2	128	131	87	13	2
B05	B05	B05 EB	A417 between Zoons and C&G rbouts	66701-27324	Eastbound	1006	149	57	1212	1297	803	125	68	996	1097	1315	146	40	1501	1561	983	136	58
		B05 WB		27322-26084	Westbound	1410	208	80	1698	1818	829	129	70	1028	1133	1143	127	35	1305	1357	1057	146	62
B06	B06	B06 EB	Hucclecote Rd under M5	65416-26092	Eastbound	420	59	10	489	504	341	62	14	417	438	418	52	7	476	487	384	56	10
		B06 WB		26092-65416	Westbound	318	45	7	370	381	360	66	14	440	462	556	69	9	635	649	402	59	10
B07	B07	B07 EB	Lobleys Dr over M5	26047-65966	Eastbound	426	60	10	496	511	203	37	8	248	260	292	36	5	334	341	283	41	7
		B07 WB		65966-26047	Westbound	209	29	5	244	251	230	42	9	282	295	502	62	9	572	585	294	43	8
B08	B08	B08 NB	Upton Ln over M5	26044-26046	Northbound	107	15	3	125	128	86	16	3	105	110	114	14	2	130	133	99	14	3
		B08 SB		26046-26044	Southbound	103	14	2	120	124	84	15	3	102	107	118	15	2	135	138	98	14	3
B09	B09	B09 NB	The Ash Path over M5	26044-26045	Northbound	47	7	1	54	56	46	8	2	56	58	57	7	1	65	66	49	7	1
		B09 SB		26045-26044	Southbound	40	6	1	46	48	39	7	2	47	49	48	6	1	54	56	42	6	1
B10	B10	B10 NB	B4073 under M5	65413-26017	Northbound	186	26	4	216	223	140	26	6	172	180	210	26	4	239	245	170	25	4
		B10 SB		26017-65413	Southbound	194	27	5	226	233	151	28	6	184	193	199	25	3	228	233	175	26	5
B11	B11	B11 NB	Winnycroft Ln over M5	26015-26014	Northbound	147	21	3	172	177	79	14	3	96	101	212	26	4	242	248	129	19	3
		B11 SB		26014-26015	Southbound	160	23	4	187	192	74	14	3	90	95	163	20	3	186	190	118	17	3
B12	B12	B12 NB	A4173 south of Tuffley, north of Whaddon	65887-27197	Northbound	340	50	19	409	438	244	38	21	303	333	372	41	11	425	442	301	42	18
		B12 SB		27197-65887	Southbound	295	44	17	356	381	230	36	19	285	314	319	35	10	365	379	269	37	16
B13	B13	B13 NB	Naas Ln over M5	link not modelled	Northbound	101	14	2	118	121	37	7	1	45	48	83	10	1	95	97	65	9	2
		B13 SB		link not modelled	Southbound	66	9	2	76	79	41	8	2	50	53	104	13	2	119	121	63	9	2
B14	B14	B14 NB	Haresfield Ln over M5	link not modelled	Northbound	29	4	1	33	34	24	4	1	29	31	30	4	1	34	35	27	4	1
		B14 SB		link not modelled	Southbound	38	5	1	45	46	28	5	1	34	36	42	5	1	48	49	34	5	1
B15	B15	B15 NB	B4008 between M5 J12 and A38	65110-27309	Northbound	1190	167	28	1385	1427	808	148	32	988	1036	1417	176	24	1617	1653	1062	155	27
		B15 SB		27304-65109	Southbound	1251	176	29	1456	1500	744	136	30	910	955	1043	129	18	1190	1216	952	139	25
C01	C01	C01 EB	A40 east of M5 J11	65492-27088	Eastbound	1736	257	98	2091	2238	1025	160	86	1271	1401	1521	169	46	1736	1805	1330	184	78
		C01 WB		27084-60315	Westbound	1569	232	89	1889	2022	1150	179	97	1426	1571	1902	211	58	2171	2258	1444	200	85
C02	B03 C02	B03 C02 EB	Brookfield Rd over M5	27531-26049	Eastbound	400	56	9	465	479	127	23	5	155	163	154	19	3	176	180	203	30	5
		B03 C02 WB		26049-27531	Westbound	142	20	3	165	171	144	26	6	176	185	375	46	6	427	437	202	30	5
C03	C03	C03 NB	A46 south of Shurdington, to the south of jct with Badgeworth Ln	27588-26050	Northbound	772	99	24	895	931	520	72	29	621	665	831	76	8	915	928	661	80	22
		C03 SB		26050-27588	Southbound	790	101	25	915	953	484	68	27	579	619	816	75	8	899	912	644	78	22
C04	C04	C04 NB	Leckhampton Hill between Leckhampton and Ullenwood	26058-27054	Northbound	291	30	5	327	335	189	25	5	218	226	295	17	2	314	317	241	24	4
		C04 SB		27054-26058	Southbound	261	27	5	293	300	175	23	5	203	210	248	14	2	264	267	215	22	4
C05	C05	C05 NB	A435 to the north of jct with A436	27110-27109	Northbound	333	31	8	373	385	202	24	11	237	254	456	38	7	501	511	298	30	10
		C05 SB		27109-27110	Southbound	384	36	10	429	444	176	21	10	207	222	312	26	5	343	350	262	26	8
C06	C06 I02	C06 I02 EB	Unnamed road through Dowdeswell, to the east of jct with A40	26063-26039	Eastbound	17	2	0	20	20	20	4	1	25	26	30	4	1	34	35	22	3	1
		C06 I02 WB		26039-26063	Westbound	29	4	1	34	35	20	4	1	24	25	24	3	0	28	28	23	3	1
C07	C07 I01	C07 I01 EB	A40 between Whittington, Andoversford and Dowdeswell	26040-60550	Eastbound	314	46	18	379	405	244	38	21	303	334	347	39	11	396	412	288	40	17
		C07 I01 WB		60550-26040	Westbound	322	48	18	388	415	277	43	23	344	379	374	42	11	427	444	314	43	18
D01	D01	D01 EB	Church Rd between Shurdington and Leckhampton	27108-26053	Eastbound	214	30	5	249	256	129	24	5	157	165	203	25	3	232	237	170	25	4
		D01 WB		26053-27108	Westbound	235	33	6	273	281	128	23	5	157	165	246	31	4	281	287	185	27	5
D02	D02	D02 NB	A417 between bridge over Bentham Ln and jct with A436	26075-60292	Northbound	956	135	171	1262	1519	791	180	199	1171	1469	1018	194	125	1337	1524	889	173	173
		D02 SB		60292-26075	Southbound	1172	290	195	1657	1950	817	157	185	1158	1436	1279	122	95	1496	1639	1021	181	165
D03	D03	D03 EB	Unnamed road between Witcombe and Birdlip	26024-26023	Eastbound	228	36	2	266	269	80	17	1	98	100	167	28	2	197	201	139	24	2
		D03 WB		26023-26024	Westbound	237	37	2	277	280	148	31	2	181	185	377	63	6	446	454	228	40	3
D04	D04 F05	D04 F05 EB	Buckholt Rd between A46 and B4070	link not modelled	Eastbound	38	5	1	45	46	18	3	1	22	23	15	2	0	17	18	23	3	1
		D04 F05 WB		link not modelled	Westbound	19	3	0	22	22	22	4	1	26	28	50	6	1	58	59	28	4	1
D05	D05 F04	D05 F04 EB	Unnamed road east of Cranham, to the west of jct with B4070	26070-26022	Eastbound	26	4	1	30	31	12	2	0	14	15	16	2	0	18	18	16	2	0
		D05 F04 WB		26022-26070	Westbound	19	3	0	22	22	14	3	1	17	18	30	4	1	35	35	19	3	0
E01	E01	E01 EB	Welsh Way west of Perrott's Brook and jct with A435	65390-65391	Eastbound	69	10	2	81	83	29	5	1	35	37	53	7	1	61	62	45	7	1
		E01 WB		65391-65390	Westbound	55	8	1	64	66	26	5	1	31	33	58	7	1	66	67	41	6	1
E02	A06 E02	A06 E02 NB	Gloucester Rd, Stratton between Baunton Ln and Overley Rd	65674-26010	Northbound	139	20	3	162	167	111	20	4	135	142	163	20	3	186	190	132	19	3
		A06 E02 SB		26010-65674	Southbound	139	20	3	162	166	93	17	4	113	119	137	17	2	157	160	116	17	3
E03	E03	E03 EB	A419 north of Coates	65877-27341	Eastbound	495	73	28	596	638	243	38	20	301	332	251	28	8	286	298	310	43	18
		E03 WB		27341-65877	Westbound	219	32	12	264	283	257	40	22	319	351	506	56	15	577	600	309	43	18
E04	A08 E04	A08 E04 NB	A417 NE of Stratton	65470-60540	Northbound	778	138	117	1032	1207	701	134	141	976	1187	1071	117	88	1276	1408	811	132	122
		A08 E04 SB		65471-60529	Southbound	1021	181	153	1355	1585	630	120	127	877	1067	915	100	75	1090	1202	799	130	120
F01	F01	F01 NB	A4173 south of Brookthorpe, to the north of jct with Styles Ln	65959-26012	Northbound	413	61	23	498	533	362	56	30	449	494	499	55	15	569	592	410	57	24
		F01 SB		26012-65959	Southbound	306	45	17	368	394	306	48	26	379	418	553	61	17	631	656	367	51	22
F02	F02	F02 NB	B4073 through Painswick Beacon, to the west of golf course	27594-27507	Northbound	68	10	2	79	82	68	12	3	83	87	98	12	2	112	114	76	11	2
		F02 SB		27507-27594	Southbound	93	13	2	108	112	66	12	3	81	85	80	10	1	92	94	77	11	2
F03	F03	F03 NB	A46 east of Painswick Beacon, to the east of golf course	27595-26021	Northbound	291	43	16	351	376	178	28	15	220	242	254	28	8	290	302	226	31	13
		F03 SB		26021-27595	Southbound	225	33	13	271	290	176	27	15	218	240	338	38	10	386	401	229	31	13
F04	D05 F04	D05 F04 EB	Unnamed road east of Cranham, to the west of jct with B4070	26070-26022	Eastbound	26	4	1	30	31	12	2	0	14	15	16	2	0	18	18	16	2	0
		D05 F04 WB		26022-26070	Westbound	19	3	0	22	22	14	3	1	17	18	30	4	1	35	35	19	3	0
F05	D04 F05	D04 F05 EB	Buckholt Rd between A46 and B4070	link not modelled	Eastbound	38	5	1	45	46	18	3	1	22	23	15	2	0	17	18	23	3	1
		D04 F05 WB		link not modelled	Westbound	19	3	0	22	22	22	4	1	26	28	50	6	1	58	59	28	4	1
F06	F06	F06 NB	B4070 south of Birdlip	26022-65895	Northbound	273	53	8	333	345	124	24	3	152	157	149	23	2	175	178	168	31	4
		F06 SB		65895-26022	Southbound	134	26	4	163	169	122	24	3	149	154	286	44	5	335	342	165	30	4
F06b	F06b	F06b NB	Unnamed road between Birdlip and Brimpsfield	26030-26025	Northbound	18	3	0	21	22	17	3	1	21	22	71	9	1	81	83	31	5	1
		F06b SB		26025-26030	Southbound	21	3	1	25	26	7	1	0	9	9	11	1	0	12	13	12	2	0
F07	F07	F07 NB	A417 south of Stockwell	26034-60286	Northbound	746	121	149	1016	1240	659	158	160	977	1217	905	152	90	1147	1282	742	147	140
		F07 SB		60286-26034	Southbound	875	212	160	1247	1487	637	118	145	900	1118	941	100	73	1114	1224	773	137	131
F08	F08 H06	F08 H06 EB	Unnamed road SW of Cockleford	26032-26035	Eastbound	4	1	0	5	5	2	0	0	3	3	4	1	0	5	5	3	0	0
		F08 H06 WB		26035-26032	Westbound	1	0	0	1	1	1	0	0	1	1	4	0	0	4	4	2	0	0
F09	F09	F09 NB	A435 north of Cockleford, east of Cowley	65412-26036	Northbound	280	30	4	314	321	153	22	6	180	189	397	33	4	434	440	245	27	5
		F09 SB		26036-65412	Southbound	374	41	6	420	429	138	20	5	163	171	260	22	3	285	289	228	25	5
G01	G01	G01 NB	A46 to the south of jct with A417	60262-60266	Northbound	837	121	29	987	1031	483	67	24	574	611	708	82	11	802	819	629	83	22
		G01 SB		27581-60262	Southbound	463	67	16	546	570	437	60	22	519	552	751	87	12	851	869	522	69	18
G02	G02 H02	G02 H02 NB	Bentham Ln under A417	26024-26064	Northbound	16	2	0	19	19	11	2	0	14	14	21	3	0	24	25	15	2	0
		G02 H02 SB		26064-26024	Southbound	15	2	0	18	18	13	2	1	16	17	26	3	0	29	30	17	2	0
G03	G03	G03 NB	B4070 north of Birdlip	65894-60289	Northbound	304	49	10	363	378	121	23	7	151	162	129	14	4	147	153	169	27	7
		G03 SB		60289-65894	Southbound	148	29	9	186	200	177	43	10	230	245	397	75	3	475	480	225	48	8
G04	G04	G04 EB	Unnamed road between A417 and Brimpsfield	26030-26031	Eastbound	32	4	1	37	38	6	1	0	7	8	5	1	0	5	6	12	2	0
		G04 WB		26031-26030	Westbound	15	2	0	17	18	18	3	1	22	24	88	11	1	101	103	35	5	1
G05	G05	G05 NB	Unnamed road SE of Syde	link not modelled	Northbound	2	0	0	3	3	2	0	0	2	2	2	0	0	2	2	2	0	0
		G05 SB		link not modelled	Southbound	3	0	0	3	3	4	1	0	4	5	16	2	0	18	18	6	1	0
G06	G06	G06 EB	Jackbarrow Rd through Winstone	26069-26028	Eastbound	29	4	1	33	34	17	3	1	21	22	24	3	0	27	28	22	3	1
		G06 WB		26028-26069	Westbound	25	4	1	29	30	14	3	1	17	18	27	3	0	31	31	20	3	1
G07	G07	G07 EB	Unnamed road SE of Duntisbourne Abbotts	link not modelled	Eastbound	3	0	0	3	4	2	0	0	3	3	3	0	0	3	4	3	0	0
		G07 WB		link not modelled	Westbound	3	0	0	3	3	2	0	0	3	3	3	0	0	4	4	3	0	0
G08	G08	G08 NB	Crabtree Ln SE of Duntisbourne Leer, to the SE of jct with Longhill Rd	26019-26068	Northbound	5	1	0	5	5	4	1	0	5	5	6	1	0	7	7	5	1	0
		G08 SB		26068-26019	Southbound	6	1	0	6	7	4	1	0	5	5	5	1	0	5	5	5	1	0
H01	H01	H01 NB	A46 to the north of jct with A417	27583-26026	Northbound	817	127	30	975	1020	512	72	32	617	665	813	65	8	886	898	664	84	26
		H01 SB		26026-27583	Southbound	732	71	19	822	850	473	64	23	561	595	914	93	9	1016	1030	648	73	19
H02	G02 H02	G02 H02 NB	Bentham Ln under A417	26024-26064	Northbound	16	2	0	19	19	11	2	0	14	14	21	3	0	24	25	15	2	0
		G02 H02 SB		26064-26024	Southbound	15	2	0	18	18	13	2	1	16	17	26	3	0	29	30	17	2	0
H03	H03	H03 NB	Leckhampton Hill to the north of jct with A436	26080-27589	Northbound	361	43	5	409	417	171	24	6	201	210	230	15	2	247	250	233	27	5
		H03 SB		27589-26080	Southbound	194	21	5	220	228	163	17	4	184	190	225	21	2	248	251	186	19	4
H04	H04	H04 EB	A436 to the east of jcts with A417, Leckhampton Hill	26080-26060	Eastbound	413	108	64	585	681	282	50	56	388	472	402	29	24	455	491	345	59	50
		H04 WB		26060-26080	Westbound	334	44	45	423	491	301	62	59	422	511	429	100	31	560	607	341	67	49
H05	H05	H05 EB	Unnamed road between Cowley and Stockwell	26034-26035	Eastbound	4	1	0	5	5	3	0	0	3	3	4	1	0	5	5	3	1	0
		H05 WB		26035-26034	Westbound	3	0	0	4	4	3	0	0	3	3	10	1	0	11	11	4	1	0
H06	F08 H06	F08 H06 EB	Unnamed road SW of Cockleford	26032-26035	Eastbound	4	1	0	5	5	2	0	0	3	3	4	1	0	5	5	3	0	0
		F08 H06 WB		26035-26032	Westbound	1	0	0	1	1	1	0	0	1	1	4	0	0	4	4	2	0	0
H07	H07	H07 EB	Unnamed road east of Brimpsfield and A417	26032-26033	Eastbound	6	1	0	7	7	3	1	0	4	4	4	1	0	5	5	4	1	0
		H07 WB		26033-26032	Westbound	8	1	0	10	10	9	2	0	11	12	54	7	1	62	64	20	3	1
H08	H08	H08 NB	Unnamed road south of Elkstone	65411-26059	Northbound	91	13	2	106	110	54	10	2	67	70	230	28	4	262	268	107	16	3
		H08 SB		26059-65411	Southbound	161	23	4	188	193	37	7	1	45	47	68	8	1	77	79	76	11	2
H09	H09	H09 NB	Unnamed road SE of Elkstone	link not modelled	Northbound	6	1	0	7	7	2	0	0	3	3	2	0	0	2	2	3	0	0
		H09 SB		link not modelled	Southbound	2	0	0	2	2	4	1	0	5	5	5	1	0	6	6	4	1	0
H10	H10	H10 EB	Unnamed road east of A417, between Winstone and Rapsgate	link not modelled	Eastbound	4	1	0	5	5	3	1	0	3	4	4	0	0	4	4	3	1	0
		H10 WB		link not modelled	Westbound	4	1	0	4	4	2	0	0	3	3	3	0	0	4	4	3	0	0
I01	C07 I01	C07 I01 EB	A40 between Whittington, Andoversford and Dowdeswell	26040-60550	Eastbound	314	46	18	379	405	244	38	21	303	334	347	39	11	396	412	288	40	17
		C07 I01 WB		60550-26040	Westbound	322	48	18	388	415	277	43	23	344	379	374	42	11	427	444	314	43	18
I02	C06 I02	C06 I02 EB	Unnamed road through Dowdeswell, to the east of jct with A40	26063-26039	Eastbound	17	2	0	20	20	20	4	1	25	26	30	4	1	34	35	22	3	1
		C06 I02 WB		26039-26063	Westbound	29	4	1	34	35	20	4	1	24	25	24	3	0	28	28	23	3	1
I03	I03	I03 EB	A436 through Kilkenny, to the west of jct with Gloucester Rd	27112-60546	Eastbound	344	78	44	466	531	244	48	41	333	395	320	51	19	390	419	289	56	36
		I03 WB		60546-27112	Westbound	277	63	35	376	429	270	53	46	368	437	376	60	22	459	493	298	58	37
I04	I04	I04 EB	Unnamed road between Upper Coberley and Withington	link not modelled	Eastbound	1	0	0	1	1	2	0	0	2	2	2	0	0	2	2	2	0	0
		I04 WB		link not modelled	Westbound	2	0	0	2	2	2	0	0	2	2	1	0	0	1	1	2	0	0
I05	I05	I05 NB	A435 through Colesbourne	65391-65675	Northbound	163	19	3	185	190	108	14	4	126	133	222	20	4	245	250	150	17	4
		I05 SB		65675-65391	Southbound	228	26	5	259	266	106	14	4	124	131	160	14	3	176	180	150	17	4

Site	Screenline Reference	Screenline Reference & Direction	Site Description	Links (ATC)	Direction	AM 7-10 Avg					IP 10-4 Avg					PM 4-7 Avg					12hr 7-7 Avg		
						Car	LGV	OGV	Total Veh	Total PCU	Car	LGV	OGV	Total Veh	Total PCU	Car	LGV	OGV	Total Veh	Total PCU	Car	LBV	OGV
A01	A01	A01 NB	A46 south of Pitchcombe	27384-60090	Northbound	510	75	29	614	658	364	57	31	452	498	527	59	16	602	626	443	61	26
		A01 SB		60090-27384	Southbound	487	72	28	586	627	356	56	30	442	487	525	58	16	599	623	432	60	25
A02	A02	A02 NB	B4070 south of Slad	65897-26066	Northbound	73	10	2	85	88	50	9	2	61	64	58	7	1	66	67	58	8	1
		A02 SB		26066-65897	Southbound	54	8	1	63	65	53	10	2	65	68	75	9	1	86	88	59	9	2
A03	A03	A03 NB	Calf Way north of Bisley, to the north of jct with Stancombe Ln	26001-26071	Northbound	209	29	5	243	250	92	17	4	113	118	104	13	2	119	122	125	18	3
		A03 SB		26071-26001	Southbound	104	15	2	122	125	94	17	4	115	121	184	23	3	210	215	120	18	3
A04	A04	A04 NB	Dane Ln south of Edgeworth	link not modelled	Northbound	20	3	0	23	24	11	2	0	13	14	13	2	0	15	15	14	2	0
		A04 SB		link not modelled	Southbound	12	2	0	14	15	12	2	0	14	15	23	3	0	26	27	15	2	0
A05	A05	A05 NB	Unnamed road NE of Sapperton, to the south of jct with Overley Rd	65380-26018	Northbound	53	7	1	61	63	27	5	1	33	35	41	5	1	47	48	37	5	1
		A05 SB		26018-65380	Southbound	48	7	1	56	58	29	5	1	36	37	53	7	1	61	62	40	6	1
A06	A06 E02	A06 E02 NB	Gloucester Rd, Stratton between Baunton Ln and Overley Rd	65674-26010	Northbound	139	20	3	162	167	111	20	4	135	142	163	20	3	186	190	132	19	3
		A06 E02 SB		26010-65674	Southbound	139	20	3	162	166	93	17	4	113	119	137	17	2	157	160	116	17	3
A07	A07	A07 NB	A435 between Baunton and Stratton, to the north of jct with Baunton Ln	27592-26067	Northbound	183	27	10	221	236	129	20	11	160	177	223	25	7	255	265	166	23	10
		A07 SB		26067-27592	Southbound	201	30	11	242	259	126	20	11	156	172	184	20	6	210	218	159	22	9
A08	A08 E04	A08 E04 NB	A417 NE of Stratton	65470-60540	Northbound	778	138	117	1032	1207	701	134	141	976	1187	1071	117	88	1276	1408	811	132	122
		A08 E04 SB		65471-60529	Southbound	1021	181	153	1355	1585	630	120	127	877	1067	915	100	75	1090	1202	799	130	120
A09	A09	A09 NB	White Way NE of Baunton	link not modelled	Northbound	39	5	1	45	47	36	7	1	45	47	56	7	1	64	66	42	6	1
		A09 SB		link not modelled	Southbound	58	8	1	67	69	32	6	1	39	41	47	6	1	54	55	42	6	1
A10	A10	A10 NB	A429 east of Perrott's Brook, to the north of jct with Welsh Way	60536-68010	Northbound	249	37	14	300	322	221	34	19	274	302	271	30	8	310	322	242	33	14
		A10 SB		68010-60536	Southbound	248	37	14	298	319	217	34	18	269	297	269	30	8	307	320	239	33	14
B01	B01	B01 EB	B4063 west of Staverton Bridge, north of airfield	60493-60317	Eastbound	470	66	11	547	563	353	65	14	432	453	397	49	7	453	463	397	58	10
		B01 WB		60317-60493	Westbound	409	57	10	476	490	360	66	14	441	463	485	60	8	553	565	408	60	11
B02	B02	B02 EB	A40 west of M5 J11	66709-60304	Eastbound	1141	202	171	1514	1771	791	151	159	1102	1341	1196	131	98	1425	1572	979	159	147
		B02 WB		65490-26086	Westbound	1130	200	170	1500	1754	769	147	155	1071	1303	1280	140	105	1525	1682	983	160	148
B03	B03 C02	B03 C02 EB	Brookfield Rd over M5	27531-26049	Eastbound	400	56	9	465	479	127	23	5	155	163	154	19	3	176	180	203	30	5
		B03 C02 WB		26049-27531	Westbound	142	20	3	165	171	144	26	6	176	185	375	46	6	427	437	202	30	5
B04	B04	B04 NB	Brockworth Rd over M5	65419-65417	Northbound	101	14	2	118	122	64	12	3	78	82	113	14	2	129	131	86	13	2
		B04 SB		65417-65419	Southbound	96	14	2	112	115	69	13	3	84	88	112	14	2	128	131	87	13	2
B05	B05	B05 EB	A417 between Zoons and C&G rbouts	66701-27324	Eastbound	1006	149	57	1212	1297	803	125	68	996	1097	1315	146	40	1501	1561	983	136	58
		B05 WB		27322-26084	Westbound	1410	208	80	1698	1818	829	129	70	1028	1133	1143	127	35	1305	1357	1057	146	62
B06	B06	B06 EB	Hucclecote Rd under M5	65416-26092	Eastbound	420	59	10	489	504	341	62	14	417	438	418	52	7	476	487	384	56	10
		B06 WB		26092-65416	Westbound	318	45	7	370	381	360	66	14	440	462	556	69	9	635	649	402	59	10
B07	B07	B07 EB	Lobleys Dr over M5	26047-65966	Eastbound	426	60	10	496	511	203	37	8	248	260	292	36	5	334	341	283	41	7
		B07 WB		65966-26047	Westbound	209	29	5	244	251	230	42	9	282	295	502	62	9	572	585	294	43	8
B08	B08	B08 NB	Upton Ln over M5	26044-26046	Northbound	107	15	3	125	128	86	16	3	105	110	114	14	2	130	133	99	14	3
		B08 SB		26046-26044	Southbound	103	14	2	120	124	84	15	3	102	107	118	15	2	135	138	98	14	3
B09	B09	B09 NB	The Ash Path over M5	26044-26045	Northbound	47	7	1	54	56	46	8	2	56	58	57	7	1	65	66	49	7	1
		B09 SB		26045-26044	Southbound	40	6	1	46	48	39	7	2	47	49	48	6	1	54	56	42	6	1
B10	B10	B10 NB	B4073 under M5	65413-26017	Northbound	186	26	4	216	223	140	26	6	172	180	210	26	4	239	245	170	25	4
		B10 SB		26017-65413	Southbound	194	27	5	226	233	151	28	6	184	193	199	25	3	228	233	175	26	5
B11	B11	B11 NB	Winnycroft Ln over M5	26015-26014	Northbound	147	21	3	172	177	79	14	3	96	101	212	26	4	242	248	129	19	3
		B11 SB		26014-26015	Southbound	160	23	4	187	192	74	14	3	90	95	163	20	3	186	190	118	17	3
B12	B12	B12 NB	A4173 south of Tuffley, north of Whaddon	65887-27197	Northbound	340	50	19	409	438	244	38	21	303	333	372	41	11	425	442	301	42	18
		B12 SB		27197-65887	Southbound	295	44	17	356	381	230	36	19	285	314	319	35	10	365	379	269	37	16
B13	B13	B13 NB	Naas Ln over M5	link not modelled	Northbound	101	14	2	118	121	37	7	1	45	48	83	10	1	95	97	65	9	2
		B13 SB		link not modelled	Southbound	66	9	2	76	79	41	8	2	50	53	104	13	2	119	121	63	9	2
B14	B14	B14 NB	Haresfield Ln over M5	link not modelled	Northbound	29	4	1	33	34	24	4	1	29	31	30	4	1	34	35	27	4	1
		B14 SB		link not modelled	Southbound	38	5	1	45	46	28	5	1	34	36	42	5	1	48	49	34	5	1
B15	B15	B15 NB	B4008 between M5 J12 and A38	65110-27309	Northbound	1190	167	28	1385	1427	808	148	32	988	1036	1417	176	24	1617	1653	1062	155	27
		B15 SB		27304-65109	Southbound	1251	176	29	1456	1500	744	136	30	910	955	1043	129	18	1190	1216	952	139	25
C01	C01	C01 EB	A40 east of M5 J11	65492-27088	Eastbound	1736	257	98	2091	2238	1025	160	86	1271	1401	1521	169	46	1736	1805	1330	184	78
		C01 WB		27084-60315	Westbound	1569	232	89	1889	2022	1150	179	97	1426	1571	1902	211	58	2171	2258	1444	200	85
C02	B03 C02	B03 C02 EB	Brookfield Rd over M5	27531-26049	Eastbound	400	56	9	465	479	127	23	5	155	163	154	19	3	176	180	203	30	5
		B03 C02 WB		26049-27531	Westbound	142	20	3	165	171	144	26	6	176	185	375	46	6	427	437	202	30	5
C03	C03	C03 NB	A46 south of Shurdington, to the south of jct with Badgeworth Ln	27588-26050	Northbound	772	99	24	895	931	520	72	29	621	665	831	76	8	915	928	661	80	22
		C03 SB		26050-27588	Southbound	790	101	25	915	953	484	68	27	579	619	816	75	8	899	912	644	78	22
C04	C04	C04 NB	Leckhampton Hill between Leckhampton and Ullenwood	26058-27054	Northbound	291	30	5	327	335	189	25	5	218	226	295	17	2	314	317	241	24	4
		C04 SB		27054-26058	Southbound	261	27	5	293	300	175	23	5	203	210	248	14	2	264	267	215	22	4
C05	C05	C05 NB	A435 to the north of jct with A436	27110-27109	Northbound	333	31	8	373	385	202	24	11	237	254	456	38	7	501	511	298	30	10
		C05 SB		27109-27110	Southbound	384	36	10	429	444	176	21	10	207	222	312	26	5	343	350	262	26	8
C06	C06 I02	C06 I02 EB	Unnamed road through Dowdeswell, to the east of jct with A40	26063-26039	Eastbound	17	2	0	20	20	20	4	1	25	26	30	4	1	34	35	22	3	1
		C06 I02 WB		26039-26063	Westbound	29	4	1	34	35	20	4	1	24	25	24	3	0	28	28	23	3	1
C07	C07 I01	C07 I01 EB	A40 between Whittington, Andoversford and Dowdeswell	26040-60550	Eastbound	314	46	18	379	405	244	38	21	303	334	347	39	11	396	412	288	40	17
		C07 I01 WB		60550-26040	Westbound	322	48	18	388	415	277	43	23	344	379	374	42	11	427	444	314	43	18
D01	D01	D01 EB	Church Rd between Shurdington and Leckhampton	27108-26053	Eastbound	214	30	5	249	256	129	24	5	157	165	203	25	3	232	237	170	25	4
		D01 WB		26053-27108	Westbound	235	33	6	273	281	128	23	5	157	165	246	31	4	281	287	185	27	5
D02	D02	D02 NB	A417 between bridge over Bentham Ln and jct with A436	26075-60292	Northbound	956	135	171	1262	1519	791	180	199	1171	1469	1018	194	125	1337	1524	889	173	173
		D02 SB		60292-26075	Southbound	1172	290	195	1657	1950	817	157	185	1158	1436	1279	122	95	1496	1639	1021	181	165
D03	D03	D03 EB	Unnamed road between Witcombe and Birdlip	26024-26023	Eastbound	228	36	2	266	269	80	17	1	98	100	167	28	2	197	201	139	24	2
		D03 WB		26023-26024	Westbound	237	37	2	277	280	148	31	2	181	185	377	63	6	446	454	228	40	3
D04	D04 F05	D04 F05 EB	Buckholt Rd between A46 and B4070	link not modelled	Eastbound	38	5	1	45	46	18	3	1	22	23	15	2	0	17	18	23	3	1
		D04 F05 WB		link not modelled	Westbound	19	3	0	22	22	22	4	1	26	28	50	6	1	58	59	28	4	1
D05	D05 F04	D05 F04 EB	Unnamed road east of Cranham, to the west of jct with B4070	26070-26022	Eastbound	26	4	1	30	31	12	2	0	14	15	16	2	0	18	18	16	2	0
		D05 F04 WB		26022-26070	Westbound	19	3	0	22	22	14	3	1	17	18	30	4	1	35	35	19	3	0
E01	E01	E01 EB	Welsh Way west of Perrott's Brook and jct with A435	65390-65391	Eastbound	69	10	2	81	83	29	5	1	35	37	53	7	1	61	62	45	7	1
		E01 WB		65391-65390	Westbound	55	8	1	64	66	26	5	1	31	33	58	7	1	66	67	41	6	1
E02	A06 E02	A06 E02 NB	Gloucester Rd, Stratton between Baunton Ln and Overley Rd	65674-26010	Northbound	139	20	3	162	167	111	20	4	135	142	163	20	3	186	190	132	19	3
		A06 E02 SB		26010-65674	Southbound	139	20	3	162	166	93	17	4	113	119	137	17	2	157	160	116	17	3
E03	E03	E03 EB	A419 north of Coates	65877-27341	Eastbound	495	73	28	596	638	243	38	20	301	332	251	28	8	286	298	310	43	18
		E03 WB		27341-65877	Westbound	219	32	12	264	283	257	40	22	319	351	506	56	15	577	600	309	43	18
E04	A08 E04	A08 E04 NB	A417 NE of Stratton	65470-60540	Northbound	778	138	117	1032	1207	701	134	141	976	1187	1071	117	88	1276	1408	811	132	122
		A08 E04 SB		65471-60529	Southbound	1021	181	153	1355	1585	630	120	127	877	1067	915	100	75	1090	1202	799	130	120
F01	F01	F01 NB	A4173 south of Brookthorpe, to the north of jct with Styles Ln	65959-26012	Northbound	413	61	23	498	533	362	56	30	449	494	499	55	15	569	592	410	57	24
		F01 SB		26012-65959	Southbound	306	45	17	368	394	306	48	26	379	418	553	61	17	631	656	367	51	22
F02	F02	F02 NB	B4073 through Painswick Beacon, to the west of golf course	27594-27507	Northbound	68	10	2	79	82	68	12	3	83	87	98	12	2	112	114	76	11	2
		F02 SB		27507-27594	Southbound	93	13	2	108	112	66	12	3	81	85	80	10	1	92	94	77	11	2
F03	F03	F03 NB	A46 east of Painswick Beacon, to the east of golf course	27595-26021	Northbound	291	43	16	351	376	178	28	15	220	242	254	28	8	290	302	226	31	13
		F03 SB		26021-27595	Southbound	225	33	13	271	290	176	27	15	218	240	338	38	10	386	401	229	31	13
F04	D05 F04	D05 F04 EB	Unnamed road east of Cranham, to the west of jct with B4070	26070-26022	Eastbound	26	4	1	30	31	12	2	0	14	15	16	2	0	18	18	16	2	0
		D05 F04 WB		26022-26070	Westbound	19	3	0	22	22	14	3	1	17	18	30	4	1	35	35	19	3	0
F05	D04 F05	D04 F05 EB	Buckholt Rd between A46 and B4070	link not modelled	Eastbound	38	5	1	45	46	18	3	1	22	23	15	2	0	17	18	23	3	1
		D04 F05 WB		link not modelled	Westbound	19	3	0	22	22	22	4	1	26	28	50	6	1	58	59	28	4	1
F06	F06	F06 NB	B4070 south of Birdlip	26022-65895	Northbound	273	53	8	333	345	124	24	3	152	157	149	23	2	175	178	168	31	4
		F06 SB		65895-26022	Southbound	134	26	4	163	169	122	24	3	149	154	286	44	5	335	342	165	30	4
F06b	F06b	F06b NB	Unnamed road between Birdlip and Brimpsfield	26030-26025	Northbound	18	3	0	21	22	17	3	1	21	22	71	9	1	81	83	31	5	1
		F06b SB		26025-26030	Southbound	21	3	1	25	26	7	1	0	9	9	11	1	0	12	13	12	2	0
F07	F07	F07 NB	A417 south of Stockwell	26034-60286	Northbound	746	121	149	1016	1240	659	158	160	977	1217	905	152	90	1147	1282	742	147	140
		F07 SB		60286-26034	Southbound	875	212	160	1247	1487	637	118	145	900	1118	941	100	73	1114	1224	773	137	131
F08	F08 H06	F08 H06 EB	Unnamed road SW of Cockleford	26032-26035	Eastbound	4	1	0	5	5	2	0	0	3	3	4	1	0	5	5	3	0	0
		F08 H06 WB		26035-26032	Westbound	1	0	0	1	1	1	0	0	1	1	4	0	0	4	4	2	0	0
F09	F09	F09 NB	A435 north of Cockleford, east of Cowley	65412-26036	Northbound	280	30	4	314	321	153	22	6	180	189	397	33	4	434	440	245	27	5
		F09 SB		26036-65412	Southbound	374	41	6	420	429	138	20	5	163	171	260	22	3	285	289	228	25	5
G01	G01	G01 NB	A46 to the south of jct with A417	60262-60266	Northbound	837	121	29	987	1031	483	67	24	574	611	708	82	11	802	819	629	83	22
		G01 SB		27581-60262	Southbound	463	67	16	546	570	437	60	22	519	552	751	87	12	851	869	522	69	18
G02	G02 H02	G02 H02 NB	Bentham Ln under A417	26024-26064	Northbound	16	2	0	19	19	11	2	0	14	14	21	3	0	24	25	15	2	0
		G02 H02 SB		26064-26024	Southbound	15	2	0	18	18	13	2	1	16	17	26	3	0	29	30	17	2	0
G03	G03	G03 NB	B4070 north of Birdlip	65894-60289	Northbound	304	49	10	363	378	121	23	7	151	162	129	14	4	147	153	169	27	7
		G03 SB		60289-65894	Southbound	148	29	9	186	200	177	43	10	230	245	397	75	3	475	480	225	48	8
G04	G04	G04 EB	Unnamed road between A417 and Brimpsfield	26030-26031	Eastbound	32	4	1	37	38	6	1	0	7	8	5	1	0	5	6	12	2	0
		G04 WB		26031-26030	Westbound	15	2	0	17	18	18	3	1	22	24	88	11	1	101	103	35	5	1
G05	G05	G05 NB	Unnamed road SE of Syde	link not modelled	Northbound	2	0	0	3	3	2	0	0	2	2	2	0	0	2	2	2	0	0
		G05 SB		link not modelled	Southbound	3	0	0	3	3	4	1	0	4	5	16	2	0	18	18	6	1	0
G06	G06	G06 EB	Jackbarrow Rd through Winstone	26069-26028	Eastbound	29	4	1	33	34	17	3	1	21	22	24	3	0	27	28	22	3	1
		G06 WB		26028-26069	Westbound	25	4	1	29	30	14	3	1	17	18	27	3	0	31	31	20	3	1
G07	G07	G07 EB	Unnamed road SE of Duntisbourne Abbotts	link not modelled	Eastbound	3	0	0	3	4	2	0	0	3	3	3	0	0	3	4	3	0	0
		G07 WB		link not modelled	Westbound	3	0	0	3	3	2	0	0	3	3	3	0	0	4	4	3	0	0
G08	G08	G08 NB	Crabtree Ln SE of Duntisbourne Leer, to the SE of jct with Longhill Rd	26019-26068	Northbound	5	1	0	5	5	4	1	0	5	5	6	1	0	7	7	5	1	0
		G08 SB		26068-26019	Southbound	6	1	0	6	7	4	1	0	5	5	5	1	0	5	5	5	1	0
H01	H01	H01 NB	A46 to the north of jct with A417	27583-26026	Northbound	817	127	30	975	1020	512	72	32	617	665	813	65	8	886	898	664	84	26
		H01 SB		26026-27583	Southbound	732	71	19	822	850	473	64	23	561	595	914	93	9	1016	1030	648	73	19
H02	G02 H02	G02 H02 NB	Bentham Ln under A417	26024-26064	Northbound	16	2	0	19	19	11	2	0	14	14	21	3	0	24	25	15	2	0
		G02 H02 SB		26064-26024	Southbound	15	2	0	18	18	13	2	1	16	17	26	3	0	29	30	17	2	0
H03	H03	H03 NB	Leckhampton Hill to the north of jct with A436	26080-27589	Northbound	361	43	5	409	417	171	24	6	201	210	230	15	2	247	250	233	27	5
		H03 SB		27589-26080	Southbound	194	21	5	220	228	163	17	4	184	190	225	21	2	248	251	186	19	4
H04	H04	H04 EB	A436 to the east of jcts with A417, Leckhampton Hill	26080-26060	Eastbound	413	108	64	585	681	282	50	56	388	472	402	29	24	455	491	345	59	50
		H04 WB		26060-26080	Westbound	334	44	45	423	491	301	62	59	422	511	429	100	31	560	607	341	67	49
H05	H05	H05 EB	Unnamed road between Cowley and Stockwell	26034-26035	Eastbound	4	1	0	5	5	3	0	0	3	3	4	1	0	5	5	3	1	0
		H05 WB		26035-26034	Westbound	3	0	0	4	4	3	0	0	3	3	10	1	0	11	11	4	1	0
H06	F08 H06	F08 H06 EB	Unnamed road SW of Cockleford	26032-26035	Eastbound	4	1	0	5	5	2	0	0	3	3	4	1	0	5	5	3	0	0
		F08 H06 WB		26035-26032	Westbound	1	0	0	1	1	1	0	0	1	1	4	0	0	4	4	2	0	0
H07	H07	H07 EB	Unnamed road east of Brimpsfield and A417	26032-26033	Eastbound	6	1	0	7	7	3	1	0	4	4	4	1	0	5	5	4	1	0
		H07 WB		26033-26032	Westbound	8	1	0	10	10	9	2	0	11	12	54	7	1	62	64	20	3	1
H08	H08	H08 NB	Unnamed road south of Elkstone	65411-26059	Northbound	91	13	2	106	110	54	10	2	67	70	230	28	4	262	268	107	16	3
		H08 SB		26059-65411	Southbound	161	23	4	188	193	37	7	1	45	47	68	8	1	77	79	76	11	2
H09	H09	H09 NB	Unnamed road SE of Elkstone	link not modelled	Northbound	6	1	0	7	7	2	0	0	3	3	2	0	0	2	2	3	0	0
		H09 SB		link not modelled	Southbound	2	0	0	2	2	4	1	0	5	5	5	1	0	6	6	4	1	0
H10	H10	H10 EB	Unnamed road east of A417, between Winstone and Rapsgate	link not modelled	Eastbound	4	1	0	5	5	3	1	0	3	4	4	0	0	4	4	3	1	0
		H10 WB		link not modelled	Westbound	4	1	0	4	4	2	0	0	3	3	3	0	0	4	4	3	0	0
I01	C07 I01	C07 I01 EB	A40 between Whittington, Andoversford and Dowdeswell	26040-60550	Eastbound	314	46	18	379	405	244	38	21	303	334	347	39	11	396	412	288	40	17
		C07 I01 WB		60550-26040	Westbound	322	48	18	388	415	277	43	23	344	379	374	42	11	427	444	314	43	18
I02	C06 I02	C06 I02 EB	Unnamed road through Dowdeswell, to the east of jct with A40	26063-26039	Eastbound	17	2	0	20	20	20	4	1	25	26	30	4	1	34	35	22	3	1
		C06 I02 WB		26039-26063	Westbound	29	4	1	34	35	20	4	1	24	25	24	3	0	28	28	23	3	1
I03	I03	I03 EB	A436 through Kilkenny, to the west of jct with Gloucester Rd	27112-60546	Eastbound	344	78	44	466	531	244	48	41	333	395	320	51	19	390	419	289	56	36
		I03 WB		60546-27112	Westbound	277	63	35	376	429	270	53	46	368	437	376	60	22	459	493	298	58	37
I04	I04	I04 EB	Unnamed road between Upper Coberley and Withington	link not modelled	Eastbound	1	0	0	1	1	2	0	0	2	2	2	0	0	2	2	2	0	0
		I04 WB		link not modelled	Westbound	2	0	0	2	2	2	0	0	2	2	1	0	0	1	1	2	0	0
I05	I05	I05 NB	A435 through Colesbourne	65391-65675	Northbound	163	19	3	185	190	108	14	4	126	133	222	20	4	245	250	150	17	4
		I05 SB		65675-65391	Southbound	228	26	5	259	266	106	14	4	124	131	160	14	3	176	180	150	17	4

Source: Highways England

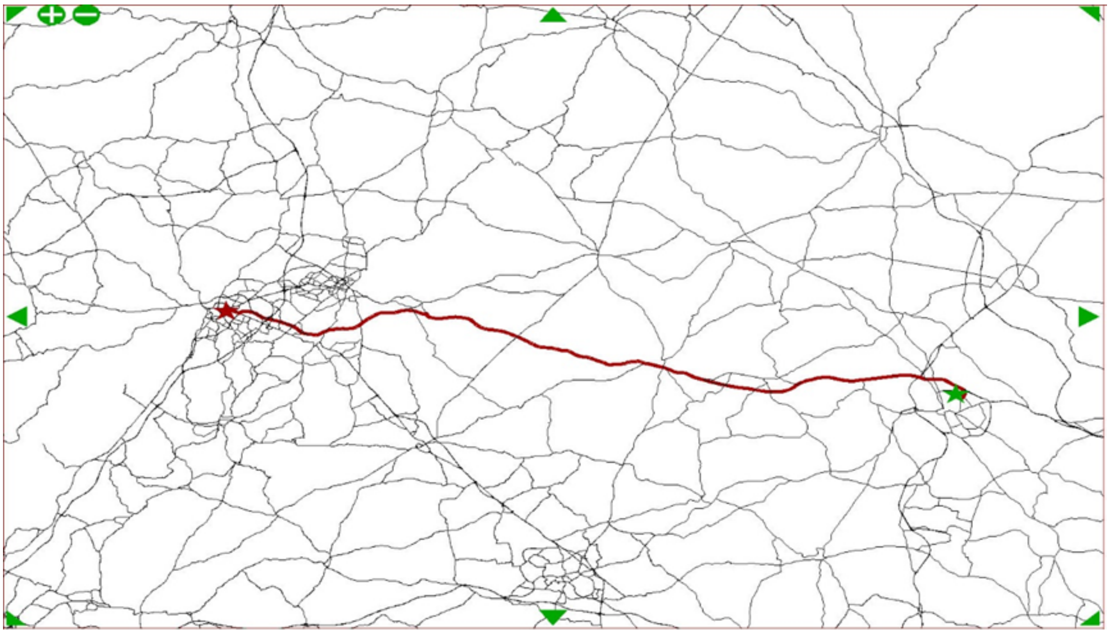
Appendix D Route analysis examples

D.1.1.1 Figure D-1 to Figure D-8 show the breakdown of paths for Gloucester – Oxford, Swindon – Tewkesbury, Cirencester – Cheltenham and Cirencester – Gloucester for the AM peak. These plots have been produced for the PM peak and these also show sensible, and expected, paths.



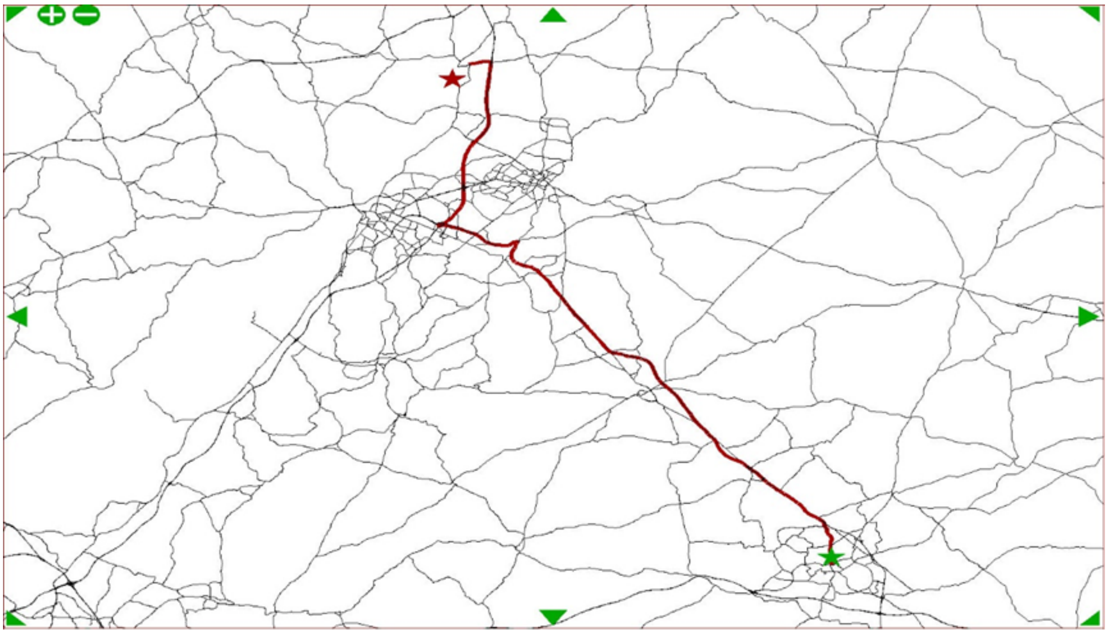
Source: Highways England

Figure D-1 Route analysis example – Gloucester-Oxford (AM peak)



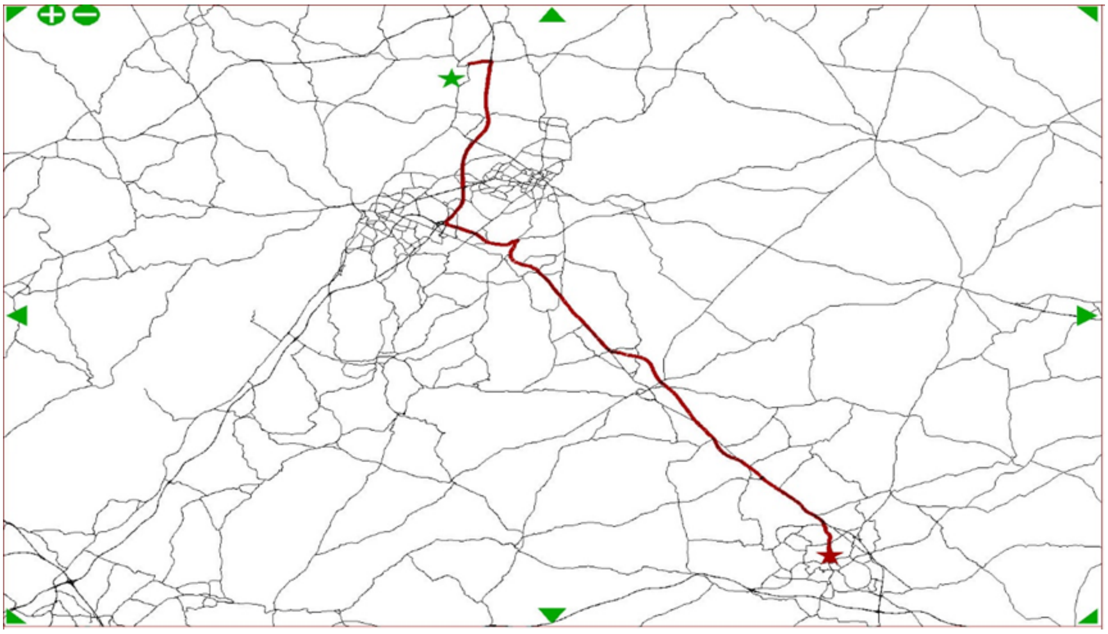
Source: Highways England

Figure D-2 Route analysis example – Oxford-Gloucester (AM peak)



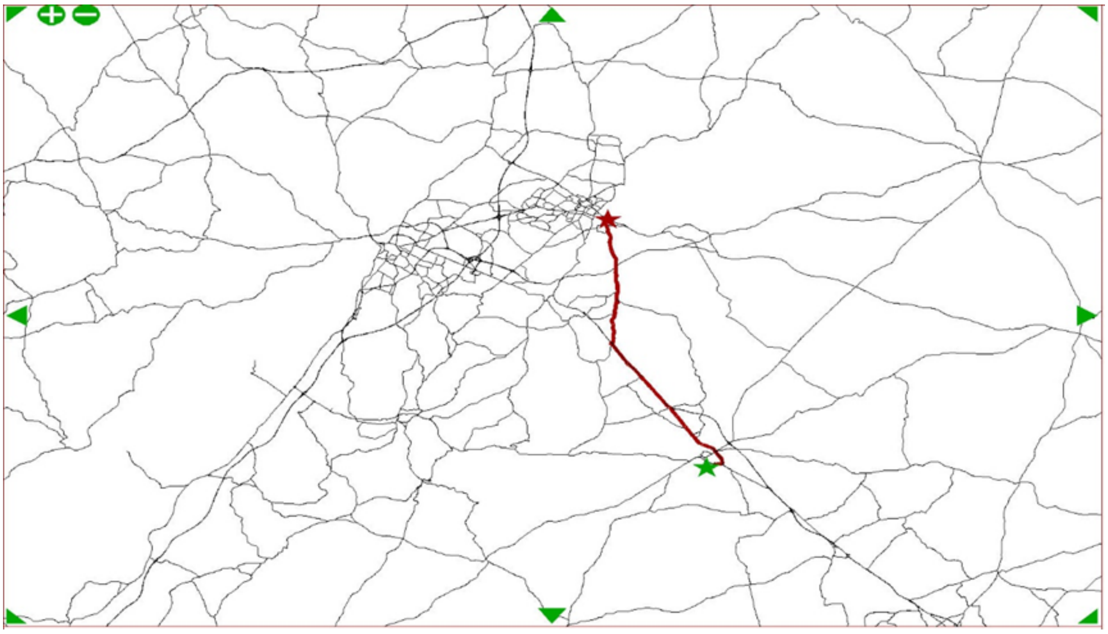
Source: Highways England

Figure D-3 Route analysis example – Swindon-Tewkesbury (AM peak)



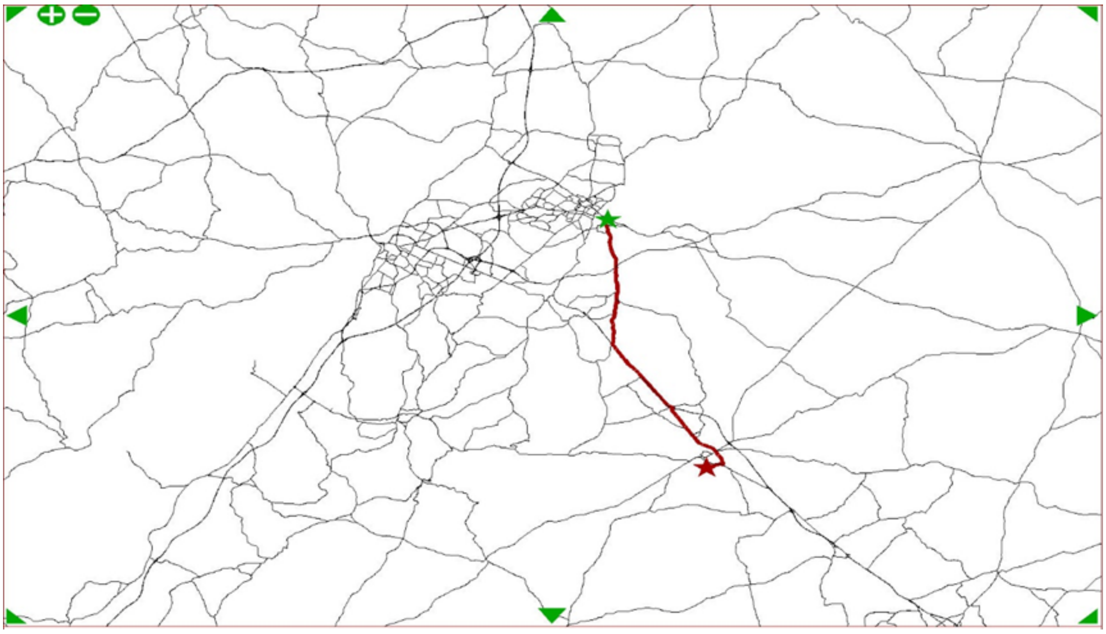
Source: Highways England

Figure D-4 Route analysis example – Tewkesbury-Swindon (AM peak)



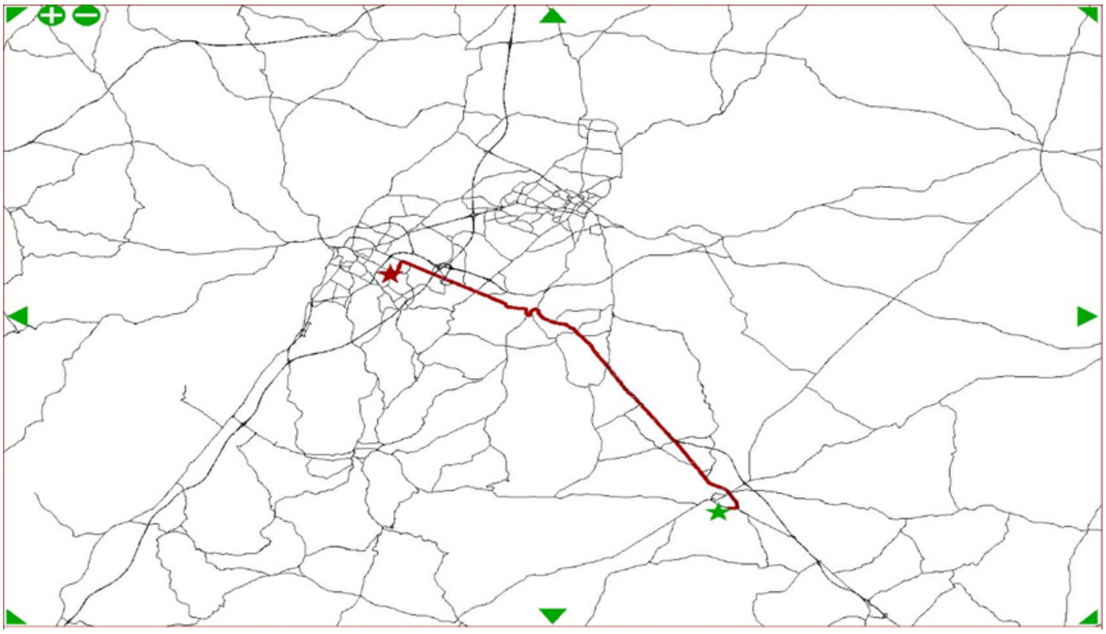
Source: Highways England

Figure D-5 Route analysis example – Cirencester-Cheltenham (AM peak)



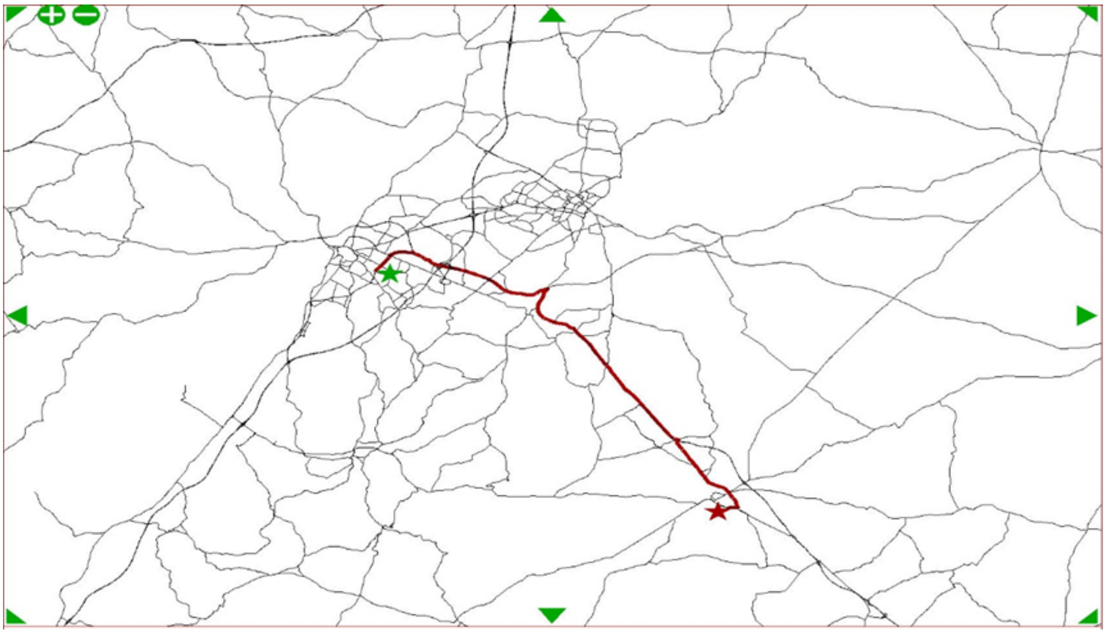
Source: Highways England

Figure D-6 Route analysis example – Cirencester-Cheltenham (AM peak)



Source: Highways England

Figure D-7 Route analysis example – Cirencester-Gloucester (AM peak)



Source: Highways England

Figure D-8 Route analysis example – Gloucester-Cirencester (AM peak)

Appendix E Traffic data review

E.1 Introduction

E.1.1.1 The scheme traffic model is based on Highway England's South-West Regional Traffic Model (SWRTM). The SWRTM is one of five Regional Traffic Models (RTMs) that cover England. The base year for these RTMs is March 2015.

E.1.1.2 TAG guidance[14] notes that former guidance in the Design Manual for Roads and Bridges had previously indicated that models based on source data more than five years old should not be used. However, TAG goes on to say that *"this simple threshold should not be used, as there can be significant changes that would make the use of more recent data inappropriate or there may have been little change and older data may be acceptable."*

E.1.1.3 TAG therefore recommends that evidence should be established on the *"scale of changes to land use and demographic characteristics, transport networks and travel patterns, with more attention given to the key movements in the model internal area, and use this evidence to assess the validity of 'old' data sources and their suitability for the intended use(s) of the model."*

E.1.1.4 With this in mind an analysis of traffic count data on the strategic road network (SRN) and local roads between 2015 and 2019 was undertaken to ascertain how traffic has changed in the intervening period.

E.1.1.5 This technical note sets out the work undertaken to ascertain how traffic in the area around the scheme has changed during the period following 2015, the base year for the scheme traffic model for PCF stage 3.

E.1.1.6 Automatic traffic count data from both WebTRIS and Gloucestershire County Council has been collated, for the scheme traffic model base year, 2015 and for 2019, the year with the most recent available data. The results of this analysis are presented in this technical note.

E.2 WebTRIS

E.2.1 Background

E.2.1.1 WebTRIS data has been obtained for the Existing A417, A417 sites to the south and west of the scheme, and for the M5 between junctions 10 and 12. Figure E-1 shows the locations of the sites which have been used in this analysis.

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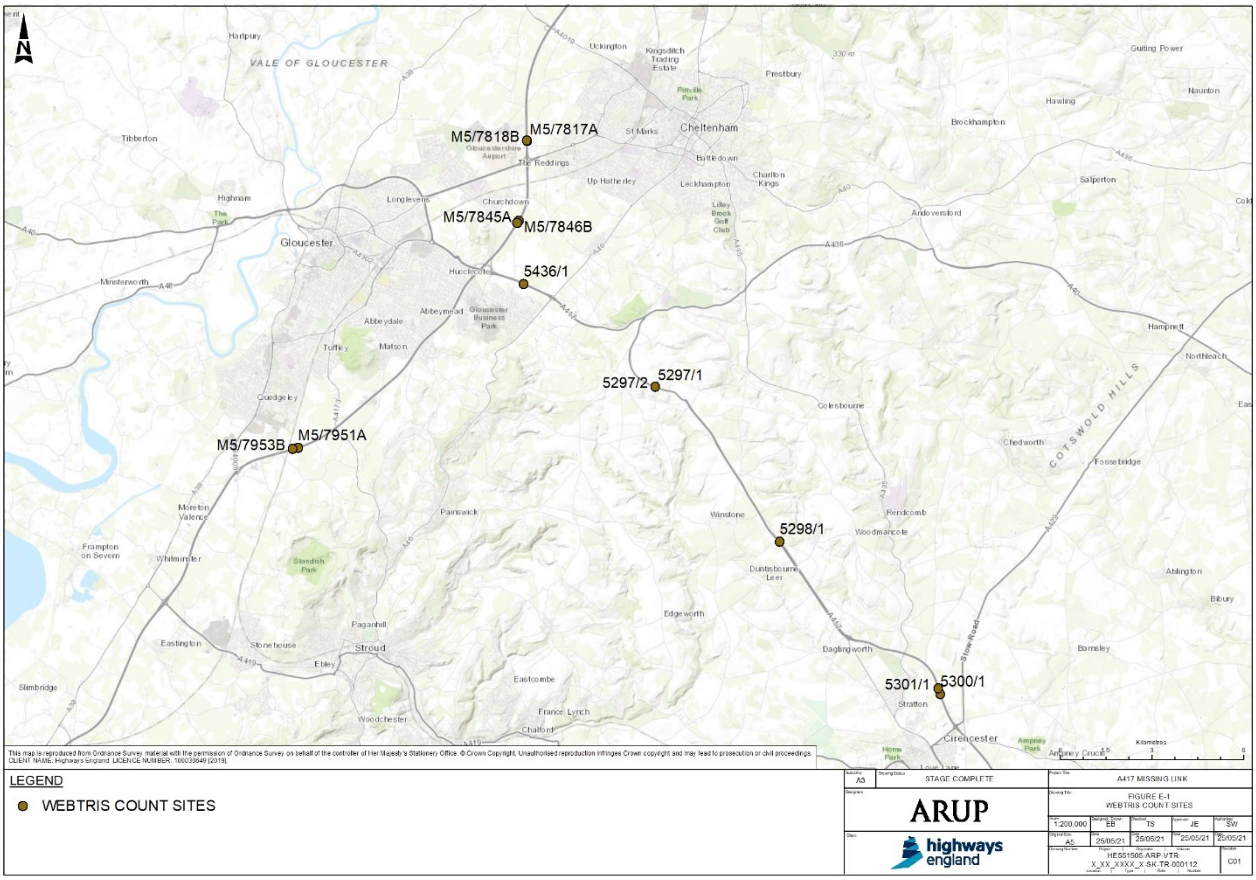
[14] Base Year Matrix Development, TAG Unit M2.2, Department for Transport, May 2020



Source: Highways England

Figure E-1 WebTRIS sites used in traffic growth analysis

E.2.2 A417 data

E.2.2.1 Table E-1 shows the average weekday traffic flow on key WebTRIS sites on the A417 for 2015 and 2019, along with percentage change between years. These sites are shown on Figure E-1.

Table E-1 March average weekday traffic volumes – A417 sites

			AM 07:00-10:00			IP 10:00-16:00			PM 16:00-19:00		
Site	**Site ref**	**Direction**	**2015**	**2019**	**Percentage change**	**2015**	**2019**	**Percentage change**	**2015**	**2019**	**Percentage change**
A417 east of M5	5436	NB	2,068	2,158	+4.4%	1,517	1,689	+11.4%	2,098	2,165	+3.2%
A417 south of Birdlip	5297	NB	1,007	960	-4.7%	967	974	+0.7%	1,145	1,120	-2.2%
A417 Stratton	5301	NB	1,039	1,045	+0.7%	972	1,028	+5.7%	1,276	1,308	+2.5%
A417 south of Birdlip	5297	SB	1,213	1,237	+2.0%	891	946	+6.2%	1,119	1,083	-3.2%
A417 Duntisbourne Abbots	5298	SB	1,420	1,446	+1.9%	926	985	+6.3%	1,184	1,170	-1.1%
A417 Stratton	5300	SB	1,362	1,416	+4.0%	867	938	+8.1%	1,087	1,121	+3.1%
Average Percentage Change, A417		Northbound			+0.1%			+5.9%			+1.2%
		Southbound			+2.6%			+6.9%			-0.4%
		2-way			+1.4%			+6.4%			+0.4%

E.2.2.2 Overall, there was some growth on the A417 during this period, particularly during the IP period. This may be due to peak spreading, arising from spare capacity during this period which is not available during the AM and PM periods.

E.2.2.3 There was a small reduction on the A417 south of Birdlip, which was most pronounced in the northbound direction during the AM period. This is likely to be due to congestion on the A417, in particular congestion at the Air Balloon roundabout and traffic re-routeing to avoid this congestion and delay.

E.2.3 M5 data

E.2.3.1 Table E-2 shows the average weekday traffic flows at WebTRIS sites on the M5 for 2015 and 2019, together with the percentage change between the two years.

E.2.3.2 Overall, there was growth on the M5 during this period. This was particularly focused to the south of M5 junction 11, which may be due to the removal of the Severn Bridge tolls.

E.2.3.3 As with the data at the A417 sites, traffic growth at the M5 sites was highest during the IP period. This may be due to peak spreading, arising from spare capacity during this period which is not available during the AM and PM peak periods.

E.2.3.4 There was a slight reduction in northbound flow on the M5 to the north of junction 11A in the AM peak period, and also north of junction 11 during the PM peak period.

Table E-2 March average weekday traffic volume – M5 sites

			AM 07:00-10:00			IP 10:00-16:00			PM 16:00-19:00		
Site	**Site ref**	**Direction**	**2015**	**2019**	**Percentage change**	**2015**	**2019**	**Percentage change**	**2015**	**2019**	**Percentage change**
M5 north of J11	7818	NB	2,734	2,630	-3.8%	2,801	2,998	+7.0%	3,171	3,138	-1.1%
M5, J11-J11A	7846	NB	2,937	2,863	-2.5%	2,766	2,924	+5.7%	3,069	3,097	+0.9%
M5 south of J11A	7953	NB	3,569	3,685	+3.3%	2,810	3,100	+10.3%	3,190	3,466	+8.7%
M5 north of J11	7817	SB	2,976	3,153	+5.9%	2,362	2,589	+9.6%	2,830	2,826	-0.1%
M5, J11-J11A	7845	SB	3,017	3,226	+6.9%	2,538	2,797	+10.2%	3,171	3,202	+1.0%
M5 south of J11A	7951	SB	3,003	3,376	+12.4%	2,535	2,884	+13.8%	3,450	3,611	+4.7%
Average Percentage Change, M5		Northbound			-1.0%			+7.7%			+2.8%
		Southbound			+8.4%			+11.2%			+1.8%
		2-way			+3.7%			+9.4%			+2.3%

E.2.4 TEMPro comparison

E.2.4.1 Following the calculation of percentage change at each site described above, comparisons have been made with TEMPro (Trip End Model Presentation Programme) forecasts of background growth in travel demand to assess the validity of the modelling work undertaken for the scheme. The TEMPro forecasts are taken from the National Trip End Model (NTEM) produced by the Department for Transport.

E.2.4.2 Table E-3 summarises the average percentage change observed across all the sites analysed on the A417 and M5 in the previous section (i.e. those on the strategic road network).

Table E-3 Average growth in traffic, all sites

		AM 07:00-10:00	IP 10:00-16:00	PM 16:00-19:00
Average percentage change, all sites	NB	-0.5%	+6.8%	+2.0%
	SB	+5.5%	+9.0%	+0.7%
	2-way	+2.5%	+7.9%	+1.4%

E.2.4.3 Table E-4 shows the forecast changes in the number of origin and destination trips given in TEMPro.

Table E-4 TEMPro 7.2 regional growth, 2015 - 2019

	AM 07:00-10:00		IP 10:00-16:00		PM 16:00-19:00	
	Origin	Destination	Origin	Destination	Origin	Destination
Gloucestershire	+2.7%	+2.7%	+2.8%	+2.8%	+2.5%	+2.5%
Wiltshire	+2.1%	+2.2%	+3.2%	+3.2%	+2.2%	+2.1%
South-West Region	+2.5%	+2.5%	+3.1%	+3.1%	+2.4%	+2.4%
Worcestershire	+1.5%	+1.7%	+.2.9%	+2.8%	+1.8%	+1.6%
West Midlands Region	+2.5%	+2.5%	+3.2%	+3.2%	+2.4%	+2.4%

E.2.4.4 From a comparison between the growth factors in Table E-3 and Table E-4, the observed traffic growth on the strategic road network is considered to be in line with TEMPro. The observed 2.5% increase in traffic during the AM period closely matches the regional forecasts for the south-west and the midlands. The observed 1.4% increase in traffic during the PM period is slightly below the 2.4% growth forecast in the south-west and midlands regions.

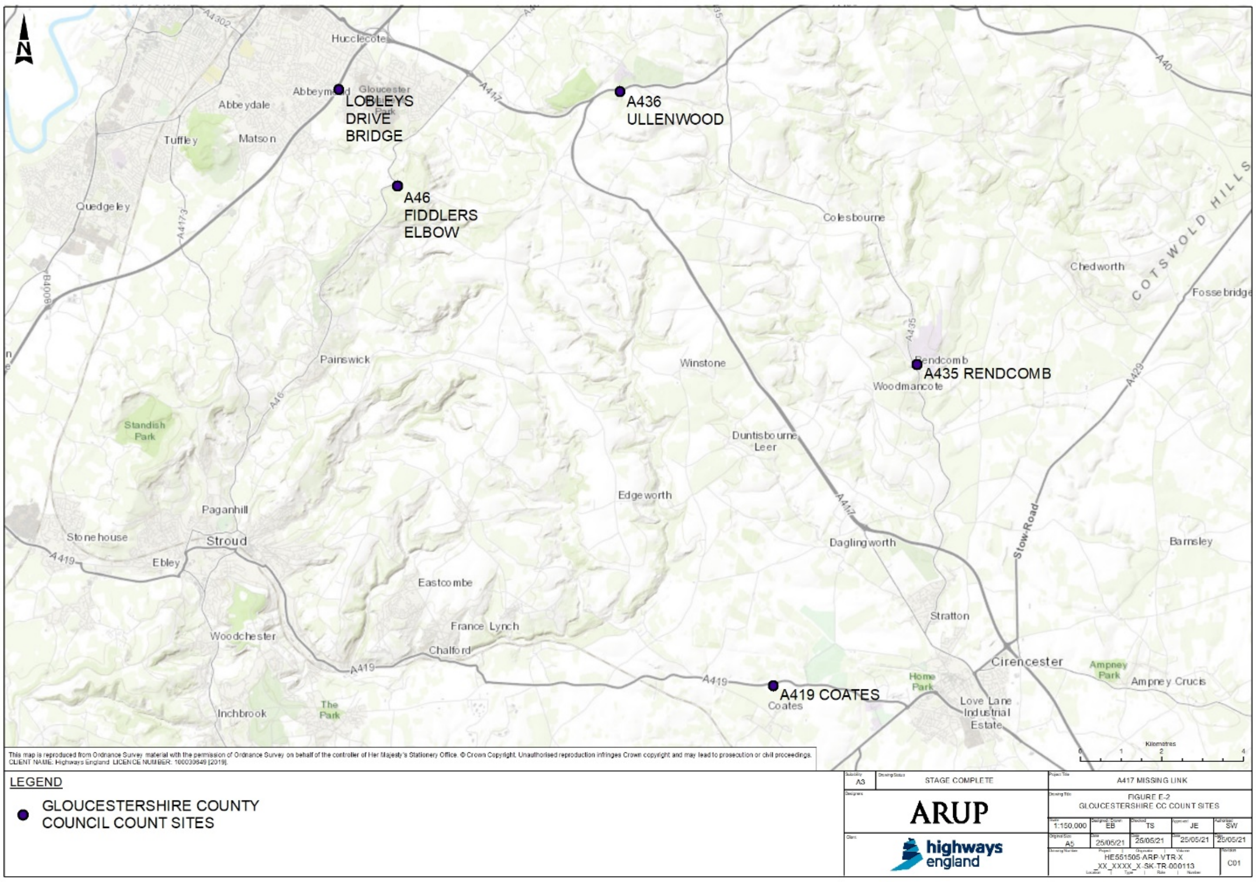
E.2.4.5 The observed IP traffic growth appears is higher than the TEMPro forecasts and this may be due to peak spreading and the removal of the Severn tolls.

E.3 Local authority data

E.3.1 Site locations

E.3.1.1 Automatic count data for a number of local roads in the study area was supplied by Gloucestershire County Council. The sites available are shown in Figure E-2.

E.3.1.2 The sites chosen are those in the vicinity of the scheme that have data available for March 2015 and March 2019, the exception being the A436 Ullenwood site, where data was only available for October in both years.



Source: Highways England

Figure E-2 Gloucestershire CC sites used in traffic growth analysis

E.3.2 Traffic growth on local roads

E.3.2.1 Table E-5 shows the average weekday traffic flow at the Gloucestershire County Council sites for 2015 and 2019, along with percentage change between years.

Table E-5 March average weekday traffic volumes – GCC sites

		AM 07:00-10:00			IP 10:00-16:00			PM 16:00-19:00		
Site	**Direction**	**2015**	**2019**	**Percentage change**	**2015**	**2019**	**Percentage change**	**2015**	**2019**	**Percentage change**
A46 Fiddlers Elbow	NB	346	314	-9.1%	215	216	+0.5%	260	252	-3.1%
A419 Coates	NB	607	606	-0.2%	302	305	+1.3%	288	307	+6.4%
A435 Rendcomb	NB	188	210	+11.6%	128	135	+5.8%	250	249	-0.1%
A436 Ullenwood[1]	WB	411	419	+1.8%	448	462	+3.0%	529	481	-9.0%
Lobleys Drive Bridge	WB	249	292	+17.3%	282	318	+12.8%	574	602	+4.9%
A46 Fiddlers Elbow	SB	263	236	-10.4%	217	221	+1.8%	344	324	-5.6%
A419 Coates	SB	268	298	+11.1%	320	338	+5.7%	582	579	-0.6%
A435 Rendcomb	SB	266	261	-2.1%	126	118	-6.0%	178	206	+15.6%
A436 Ullenwood[1]	EB	577	603	+4.6%	414	458	+10.6%	482	536	+11.3%
Lobleys Drive Bridge	EB	502	499	-0.7%	248	285	+15.0%	335	383	+14.1%
Average Percentage Change, GCC Sites	Northbound / Westbound			+4.3%			+4.7%			-0.2%
	Southbound / Eastbound			+0.5%			+5.4%			+7.0%
	2-way			+2.4%			+5.0%			+3.4%

[1]Data for October 2015 and October 2019

E.3.2.2 The growth shows considerable variation between individual sites, but overall, traffic on the local roads grew by 3-4% in the AM and PM peak periods between 2015 and 2019, and by about 6% in the IP period. The growth in the AM and PM was slightly higher than at the strategic sites, while IP growth was lower.

E.3.3 TEMPro comparison

E.3.3.1 A comparison of the observed growth on these local roads has also been made with TEMPro forecasts, and this analysis is shown in Table E-6.

Table E-6 TEMPro 7.2 Local growth, 2015 - 2019

	AM 07:00-10:00		IP 10:00-16:00		PM 16:00-19:00	
	Origin	Destination	Origin	Destination	Origin	Destination
Cheltenham	+3.7%	+2.7%	+2.7%	+2.9%	+2.6%	+3.3%
Gloucester	+4.8%	+3.5%	+3.4%	+3.5%	+3.4%	+4.2%
Cotswold	+1.3%	+2.7%	+2.3%	+2.2%	+2.3%	+1.4%
Gloucestershire County	+2.7%	+2.7%	+2.8%	+2.8%	+2.5%	+2.5%

E.3.3.2 The observed growth in the AM peak was very similar to the local TEMPro growth forecasts, while that in the PM peak period was slightly higher, while the observed growth in the IP period was considerably higher than the TEMPro forecasts.

E.4 Conclusions

E.4.1.1 Observed traffic growth between 2015 and 2019 on the strategic network compared well with TEMPro growth forecasts in the AM and PM peak periods. Observed growth in the IP period, however, was more than twice that of the TEMPro forecasts.

E.4.1.2 On the local roads, the observed growth in the AM and PM peak periods was slightly higher than the local TEMPro growth forecasts, but the observed growth in the IP periods was again more than twice that of the TEMPro forecasts.

E.4.1.3 The results from this analysis show that for the SRN the overall growth in traffic for the AM and PM peak periods is similar to that in TEMPro. For the IP period the overall traffic growth is higher than that forecast in TEMPro. This is higher increase could be as a result of peak spreading and the removal of Severn crossing tolls at the end of 2018.

E.4.1.4 The analysis of the local roads shows that for all three peak periods the growth is higher than that predicted by TEMPro. Some of these changes could well be due to congestion on the local network resulting in traffic re-routeing to alternative routes. Some changes may also arise from any local developments listed in the uncertainty log which were completed between 2015 and 2019, but it is not considered that there are any significant development completions in that time which would have materially affected the observed growth.

E.4.1.5 Overall the traffic growth on the SRN and local road networks is considered to be comparable to that assumed in the modelling and does not have a material impact on the uncertainty underlying the appraisal.

Appendix F Transport supply uncertainty log

GLOUCESTERSHIRE COUNTY COUNCIL AND/OR COMMITTED LOCAL DEVELOPMENT SCHEMES

Scheme	Classification	Included in DM?	Model area	Comments
Elmbridge Transport Scheme, Gloucester	Near certain	Yes - from 2024	Simulation	Opened in September 2017
A430 Llanthony Rd and St Ann Way (Southwest bypass) improvement, Gloucester	More than likely / near certain	Yes - from 2024	Simulation	Expected opening year is 2020
A40 Over Roundabout improvement (phase 2), Gloucester	More than likely / near certain	Yes - from 2024	Simulation	Expected > 2021
Improvements for A419 corridor, Stonehouse	More than likely / near certain	Yes - from 2024	Simulation	Expected opening year is 2020
M5 J10 'all movements' access (including link road into Cyber Park), Gloucester	More than likely / near certain	Yes - from 2024	Simulation	GCC HIF Bid - Stage 1 Approval: Now at Co-Development Stage. Included in 2024 DM following discussions with GCC
A38 Cross Key roundaobut	More than likely / near certain	Yes - from 2024	Simulation	
Junction improvement A40 Longford roundabout, Gloucester	Near certain	Yes - from 2024	Simulation	Associated with Innsworth and Twigworth developments
New A40 access roundabout	Near certain	Yes - from 2024	Simulation	Associated with Innsworth and Twigworth developments
A38 / A40 link road	Near certain	Yes - post-2024	Simulation	Associated with Innsworth and Twigworth developments
Staverton crossroads junction (B4063 / B4634), Staverton	More than likely / near certain	Yes - from 2024	Simulation	Conversion of signals to roundabout
A435/Hyde Lane/Southam Lane Signalised Junction improvements	More than likely / near certain	Yes - from 2024	Simulation	Lane allocation changes
St. Barnabas Roundabout enhancement, Gloucester	More than likely / near certain	No	Simulation	Minor scheme, not included
Cinderford Northern Quarter Spine Road, Cinderford	More than likely / near certain	No	Simulation	Remote from A417 (West of Severn), not included
Bream Road junction improvement (phase 1), Lydney	More than likely / near certain	No	Simulation	Remote from A417 (West of Severn), not included
B4066 corridor improvements, Berkeley	More than likely / near certain	No	Simulation	Minor / local scheme, not included
Local improvement for Southgate Street to St Anns Way, Gloucester	More than likely / near certain	No	Simulation	Minor scheme, not included
A46 / A438 corridor including M5 J9, Tewkesbury	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A38 outer ring road corridor, Gloucester	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A4019 corridor including bus advantage, Cheltenham	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A4019 Honeybourne Railway Bridge increased height clearance, Cheltenham	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A4151 / A4136 corridor improvements, Cinderford	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A417 replacement of existing highway with elevated section, Maisemore	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A429 improvement, Moreton-in-Marsh	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A435 corridor improvement, Bishops Cleeve	Hypothetical / Foreseeable	No	Simulation	
Highway improvement A46 (Shurdington Road) corridor, Cheltenham	Hypothetical / Foreseeable	No	Simulation	
Highway improvement B4063 corridor, Churchdown	Hypothetical / Foreseeable	No	Simulation	
Highway improvement Dursley Relief Road, Dursley	Hypothetical / Foreseeable	No	Simulation	
Highway improvement Down Hatherley Lane corridor improvements, Innsworth	Hypothetical / Foreseeable	No	Simulation	
Highway improvement London Road / Denmark Road junction, Gloucester	Hypothetical / Foreseeable	No	Simulation	
Highway improvement Merrywalks link and roundabout, Stroud	Hypothetical / Foreseeable	No	Simulation	
Highway improvement Moreton Railway Bridge including pedestrian and vehicle access, Moreton-in-Marsh	Hypothetical / Foreseeable	No	Simulation	
Highway improvement Newerne Link Road, Lydney	Hypothetical / Foreseeable	No	Simulation	
Highway improvement Tewkesbury Northern Relief Road, Tewkesbury	Hypothetical	No	Simulation	
Highway improvement Thames Street / High Street, Lechlade on Thames	Hypothetical / Foreseeable	No	Simulation	
Highway improvements Cirencester Town Centre, Cirencester	Hypothetical / Foreseeable	No	Simulation	
Highway improvements Tetbury Town Centre, Tetbury	Hypothetical / Foreseeable	No	Simulation	
Implementation of Fosse Way Highway Improvement Feasibility Study (A429 / A433), Cirencester	Hypothetical / Foreseeable	No	Simulation	
Junction improvement Allotment Corner, Kempsford	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A38 / B4066 junction including a new roundabout, Berkeley	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A40 Over Roundabout (phase 3) enhancement for outbound city traffic, Gloucester	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A4135 / B4060 Woodfield roundabout, Dursley	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A4135 / B4066 Dursley Road roundabout, Dursley	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A4151 / A4136 junction, Cinderford	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A417 - Brockworth Bypass / A46 Shurdington Road, Brockworth	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A417 / Whelford Road junction, Fairford	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A417 C&G roundabout new left turn lane from Barnwood link to Corinium Avenue, Gloucester	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A417 Zoons Court roundabout, Gloucester	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A419 / A46 Dudbridge Road roundabout, Stroud	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A419 London Road / Dr Newtons Way, Stroud	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A429 Unicorn junction (A436 / B4068), Stow-on-the-Wold	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A429 / A433 junction, Kemble	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A429 Cherry Tree junction, Cirencester	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A46 / A4173 junction, Pitchcombe	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A46 / Bath Road (Dudbridge Road), Stroud	Hypothetical / Foreseeable	No	Simulation	
Junction improvement A48 Highfield Road / Bypass, Lydney	Hypothetical / Foreseeable	No	Simulation	
Junction improvement B4226 / B4227 bridge including new highway, Cinderford	Hypothetical / Foreseeable	No	Simulation	
Junction improvement Bream Road junction (phase 2), Lydney	Hypothetical / Foreseeable	No	Simulation	
Junction improvement Five Ways junction including crossing facilities, Cirencester	Hypothetical / Foreseeable	No	Simulation	
Junction improvement Highfield Hill including traffic calming, Lydney	Hypothetical / Foreseeable	No	Simulation	
Junction improvement Priory Road providing bus advantage, Gloucester	Hypothetical / Foreseeable	No	Simulation	

Source: Highways England

HIGHWAYS ENGLAND SCHEMES (and/or schemes in RTMs DM)

	Scheme	Classification	Included in DM?	Model area	Comments
SWRTM DM	A40 Elmbridge Court (As per local 'Elmbridge Transport Scheme')	Near certain	Yes - from 2024	Simulation	
	M4 J15	More than likely / near certain [1]	Yes - from 2024	Simulation	
	M4 J16	More than likely / near certain [1]	Yes - from 2024	Simulation	
	M4 J17	More than likely / near certain [1]	Yes - from 2024	Simulation	
	A419 White Hart junction improvement, Swindon	More than likely / near certain [1]	Yes - from 2024	Simulation	
	A38 M5 J16 to Aztec West, Almondsbury	More than likely / near certain [1]	Yes - from 2024	Simulation	
	M5 J23 Signalisation	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M5 J23 Dunball roundabout improvement	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M5 J24 Huntworth roundabout improvement	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M5 J25	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M5 J30/J31 - A379 Bridge Road Widening, Exeter	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A38 Deep Lane Junction, East of Plymouth	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A380 South Devon Highway (Kingskerswell By-Pass)	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A350 Chippenham Improvements	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A338, Blackwater Junction	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A349 Dunyeat's Roundabout and Queen Anne Drive Junctions	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A349 Major Improvement	More than likely / near certain [1]	Yes - from 2024	Buffer	
	Staplegrove, Taunton	More than likely / near certain [1]	Yes - from 2024	Buffer	
	Northern Inner Distribution Road (NIDR), Taunton	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A34 Milton Interchange Improvement	More than likely / near certain [1]	Yes - from 2024	Buffer	
	A34 Chilton Interchange Improvement	More than likely / near certain [1]	Yes - from 2024	Buffer	
SWRTM	A30 Temple to Higher Carblake	Near certain [1]	Yes - from 2024	Buffer	
	M49 Avonmouth Junction	More than likely [1]	Yes - from 2024	Buffer	
	M5 Bridgwater Junctions	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
	A30 Chiverton to Carland Cross, Cornwall	More than likely [2]	No	Buffer	Located in Cornwall, too remote from A417
	M27 Southampton Junctions 5-8	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
	M271 / A35 Redbridge roundabout upgrade	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
	A31 Ringwood	Reasonably foreseeable [2]	No	Buffer	Too remote from A417
	A34 Oxford Junctions	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
	M27 Junctions 4-11: Smart Motorways	More than likely [1]	Yes - from 2024	Buffer	
	M3 Junctions 9-14: Smart Motorways	More than likely [1]	Yes - from 2024	Buffer	
	M3 J2-4a	Near certain [1]	Yes - from 2024	Buffer	
	A303 Amesbury to Berwick Down	More than likely	Yes - post-2024	Buffer	
	A303 Sparkford - Ilchester dualling	More than likely	Yes - from 2024	Buffer	
	A358 Taunton to Southfields	More than likely	Yes - from 2024	Buffer	
	M4 J3-12 SMP	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M3 Junction 9 improvement	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
	M27 Junction 9	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
	M27 Junction 10	Reasonably foreseeable [2]	No	Buffer	Junction only scheme in buffer
SERTM	M3 Junction 2-4A	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M4 Junctions 3-12 Smart Motorways	More than likely / near certain [1]	Yes - post-2024	Buffer	
	M23 Junctions 8-10: Smart Motorways	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M25 Junctions 10-16 Smart Motorway	More than likely / near certain [1]	Yes - post-2024	Buffer	
	Arundel Bypass	More than likely / near certain [2]	No	Buffer	Not included, too remote from A417
	A27 Chichester Bypass	More than likely / near certain [2]	No	Buffer	Not included, too remote from A417
MRTM	M6 Junctions 10a-13: Smart Motorway	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M5 junctions 4a-6: Smart Motorway	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M1 Junctions 23a-25: Smart Motorway	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M1 Junctions 28-31: Smart Motorway	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M6 Junctions 13-15: Smart Motorway	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M1 Junctions 16-19: SMP	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M1 Junctions 13-16: SMP	More than likely / near certain [1]	Yes - from 2024	Buffer	
	M6 Junctions 2-4: Smart Motorway	More than likely / near certain [1]	Yes - from 2024	Buffer	
SE Wales	A465 Gilwern to Brynmawr	More than likely / near certain [1]	Yes - post-2024	Buffer	
	A465 Brynmawr to Tredegar	More than likely / near certain [1]	Yes - post-2024	Buffer	

Notes

[1] - At PCF Stage 1 these schemes were classified as being at least 'More than likely' and included in the Do Minimum networks. Their probability/status has not been reviewed at PCF Stage 2 or PCF Stage 3.

[2] - These schemes are too remote from the A417 Missing Link and/or they consist of junction-only schemes in the buffer network and were therefore not included in PCF Stage 1 Do Minimum networks. Their probability/status has not been reviewed at PCF Stage 2 or PCF Stage 3.

- In June 2019 it was announced that the M4 relief road scheme near Newport would not proceed. The scheme, previously classified as "More than likely/ near certain", has been removed from the Transport Supply UL and from the traffic modelling at Stage 3

Source: Highways England

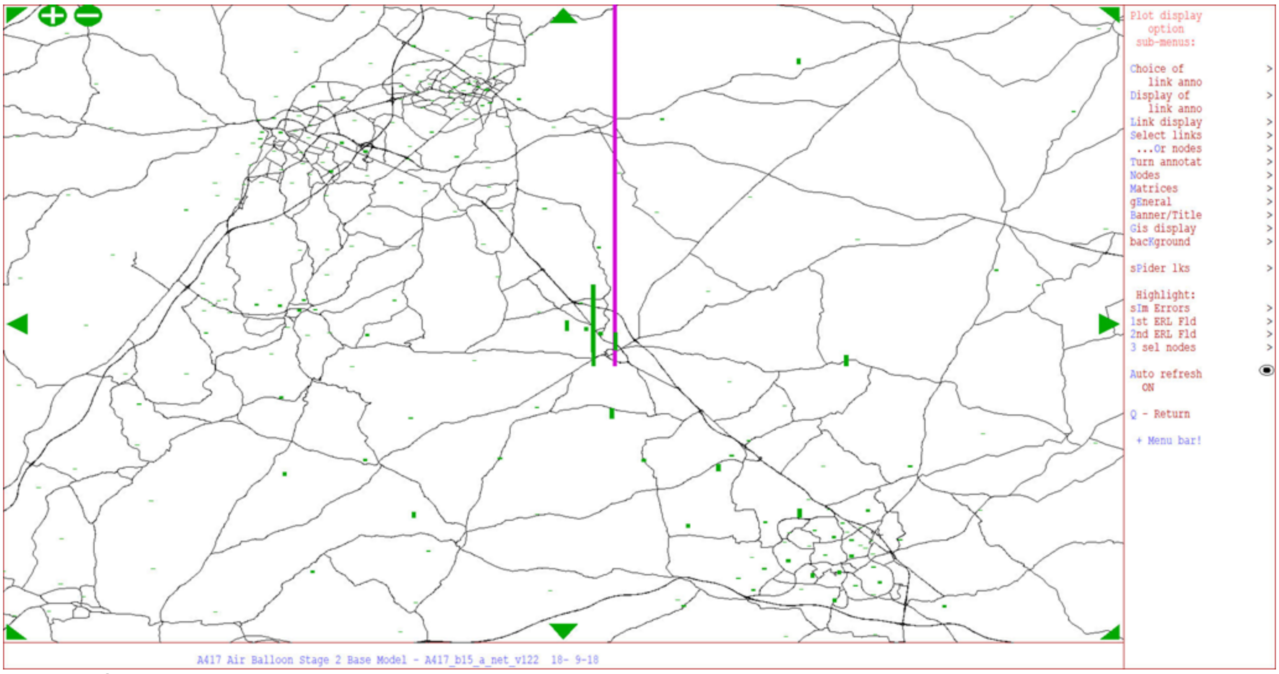
Appendix G Development uncertainty log

Site Name	Authority	Data Source	Approx. Easting	Approx. Northing	Certainty	Planning ref (if available)	Total Dwellings (Excl those occupied by March 2015)	Jobs post March 2015
Land Off Kidnappers Lane Cheltenham Gloucestershire	Cheltenham	Mapinsight / Cheltenham Borough Council	394009	219898	More Than Likely	16/00202/OUT	45	0
Cheltenham Cyber Park	Cheltenham	Cheltenham	391129	222738	More Than Likely	None	1,200	7,000
Haines And Strange Albion Street Cheltenham Gloucestershire GL52 2RH	Cheltenham	CSV Model Updates	395229	222533	Near Certain	13/00827/OUT	50	0
GCHQ Oakley Priors Road Cheltenham Gloucestershire GL52 5AJ	Cheltenham	CSV Model Updates	397443	222552	Near Certain	13/01683/REM	211	0
Car Park North Place Cheltenham Gloucestershire GL50 4DW	Cheltenham	CSV Model Updates	395093	222789	More Than Likely	12/01612/FUL	143	0
Central Cheltenham Police Station Talbot House Lansdown Road Cheltenham Gloucestershire GL51 6QT	Cheltenham	CSV Model Updates	393435	221653	Near Certain	17/00337/FUL	67	0
Cotswold Court Lansdown Road Cheltenham Gloucestershire GL50 2JA	Cheltenham	CSV Model Updates	394082	221658	Near Certain	13/01501/FUL	53	0
Land To Rear Of Nuffield Hospital Hatherley Lane Cheltenham Gloucestershire	Cheltenham	CSV Model Updates	391100	221356	More Than Likely	15/01048/OUT	27	201
Land At North Road West And Grovefield Way Cheltenham Gloucestershire	Cheltenham	CSV Model Updates	390607	221423	More Than Likely	18/01004/FUL	0	1,018
Land At Starvehall Farm New Barn Lane Cheltenham Gloucestershire	Cheltenham	CSV Model Updates	396194	223809	Near Certain	10/01243/OUT	300	0
Springbank Way Shopping Centre Springbank Way Cheltenham Gloucestershire	Cheltenham	CSV Model Updates	392054	223994	Near Certain	16/02303/FUL	34	0
Leckhampton Industrial Estate Leckhampton Road Cheltenham Gloucestershire GL53 0AL	Cheltenham	CSV Model Updates	394837	219462	Near Certain	13/00756/FUL	28	0
Land South Of 205 Leckhampton Road Leckhampton Road Cheltenham Gloucestershire	Cheltenham	CSV Model Updates	394777	219408	Near Certain	16/00272/FUL	10	0
Christ College Arle Road Cheltenham Gloucestershire GL51 8LE	Cheltenham	CSV Model Updates	393415	223192	Near Certain	14/01317/REM	90	0
Travis Perkins Gloucester Road Cheltenham Gloucestershire GL51 0SX	Cheltenham	CSV Model Updates	393637	222399	Near Certain	13/00106/FUL	107	0
John Dower House 24 Crescent Place Cheltenham Gloucestershire GL50 3RA	Cheltenham	CSV Model Updates	394711	222450	Near Certain	15/00362/FUL	68	0
Premier Products Ltd Bouncers Lane Cheltenham Gloucestershire GL52 5JD	Cheltenham	CSV Model Updates	396916	223124	Near Certain	17/00929/OUT	58	0
Phase 1 Land At Old Gloucester Road Cheltenham Gloucestershire	Cheltenham	CSV Model Updates	391500	224265	Near Certain	17/01411/OUT	90	0
Land south of Chesterton Cirencester / 'Cirencester Urban Extension'	Cotswold	Cotswold / Mapinishgt	401510	200301	More Than Likely	16/00054/OUT	2,350	500
Kingshill Development London Road Cirencester Gloucestershire	Cotswold	Cotswold / Mapinishgt	403827	202440	Near Certain	13/02942/OUT	100	503
Land South Of Winnycroft Farm Corncroft Lane Gloucester GL4 6BX	Gloucester	Mapinsight / Gloucester	385691	214768	Near Certain	14/01063/OUT	420	0
Land At Winnycroft Farm Corncroft Lane Gloucester GL4 6BX	Gloucester	Mapinsight / Gloucester	385672	214715	More Than Likely	14/01470/OUT	250	0
Land At Bakers Quay Llanthony Wharf And Monkmeadow Bounded By Southgate Street Llanthony St Ann Way Gloucester	Gloucester	Mapinsight / Gloucester	382559	217859	Near Certain	15/01144/FUL	162	0
Land At Barnwood Link Road Gloucester	Gloucester	Mapinsight / Gloucester	386357	219006	Near Certain	14/01035/OUT	0	1,031
Former Gloucester Academy Estcourt Close Gloucester GL1 3LR	Gloucester	Mapinsight / Gloucester	384044	219848	Near Certain	16/00631/OUT	90	0
Hucclecote Centre Churchdown Lane Gloucester GL3 3QN	Gloucester	Gloucester Deliverability Schdule Sites	387659	217460	Near Certain	11/00742/OUT	53	0
Former Contract Chemicals Site Bristol Road Gloucester GL2 5BX	Gloucester	Gloucester Deliverability Schdule Sites	382262	216517	Near Certain	07/00474/OUT	86	403
Former Wellman Graham St Gobain Industrial Sites Bristol Road Gloucester GL2 5BX	Gloucester	Gloucester Deliverability Schdule Sites	382339	216588	Near Certain	07/00472/OUT	231	0
Land To East West Of A38 And Naas Lane Quedgeley Gloucester GL2 5ZZ	Gloucester	Gloucester Deliverability Schdule Sites	381803	213255	Near Certain	06/01242/OUT	250	0
Mayos Land Bristol Road Quedgeley Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	380695	212948	Near Certain	13/01013/REM	48	0
Albion House 77 Southgate Street Gloucester GL1 1UB	Gloucester	Gloucester Deliverability Schdule Sites	382910	218162	Near Certain	15/00672/COU	22	0
Fitzalan House Park Road Gloucester GL1 1LZ	Gloucester	Gloucester Deliverability Schdule Sites	383205	218060	Near Certain	16/00106/JPA	35	0
Former Gloscat Buildings Brunswick Road Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	383132	218272	Near Certain	11/00107/FUL	200	0
Land At Bakers Quay Llanthony Wharf And Monkmeadow Bounded By Southgate Street Llanthony St Ann Way Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	382394	217961	Near Certain	14/00709/FUL	340	0
Land East Of Hempsted Lane Hempsted Lane Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	381753	217061	More Then Likely	13/01032/OUT	50	0
Old Hempsted Fuel Depot Hempsted Lane Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	381917	217626	Near Certain	12/00725/OUT	85	0
Norville Optical Co Ltd Paul Street Gloucester GL1 4NY	Gloucester	Gloucester Deliverability Schdule Sites	383954	217135	Near Certain	16/00815/FUL	63	0
Beatrice Webb House 75 - 81 Eastgate Street Gloucester GL1 1PN	Gloucester	Gloucester Deliverability Schdule Sites	383431	218360	Near Certain	16/00626/JPA	27	0
St Aldate Church Finlay Road Gloucester GL4 6TN	Gloucester	Gloucester Deliverability Schdule Sites	384325	216429	Near Certain	14/00449/FUL	23	0
Land Adj Newark Farm Hempsted Lane Gloucester GL2 5JS	Gloucester	Gloucester Deliverability Schdule Sites	381697	217302	Near Certain	15/01494/FUL	44	0
Former Kwik Save 103 Northgate Street Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	383441	218795	Near Certain	16/00142/FUL	95	0
Former 1 - 3 Wellington Street Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	383423	218221	Near Certain	15/01407/FUL	22	0
Land South Of Grange Road Gloucester	Gloucester	Gloucester Deliverability Schdule Sites	382676	214125	Near Certain	16/00165/OUT	250	0
Land at Sharpness	Stroud	Stroud	367566	201488	Reasonably Forseeable	None	2,000	0
Gateway 12 Davy Way, Hardwicke, Gloucester, Gloucestershire	Stroud	Mapinsight / Stroud	380655	211360	Near Certain	S.14/1518/FUL	0	467
Land North Of Alkerton Road Alkerton, Eastington, Gloucestershire	Stroud	Mapinsight / Stroud	377199	205548	More Than Likely	S.14/2879/OUT	36	0
Land at Quedgeley Trading Estate East Haresfield Stonehouse	Stroud	Stroud	380465	211049	More Than Likely	16/1724/OUT	0	2,149
MOD Ashchurch	Tewkesbury	Tewsksbury	393283	233325	Hypothetical	None	2,000	900
Land at Perrybrook, Brockworth	Tewkesbury	Tewksbury	389341	217153	Near Certain	12/01256/OUT	1,500	540
Innsworth	Tewkesbury	Tewkesbury	385817	221493	Near Certain	15/00749/OUT	1,300	750
South Churchdown	Tewkesbury	Tewkesbury	386733	220191	Reasonably Forseeable	None	635	3,500
Elms Park	Tewkesbury	Tewsksbury	393152	224140	More Than Likely	16/02000/OUT	4,285	4,027
Land To The Rear Of Invista Green Street Brockworth GL3 4LS	Tewkesbury	Mapinsight / Tewsksbury	388683	216080	Near Certain	11/00091/OUT	200	200
Nerva Meadows Plots 3200, 7400, 7520 Gloucester Business Park Brockworth	Tewkesbury	Mapinsight / Tewsksbury	387977	215844	More Than Likely	15/01378/OUT	106	0
Parcel 3745 Cheltenham Road East Churchdown Gloucester Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	386344	220486	More Than Likely	16/00738/OUT	465	0
Land At Tewkesbury Road Twigworth	Tewkesbury	Mapinsight / Tewsksbury	384791	222067	Near Certain	15/01149/OUT	725	0
Land To East Of Tewkesbury Road And North Of Longford Lane Longford Gloucester Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	384472	220504	Near Certain	15/00814/APP	107	0
Land To East Of Tewkesbury Road And North Of Longford Lane Longford Gloucester Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	384696	220627	More Than Likely	16/00853/FUL	197	0
Cleevelands Evesham Road Bishops Cleeve	Tewkesbury	Mapinsight / Tewsksbury	395090	228284	Near Certain	10/01216/OUT	550	250
Land To The West Of Evesham Road (North Cleevelands) Evesham Road Gotherington	Tewkesbury	Tewkesbury	395337	228718	More Than Likely	17/00399/OUT	500	0
Land To The West Of Farm Lane Shurdington	Tewkesbury	Mapinsight / Tewsksbury	393565	219502	Near Certain	14/00838/FUL	377	0
Bentham Works Bentham Lane Bentham GL51 4UT	Tewkesbury	Mapinsight / Tewsksbury	391527	216234	Near Certain	13/00794/FUL	49	0
Bentham Country Club Bentham Lane Bentham Cheltenham Gloucestershire GL3 4UD	Tewkesbury	Mapinsight / Tewsksbury	391280	216259	More Than Likely	15/00751/OUT	39	0
Plot 6200 Gloucester Business Park Brockworth Gloucester Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	388303	215860	More Than Likely	17/00005/APP	0	293
Homelands Farm Gotherington Lane Bishops Cleeve GL52 8EN	Tewkesbury	Mapinsight / Tewsksbury	396351	228744	Near Certain	10/01005/OUT	450	50
Land At Beckford Road Alderton	Tewkesbury	Mapinsight / Tewsksbury	399725	233244	Near Certain	13/00114/FUL	47	0
Land To The West Of Lassington Lane Highnam Gloucester Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	379583	221223	Near Certain	14/00583/OUT / 16/00858/APP	88	0
Land At Hector Farm Hygrove Lane Minsterworth Gloucester Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	378982	218087	Near Certain	16/00670/OUT	9	0
Apple Tree Inn Main Road Minsterworth Gloucestershire GL2 8JQ	Tewkesbury	Mapinsight / Tewsksbury	378732	217645	More Than Likely	15/01018/OUT	9	0
Pound Cottage Main Road Minsterworth Gloucestershire GL2 8JH	Tewkesbury	Mapinsight / Tewsksbury	378530	217411	Near Certain	16/01293/OUT	7	0
Part Parcel 3947 Main Road Minsterworth Gloucestershire	Tewkesbury	Mapinsight / Tewsksbury	378411	217311	Near Certain	16/00823/OUT	4	0
Part Parcel 1228 Main Road Minsterworth	Tewkesbury	Mapinsight / Tewsksbury	378151	217232	More Than Likely	16/00822/OUT	6	0
Land Adjacent To Minsterworth Village Hall Main Road Minsterworth	Tewkesbury	Mapinsight / Tewsksbury	377636	217184	More Than Likely	15/00197/FUL	14	0
Part Parcel 3400 Columbine Road Walton Cardiff Tewkesbury Gloucestershire	Tewkesbury	CSV Model Updates	390305	231076	Near Certain	16/00177/FUL	261	0
Adjacent 74 Evesham Road Bishops Cleeve Cheltenham Gloucestershire	Tewkesbury	CSV Model Updates	395665	228547	Near Certain	15/01177/FUL	71	0
Parcel 7561 Malleson Road Gotherington Cheltenham Gloucestershire	Tewkesbury	CSV Model Updates	395761	229621	More Than Likely	16/00965/OUT	50	0
Part Parcel 0085 Land West Of Bredon Road Bredon Road Tewkesbury Gloucestershire	Tewkesbury	CSV Model Updates	390104	233953	More Than Likely	16/00663/APP	68	0
Parcel 3441 And 3629 Land Between Greet Road And Gretton Road Winchcombe	Tewkesbury	CSV Model Updates	402419	229364	Near Certain	13/00986/APP	85	0
Land Parcels 4331 4619 And 5837 Pamington Lane Pamington Tewkesbury Gloucestershire	Tewkesbury	CSV Model Updates	393837	233487	Near Certain	14/00972/OUT	150	0
Land Adjacent Cornerways High Street Twyning	Tewkesbury	CSV Model Updates	389619	236802	Near Certain	13/00978/FUL	58	0
Land East Of Willow Bank Road Alderton Tewkesbury GL20 8NJ	Tewkesbury	CSV Model Updates	399926	232956	Near Certain	14/00414/FUL	24	0
Parcel 2521 & 3722 Banady Lane Stoke Orchard	Tewkesbury	CSV Model Updates	392331	228223	Near Certain	14/00074/OUT	45	0
Coal Research Establishment (CRE) Stoke Road Stoke Orchard Cheltenham Gloucestershire	Tewkesbury	CSV Model Updates	391955	228369	Near Certain	14/01053/FUL	38	0
Coal Research Establishment (CRE) Stoke Road Stoke Orchard Cheltenham Gloucestershire	Tewkesbury	CSV Model Updates	391786	228379	Near Certain	12/00186/APP	100	0
Land On The East Side Of Cheltenham Road East Churchdown Gloucester Gloucestershire	Tewkesbury	CSV Model Updates	387774	222335	Near Certain	15/01115/FUL	0	300
Plot 5030 Gloucester Business Park Brockworth	Tewkesbury	CSV Model Updates	388364	216630	Near Certain	08/01461/FUL	27	0
Gloucester Business Park Brockworth Gloucester Gloucestershire	Tewkesbury	CSV Model Updates	387986	216211	Near Certain	83/00046/OUT	1,000	0
Gloucester Business Park Brockworth Gloucester Gloucestershire	Tewkesbury	CSV Model Updates	387986	216211	Near Certain	83/00046/OUT	0	5,882

Source: Highways England

Appendix H HEDDiT Development Distribution Examples

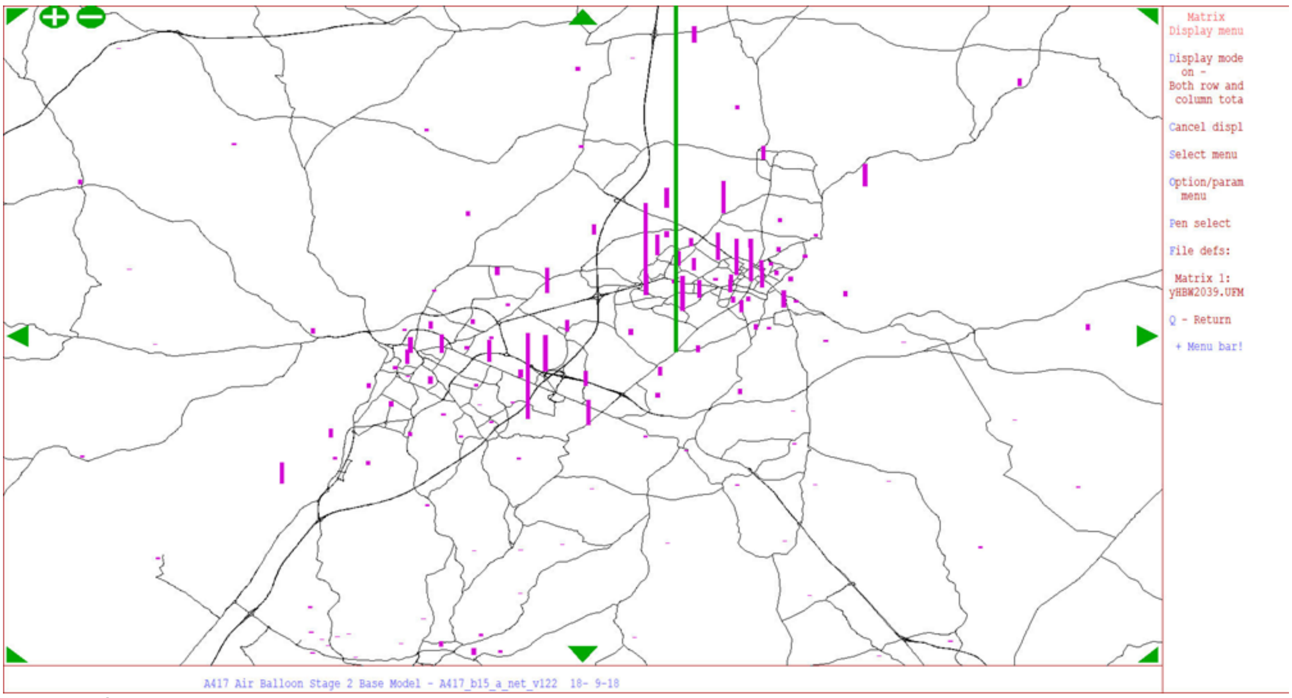
H.1.1.1 The following figures show trip distribution patterns associated with a selection of developments.



Note: Origin/home locations are shown as green bars, while the destination/work location is shown with a magenta bar.

Source: Highways England

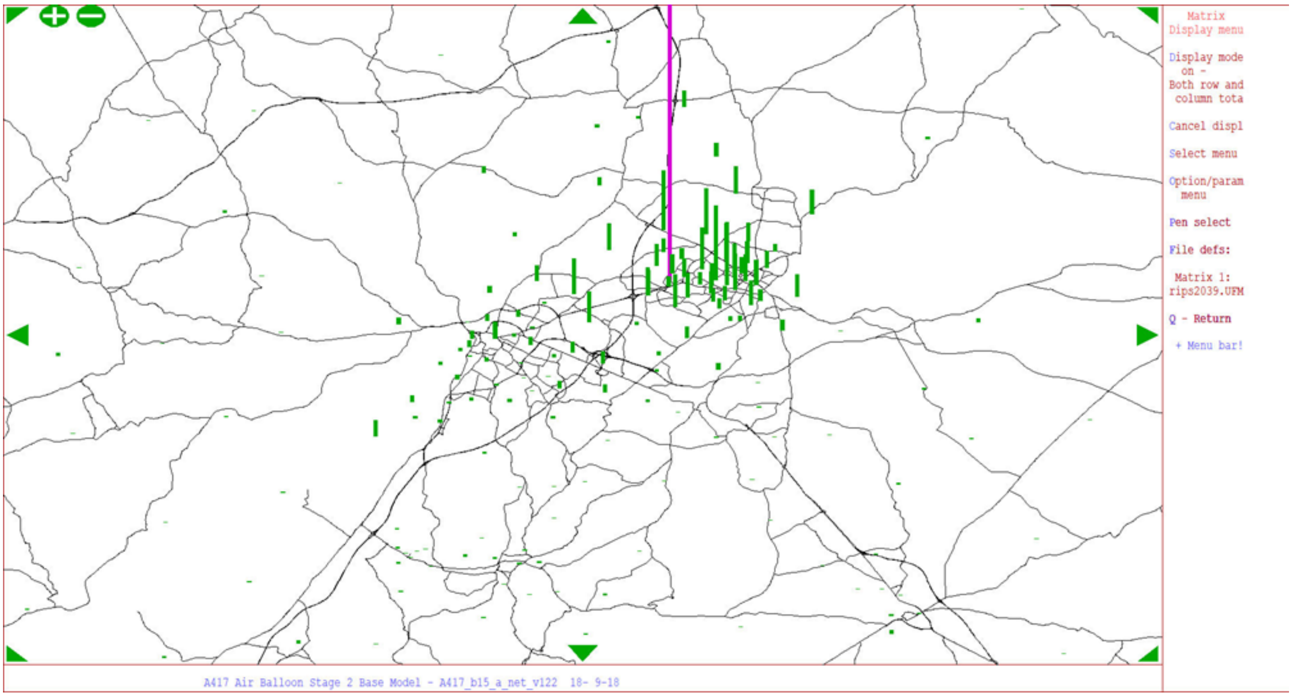
Figure H-1 Origin of trips to Cirencester urban extension development



Note: Origin/home locations are shown as green bars, while the destination/work location is shown with a magenta bar

Source: Highways England

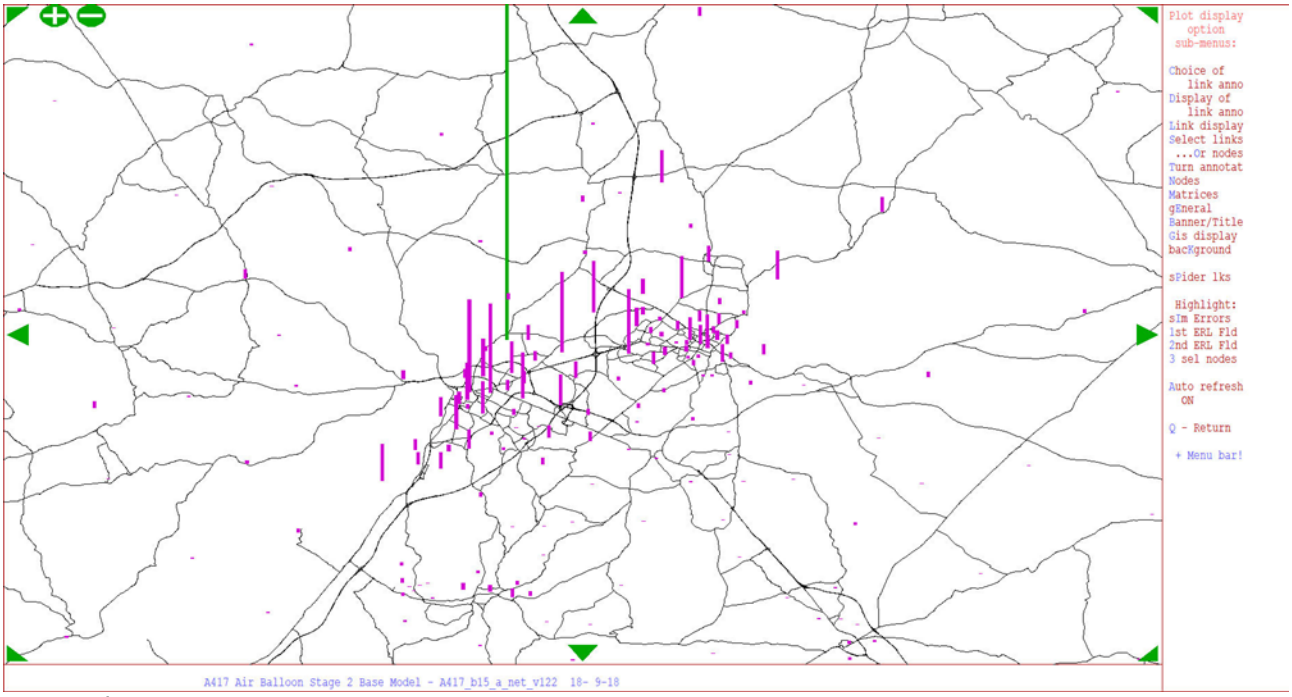
Figure H-2 Destination of commute trips from Farm Lane, Shurdington development



Note: Origin/home locations are shown as green bars, while the destination/work location is shown with a magenta bar

Source: Highways England

Figure H-3 Origin of commute trips to Cyber Park development

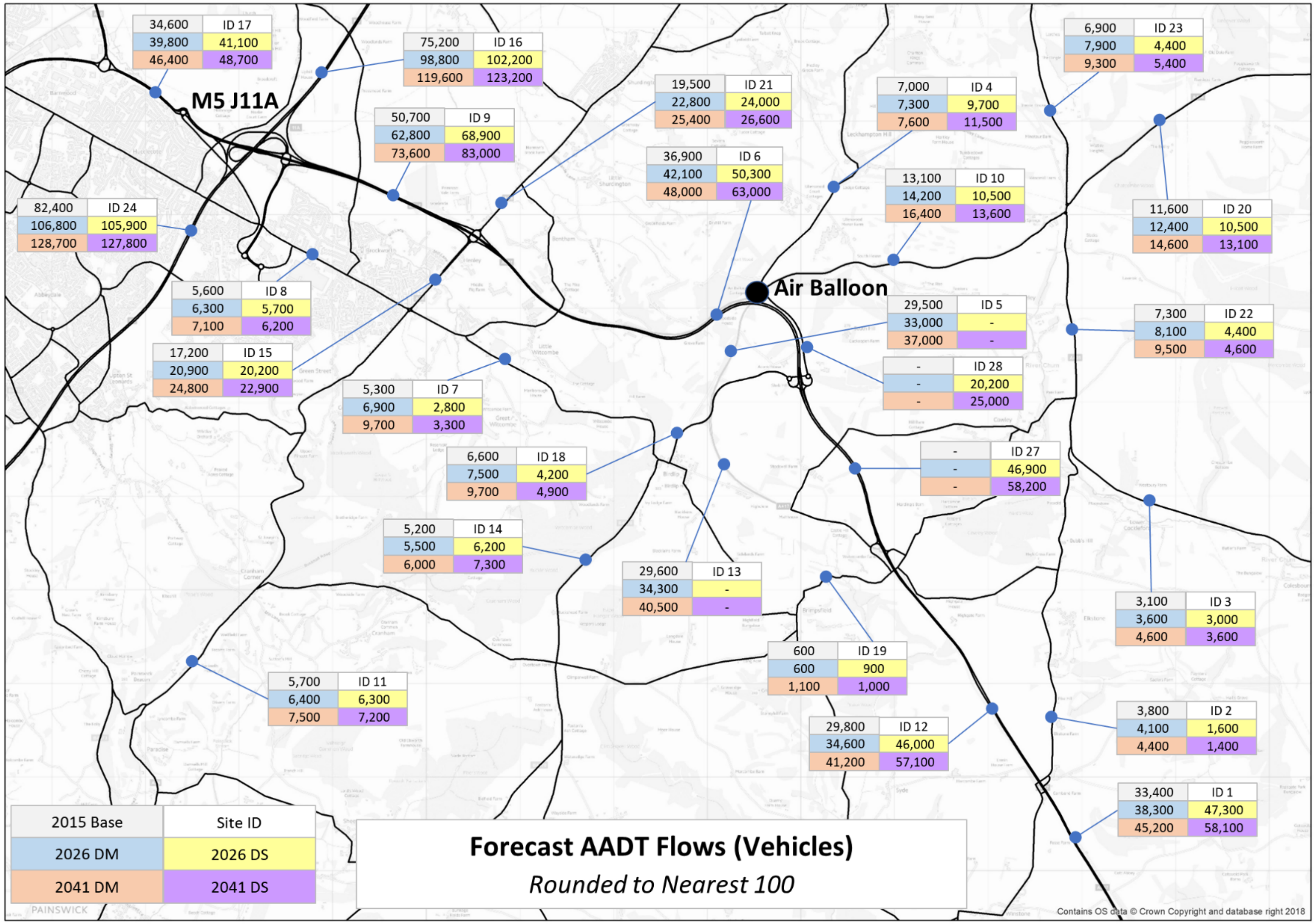


Note: Origin/home locations are shown as green bars, while the destination/work location is shown with a magenta bar

Source: Highways England

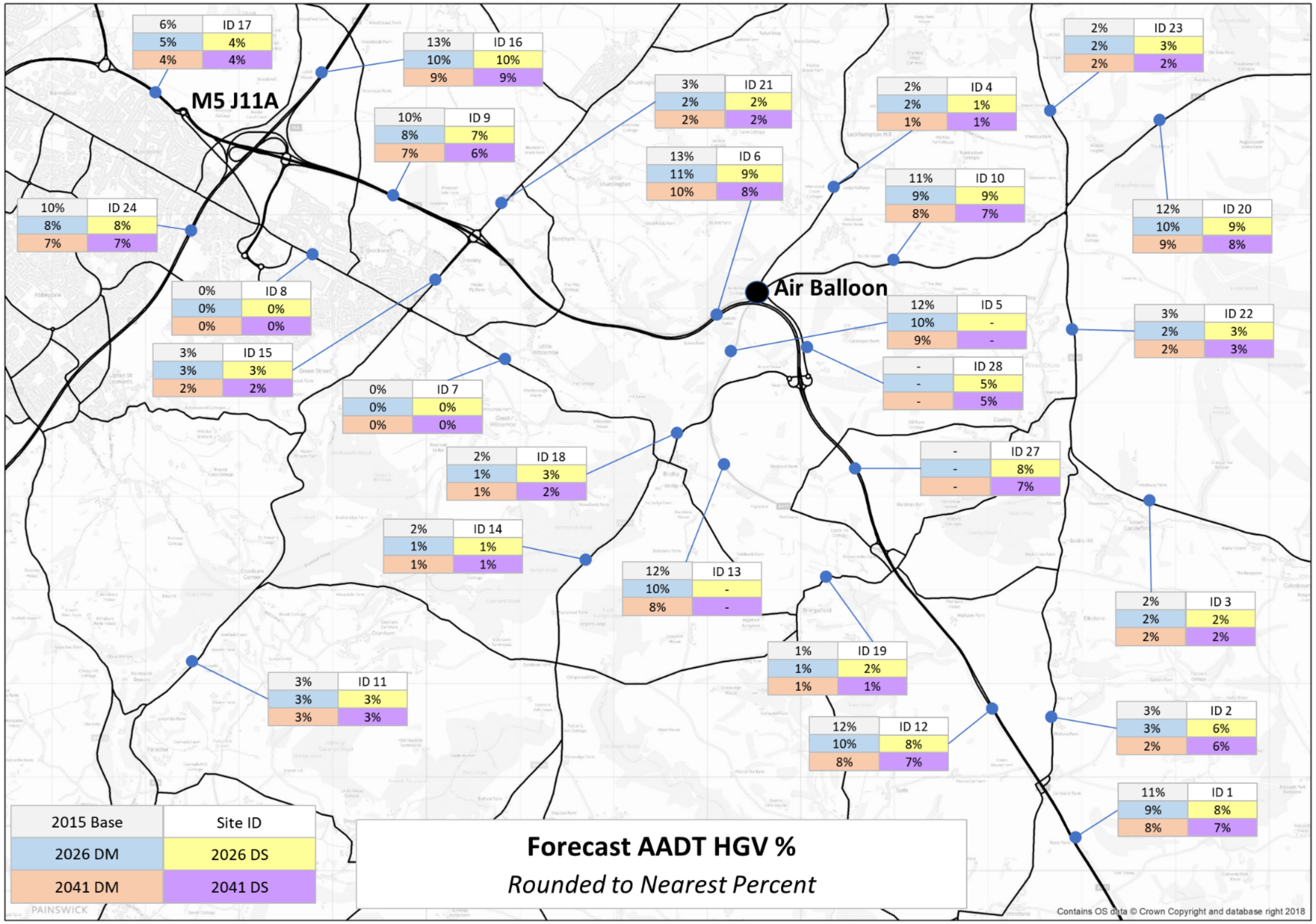
Figure H-4 Origin of trips from Innsworth development

Appendix I Forecast traffic flow plots



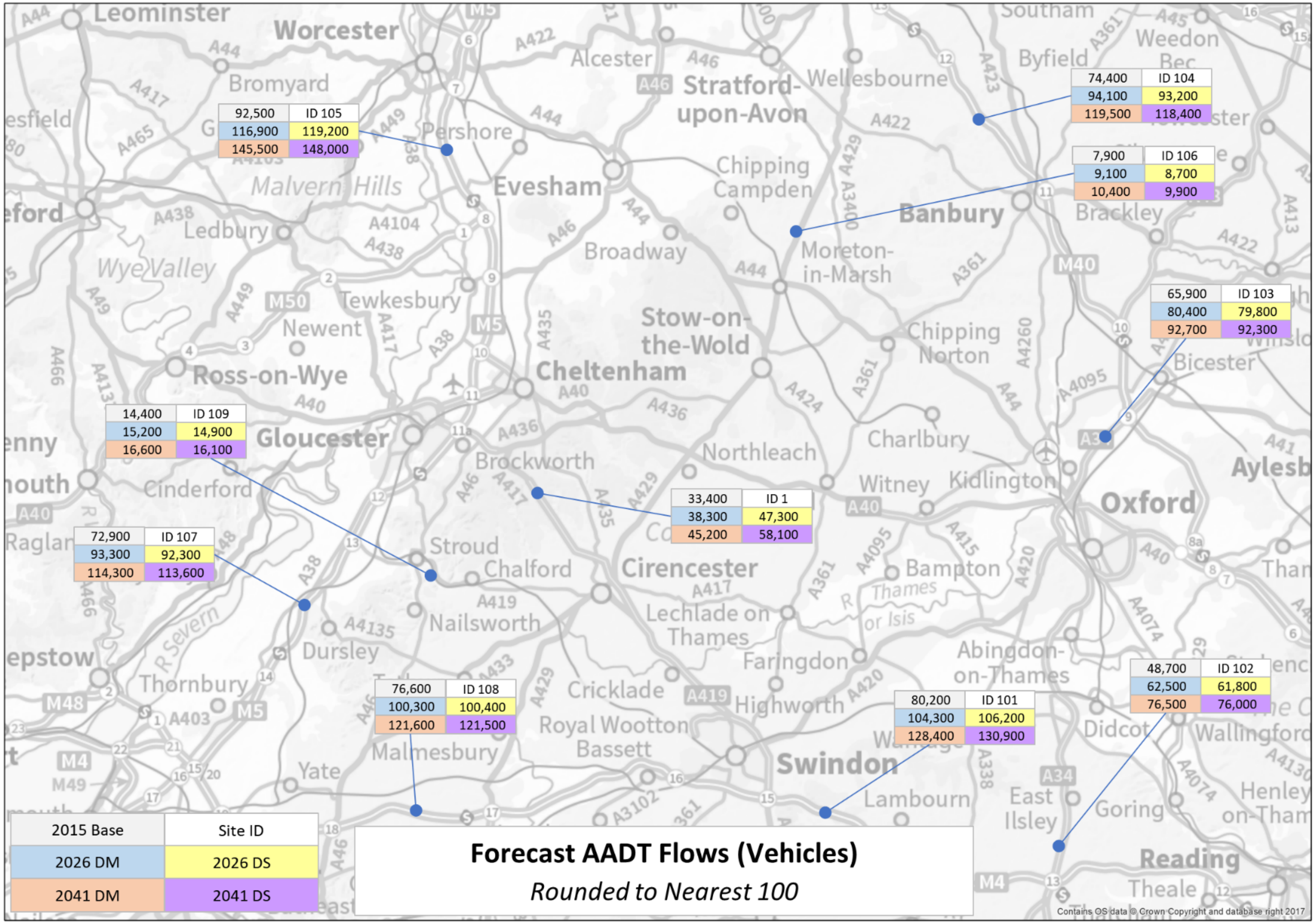
Source: Highways England

Figure I-1 Forecast AADT flows in local area



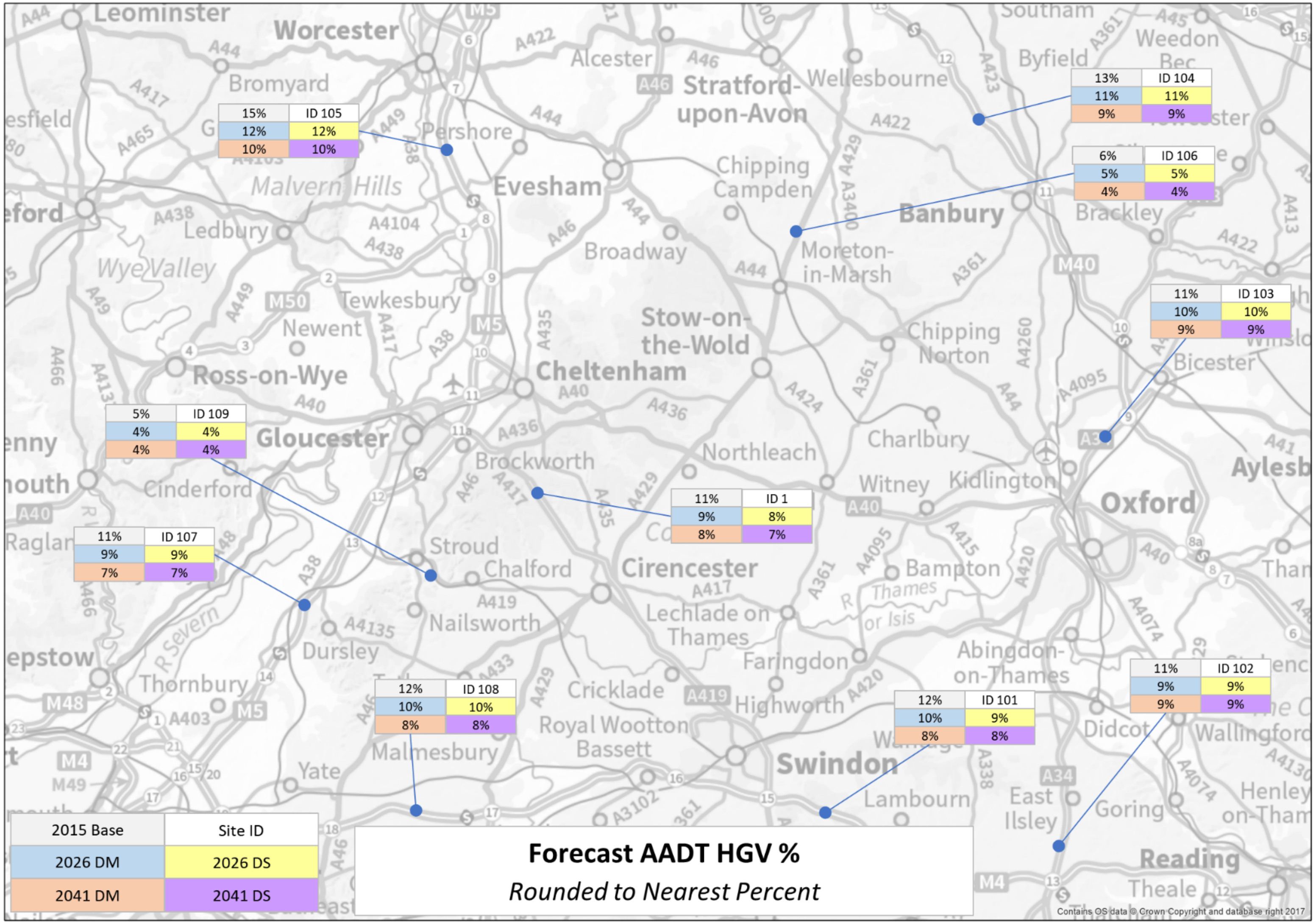
Source: Highways England

Figure I-2 Forecast AADT HGV proportion in local area



Source: Highways England

Figure I-3 Forecast AADT flows in wider area



Source: Highwys England

Figure I-4 Forecast AADT HGV proportion in wider area

Appendix J Operational assessment technical note

Subject:	**Operational Assessment Technical Note**
To:	
Document Reference:	HE551505-ARP-HGN-X_XX_XXXX_X-FN-D-000001
Revision:	**P10**
Suitability (status):	**S3**
Date:	11 December 2020
Copies:	
From:	

J.1 Introduction

J.1.1 Purpose of this document

J.1.1.1 The purpose of this technical note is to summarise the operational modelling approach and output results to assess the operational performance of three roundabout junctions in the 2041 scheme design year. These junctions are:

- Ullenwood junction
- Shab Hill eastern roundabout
- Shab Hill western roundabout

J.1.2 Scheme description

J.1.2.1 The scheme would provide 3.4 miles (5.5km) of new, rural all-purpose dual carriageway for the A417. The new dual carriageway would connect the existing A417 Brockworth bypass with the existing dual carriageway A417 south of Cowley. The new dual carriageway would be completed in-line with current trunk road design standards. The section to the west of the existing Air Balloon roundabout would follow the existing A417 corridor, but to the south and east of the Air Balloon roundabout, the corridor would be offline, away from the existing road corridor.

J.1.2.2 The project would include a new crossing near Emma's Grove for walkers, cyclists and horse riders including disabled users, which would accommodate the Cotswold Way National Trail. A new junction would be incorporated at Shab Hill, providing a link from the A417 to the A436 (towards the A40 and Oxford), and to the B4070 (for Birdlip and other local destinations).

J.1.2.3 A new 37m wide multi-purpose crossing would provide essential mitigation for bats and enhancement opportunity of ecology and landscape integration. The public would also further benefit as the crossing would accommodate the Gloucestershire Way and provide an improved visitor experience.

J.1.2.4 A new junction would be included near Cowley, replacing the existing Cowley roundabout, making use of an existing underbridge to provide access to local destinations. The use of the existing underbridge would allow for all directions of travel to be made.

J.1.2.5 The current A417 between the existing 'Air Balloon roundabout' and 'Cowley roundabout' would be detrunked for its entire length. Some lengths of the existing road would be converted into a route for walkers, cyclists and horse riders including disabled users. Other sections would be retained as lower-class public roads, maintaining local access for residents. Some of the route would provide Common Land.

J.1.2.6 The layout of the scheme, as set out in the VISSIM operational transport model is summarised in Figure J-1.

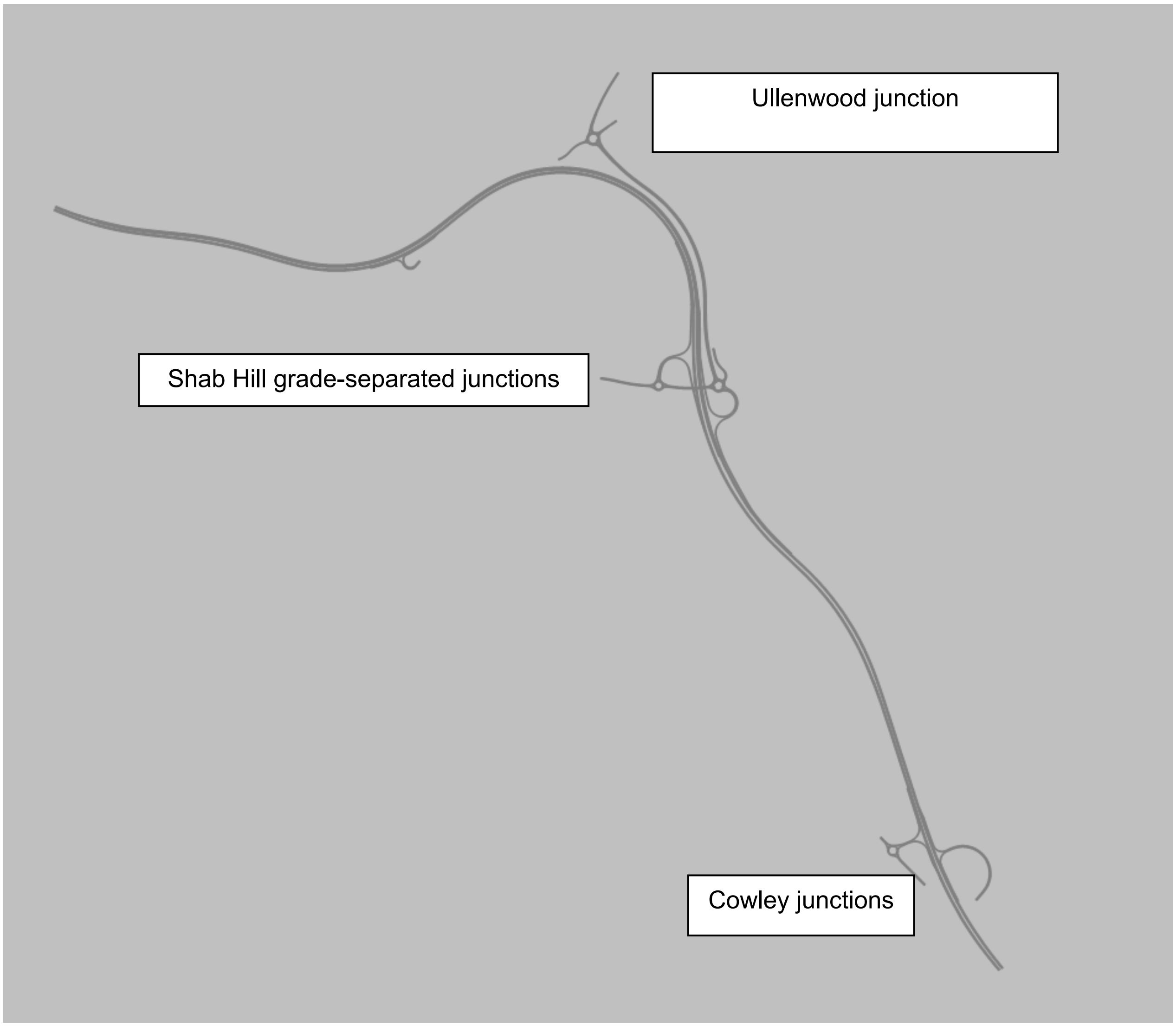


Figure J-1 Route layout as presented in the operational transport model

J.2 Approach to modelling

J.2.1 Traffic flows

J.2.1.1 The operational assessments have utilised traffic flows extracted from the scheme traffic model for the 2041 design forecast year that represent an average across the whole AM (07:00-10:00) and PM (16:00-19:00) periods using a cordon process.

J.2.1.2 To provide a more robust assessment, a set of factors were derived by Highways England at PCF stage 2 to convert the average hour flows into peak hour equivalents.

J.2.1.3 Peak period to peak hour factors for light duty vehicles (LDV) and heavy duty vehicles (HDV) separately were derived using automatic traffic count (ATC) data at 30 different locations along the A417/419 corridor. The resulting period to hour factors are presented in Table J-1. These factors have been applied at PCF stage 3.

Table J-1 Peak period to peak hour factors

Period	LDV	HDV	Combined
AM	1.172	1.027	1.148
PM	1.114	1.058	1.108

J.2.2 Modelling software

J.2.2.1 Each of the three study junctions have been modelled in three ways to determine their operational performance using the following software:

- VISSIM 11.00-11
- Junctions 9 (base mode)
- Junctions 9 (advanced mode)

J.2.2.2 The traffic modelling has been used to inform the design of the junctions and has been an iterative process, working closely with the highway design team, to identify and modify the layout of each junction to balance the future traffic flows and turning movements.

J.2.3 Junctions 9 'basic' vs 'advanced' mode

J.2.3.1 A base model has been built in the ARCADY module of Junctions 9. It was initially built using the 'basic mode' using the 'flat' traffic profile.

J.2.3.2 The 'basic' model outputs were shown to overestimate capacity when compared with the outputs from the initial micro-simulation model, which appeared to be due to uneven lane usage on some arms of the roundabouts. ARCADY uses empirical models that relate the entry flow on a roundabout arm to the opposing circulating flow past the arm. The software user manual indicates:

"Capacity increases continuously with entry width… ARCADY assumes that the entire entry width is available to all vehicles most of the time.

If traffic predominately uses only part of the road. For example, if 90% of traffic turns left, then a lane marked for left-turners would clearly be used far more than *a lane for right-turners. ARCADY continues to assume that the entire entry width is available which may lead to an overestimate of capacity."*

J.2.3.3 Given the uneven lane usage, it was necessary to run the lane simulation mode in the 'advanced mode' of ARCADY to better represent the proposed operation of the junction.

J.2.3.4 The results summarised in section 4 of this document should be read in the context of the limitations of the ARCADY software for modelling uneven lane usage. The software user manual indicates that:

"Lane Simulation Mode in Junctions 9 is provided as a tool to investigate alternative lane configurations at roundabouts…It should not be taken as forecasting junction performance to the same level of accuracy as the main ARCADY model... Although it makes use of the core ARCADY model, it is not itself derived from empirical studies. Therefore, engineering judgement should be applied to both the application of the model and the interpretation of results."

J.2.4 VISSIM

J.2.4.1 A micro-simulation model of the scheme has been developed using VISSIM version 11.00-11. This was initially developed to aid the production of an animation for use in the scheme public consultation. This software allows a clear detailed assessment of the interaction between key junctions and network infrastructure. Although the model is not validated since the junctions do not currently exist, the model has provided a useful investigative tool to understand junction operation. This has allowed for further assessment of the three roundabouts alongside the junctions 9 models.

J.3 Modelling results

J.3.1 Introduction

J.3.1.1 The junctions have been analysed in terms of ratio to flow capacity (RFC), queue, and delay. The queue for each arm is measured in passenger car unit (PCUs, each PCU is equivalent to 5.75m).

J.3.1.2 RFC is the ratio of flow to capacity for an approach with an acceptable RFC being defined as 0.85. While an RFC of 0.85 is below absolute capacity (RFC < 1.0), at this point the performance of the approach decreases and becomes less efficient and congestion is likely to occur. Junctions 9 cannot calculate the RFC for each arm when the lane simulation module in the advanced mode is used and as such, the RFC columns are left blank for all scenarios using the module.

J.3.1.3 The delay is the number of extra seconds a vehicle would expect to take through the junction when compared to the free flow situation.

J.3.1.4 Due to the variation in queue length over the modelled period caused by the build-up and release of traffic and the variation in demand, the modelled queue lengths reported in VISSIM are the average of the maximum queue lengths in five-minute intervals, averaged across the hour. This is similar to the mean max queue (MMQ) that would be typically quoted from other junction modelling software.

J.3.1.5 Due to the different modelling methodologies utilised by the modelling software, some differences in the results are to be expected, such as differences in the reported queue lengths and delay from VISSIM and junctions 9. It is considered that these differences are within reasonable limits and are therefore acceptable.

J.3.2 Ullenwood junction

J.3.2.1 The existing Air Balloon roundabout would be removed. The new Ullenwood junction would be constructed and combined with the A436/Leckhampton Hill priority junction to form a four-arm 50m ICD roundabout with a link to the A417 and Cold Slad Lane.

J.3.2.2 The initial design of this junction included one-lane entries on each arm and a segregated left turning lane, which allowed traffic to leave the westbound A436 without using the roundabout circulatory carriageway to access the link to the A417 at Shab Hill. Initial operational modelling undertaken in both VISSIM and Junctions 9 showed that this layout would operate over capacity.

J.3.2.3 A review of the models and traffic movements identified that the design should provide for two-lanes at the entry from Leckhampton Hill with both lanes allowing straight-ahead movements onto the A436 Link Road. Similarly, the review identified the A436 would benefit from both lanes allowing left-turns onto the A436 Link Road. From this, the layout was updated to remove the segregated left-turning lane and allow for a two-lane exit on the A436 Link Road. Increased entry width and flare on the A417 link to the roundabout was also required to provide enough capacity for the large traffic flow from this arm.

J.3.2.4 The operation of Ullenwood junction has therefore been assessed using geometric parameters measured from the design fix 2c scheme layout drawing, as shown in the General Arrangement Plans (Document Reference 2.6A).

J.3.2.5 The proposed roundabout includes an access arm to/from Cold Slad Lane, which is not included within the scheme traffic model. Given that this local access is not included in the scheme traffic model and that traffic demand on this arm is likely to be negligible, it has been excluded from the model results set out below.

J.3.2.6 The modelling results for this roundabout junction are summarised in Table J-2.

Table J-2 2041 Ullenwood junction results

2041	AM			PM		
	RFC	**Queue (PCU)**	**Delay (s)**	**RFC**	**Queue (PCU)**	**Delay (s)**
Junctions 9 (basic mode)						
Leckhampton Hill	0.47	0.9	5.44	0.51	1	5.33
A436	0.49	1	6.44	0.75	3	13.23
A436 Link Road	0.67	2.1	5.62	0.53	1.2	3.9
Junctions 9 (advanced mode)						
Leckhampton Hill		1.4	8.18		1.6	7.74
A436		1.1	6.87		3.5	14.44
A436 Link Road		5.7	13.62		2.8	8.25
VISSIM						

Leckhampton Hill		4.1	8.22		3.8	4.31
A436		2.0	4.42		4.2	6.20
A436 Link Road		4.5	2.98		0.3	1.94

J.3.2.7 The modelling results indicate that the proposed Ullenwood junction is forecast to operate within capacity in the 2041 scheme design year, with some limited queuing on the A436 Link Road in the morning peak hour and on the A436 approach in the evening peak hour.

J.3.3 Shab Hill eastern roundabout

J.3.3.1 The scheme would incorporate a new grade-separated junction at Shab Hill, connecting two roundabouts via an underpass.

J.3.3.2 The eastern roundabout has been designed to have a 50m ICD with four-arms, including the eastbound on and off-slips to the A417. The roundabout provides a link from the A417 to the A436 from Oxford, referred to as the A436 link road, with a climbing lane for southbound traffic on the approach to the junction.

J.3.3.3 The initial design of this junction included one-lane entries on the A417 off-slip and from the underpass. Initial operational modelling undertaken in both VISSIM and junctions 9 showed that this layout would operate over capacity.

J.3.3.4 A review of the models and traffic movements identified that the design of the eastern roundabout at Shab Hill should provide for two-lanes at the entry from the A417 off-slip and from the underpass. The layout was updated, and the operation re-assessed. The interim modelling results indicated that the proposed eastern roundabout was forecast to operate with queues on the A436Link Road, and queues and delay on the A417 off-slip in the evening peak hour.

J.3.3.5 A further review of the traffic movements identified that the junction would operate better if the layout was updated to include a two-lane exit on the A436 Link Road, which would allow both entry lanes on the A417 off-slip and from the underpass to exit onto the A436 Link Road. It was also identified that a two-lane exit on the underpass arm would allow both entry lanes on the A436 Link Road to exit to the underpass. From this, the layout was updated for design fix 2c to include the two-lane exits, with traffic merging on the exit arms.

J.3.3.6 The operation of the eastern roundabout at Shab Hill has been assessed using geometric parameters measured from the design fix 2c scheme layout drawing, as shown in the General Arrangement Plans (Document Reference 2.6A).

J.3.3.7 The proposed roundabout includes an access arm to/from the lane to the Rushwood Kennels and Cattery, which is not included within the scheme traffic model. Given that this local access is not included in the scheme traffic model and that traffic demand on this arm is likely to be negligible, it has been excluded from the model results set out below.

J.3.3.8 The modelling results for this roundabout junction are summarised in Table J-3.

Table J-3 2041 Shab Hill eastern roundabout results

2041	AM			PM		
	RFC	**Queue (PCU)**	**Delay (s)**	**RFC**	**Queue (PCU)**	**Delay (s)**
Junctions 9 (basic mode)						
A417 SB off slip	0.5	1.1	5.13	0.46	0.9	5.84
Underpass	0.63	1.8	9.21	0.45	0.8	5.37
A436 Link Road	0.51	1.1	3.25	0.64	1.8	4.36
Junctions 9 (advanced mode)						
A417 SB off slip		1.8	7.18		1.5	8.65
Underpass		2	10.02		1	5.37
A436 Link Road		1.9	5.66		2.6	6.34
VISSIM						
A417 SB off slip		5.6	6.94		5.1	7.60
Underpass		3.0	3.11		0.9	1.94
A436 Link Road		2.6	2.94		1.4	2.22

J.3.3.9 The modelling results indicate that the proposed Shab Hill eastern roundabout is forecast to operate within capacity in the 2041 scheme design year, with some small queues and delay on all arms in both morning and evening peak hours.

J.3.4 Shab Hill western roundabout

J.3.4.1 The western roundabout at the grade-separated junction at Shab Hill would provide a link from the A417 to Birdlip via the B4070. It has been designed to have a 40m ICD with three-arms, including the westbound on and off-slips to the A417.

J.3.4.2 The initial design of this junction included one-lane entries on the three arms. Initial operational modelling undertaken in both VISSIM and junctions 9 showed that this layout would operate largely within capacity and therefore no further review or changes to the layout was undertaken.

J.3.4.3 The operation of western roundabout at Shab Hill has been assessed using geometric parameters measured from the design fix 2c scheme layout drawing, as shown in the General Arrangement Plans (Document Reference 2.6A).

J.3.4.4 The modelling results for this roundabout junction are summarised in Table J-4.

Table J-4 2041 Shab Hill western roundabout results

2041	AM			PM		
	RFC	Queue (PCU)	Delay (s)	RFC	Queue (PCU)	Delay (s)
Junctions 9 (basic mode)						
Underpass	0.48	1	5	0.79	3.7	11.88
B4070	0.5	1	8.93	0.27	0.4	6.99
A417 NB off slip	0.27	0.4	4.58	0.31	0.4	4.28
Junctions 9 (advanced mode)						

2041	AM			PM		
	RFC	Queue (PCU)	Delay (s)	RFC	Queue (PCU)	Delay (s)
Underpass		1.2	5.45		3.9	12.01
B4070		1.1	9.32		0.5	7.42
A417 NB off slip		0.5	4.7		0.6	4.41
VISSIM						
Underpass		2.0	1.74		2.3	2.02
B4070		1.5	2.17		1.8	4.45
A417 NB off slip		1.0	2.10		1.3	3.01

J.3.4.5 The modelling results indicate that the design of the Shab Hill western roundabout would work largely within capacity in the 2041 scheme design year, with some queuing on the underpass arm in the evening peak hour.

J.4 Summary and conclusion

J.4.1.1 This technical note has summarised operational assessments undertaken for three roundabout junctions included in the scheme, as follows:

- Ullenwood junction
- Shab Hill eastern roundabout
- Shab Hill western roundabout

J.4.1.2 The junction capacity assessments have been undertaken for the design year of 2041, and utilised traffic demand extracted from the scheme traffic model. The average hour flows were converted into peak hour flows using factors derived from existing A417 traffic count data.

J.4.1.3 Each of the three study junctions have been modelled in three ways to determine their operational performance using VISSIM 11.00-11 and junctions 9, utilising the basic and advanced mode modules.

J.4.1.4 The traffic modelling was used to inform the design of the junctions, which has been an iterative process to identify and modify the layout of each junction to balance the future traffic flows and turning movements.

J.4.1.5 The final modelling results for each of the junctions have shown that the updated designs would work largely within capacity in the 2041 scheme design year.

Appendix K Scheme cost profile

Highways England
Commercial Services Division

Economics Information for the whole package - Most Likely Cost

Funding Directorate	Major Projects (MP)
Project / Scheme Name	A417 Missing Link
Option Name	Option 30 Parallel Route
Estimate Release Date	16/09/2020
Current PCF Stage	Developing
Type of Estimate	3. Development - Preliminary Design
Lead Cost Engineer	James Chung

Estimate Release Notes

- If you have any questions regarding the information provided please contact CommercialServicesDivision@highwaysengland.co.uk
- Rebased 2010 calendar year profiles for Economic Calculations - All costs are in the factor cost unit of account.
- The expenditure profiles are based upon cost estimates for each financial year prepared at a base date and then inflated to outturn costs using HE projected construction related inflation. These costs have then been rebased to 2010 calendar year profiles for economic calculations, using the GDP-deflator series as published in the WebTAG Databook.
- The costs exclude all VAT. All historic costs have been removed - previous years and an approximate of this years spend that occurs in the past.

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Total (Excl Hist)
PREPARATION EXPENDITURE PROFILE	£0	£2,935,690	£2,673,651	£16,608,588	£533,436	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£22,751,364
SUPERVISION EXPENDITURE PROFILE	£0	£0	£0	£0	£906,511	£3,473,176	£2,925,028	£896,807	£592,313	£0	£0	£0	£0	£0	£0	£0	£8,793,835
WORKS EXPENDITURE PROFILE	£0	£0	£0	£0	£55,829,678	£86,316,880	£64,750,585	£10,365,708	£139,359	£81,703	£0	£0	£0	£0	£0	£0	£217,483,913
LANDS EXPENDITURE PROFILE	£0	£1,663,707	£2,828,848	£1,281,005	£9,949,198	£3,825,665	£1,737,966	£2,131,432	£1,202,766	£525,817	£233,863	£137,297	£89,561	£65,725	£5,359	£0	£25,678,208
TOTAL EXPENDITURE FORECAST	**£0**	**£4,599,397**	**£5,502,499**	**£17,889,593**	**£67,218,823**	**£93,615,721**	**£69,413,579**	**£13,393,947**	**£1,934,438**	**£607,519**	**£233,863**	**£137,297**	**£89,561**	**£65,725**	**£5,359**	**£0**	**£274,707,319**

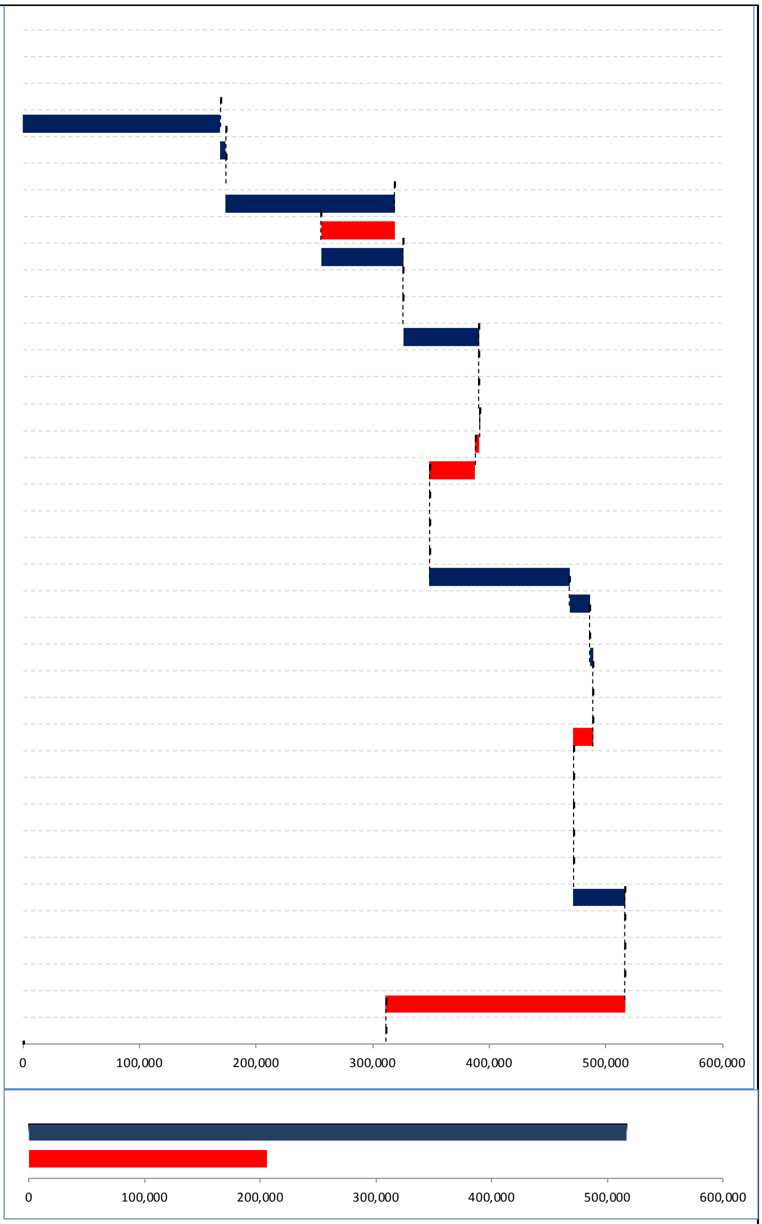
PREPARATION EXPENDITURE PROFILE	0%	64%	49%	93%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%
SUPERVISION EXPENDITURE PROFILE	0%	0%	0%	0%	1%	4%	4%	7%	31%	0%	0%	0%	0%	0%	0%	0%	3%
WORKS EXPENDITURE PROFILE	0%	0%	0%	0%	83%	92%	93%	77%	7%	13%	0%	0%	0%	0%	0%	0%	79%
LANDS EXPENDITURE PROFILE	0%	36%	51%	7%	15%	4%	3%	16%	62%	87%	100%	100%	100%	100%	100%	0%	9%
TOTAL EXPENDITURE FORECAST (ALL COSTS INCLUDED)	**0.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**

Source: Highwys England

Figure K-1 Scheme cost profile

Appendix L Waterfall chart

Categories	£000s
Smoother Flow	255,837
Business Users	173,996
Journey Times	169,310
Vehicle Operating Costs	4,686
Customers/Users (excluding business)	81,841
Journey Times	145,003
Vehicle Operating Costs	-63,162
Reliability (Business and Customers)	70,502
Safety	64,890
Safety	64,890
Environmental Impacts	-42,448
Noise	466
Local Air Quality	-3,630
Greenhouse Gases	-39,284
Landscape	Not Assessed
Wider Economic Impacts	140,327
Agglomeration	120,163
Market Competition	17,400
Dependent Development	Not Monetised
Labour Supply	2,764
Customer Impact	-17,148
Traffic delays due to Construction	-17,148
Traffic delays due to Maintenance	Not Assessed
Journey Quality	Not Assessed
Developer contributions	Not Assessed
Indirect tax contributions	44,691
[Other - please specify]	Not Assessed
Costs	
Cost to Broad Transport Budget	205,457
Cost savings	Not Assessed
Present Value of Benefits	***516,651***
Present Value of Costs	***205,457***
BENEFIT COST RATIO	**2.51**
VALUE FOR MONEY	**0**



Source: Highways England

Figure L-1 Waterfall chart

Appendix M Robustness of economic appraisal

Total user benefits by time period

M.1.1.1 Table M1 shows total user benefits by time period. The weekday morning and evening peak periods provide around half of the total user benefits. Morning, evening peak and IP periods contribute to 73% of the total benefits. Over the weekends 19% of the total benefits accrued.

Table M-1 Total user benefits by time period (£000s)

Time Period	User Benefits	Annualisation
AM (weekday)	53,322	759
IP (weekday)	62,396	1,518
PM (weekday)	72,319	759
OP (weekday)	18,957	3,036
Weekends	48,845	2,688
TOTAL	**255,839**	**8,760**

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

Total user benefits by type of benefit

M.1.1.2 Table M2 shows total user benefits by benefit type. As expected, the scheme provides large amounts of travel time benefits by replacing the congested single carriageway section with the modern dual carriageway. The scheme also sees a large amount of vehicle operating cost disbenefits, which is a result of the increased vehicle kilometres forecast to arise. Impacts on toll charges is negligible.

Table M-2 Total user benefits by benefit type (£000s)

Benefit Type	User Benefits
Travel Time	314,313
Vehicle Operating Costs	-58,490
Tolls	14
TOTAL	**255,837**

Source: Highways England

Notes: All monetary values are expressed in 2010 prices, discounted to 2010

Journey time benefits by time change band

M.1.1.3 Table M3 presents journey time benefits by time change band for business users over the 60-year appraisal period.

M.1.1.4 Table M4 presents the same information for consumers. For clarity, as an example, the journey time benefits presented for the ±0-2 minute bands are the sum of benefits between -2 minutes and +2 minutes.

Table M-3 Journey time benefit by time change band – business user (£000s)

Time Band	The scheme
± 0 - 2 mins	-10,772
± 2 - 5 mins	142,847
> ± 5 mins	37,236
TOTAL	**169,311**

Source: Highways England
Notes: All monetary values are expressed in 2010 prices, discounted to 2010

Table M-4 Journey time benefit by time change band – non-business user (£000s)

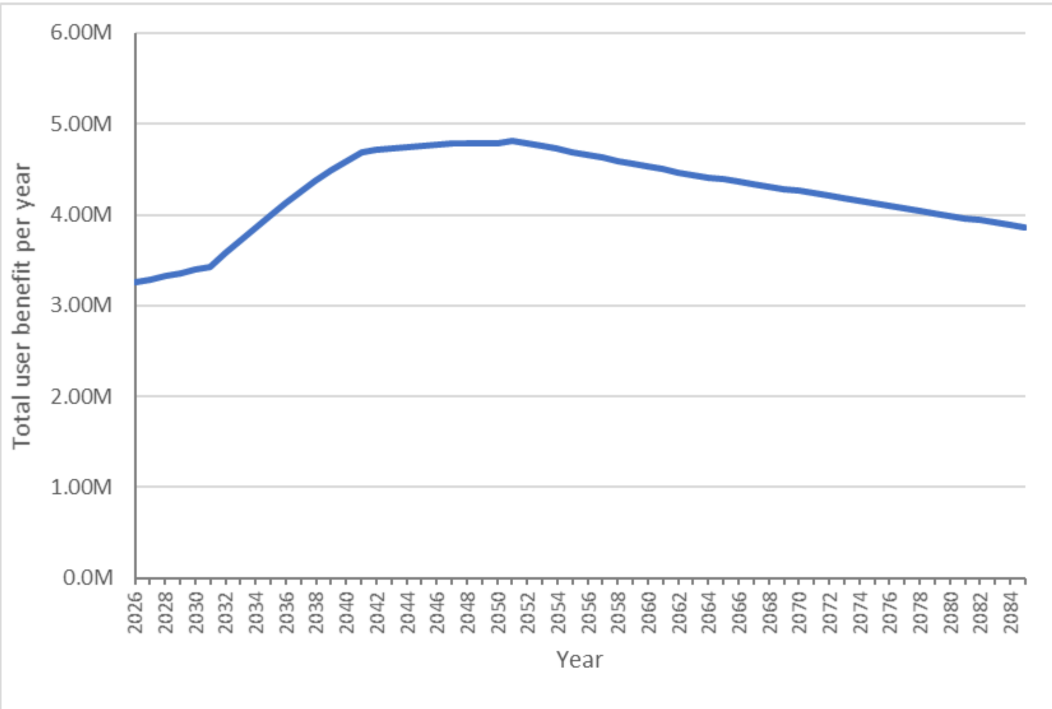
Time Band	The scheme
± 0 - 2 mins	-10,801
± 2 - 5 mins	125,588
> ± 5 mins	30,217
TOTAL	**145,004**

Source: Highways England
Notes: All monetary values are expressed in 2010 prices, discounted to 2010

M.1.1.5 The table shows that most of the journey time benefits are incurred by time savings of between ± 2 and 5 minutes. Negative changes in journey times (±< 2 minutes) result in disbenefits.

Profile of user benefits over the assessment period

M.1.1.6 Figure M-1 illustrates the profile of user benefits over the 60-year appraisal period. From the figure, it can be noted that the accrual of user benefits steadily increasing to 2051 (the last modelled year) before gradually declining thereafter. The scheme is forecast to accrue 50% of the total benefits by 2053.



Source: Highways England
Note: All monetary values are expressed in 2010 prices, discounted to 2010

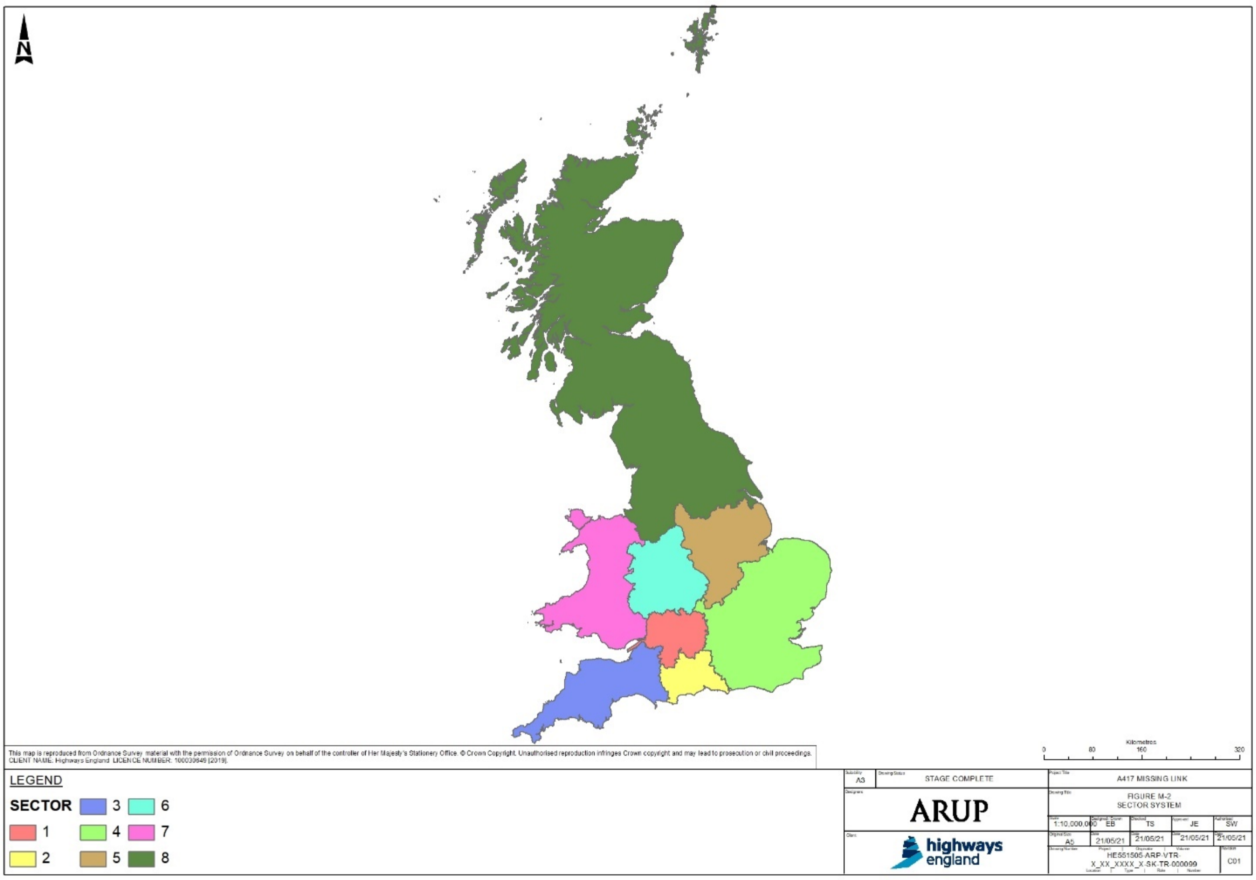
Figure M-1 A417 profile of user benefits over the assessment period

Geographical sectorisation of user benefits

M.1.1.7 To confirm that the distribution of user benefits that arise from the scheme are sensible, and to demonstrate the robustness of the economic assessment, a sector to sector analysis of user time benefits has been undertaken.

15.3.4 The sector system used to analyse the user time benefits is identified and shown in Figure M-2 (this sector system was also used to summarise impacts arising from the Variable Demand Model (VDM)):

- sector 1 – Main impact area of the scheme
- sector 2 – Hampshire, east Dorset and south Wiltshire
- sector 3 – Cornwall, Devon, Somerset and west Dorset
- sector 4 – London, South East and the East of England
- sector 5 – East Midlands
- sector 6 – West Midlands
- sector 7 – Wales
- sector 8 – north and Scotland.



Source: Highways England

Figure M-2 Sector system

M.1.1.8 Sectorised user time benefits are presented in Table M-5 for 2026, Table M-6 for 2031, Table M-7 for 2041, Table M-8 for 2051 and Table M-9 for the total 60-year appraisal period. All monetary values shown in the tables are expressed in 2010 prices, discounted to 2010.

Table M-5 User time benefits by sector (£000s) – 2026

	1	2	3	4	5	6	7	8	Total
1	1,705	130	9	340	20	785	72	311	3,372
2	163	0	-1	32	41	343	13	95	687
3	-20	0	0	-32	-82	-92	1	-56	-282
4	343	5	-43	58	21	495	-17	52	914
5	25	8	-8	5	0	5	-12	0	23
6	411	270	-25	317	-8	-95	-15	-9	846
7	6	12	0	0	-11	-36	0	-18	-46
8	199	30	-11	13	0	2	-4	0	229
Total	2,832	454	-79	734	-18	1,407	37	376	5,743

Source: Highways England

Note: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

Table M-6 User time benefits by sector (£000s) – 2031

	1	2	3	4	5	6	7	8	Total
1	1,625	135	21	333	34	618	76	290	3,132
2	157	0	0	36	43	342	17	104	698
3	-25	-1	1	-38	-54	-164	0	-111	-392
4	322	6	-25	60	20	512	0	66	962
5	19	8	-10	5	0	1	-9	-2	13
6	411	291	-44	323	-9	-85	-11	-11	864
7	5	12	0	-12	-16	-44	0	-23	-78
8	172	31	-23	18	0	0	-4	0	193
Total	2,686	481	-80	725	18	1,180	69	313	5,393

Source: Highways England

Note: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

Table M-7 User time benefits by sector (£000s) – 2041

	1	2	3	4	5	6	7	8	Total
1	1,994	136	46	380	28	581	135	261	3,561
2	117	0	0	49	62	388	18	124	759
3	11	-1	3	-40	-57	-195	16	-135	-399
4	326	5	-5	82	32	549	23	91	1,103
5	12	8	-16	6	0	5	-4	0	11
6	399	311	-88	335	-12	-54	-10	-13	868
7	30	12	1	-33	-10	-53	0	-27	-80
8	155	40	-52	27	0	1	-4	0	166
Total	3,045	511	-111	805	44	1,222	174	301	5,989

Source: Highways England

Note: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

Table M-8 User time benefits by sector (£000s) – 2051

	1	2	3	4	5	6	7	8	Total
1	2,173	132	64	377	8	506	91	219	**3,570**
2	64	0	0	51	64	373	9	137	**698**
3	38	0	5	-53	-67	-206	2	-142	**-421**
4	253	4	13	82	28	515	33	81	**1,009**
5	12	8	-11	6	0	5	-2	0	**18**
6	428	318	-88	336	-16	-188	-6	-21	**762**
7	30	12	0	-30	-16	-68	0	-34	**-106**
8	158	35	-40	26	0	0	-2	0	**176**
Total	**3,157**	**509**	**-59**	**796**	**1**	**937**	**125**	**241**	**5,706**

Source: Highways England

Note: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

Table M-9 User time benefits by sector (£000s) – 60-year appraisal period

	1	2	3	4	5	6	7	8	Total
1	112,274	7,330	2,873	20,323	853	30,183	5,284	13,267	**192,387**
2	5,035	0	-19	2,628	3,271	20,335	670	7,021	**38,941**
3	1,201	-26	210	-2,601	-3,519	-10,566	234	-7,248	**-22,316**
4	15,407	259	93	4,261	1,497	28,574	1,331	4,369	**55,791**
5	750	434	-653	336	0	251	-217	-5	**897**
6	23,076	17,059	-4,345	18,309	-762	-7,968	-449	-982	**43,936**
7	1,379	650	-6	-1,456	-799	-3,302	0	-1,657	**-5,190**
8	8,894	1,912	-2,117	1,343	6	-5	-165	0	**9,869**
Total	**168,017**	**27,618**	**-3,964**	**43,143**	**546**	**57,502**	**6,687**	**14,766**	**314,315**

Source: Highways England

Note: All monetary values are expressed in 2010 prices, discounted to 2010. Numbers may not sum due to rounding.

M.1.1.9 At the sector to sector level, user benefits appear to be sensible with benefits distributed in line with expectations. The user benefits on a sector to sector basis are also comparable, in terms of distribution pattern, between modelled year.

M.1.1.10 As would be expected, the largest benefits in all scenarios are associated with the sector in which the scheme is located (sector 1). Intra-sector benefits are the largest and contribute to between a quarter and a third of total benefits. The next largest benefits occur in both directions between sector 1 and sector 6, which is as expected and reflects improved travel times between the main study area and the West Midlands. Benefits associated with sector 1 also tend to be greater for northbound movements (e.g. towards the West Midlands and the north) than the southbound equivalent, which reflects the larger journey time savings forecast to occur in the westbound direction on the A417.

M.1.1.11 The distribution of benefits away from the main study area (sector 1) also appear to be sensible and are consistent. For example, benefits occur in both directions between sector 4 and sector 6 and between sector 2 and sector 6. These relate to movements between the West Midlands and the south and south-east, which are forecast to experience reductions in journey times as a result of improvements to the A417 route.

M.1.1.12 Although relatively minor compared to the benefits, disbenefits are also forecast to occur with certain sector-to-sector movements and these also appear to be sensible and consistent. The largest disbenefits generally occur between the south-west (sector 3) and sectors in the West Midlands (sector 6) and the north and Scotland (sector 8). This is a result of the impact of the scheme with increases in traffic forecast on the M5 north of Gloucestershire, which would in turn lead to a slight reduction in speeds on this section of the motorway. This impact on the northernmost section of the M5 outweighs the reduced flow (and associated increased speed) on the M5 sections south of Gloucester (J11a).

Analysis of TUBA warning messages

M.1.1.13 Running TUBA generates a considerable number of warnings as the software analyses the multiple input model skims at the individual purpose level, for each time period and origin destination pair. Table M-10 summarises the aggregated warnings produced by TUBA.

Table M-10 Summary of TUBA warnings

Warning type	Number of warnings
Ratio of DM to DS travel time lower than limit	128
Ratio of DM to DS travel time higher than limit	1,424
Ratio of DM to DS travel distance lower than limit	1,758
Ratio of DM to DS travel distance higher than limit	909
DM speeds less than limit	3,893
DM speeds greater than limit	9,215,754
DS speeds less than limit	3,616
DS speeds greater than limit	9,066,768
DM trips greater than limit	106
DS trips greater than limit	106
Possible introduction of new mode 1 of DM and DS time to zero, but not both	7
Possible introduction of new mode 1 of DM and DS distance is zero, but not both	152

Source: Highways England

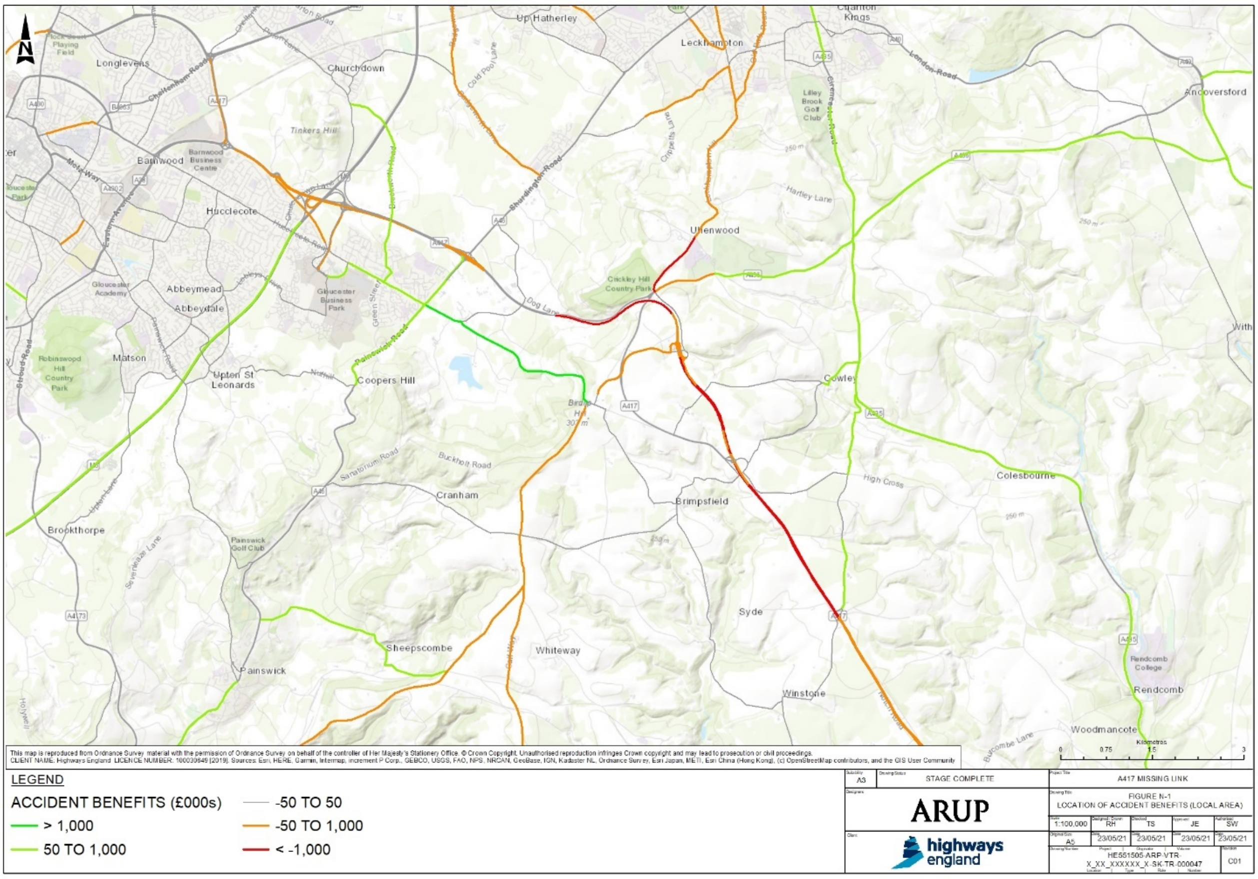
Notes: All monetary values are expressed in 2010 prices, discounted to 2010

M.1.1.14 The warnings produced by TUBA at PCF stage 3 have been investigated through analysis and checking of the Simulation and Assignment of Traffic to Urban Road Network (SATURN) assignment models. In all cases the warnings related directly to traffic affected by the proposed scheme including movements that both benefit from the proposals and those that are adversely affected due to existing routes being stopped up or diverted. Therefore, it can be concluded that the OD route patterns were as expected given the nature of the scheme being appraised and that the warnings highlighted by TUBA were genuine effects resulting from the implementation of the scheme.

M.1.1.15 The large increase in the number of warnings produced by TUBA in comparison to previous reports is due to changes within TUBA 1.9.14 to be more informative and assist users in identifying issues. This change and expected increase in warnings has been confirmed by the software developer and discussed and agreed with the Transport Planning Group and Economic Group representatives.

Appendix N Accident benefits

N.1.1.1 In Figure N-1 and Figure N-2 ,benefits (reductions in the costs associated with accidents) are shown in green and disbenefits (increase in costs associated with accidents) are shown in oranges and reds. Benefits and disbenefits are based on links only.

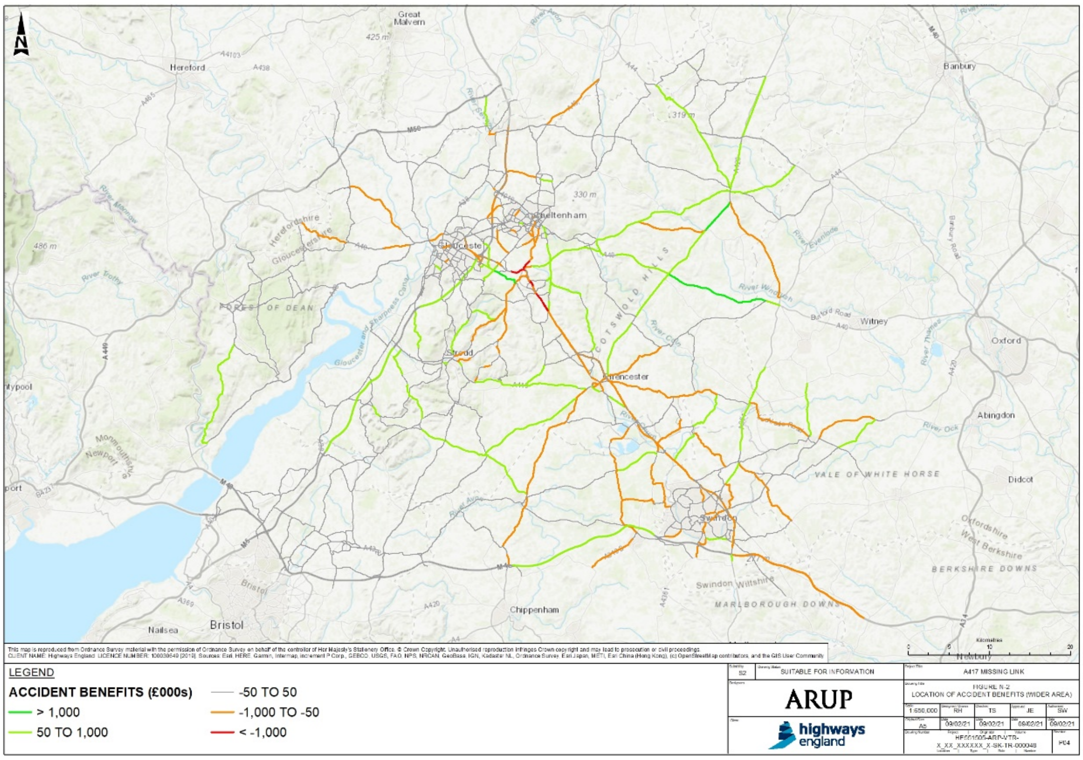


Source: Highways England

Figure N-1 Do-Something – location of accident benefits (local area)

N.1.1.2 The A417 appears as a disbenefit for three reasons:

- The current dual-carriageway sections have a disbenefit in terms of accidents as the scheme attracts vehicles to the A417 and this results in an increase in the number of accidents.
- The scheme appears as showing disbenefits as these are new sections of road that are not in the DM and thus there is nothing for these sections of road to be compared against and so show a disbenefit.
- Only link benefits/disbenefits are shown. Disbenefits at junctions (assessed using the ‘Separate Link and Junction’ mode in COBALT) are not represented, which are greater in the DM.



Source: Highways England

Figure N-2 Do-Something – location of accident benefits (wider area)

Appendix O Distributional impact appraisal screening proforma

Indicator	(a) Appraisal output criteria	(b) Potential impact (yes/no, positive/negative if known)	(c) Qualitative comments	(d) Proceed to step 3
User benefits	The TUBA user benefit analysis software or an equivalent process has been used in the appraisal; and/or the value of user benefits Transport Economic Efficiency (TEE) table is non-zero.	Yes, positive	User benefits would be achieved from the removal of delays on the existing single carriageway section of the A417 and its replacement with a modern dual carriageway alignment.	Yes
Noise	Any change in alignment of transport corridor or any links with significant changes (>25% or <-20%) in vehicle flow, speed or %HDV content. Also note comment in TAG unit A3.	Yes, negative and positive	The TAG results indicate that the scheme would result in an overall benefit. Benefits are due to a reduction in traffic using the bypassed section of A417 and on some minor roads. Attenuation from alignment changes and the relatively unpopulated area adjacent to this option results in an overall benefit. Mitigation measures may reduce impacts at locations where barriers and bunds can be incorporated in addition to the thin surface course on the new scheme. Mitigation design requires further assessment at PCF stage 3. Further assessment for Distributional Impacts associated with noise is recommended for the scheme.	Yes
Air quality	Any change in alignment of transport corridor or any links with significant changes in vehicle flow, speed or % heavy duty vehicle (HDV) content: • Change in 24-hour average annual daily traffic (AADT) of 1000 vehicles or more • Change in 24-hour AADT of HDV of 200 HDV vehicles or more	Negative	The TAG local air quality results indicate that there is a net deterioration in local air quality within the study area for the scheme. Overall, there is a negative impact on local air quality PM2.5 concentrations and on regional NOx emissions. A Distributional Impact appraisal will be undertaken to investigate the spatial distribution of impacts within the study area across the lower super output areas that the scheme is within. The study area will be the same as identified within the Environmental Assessment Report.	Yes

Indicator	(a) Appraisal output criteria	(b) Potential impact (yes/no, positive/negative if known)	(c) Qualitative comments	(d) Proceed to step 3
	• Change in daily average speed of 10kph or more • Change in peak hour speed of 20kph or more • Change in road alignment of 5m or more		Further assessment for Distributional Impacts associated with air quality is recommended for the scheme.	
Accidents	Any change in alignment of transport corridor (or road layout) that may have positive or negative safety impacts, or any links with significant changes in vehicle flow, speed, %HGV content or any significant change (>10%) in the number of pedestrians, cyclists or motorcyclists using road network.	Yes, positive	A reduction in the number of serious and fatal casualties results from the conversion of the existing single carriageway of the A417 to a modern dual carriageway. There is an increase in the number of accidents and slight casualties due to increases in traffic in the A417 corridor, however the net result is beneficial.	Yes
Security	Any change in public transport waiting/interchange facilities including pedestrian access expected to affect user perceptions of personal security.	No	TAG unit A4.2 notes that changes to the transport system should consider impacts on women, younger people (teenagers), older people, people with disabilities and Black and Minority Ethnic (BME) communities, and potential security impacts (adverse or beneficial) on these groups should be identified. Impacts on security as a result of the scheme are likely to be Neutral, as scores for each security indicator identified within Table 4.1 of TAG unit A4.1 are predicted to be the same with or without the scheme in place. There are not anticipated to be any changes to public transport waiting facilities/interchange facilities or to informal surveillance as a result of the scheme. However, CCTV and other route monitoring infrastructure would be installed, provided to a level which is consistent with the wider A417/A419 corridor which would be beneficial for pedestrians. There is the potential for walker, cyclist and horse-rider (WCH) routes to be affected, and consideration of measures such as footbridges and underpasses has been given to retain and potentially enhance connectivity	No

Indicator	(a) Appraisal output criteria	(b) Potential impact (yes/no, positive/negative if known)	(c) Qualitative comments	(d) Proceed to step 3
			and access for WCHs along the network. The potential provision of underpasses may adversely affect the personal security of pedestrians, should they be provided. There is the potential for the scheme to provide new lighting at new junctions for example, although existing lighting would not be removed, so any impacts on security would be positive. The scheme would also result in changes to landscaping with new screening planting and cuttings provided as appropriate, although this is not anticipated to affect personal security. Given that overall impacts on security are likely to be Neutral for the scheme, further assessment for Distributional Impacts is not deemed to be necessary.	
Severance	Introduction or removal of barriers to pedestrian movement, either through changes to road crossing provision, or through introduction of new public transport or road corridors. Any areas with significant changes (>10%) in vehicle flow, speed, %HGV content.	Yes, positive	The scheme is predicted to result in a slight decrease in severance for pedestrians within the study area. A number of sensitive receptors have been identified in the area, including three schools, two community centres and several churches and leisure facilities. All of these are located within residential settlements. The assessment found that a moderate positive impact on severance is predicted for pedestrians travelling to or from Birdlip. Additionally, a slight positive impact on severance has been predicted for pedestrians travelling to or from Bentham, Brimpsfield, Coberley, Cowley, Great Witcombe and Ullenwood. Finally, no severance impacts are predicted for pedestrians travelling to or from Elkstone and Little Witcombe. Thanks to new segregated crossings at Grange Farm, Stockwell Farm, Cowley Lane, and for the Cotswold Way and Gloucestershire Way, the scheme is likely to reduce severance through the provision of new, safe WCH routes which do not require pedestrians to cross the A417 at grade. Additionally, new WCH routes would be created, such as the conversion of part of the existing A417 alignment near Birdlip into a WCH-only route. These enhanced WCH routes not only affect residential areas, but	Yes

Indicator	(a) Appraisal output criteria	(b) Potential impact (yes/no, positive/negative if known)	(c) Qualitative comments	(d) Proceed to step 3
			also amenities which concentrate large numbers of people who are considered part of vulnerable social groups. These include National Star College in Ullenwood, where young people with disabilities receive an education; and Birdlip Primary School, which is attended by children from the area. Overall, no severance is expected for most of the analysed locations. However, there is one instance where a slight severance is expected, although it must be noted that this is still an improvement from the existing moderate severance. This slight severance is expected to occur for people in Bentham who may wish to travel to certain places located south of the A417, particularly to the 417 Bike Park. However, overall severance in Bentham is predicted to improve from moderate to slight because of new crossings in the Crickley Hill area, which would lead to an improvement in route access and safety for trips to other locations south of the A417.	
Accessibility	Changes in routeings or timings of current public transport services, any changes to public transport provision, including routeing, frequencies, waiting facilities (bus stops/rail stations) and rolling stock, or any indirect impacts on accessibility to services (e.g. demolition & re-location of a school).	No	Access to services within the area are unlikely to be affected by the scheme, as the scheme is not anticipated to directly affect public transport services. Public transport routes (including buses and rail) would not be permanently affected by the scheme, waiting facilities (bus stops and rail stations) are not anticipated to be permanently affected and indirect impacts on accessibility to services (e.g. demolition and relocation of a school) would not occur. Therefore, the expected impact on accessibility for the scheme would be Neutral, marginal in extent and dispersed among social groups, and further assessment for Distributional Impacts is deemed unnecessary.	No
Affordability	In cases where the following charges would occur; Parking charges (including where changes in the allocation of free or reduced fee spaces may occur); Car	Yes, negative and positive	There would be no changes to parking charges, road user charges, public transport fares or public transport concession availability. There would be some impact on car fuel and non-fuel operating costs, and some increase in	Yes

Indicator	(a) Appraisal output criteria	(b) Potential impact (yes/no, positive/negative if known)	(c) Qualitative comments	(d) Proceed to step 3
	fuel and non-fuel operating costs (where, for example, rerouteing or changes in journey speeds and congestion occur resulting in changes in costs); Road user charges (including discounts and exemptions for different groups of travellers); Public transport fare changes (where, for example premium fares are set on new or existing modes or where multi-modal discounted travel tickets become available due to new ticketing technologies); or Public transport concession availability (where, for example concession arrangements vary as a result of a move in service provision from bus to light rail or heavy rail, where such concession entitlement is not maintained by the local authority.		journey distances (and associated costs) for some local movements.	

Source: Highways England

Appendix P ComMA data annex

P.1 Scheme costs

Table P-1 Scheme investment cost profile in 2010 prices

Year		2010 factor prices (not discounted)	2010 market prices (discounted)
SoW year	2020	5,473,000	3,879,913
Works year 2	2021	6,545,000	4,482,970
Works year 3	2022	21,289,000	14,088,705
Works year 4	2023	79,990,000	51,145,938
Works year 5	2024	111,407,000	68,825,216
Works year 6	2025	82,597,000	49,301,374
Works year 7	2026	15,948,000	9,197,306
Works year 8	2027	2,290,000	1,275,997
Works year 9	2028	730,000	393,004
Works year 10	2029	278,000	144,603
Works year 11	2030	162,000	81,416
Works year 12	2031	107,000	51,956
Works year 13	2032	79,000	37,063
Works year 14	2033	6,000	2,720

Table P-2 Scheme O & M cost profile in 2010 prices

Year		2010 factor prices (not discounted)	2010 market prices (discounted)
Opening year	2026	165,000	95,156
Year 2	2027	166,000	92,496
Year 3	2028	166,000	89,368
Year 4	2029	165,000	85,826
Year 5	2030	166,000	83,426
Year 6	2031	166,000	80,605
Year 7	2032	165,000	77,410
Year 8	2033	166,000	75,245
Year 9	2034	166,000	72,701
Year 10	2035	165,000	69,819
Year 11	2036	166,000	67,867
Year 12	2037	166,000	65,572
Year 13	2038	165,000	62,973
Year 14	2039	166,000	61,212
Year 15	2040	166,000	59,142
Year 16	2041	165,000	56,798
Year 17	2042	166,000	55,210

Year		2010 factor prices (not discounted)	2010 market prices (discounted)
Year 18	2043	166,000	53,343
Year 19	2044	165,000	51,229
Year 20	2045	166,000	49,796
Year 21	2046	166,000	48,112
Year 22	2047	165,000	46,205
Year 23	2048	166,000	44,913
Year 24	2049	166,000	43,394
Year 25	2050	165,000	41,877
Year 26	2051	166,000	40,903
Year 27	2052	166,000	39,712
Year 28	2053	165,000	38,323
Year 29	2054	166,000	37,432
Year 30	2055	166,000	36,342
Year 31	2056	165,000	35,071
Year 32	2057	166,000	34,256
Year 33	2058	166,000	33,258
Year 34	2059	165,000	32,095
Year 35	2060	166,000	31,349
Year 36	2061	166,000	30,436
Year 37	2062	165,000	29,372
Year 38	2063	166,000	28,689
Year 39	2064	166,000	27,853
Year 40	2065	165,000	26,879
Year 41	2066	166,000	26,254
Year 42	2067	166,000	25,490
Year 43	2068	165,000	24,598
Year 44	2069	166,000	24,026
Year 45	2070	166,000	23,327
Year 46	2071	165,000	22,511
Year 47	2072	166,000	21,988
Year 48	2073	166,000	21,347
Year 49	2074	165,000	20,601
Year 50	2075	166,000	20,122
Year 51	2076	166,000	19,536
Year 52	2077	165,000	18,852
Year 53	2078	166,000	18,414
Year 54	2079	166,000	17,878
Year 55	2080	165,000	17,253
Year 56	2081	166,000	16,852
Year 57	2082	166,000	16,361
Year 58	2083	165,000	15,789

Year		2010 factor prices (not discounted)	2010 market prices (discounted)
Year 59	2084	166,000	15,422
Year 60	2085	166,000	14,973

P.2 Scheme benefits/disbenefits

Journey times

Table P-3 Average journey times during construction period along route by phase (minutes)

	Phase 1	Phase 2 (if relevant)	Phase 3 (if relevant)
Without scheme	This information is not available from QUARDO		
With scheme			

Table P-4 Average journey times along route (minutes)

	Opening year	Design year	Change (%)
Without scheme	00:07:53	00:08:29	8%
With scheme	00:05:05	00:05:10	2%

Safety

Table P-5 Number of accidents by year

Year		Without scheme	With scheme	Difference
Opening year	2026	1,001.10	1,000.10	-1.00
Year 2	2027	990.40	989.60	-0.80
Year 3	2028	979.90	979.00	-0.90
Year 4	2029	969.40	968.50	-0.90
Year 5	2030	969.10	968.40	-0.70
Year 6	2031	970.70	970.00	-0.70
Year 7	2032	970.10	969.50	-0.60
Year 8	2033	969.40	968.90	-0.50
Year 9	2034	968.60	968.20	-0.40
Year 10	2035	967.70	967.40	-0.30
Year 11	2036	966.70	966.60	-0.10
Year 12	2037	965.60	965.60	0.00
Year 13	2038	964.40	964.60	0.20
Year 14	2039	963.30	963.40	0.10
Year 15	2040	972.30	972.40	0.10
Year 16	2041	981.30	981.50	0.20
Year 17	2042	988.70	989.10	0.40
Year 18	2043	996.20	996.60	0.40

Year		Without scheme	With scheme	Difference
Year 19	2044	1,003.60	1,004.20	0.60
Year 20	2045	1,011.10	1,011.80	0.70
Year 21	2046	1,018.50	1,019.20	0.70
Year 22	2047	1,025.90	1,026.80	0.90
Year 23	2048	1,033.30	1,034.40	1.10
Year 24	2049	1,040.70	1,041.90	1.20
Year 25	2050	1,048.10	1,049.40	1.30
Year 26	2051	1,055.50	1,057.00	1.50
Year 27	2052	1,055.50	1,057.00	1.50
Year 28	2053	1,055.50	1,057.00	1.50
Year 29	2054	1,055.50	1,057.00	1.50
Year 30	2055	1,055.50	1,057.00	1.50
Year 31	2056	1,055.50	1,057.00	1.50
Year 32	2057	1,055.50	1,057.00	1.50
Year 33	2058	1,055.50	1,057.00	1.50
Year 34	2059	1,055.50	1,057.00	1.50
Year 35	2060	1,055.50	1,057.00	1.50
Year 36	2061	1,055.50	1,057.00	1.50
Year 37	2062	1,055.50	1,057.00	1.50
Year 38	2063	1,055.50	1,057.00	1.50
Year 39	2064	1,055.50	1,057.00	1.50
Year 40	2065	1,055.50	1,057.00	1.50
Year 41	2066	1,055.50	1,057.00	1.50
Year 42	2067	1,055.50	1,057.00	1.50
Year 43	2068	1,055.50	1,057.00	1.50
Year 44	2069	1,055.50	1,057.00	1.50
Year 45	2070	1,055.50	1,057.00	1.50
Year 46	2071	1,055.50	1,057.00	1.50
Year 47	2072	1,055.50	1,057.00	1.50
Year 48	2073	1,055.50	1,057.00	1.50
Year 49	2074	1,055.50	1,057.00	1.50
Year 50	2075	1,055.50	1,057.00	1.50
Year 51	2076	1,055.50	1,057.00	1.50
Year 52	2077	1,055.50	1,057.00	1.50
Year 53	2078	1,055.50	1,057.00	1.50
Year 54	2079	1,055.50	1,057.00	1.50
Year 55	2080	1,055.50	1,057.00	1.50
Year 56	2081	1,055.50	1,057.00	1.50
Year 57	2082	1,055.50	1,057.00	1.50
Year 58	2083	1,055.50	1,057.00	1.50
Year 59	2084	1,055.50	1,057.00	1.50
Year 60	2085	1,055.50	1,057.00	1.50

Table P-6 Number of fatal casualties by year

Year		Without scheme	With scheme	Difference
Opening year	2026	14.4	13.2	-1.2
Year 2	2027	14.3	13.1	-1.2
Year 3	2028	14.0	12.9	-1.1
Year 4	2029	13.9	12.8	-1.1
Year 5	2030	13.9	12.8	-1.1
Year 6	2031	13.9	12.8	-1.1
Year 7	2032	13.9	12.8	-1.1
Year 8	2033	13.9	12.8	-1.1
Year 9	2034	13.9	12.8	-1.1
Year 10	2035	13.9	12.8	-1.1
Year 11	2036	13.9	12.8	-1.1
Year 12	2037	13.9	12.8	-1.1
Year 13	2038	13.9	12.8	-1.1
Year 14	2039	13.8	12.7	-1.1
Year 15	2040	14.0	12.9	-1.1
Year 16	2041	14.1	13.1	-1.0
Year 17	2042	14.2	13.2	-1.0
Year 18	2043	14.3	13.3	-1.0
Year 19	2044	14.4	13.4	-1.0
Year 20	2045	14.5	13.5	-1.0
Year 21	2046	14.6	13.6	-1.0
Year 22	2047	14.7	13.7	-1.0
Year 23	2048	14.8	13.8	-1.0
Year 24	2049	14.9	13.9	-1.0
Year 25	2050	15.0	14.0	-1.0
Year 26	2051	15.2	14.1	-1.1
Year 27	2052	15.2	14.1	-1.1
Year 28	2053	15.2	14.1	-1.1
Year 29	2054	15.2	14.1	-1.1
Year 30	2055	15.2	14.1	-1.1
Year 31	2056	15.2	14.1	-1.1
Year 32	2057	15.2	14.1	-1.1
Year 33	2058	15.2	14.1	-1.1
Year 34	2059	15.2	14.1	-1.1
Year 35	2060	15.2	14.1	-1.1
Year 36	2061	15.2	14.1	-1.1
Year 37	2062	15.2	14.1	-1.1
Year 38	2063	15.2	14.1	-1.1
Year 39	2064	15.2	14.1	-1.1

Year		Without scheme	With scheme	Difference
Year 40	2065	15.2	14.1	-1.1
Year 41	2066	15.2	14.1	-1.1
Year 42	2067	15.2	14.1	-1.1
Year 43	2068	15.2	14.1	-1.1
Year 44	2069	15.2	14.1	-1.1
Year 45	2070	15.2	14.1	-1.1
Year 46	2071	15.2	14.1	-1.1
Year 47	2072	15.2	14.1	-1.1
Year 48	2073	15.2	14.1	-1.1
Year 49	2074	15.2	14.1	-1.1
Year 50	2075	15.2	14.1	-1.1
Year 51	2076	15.2	14.1	-1.1
Year 52	2077	15.2	14.1	-1.1
Year 53	2078	15.2	14.1	-1.1
Year 54	2079	15.2	14.1	-1.1
Year 55	2080	15.2	14.1	-1.1
Year 56	2081	15.2	14.1	-1.1
Year 57	2082	15.2	14.1	-1.1
Year 58	2083	15.2	14.1	-1.1
Year 59	2084	15.2	14.1	-1.1
Year 60	2085	15.2	14.1	-1.1

Table P-7 Number of serious casualties by year

Year		Without scheme	With scheme	Difference
Opening year	2026	137.2	133.7	-3.5
Year 2	2027	135.9	132.3	-3.6
Year 3	2028	134.4	130.8	-3.6
Year 4	2029	133.0	129.4	-3.6
Year 5	2030	133.0	129.4	-3.6
Year 6	2031	133.1	129.5	-3.6
Year 7	2032	133.0	129.6	-3.4
Year 8	2033	132.9	129.5	-3.4
Year 9	2034	132.8	129.4	-3.4
Year 10	2035	132.7	129.2	-3.5
Year 11	2036	132.5	129.1	-3.4
Year 12	2037	132.4	129.0	-3.4
Year 13	2038	132.2	128.8	-3.4
Year 14	2039	132.0	128.7	-3.3
Year 15	2040	133.2	129.9	-3.3
Year 16	2041	134.4	131.1	-3.3
Year 17	2042	135.4	132.1	-3.3
Year 18	2043	136.4	133.1	-3.3

Year		Without scheme	With scheme	Difference
Year 19	2044	137.4	134.1	-3.3
Year 20	2045	138.4	135.1	-3.3
Year 21	2046	139.5	136.2	-3.3
Year 22	2047	140.5	137.2	-3.3
Year 23	2048	141.6	138.2	-3.4
Year 24	2049	142.6	139.3	-3.3
Year 25	2050	143.7	140.3	-3.4
Year 26	2051	144.7	141.3	-3.4
Year 27	2052	144.7	141.3	-3.4
Year 28	2053	144.7	141.3	-3.4
Year 29	2054	144.7	141.3	-3.4
Year 30	2055	144.7	141.3	-3.4
Year 31	2056	144.7	141.3	-3.4
Year 32	2057	144.7	141.3	-3.4
Year 33	2058	144.7	141.3	-3.4
Year 34	2059	144.7	141.3	-3.4
Year 35	2060	144.7	141.3	-3.4
Year 36	2061	144.7	141.3	-3.4
Year 37	2062	144.7	141.3	-3.4
Year 38	2063	144.7	141.3	-3.4
Year 39	2064	144.7	141.3	-3.4
Year 40	2065	144.7	141.3	-3.4
Year 41	2066	144.7	141.3	-3.4
Year 42	2067	144.7	141.3	-3.4
Year 43	2068	144.7	141.3	-3.4
Year 44	2069	144.7	141.3	-3.4
Year 45	2070	144.7	141.3	-3.4
Year 46	2071	144.7	141.3	-3.4
Year 47	2072	144.7	141.3	-3.4
Year 48	2073	144.7	141.3	-3.4
Year 49	2074	144.7	141.3	-3.4
Year 50	2075	144.7	141.3	-3.4
Year 51	2076	144.7	141.3	-3.4
Year 52	2077	144.7	141.3	-3.4
Year 53	2078	144.7	141.3	-3.4
Year 54	2079	144.7	141.3	-3.4
Year 55	2080	144.7	141.3	-3.4
Year 56	2081	144.7	141.3	-3.4
Year 57	2082	144.7	141.3	-3.4
Year 58	2083	144.7	141.3	-3.4
Year 59	2084	144.7	141.3	-3.4
Year 60	2085	144.7	141.3	-3.4

Table P-8 Number of slight casualties by year

Year		Without scheme	With scheme	Difference
Opening year	2026	1,263.70	1,262.00	-1.70
Year 2	2027	1,250.60	1,248.90	-1.70
Year 3	2028	1,237.40	1,235.80	-1.60
Year 4	2029	1,224.30	1,222.80	-1.50
Year 5	2030	1,224.20	1,222.70	-1.50
Year 6	2031	1,226.20	1,224.80	-1.40
Year 7	2032	1,225.60	1,224.30	-1.30
Year 8	2033	1,224.80	1,223.60	-1.20
Year 9	2034	1,223.80	1,222.80	-1.00
Year 10	2035	1,222.80	1,221.90	-0.90
Year 11	2036	1,221.70	1,220.90	-0.80
Year 12	2037	1,220.40	1,219.60	-0.80
Year 13	2038	1,219.00	1,218.40	-0.60
Year 14	2039	1,217.50	1,217.10	-0.40
Year 15	2040	1,228.90	1,228.60	-0.30
Year 16	2041	1,240.40	1,240.10	-0.30
Year 17	2042	1,249.70	1,249.60	-0.10
Year 18	2043	1,259.10	1,259.10	0.00
Year 19	2044	1,268.50	1,268.50	0.00
Year 20	2045	1,277.80	1,278.10	0.30
Year 21	2046	1,287.10	1,287.60	0.50
Year 22	2047	1,296.40	1,297.10	0.70
Year 23	2048	1,305.70	1,306.60	0.90
Year 24	2049	1,315.10	1,316.10	1.00
Year 25	2050	1,324.50	1,325.60	1.10
Year 26	2051	1,333.80	1,335.00	1.20
Year 27	2052	1,333.80	1,335.00	1.20
Year 28	2053	1,333.80	1,335.00	1.20
Year 29	2054	1,333.80	1,335.00	1.20
Year 30	2055	1,333.80	1,335.00	1.20
Year 31	2056	1,333.80	1,335.00	1.20
Year 32	2057	1,333.80	1,335.00	1.20
Year 33	2058	1,333.80	1,335.00	1.20
Year 34	2059	1,333.80	1,335.00	1.20
Year 35	2060	1,333.80	1,335.00	1.20
Year 36	2061	1,333.80	1,335.00	1.20
Year 37	2062	1,333.80	1,335.00	1.20
Year 38	2063	1,333.80	1,335.00	1.20
Year 39	2064	1,333.80	1,335.00	1.20
Year 40	2065	1,333.80	1,335.00	1.20

Year		Without scheme	With scheme	Difference
Year 41	2066	1,333.80	1,335.00	1.20
Year 42	2067	1,333.80	1,335.00	1.20
Year 43	2068	1,333.80	1,335.00	1.20
Year 44	2069	1,333.80	1,335.00	1.20
Year 45	2070	1,333.80	1,335.00	1.20
Year 46	2071	1,333.80	1,335.00	1.20
Year 47	2072	1,333.80	1,335.00	1.20
Year 48	2073	1,333.80	1,335.00	1.20
Year 49	2074	1,333.80	1,335.00	1.20
Year 50	2075	1,333.80	1,335.00	1.20
Year 51	2076	1,333.80	1,335.00	1.20
Year 52	2077	1,333.80	1,335.00	1.20
Year 53	2078	1,333.80	1,335.00	1.20
Year 54	2079	1,333.80	1,335.00	1.20
Year 55	2080	1,333.80	1,335.00	1.20
Year 56	2081	1,333.80	1,335.00	1.20
Year 57	2082	1,333.80	1,335.00	1.20
Year 58	2083	1,333.80	1,335.00	1.20
Year 59	2084	1,333.80	1,335.00	1.20
Year 60	2085	1,333.80	1,335.00	1.20

Environment

Table P-9 NOx emissions (tonnes)

Year		Without scheme	With scheme	Difference
Opening year	2026	175.6	186.6	11.0
Year 2	2027	172.9	184.0	11.0
Year 3	2028	170.3	181.3	11.0
Year 4	2029	167.7	178.7	11.0
Year 5	2030	165.1	176.1	11.0
Year 6	2031	162.4	173.4	11.0
Year 7	2032	159.8	170.8	11.0
Year 8	2033	157.2	168.2	11.0
Year 9	2034	154.6	165.6	11.0
Year 10	2035	151.9	162.9	11.0
Year 11	2036	149.3	160.3	11.0
Year 12	2037	146.7	157.7	11.0
Year 13	2038	144.0	155.1	11.0
Year 14	2039	141.4	152.4	11.0
Year 15	2040	138.8	149.8	11.0
Year 16	2041	136.2	147.2	11.0
Year 17	2042	136.2	147.2	11.0
Year 18	2043	136.2	147.2	11.0
Year 19	2044	136.2	147.2	11.0
Year 20	2045	136.2	147.2	11.0
Year 21	2046	136.2	147.2	11.0
Year 22	2047	136.2	147.2	11.0
Year 23	2048	136.2	147.2	11.0

Year		Without scheme	With scheme	Difference
Year 24	2049	136.2	147.2	11.0
Year 25	2050	136.2	147.2	11.0
Year 26	2051	136.2	147.2	11.0
Year 27	2052	136.2	147.2	11.0
Year 28	2053	136.2	147.2	11.0
Year 29	2054	136.2	147.2	11.0
Year 30	2055	136.2	147.2	11.0
Year 31	2056	136.2	147.2	11.0
Year 32	2057	136.2	147.2	11.0
Year 33	2058	136.2	147.2	11.0
Year 34	2059	136.2	147.2	11.0
Year 35	2060	136.2	147.2	11.0
Year 36	2061	136.2	147.2	11.0
Year 37	2062	136.2	147.2	11.0
Year 38	2063	136.2	147.2	11.0
Year 39	2064	136.2	147.2	11.0
Year 40	2065	136.2	147.2	11.0
Year 41	2066	136.2	147.2	11.0
Year 42	2067	136.2	147.2	11.0
Year 43	2068	136.2	147.2	11.0
Year 44	2069	136.2	147.2	11.0
Year 45	2070	136.2	147.2	11.0
Year 46	2071	136.2	147.2	11.0
Year 47	2072	136.2	147.2	11.0
Year 48	2073	136.2	147.2	11.0
Year 49	2074	136.2	147.2	11.0
Year 50	2075	136.2	147.2	11.0
Year 51	2076	136.2	147.2	11.0
Year 52	2077	136.2	147.2	11.0
Year 53	2078	136.2	147.2	11.0
Year 54	2079	136.2	147.2	11.0
Year 55	2080	136.2	147.2	11.0
Year 56	2081	136.2	147.2	11.0
Year 57	2082	136.2	147.2	11.0
Year 58	2083	136.2	147.2	11.0
Year 59	2084	136.2	147.2	11.0
Year 60	2085	136.2	147.2	11.0

Table P-10 PM2.5 emissions (tonnes)

Year		Without scheme	With scheme	Difference
Opening year	2026	17.6	18.6	1.0
Year 2	2027	17.8	18.8	1.0
Year 3	2028	18.0	19.0	1.0
Year 4	2029	18.1	19.2	1.1
Year 5	2030	18.3	19.4	1.1
Year 6	2031	18.5	19.6	1.1
Year 7	2032	18.6	19.8	1.2
Year 8	2033	18.8	20.0	1.2
Year 9	2034	19.0	20.2	1.2
Year 10	2035	19.2	20.4	1.3
Year 11	2036	19.3	20.6	1.3
Year 12	2037	19.5	20.8	1.3
Year 13	2038	19.7	21.0	1.4
Year 14	2039	19.8	21.3	1.4

Year		Without scheme	With scheme	Difference
Year 15	2040	20.0	21.5	1.4
Year 16	2041	20.2	21.7	1.5
Year 17	2042	20.2	21.7	1.5
Year 18	2043	20.2	21.7	1.5
Year 19	2044	20.2	21.7	1.5
Year 20	2045	20.2	21.7	1.5
Year 21	2046	20.2	21.7	1.5
Year 22	2047	20.2	21.7	1.5
Year 23	2048	20.2	21.7	1.5
Year 24	2049	20.2	21.7	1.5
Year 25	2050	20.2	21.7	1.5
Year 26	2051	20.2	21.7	1.5
Year 27	2052	20.2	21.7	1.5
Year 28	2053	20.2	21.7	1.5
Year 29	2054	20.2	21.7	1.5
Year 30	2055	20.2	21.7	1.5
Year 31	2056	20.2	21.7	1.5
Year 32	2057	20.2	21.7	1.5
Year 33	2058	20.2	21.7	1.5
Year 34	2059	20.2	21.7	1.5
Year 35	2060	20.2	21.7	1.5
Year 36	2061	20.2	21.7	1.5
Year 37	2062	20.2	21.7	1.5
Year 38	2063	20.2	21.7	1.5
Year 39	2064	20.2	21.7	1.5
Year 40	2065	20.2	21.7	1.5
Year 41	2066	20.2	21.7	1.5
Year 42	2067	20.2	21.7	1.5
Year 43	2068	20.2	21.7	1.5
Year 44	2069	20.2	21.7	1.5
Year 45	2070	20.2	21.7	1.5
Year 46	2071	20.2	21.7	1.5
Year 47	2072	20.2	21.7	1.5
Year 48	2073	20.2	21.7	1.5
Year 49	2074	20.2	21.7	1.5
Year 50	2075	20.2	21.7	1.5
Year 51	2076	20.2	21.7	1.5
Year 52	2077	20.2	21.7	1.5
Year 53	2078	20.2	21.7	1.5
Year 54	2079	20.2	21.7	1.5
Year 55	2080	20.2	21.7	1.5
Year 56	2081	20.2	21.7	1.5
Year 57	2082	20.2	21.7	1.5
Year 58	2083	20.2	21.7	1.5
Year 59	2084	20.2	21.7	1.5
Year 60	2085	20.2	21.7	1.5

Table P-11 Greenhouse gas emissions (tonnes CO2e)

Year		Without scheme	With scheme	Difference
Opening year	2026	178,650.4	189,546.0	10,895.6
Year 2	2027	179,823.5	191,039.7	11,216.2
Year 3	2028	180,996.6	192,533.4	11,536.8
Year 4	2029	182,169.7	194,027.1	11,857.4
Year 5	2030	183,342.9	195,520.9	12,178.0
Year 6	2031	184,516.0	197,014.6	12,498.6
Year 7	2032	185,689.1	198,508.3	12,819.2

Year		Without scheme	With scheme	Difference
Year 8	2033	186,862.2	200,002.0	13,139.8
Year 9	2034	188,035.3	201,495.7	13,460.5
Year 10	2035	189,208.4	202,989.5	13,781.1
Year 11	2036	190,381.5	204,483.2	14,101.7
Year 12	2037	191,554.6	205,976.9	14,422.3
Year 13	2038	192,727.7	207,470.6	14,742.9
Year 14	2039	193,900.8	208,964.3	15,063.5
Year 15	2040	195,073.9	210,458.1	15,384.1
Year 16	2041	196,247.0	211,951.8	15,704.7
Year 17	2042	196,247.0	211,951.8	15,704.7
Year 18	2043	196,247.0	211,951.8	15,704.7
Year 19	2044	196,247.0	211,951.8	15,704.7
Year 20	2045	196,247.0	211,951.8	15,704.7
Year 21	2046	196,247.0	211,951.8	15,704.7
Year 22	2047	196,247.0	211,951.8	15,704.7
Year 23	2048	196,247.0	211,951.8	15,704.7
Year 24	2049	196,247.0	211,951.8	15,704.7
Year 25	2050	196,247.0	211,951.8	15,704.7
Year 26	2051	196,247.0	211,951.8	15,704.7
Year 27	2052	196,247.0	211,951.8	15,704.7
Year 28	2053	196,247.0	211,951.8	15,704.7
Year 29	2054	196,247.0	211,951.8	15,704.7
Year 30	2055	196,247.0	211,951.8	15,704.7
Year 31	2056	196,247.0	211,951.8	15,704.7
Year 32	2057	196,247.0	211,951.8	15,704.7
Year 33	2058	196,247.0	211,951.8	15,704.7
Year 34	2059	196,247.0	211,951.8	15,704.7
Year 35	2060	196,247.0	211,951.8	15,704.7
Year 36	2061	196,247.0	211,951.8	15,704.7
Year 37	2062	196,247.0	211,951.8	15,704.7
Year 38	2063	196,247.0	211,951.8	15,704.7
Year 39	2064	196,247.0	211,951.8	15,704.7
Year 40	2065	196,247.0	211,951.8	15,704.7
Year 41	2066	196,247.0	211,951.8	15,704.7
Year 42	2067	196,247.0	211,951.8	15,704.7
Year 43	2068	196,247.0	211,951.8	15,704.7
Year 44	2069	196,247.0	211,951.8	15,704.7
Year 45	2070	196,247.0	211,951.8	15,704.7
Year 46	2071	196,247.0	211,951.8	15,704.7
Year 47	2072	196,247.0	211,951.8	15,704.7
Year 48	2073	196,247.0	211,951.8	15,704.7
Year 49	2074	196,247.0	211,951.8	15,704.7
Year 50	2075	196,247.0	211,951.8	15,704.7
Year 51	2076	196,247.0	211,951.8	15,704.7
Year 52	2077	196,247.0	211,951.8	15,704.7
Year 53	2078	196,247.0	211951.8	15,704.7
Year 54	2079	196,247.0	211951.8	15,704.7
Year 55	2080	196,247.0	211951.8	15,704.7
Year 56	2081	196,247.0	211951.8	15,704.7
Year 57	2082	196,247.0	211951.8	15,704.7
Year 58	2083	196,247.0	211951.8	15,704.7
Year 59	2084	196,247.0	211951.8	15,704.7
Year 60	2085	196,247.0	211951.8	15,704.7

Appendix Q ComMA summary

Q.1 High level benefits and costs (£000s)

Table Q-1 High level summary of benefits and costs (£000s)

Present value of benefits (initial)	305,821
Present value of benefits (adjusted)	516,650
Present value of costs	205,457
Initial BCR	1.49
Adjusted BCR	2.51

Q.2 Sources of costs

Q.2.1.1 Construction costs for the scheme were provided by Highways England’s commercial team in September 2020 and are based on the design at August 2020. In addition to the construction costs, maintenance costs have been included in the appraisal and these costs include the operation and maintenance costs calculated by using values included within Part 2, chapter 9 of the COBA manual.

Q.2.1.2 These costs already make allowance for risk and contingencies and have been rebased to 2010.

Q.3 Sources of benefits

Q.3.1.1 The scheme enhances the strategic network, supports the vision and business strategy of the DfT and Highways England. It also supports the economic growths and aspirations of local transport authority for the area.

Q.3.1.2 Journey time benefits for business, commuting and other users are expected to result from the diversion of A417 traffic away from the Ullenwood roundabout, which would alleviate the congestion pinch-point and improve traffic flow on the A417 and the A436, as well as the provision of grade separation at Cowley roundabout.

Q.3.1.3 In addition to reduced journey times, journey time reliability improvements are expected to support economic growth in the region.

Q.3.1.4 Benefits also result from a forecast decrease in fatal and serious RTAs in the study area, due to the traffic rerouting from the poorer quality existing road to a new modern dual carriageway, and the removal of A417 traffic from the Cowley and A436/Leckhampton Hill roundabouts.

Q.3.1.5 The wider economic impact benefits are accumulated from the non-transport market. This includes the induced investment due to the increased attractiveness of households’ and firms’ locations and desired level of activities, change of firms’ demand and level of employment. These benefits would be facilitated by improving the agglomeration in the local area as a result of a transport investment.

Q.3.1.6 The noise impacts are expected to reduce due to a reduction in traffic on minor roads. Overall a greater number of households would experience a decrease in traffic noise compared to the number of households that would experience an increase.

Q.3.1.7 The local ambient air quality (NOx and PM2.5) within the Birdlip AQMA is expected to improve, although the scheme is predicted to result in an overall increase in regional emissions of NOx and PM2.5 due to increased journey distances.

Q.3.1.8 Journey quality benefits are expected to result from the scheme, due to improved information and safety provision on the route.

Table Q-2 Demand growth along the route (Do-Minimum)

Link	AADT (opening year)	AADT (design year)	AADT change (%)
60270_65473	23,731	28,129	18.53%
65473_60292	23,731	28,129	18.53%
60292_26075	23,731	28,129	18.53%
26075_26076	23,731	28,129	18.53%
26076_26077	26,454	30,569	15.56%
26077_26078	15,459	18,280	18.25%
26078_26079	25,347	28,936	14.16%
26079_26073	18,347	21,204	15.57%
26073_60290	18,347	21,204	15.57%
60290_60289	18,347	21,204	15.57%
60289_60286	17,810	20,936	17.55%
60286_26034	17,810	20,936	17.55%
26034_27318	17,793	20,920	17.57%
27318_26034	16,450	19,552	18.86%
26034_60286	16,451	19,554	18.86%
60286_60289	16,451	19,554	18.86%
60289_60290	14,681	15,797	7.60%
60290_26073	14,681	15,797	7.60%
26073_26074	14,681	15,796	7.60%
26074_26096	21,125	22,737	7.63%
26096_26075	18,323	19,830	8.22%
26075_60292	18,323	19,830	8.22%
60292_60269	18,323	19,830	8.22%
Distance-weighted average	18,769	21,583	15.00%

Q.4 Demand growth along the route (Do-Something)

Table Q-3 Demand growth along the route (Do-Something)

Link	AADT (opening year)	AADT (design year)	AADT change (%)
60270_65473	25,161	31,598	25.58%
65473_94327	25,161	31,598	25.58%
94327_94350	25,161	31,598	25.58%
94350_94351	25,161	31,598	25.58%
94351_94352	25,161	31,598	25.58%
94352_94310	25,161	31,598	25.58%
94310_94308	20,247	25,342	25.16%
94308_94309	24,111	29,830	23.72%
94309_94332	24,111	29,830	23.72%
94330_94335	22,807	28,382	24.45%
94335_94300	22,807	28,382	24.45%
94300_94311	19,987	24,730	23.73%
94311_94312	25,179	31,438	24.86%
94312_60269	25,179	31,438	24.86%
Distance-weighted average	24,329	30,383	24.88%

Q.5 Key monetised benefits and costs

Table Q-4 Key monetised benefits and costs

Category	Benefits and costs in £'000 (PV)
Business Users	
Journey Time Savings	169,310
Vehicle Operating Costs	4,686
Non-Business users	
Journey Time Savings	145,003
Vehicle Operating Costs	-63,162
Reliability	
Business Reliability	39,918
Non-business Reliability	30,584
Safety	
Safety	64,890
Environmental Impacts	
Noise	466
Local Air Quality	-3,630
Greenhouse Gases	-39,284
Landscape	0
Wider Economic Impacts	
Agglomeration	120,163
Market Competition	17,400
Dependent Development	
Labour Supply	2,764
Customer Impact	
Traffic delays due to Construction	-17,148
Traffic impacts due to Maintenance	
Journey Quality	
Developer contributions	
Developer contributions	
Other Impacts	
Indirect tax Revenues	44,691
[Other - please specify]	
Costs	
Cost to Broad Transport Budget	205,457
Cost savings (where relevant)*	

*The cost savings row should only be completed where the option being considered will deliver financial savings to Highways England'

Q.6 Key quantified benefits/costs

[Complete table with quantitative data in units specified in right-hand column

Table Q-5 Key monetised benefits and costs

Category	Quantified impacts	Units
Journey times		
Journey Time Savings	Y2026 00:02:48 Y2041 00:03:19	*(average saving per journey on scheme sections in minutes)**
Safety		
Accidents	-51.8	*(total number saved)*
Fatalities	66.1	*(total number saved)*
Seriously injured	201.2	*(total number saved)*
Slightly injured	-29.4	*(total number saved)*
Environmental Impacts		
Number of noise important areas affected	5	*(number)*
Names of AQMAs	Birdlip AQMA	*(names)*
Change in NOx emissions	661	*(tonnes)*
Change in PM2.5 emissions	85	*(tonnes)*
Change in greenhouse gas emissions	903,811	*(tonnes CO2e)*
Customer Impact: Totals		
Traffic delays due to Construction	2,012,556	*(total loss on scheme sections in hours)*
Traffic impacts due to Maintenance		*(total impact on scheme sections in hours)*
Customer Impact: Per journey		
Traffic delays due to construction (cars)	This information is not available from QUADRO	*(average loss per journey on scheme sections in minutes) **
Traffic delays due to construction (LGVs)		*(average loss per journey on scheme sections in minutes) **
Traffic delays due to construction (HGVs)		*(average loss per journey on scheme sections in minutes) **
Traffic impacts due to maintenance (cars)		*(average impact per journey on scheme sections in minutes) **
Traffic impacts due to maintenance (LGVs)		*(average impact per journey on scheme sections in minutes) **
Traffic impacts due to maintenance (HGVs)		*(average impact per journey on scheme sections in minutes) **

**Defined as total saving or loss on all scheme sections per day divided by distance-weighted AADT on scheme sections*

Strategic Outcome	KPI	Things to consider (delete this column once table is completed)	Scheme contribution – qualitative	Scheme contribution - quantitative
Making the network safer	The number of KSIs on the SRN.	*How the scheme will contribute to decreasing:* • *Incident numbers* • *Casualty numbers*	The scheme provides a new dual carriageway alignment and grade separated junction with a new single carriageway link facilitating the access between the new and existing A417 routes. The repurposing of the existing A417 link would improve accessibility for non-motorised users and the new alignment with modern dual carriageway standard would reduce the accident rate compared to the existing one. Not only would this reduce the conflicts between the motorised users and non-motorised users, but also it would result in the reduction in the number of killed or seriously injured (KSI) casualties.	COBALT analysis shows that the scheme is forecasted to lead to a large reduction in the number fatalities or seriously injured, 66 less fatalities and 201 less seriously injured causalities over 60-years appraisal period. There is forecast to be an increase of 52 in the total number of accidents and an increase of 29 in slight casualties, which is a result of the forecast increase in total traffic (vehicle kilometres) within the COBALT study area arising from the scheme.
Delivery of better environmental outcomes	Noise: Number of Noise Important Areas mitigated. Biodiversity: Delivery of improved biodiversity, as set out in the Company's Biodiversity Action Plan	• *Noise Important Areas impacts / mitigations /* • *Biodiversity impacts / mitigations / improvements* • *Air Quality impacts / mitigations / improvements* *How the scheme will contribute:* • *to facilitating ULEV fleet uptake* • *to network resilience to flooding and improve water quality*	The scheme is expected to reduce noise impacts due in part to a reduction in traffic on minor roads. Overall a greater number of households would experience a decrease in traffic noise compared to the number of households that would experience an increase. The scheme is forecasted to increase local ambient air quality (NOx and PM2.5) within the Birdlip AQMA by reducing pollution from traffic congestion, although the scheme is predicted to increase regional emissions of NOx and PM2.5 due to increased journey distances overall. Journey quality benefits associated with improved information and safety provision. Mitigation measures have been included to reduce the impact of the new A417 corridor upon dwellings that would realise the largest noise increases from a new traffic noise source. These are a combination of carefully	The results forecast an overall positive benefit both in monetisation and health benefits. The number of dwellings realising higher daytime noise levels is 36, whilst by comparison, there would be 119 dwellings which would benefit from reduced daytime noise exposure. The night-time noise exposure levels would result in 24 dwellings realising higher noise levels, whilst 48 dwellings would benefit from noise reductions. With the scheme in place, there would remain five Noise Important Areas (NIAs) which lie within the affected route of the scheme. Two of these NIAs would benefit from noise reductions of between 12dB (No.1 & 2 Air Balloon Cottages) and 26dB (Castle Hill Cottage) in the Forecast Year, 2041, as a direct result of the new scheme alignment. Two further NIAs (Fernbank and Crickley Court), would benefit from noise

Strategic Outcome	KPI	Things to consider (delete this column once table is completed)	Scheme contribution – qualitative	Scheme contribution - quantitative
			considered landscaping and noise mitigation design (earth bunds and Cotswold stone walls), to help reduce the spread of traffic noise along the proposed scheme corridor. Due to increases in vehicle kilometres and changes in speed, the scheme leads to an increase in greenhouses gas emissions and therefore a negative impact in monetary terms.	reductions of between 3dB and 8dB(A) in the Forecast Year, as a direct result of the inclusion of proposed noise mitigation (noise barriers). NIA (Woodside House) would be removed as part of the scheme proposals. There will be three dwellings that would be eligible for Noise Insulation under the Noise Insulation Regulations. The scheme is forecast to increase NOx emissions by 661 tonnes and PM2.5 by 85 tonnes over the 60-year appraisal period compared to 'without scheme' due to increased traffic volumes. The scheme is forecast to increase Greenhouse gases by 903,811 tonnes compared to the 'without scheme' over the 60-year appraisal period, due to increased traffic volumes on the A417/A419 corridor between the M5 and M4.
Helping cyclists / walkers and other vulnerable users	The number of new and upgraded crossings	*Consider and provide details if the scheme will:* • *Provide any safe crossings* • *Integrate with other existing and emerging networks* • *Deliver commitments under Public Sector Equality Duty* • *Improve provision of / considered cycling improvements*	With scheme in place there would be an enhanced Public Rights of Way network, as assessed in ES chapter 12 Population and Human Health (Document Reference 6.2), and as detailed in the Public Rights of Way Management Plan (Annex F of ES Appendix 12.1 (Document Reference 6.4)). In summary there would be improved access for WCH with; • proposed Cotswold Way crossing and Gloucestershire Way crossing. • proposed Cowley and Stockwell Farm overbridges. • repurposed A417 including the proposed Air Balloon Way with a motor traffic free route for WCH between the Cotswolds Way	

Strategic Outcome	KPI	Things to consider (delete this column once table is completed)	Scheme contribution – qualitative	Scheme contribution - quantitative
			crossing and new areas of parking near the Golden Heart Inn. • proposed Grove Farm underpass, providing a safe north/south crossing of the existing A417 • proposed new bridleway connection between Dog Lane and Cold Slad to provide a safe east/west route between Brockworth and the Cotswold Way crossing. • stopping up of traffic from Cowley junction to Cowley and providing a WCH route between the Air Balloon Way and Cowley village.	

Appendix R 8% Gradient Methodology

Subject:	**Technical note on 8% gradient modelling approach**
To:	
Document Reference:	**HE551505-ARP-HGN-X_XX_XXXX_X-FN-TR-000002**
Revision:	**P04**
Suitability (status):	**S2**
Date:	13 August 2020
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R.1 Introduction

R.1.1.1 The scheme design announced in the preferred route announcement (PRA) in Spring 2019 had a 7% gradient on the section climbing the Cotswold escarpment from Brockworth to Shab Hill and this continued during design fix 2 and 3 of the initial 7% gradient design in PCF stage 3. Eastbound (climbing the escarpment) the scheme has consisted of two lanes and a climbing lane, with two lanes for westbound traffic and this is consistent between the 7% and 8% gradient schemes.

R.1.1.2 During the design of the scheme an alternative 8% option has been developed to assess the efficiencies gained from a steeper gradient of 8% in comparison to the 7% gradient. These efficiencies are in relation to construction time and the amount of material to be excavated.

R.1.1.3 This change in gradient has been incorporated into the design and this technical note sets out the proposed methodology for capturing the impact of the change in gradient in the SATURN scheme traffic model and more specifically the network coding.

R.2 Methodology

R.2.1 7% scheme

R.2.1.1 The scheme traffic model used to assess the impact and the economic performance of the 7% scheme uses the speed flow curve (SFC) shown in Table R-1 for this section of the scheme.

Table R-1 Speed flow curve between the A46 and Shab Hill – 7% gradient

Direction	SFC	Free flow speed (kph)	Speed at capacity (kph)	Capacity (pcu/hr)	Power	Description
Eastbound; Up	8	112	80	6,298	2.8	Rural All-Purpose D3

R.2.2 8% scheme option

R.2.2.1 For assessing the 8% scheme it has been assumed that the change in gradient would have an impact on heavy goods vehicles (HGV) only in terms of journey time, noise and air quality, vehicle journey time reliability and accident benefits.

R.2.2.2 In modelling the 8% gradient there are two issues that need to be dealt with and these are:

- within SATURN it is not possible to have different speed flow curves for different vehicle classes; and
- the TrafficMaster journey time data is not broken down into cars/light goods vehicles and HGVs.

R.2.2.3 The two issues above restrict the ability to model the impact of steep gradients accurately on HGVs and the second issue is of particular importance as without this information it is hard to distinguish between the impact of congestion and gradient in the Base and DM scheme traffic models. Table R-2 shows the speeds extracted from the 2015 base year scheme traffic model for the A417 Missing Link for cars, light goods vehicles (LGVs) and HGVs.

Table R-2 Car, LGV and HGV speeds from the 2015 Base SATURN model

Section	Distance	AM Peak		
		Car (kph)	LGV (kph)	HGV (kph)
Brockworth bypass to Air Balloon	1,627	75.96	75.96	75.96
Air Balloon to Birdlip	1,099	77.95	77.95	77.95
		IP		
Brockworth bypass to Air Balloon	1,627	77.88	77.88	77.88
Air Balloon to Birdlip	1,099	78.65	78.65	78.65
		PM Peak		
Brockworth bypass to Air Balloon	1,627	77.14	77.14	77.14
Air Balloon to Birdlip	1,099	78.08	78.08	78.08

R.2.2.4 As can be seen from Table R-2 the speeds for cars, LGVs and HGVs are all the same for both sections of the A417 Missing Link and this is due to not being able to separate out journey times in the TrafficMaster data by vehicle class and therefore it is not been possible to determine if the HGV speeds in the base scheme traffic model are due to congestion or the gradient.

R.2.3 Speed flow curves and KLUNK

R.2.3.1 It was initially proposed to use the KLUNK parameter in SATURN to apply a reduced speed to the 8% gradient section for HGVs using a bespoke speed flow curve. The reduction in speed would be based on calculations set out in Part 5 of the COBA 2019 User Manual[15]. This part of the manual presents a series of calculations that can be used to predict vehicle speeds on rural all-purpose dual carriageways under certain conditions. Further discussions relating to KLUNK showed that when KLUNK is activated, CLICKS no longer applies and thus all speed flow curves need to be included in the KLUNK file and the maximum speed of 91kph for HGVs set within this file for each speed flow curve. On further

[15] https://www.tamesoftware.co.uk/manuals/COBA2019_MANUAL/COBA2019%20Part%205.pdf

review, it was noted that there was an issue when applying this approach to the scheme traffic model (and the RTMs in general), as the buffer links are modelled as fixed speed rather than using speed flow curves. This meant that on those links with speeds greater than 91kph, HGVs could exceed their speed limit previously defined by CLICKS. This mainly affected the strategic road network (SRN) and those dual carriageways not included in the SRN. The impact of this is reassignment is across the scheme traffic model network as a whole and not just restricted to those links impacted by the 8% gradient scheme.

R.2.4 Time penalties

R.2.4.1 As a result of the issues identified with the KLUNK approach described in Section R.2.3 of this report, an alternative approach was required to ensure that reassignment within the scheme traffic model was due to the changes to the scheme design only.

R.2.4.2 The alternative approach developed was to apply time penalties for HGVs to those links impacted by the change in gradient.

R.2.4.3 From information provided by the wider design team, it has been possible to identify the section of the scheme that is an 8% gradient and then the transition section from the 8% gradient to no gradient. In the transition section the point at which the gradient reaches 4% has been selected as an interim point in the gradient transition.

R.2.4.4 The section of 8% gradient and the transition section from 8% to 4% will have time penalties applied, as on these sections an HGV is unlikely to achieve 91kph. Additional nodes will be coded, creating additional links for these sections against which the time penalties will be applied.

R.2.4.5 As discussed in Section R.2.2 of this report the TrafficMaster journey time data only provides average journey times for all vehicles and thus it is not possible to determine accurately the time penalty to apply to HGVs to ensure they travel at a speed that is consistent with an 8% gradient. There is also a need to ensure a consistent approach is taken to modelling HGV flows on links with steep gradients between the DM scheme traffic models and the DS scheme traffic models.

R.2.4.6 With these considerations, it is proposed to calculate and apply penalties to increase the journey times for HGVs, such that their speeds are equivalent to the (lower) speeds in the DM scheme traffic models. In this way, HGVs will receive no benefit from a less steep gradient but will receive a benefit from no longer having to negotiate the Air Balloon roundabout.

R.2.4.7 This approach has been taken as although the capacity increases as a result of the scheme, the gradient between the DM and DS stays similar and thus HGVs will still not be able to travel at the HGV speed limit. The time penalties applied to the HGVs for 2024 and 2039 can be seen in Table R-3 and Table R-4 respectively.

Table R-3 HGV time penalties for 2024

Section	DM Speed (kph)			7% DS Speed (kph)			8% Time Penalty (seconds)		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
8% gradient	75	77	76	91	91	91	10	8	9
8% to 4% gradient	77	78	78	91	91	91	6	6	6

Table R-4 HGV time penalties for 2039

Section	DM Speed (kph)			7% DS Speed (kph)			8% Time Penalty (seconds)		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
8% gradient	74	75	75	91	91	91	11	10	10
8% to 4% gradient	77	77	77	91	91	91	6	6	6

R.3 Results

R.3.1 Introduction

R.3.1.1 The impact of these changes to the scheme traffic model have been assessed using the 2024 AM peak and 2039 AM peak models, which have been run as fixed assignments. All time periods have been modelled for 2024 and 2039, but to avoid unnecessary repetition only 2024 AM and 2039 inter peak have been reported on in this technical note. The impact of this approach has been assessed by looking at the impact on journey times for cars and HGVs and traffic assignment. All results have been compared to the previous 7% gradient DS scheme traffic models (run as fixed assignment, to ensure changes are due only to the updated scheme coding).

R.3.2 2024 AM

Journey times

R.3.2.1 Journey times for the section between the A46 junction and the Shab Hill junction have been extracted from both scheme traffic models and these are in Table R-5.

Table R-5 Journey time comparison of 7% and 8% gradients for the 2024 AM peak

Direction	Vehicle type	7% gradient		8% gradient		Change	
		Time (mm:ss)	Speed (kph)	Time (mm:ss)	Speed (kph)	Time (mm:ss)	Speed (kph)
Eastbound; Up	Cars	02:00	109	02:00	109	00:00	0
	HGVs	02:24	90	02:40	81	00:16	-9
Westbound: Down	Cars	02:26	105	02:26	105	00:00	0
	HGVs	02:49	91	02:49	91	00:00	0

R.3.2.2 From Table R-5 it can be seen that for the 8% gradient there is no impact on the journey times for cars, whereas, the scheme traffic model shows an increase in journey times for HGVs equivalent to the time penalty applied. As expected, this therefore reduces the effective HGV speed, as these are the vehicle type impacted most by a change in gradient.

R.3.2.3 Westbound sees no change in journey times as a result of the change in gradient.

Traffic flows

R.3.2.4 Table R-6 shows the vehicle flows on the A417 for the 7% and 8% gradients for all vehicles and HGVs. All vehicle numbers are in passenger car units (PCU) and HGVs have a PCU factor of 2.5.

Table R-6 Changes in 2024 AM peak traffic flows between the 7% and 8% gradient

Direction	Vehicle type	7% gradient	8% gradient	Change
Eastbound: Up	All vehicles	2,332	2,333	1
	HGVs	441	440	-1
Westbound; Down	All vehicles	2,042	2,045	3
	HGVs	452	452	0

R.3.2.5 Table R-6 shows that the impact on traffic flows in both directions is minimal. There is a decrease of one PCU for HGVs travelling eastbound uphill, demonstrating the additional time penalty has a minimal impact on the assignment of HGVs. There is also an increase in three PCUs for the westbound travel, these additional vehicles are all cars.

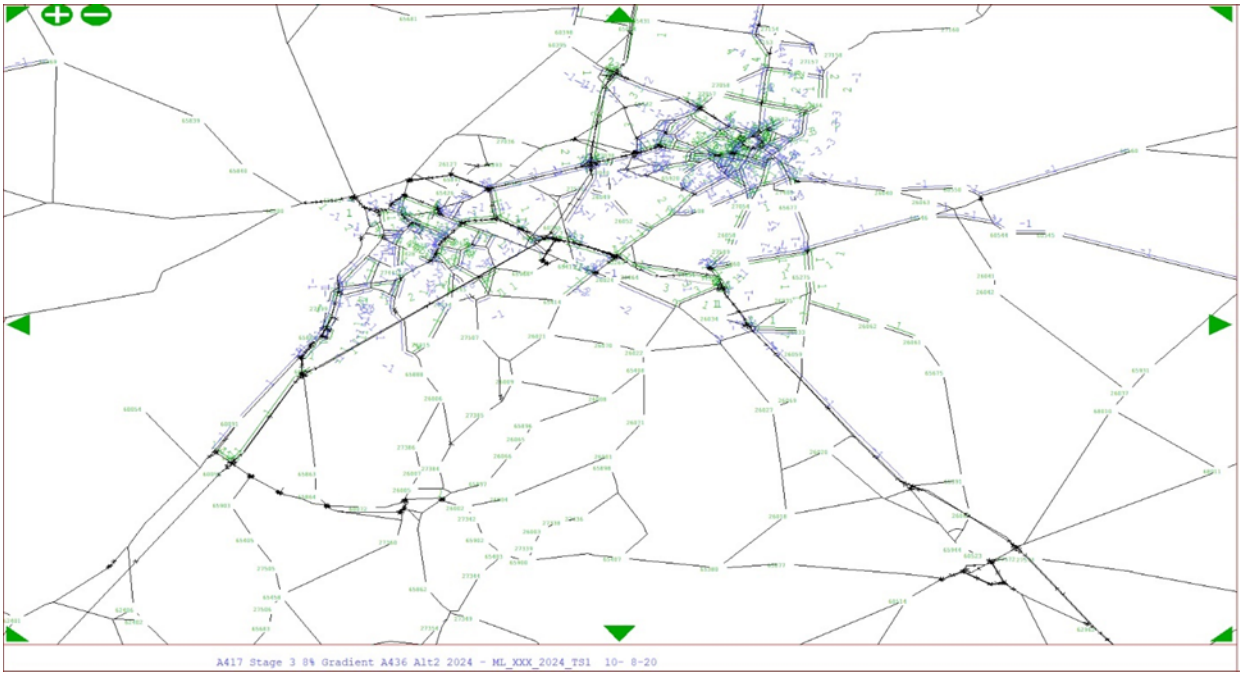

Figure R-1 Changes in 2024 AM traffic flows for Gloucester for all vehicles

R.3.2.6 Figure R-1 shows the impacts on traffic flows around Gloucester and Cheltenham for all vehicles is minimal. Changes in traffic are less than seven PCUs, which equates to less than a one percent change in traffic flows.

R.3.2.7 Some of the changes in Figure R-1 are in relation to the change in the gradient and these are predominantly HGV trips, other changes in this area are due to the software making small changes to some routes between zones. These changes are limited in size and geographical area and therefore acceptable.

R.3.2.8 Figure R-2 shows the impact of modelling the 8% gradient over a wider area to include the M4/M5 corridor.

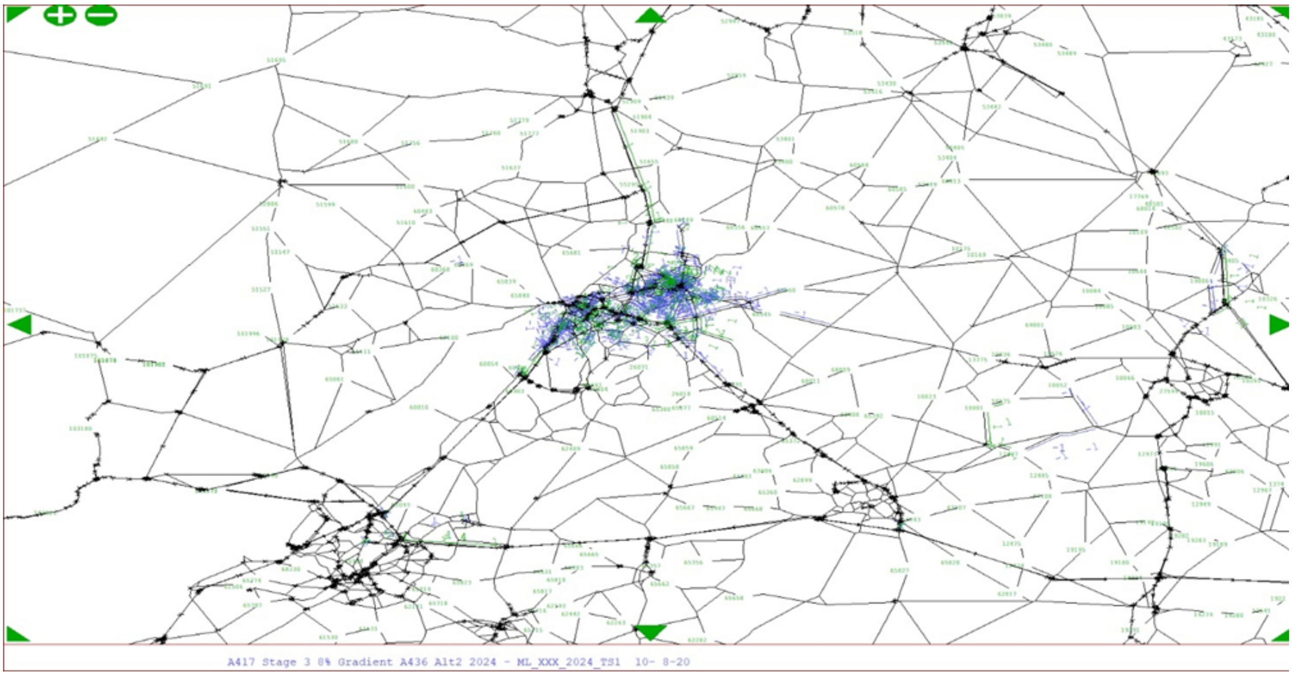

Figure R-2 Changes in 2024 AM traffic flows for the wider area

R.3.2.9 Figure R-2 shows the scheme traffic model has a limited impact on the M4/M5 and long-range trips. There are isolated changes in the wider area, but the changes are minimal and are one PCU.

R.3.3 2039 inter peak

Journey times

R.3.3.1 Journey times for the section between the A46 junction and the Shab Hill junction have been extracted from both scheme traffic models and these are in Table R-7.

Table R-7 Journey time comparison of 7% and 8% gradients for 2039 DS inter peak

Direction	Vehicle type	7% gradient		8% gradient		Change	
		Time (mm:ss)	Speed (kph)	Time (mm:ss)	Speed (kph)	Time (mm:ss)	Speed (kph)
Eastbound; Up	Cars	01:59	109	01:59	109	00:00	0
	HGVs	02:24	90	02:40	81	00:16	-9
Westbound: Down	Cars	02:33	100	02:33	100	00:00	0
	HGVs	02:50	90	02:50	90	00:00	0

R.3.3.2 From Table R-7 it can be seen that for the 8% gradient there is no impact on the journey times for cars, whereas, the scheme traffic model shows an increase in journey times for HGVs equivalent to the time penalty applied. As expected, this therefore reduces the effective HGV speed, as these are the vehicle type impacted most by a change in gradient.

R.3.3.3 Westbound sees no change in journey times as a result of the change in gradient.

Traffic flows

R.3.3.4 Table R-8 shows the vehicle flows on the A417 for the 7% and 8% gradients for all vehicles and HGVs in PCUs.

Table R-8 Changes in 2039 DS inter peak traffic flows between the 7% and 8% gradient

Direction	Vehicle type	7% gradient	8% gradient	Change
Eastbound	All vehicles	2,198	2,192	-6
	HGVs	443	437	-6
Westbound	All vehicles	2,409	2,411	2
	HGVs	505	505	0

R.3.3.5 Table R-8 shows that for the eastbound direction overall there has been a decrease of six PCUs and that HGV traffic has decreased by six PCUs. As shown in Table R-8 there westbound traffic has increased by two PCUs.

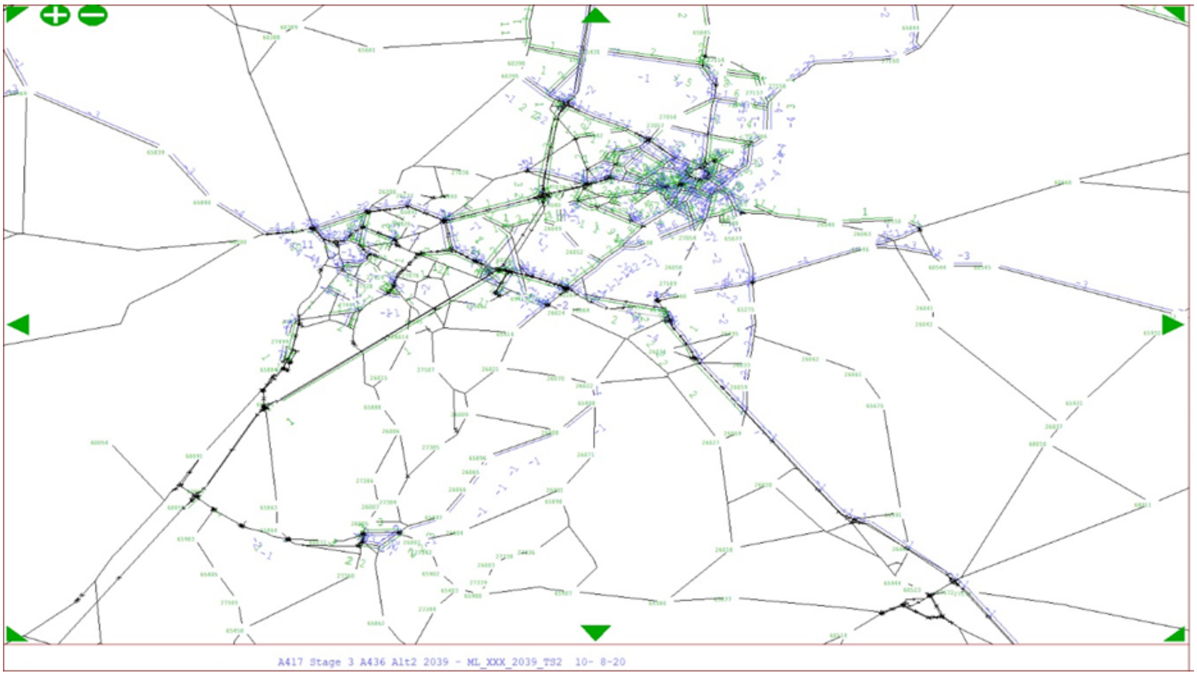

Figure R-3 Changes in 2039 inter peak traffic flows for all vehicles for Gloucester

R.3.3.6 Figure R-3 shows there is some impact of the 8% gradient on traffic flows in Gloucester and Cheltenham for all vehicles. A review of Gloucester and Cheltenham show these changes are greater than for 2024, but the changes in traffic are less than 20 PCUs, which equates to less than a five percent change in traffic flows.

R.3.3.7 Some of the changes in Figure R-3 are in relation to the change in the gradient and these are predominantly HGV trips, other changes in this area are due to the software making small changes to some routes between zones. These changes are limited in size and geographical area and therefore acceptable.

R.3.3.8 Figure R-4 shows the impact of modelling the 8% gradient over a wider area to include the M4/M5 corridor.

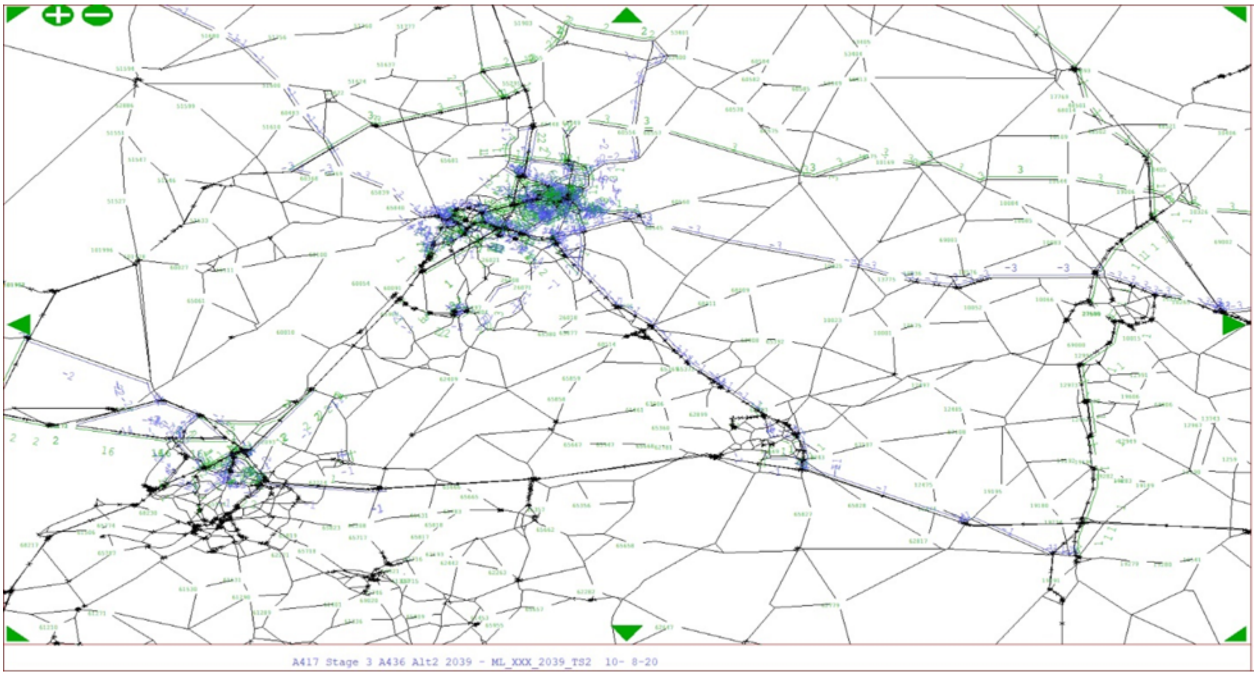

Figure R-4 Changes in 2039 inter peak traffic flows for all vehicles for the wider area

R.3.3.9 Figure R-4 shows that there is no impact on the M4/M5 and wider area of the change in gradient, but there are some changes on the A40 corridor and some other routes between Gloucestershire and the east, but these differences are less than three PCUs.

R.4 Conclusion

R.4.1.1 As outlined, there have been a number of changes to the scheme following the preferred route announcement in Spring 2019. Of primary relevance to the scheme traffic model is the increase in the gradient on the Cotswold escarpment from the 7% gradient in the PRA option to an 8% gradient in the scheme to be taken forward.

R.4.1.2 This note has set out the proposed approach to model the reduced speeds of HGVs when climbing the escarpment, following the investigation of two alternative approaches using the KLUNK parameter and time penalties within the SATURN software.

R.4.1.3 Due to the network coding of the Regional Traffic Models, from which the scheme traffic model has been developed, the KLUNK approach is unsuitable and cannot be implemented. Therefore, time penalties have been utilised to reduce the effective speeds of HGVs when climbing the escarpment.

R.4.1.4 Time penalties have been calculated on the basis on the modelled speeds of HGVs in the DM scheme traffic models, on the existing links of the A417 where steep gradients are present between the A46 junction and the Birdlip junction. In this way, HGVs will receive no benefit from a less steep gradient but will receive a benefit from no longer having to negotiate the Air Balloon roundabout.

R.4.1.5 The note then demonstrates the impacts of this revised model coding on journey times and traffic flows for the 2024 AM and 2039 inter peak periods. Results are presented based on fixed assignments, such that the changes shown are solely due to the revised scheme coding. Updated results based on the outputs of the variable demand modelling process will be presented in the transport forecasting package and other associated deliverables in the future.

R.4.1.6 For both the modelling shows an increase in journey time for HGVs travelling eastbound and a small decrease in traffic travelling eastbound, and this is attributable to a reduction in HGVs. In the wider area there are changes in traffic flows, but these are limited in size and proportion and journey times have not been impacted.

R.4.1.7 Overall, the approach that has been developed for modelling the 8% gradient is robust and has been demonstrated to produce the expected increase to journey times for HGVs on the scheme, compared to the previous 7% gradient scheme.

R.4.1.8 It is recommended that this time penalty approach is used for modelling the impact of the 8% gradient scheme.