A417 Missing Link
TR010056

7.4 Scheme Assessment Report

Planning Act 2008

APFP Regulation 5(2)(q)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 7

May 2021

Infrastructure Planning

Planning Act 2008

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

A417 Missing Link

Development Consent Order 202[x]

7.4 Scheme Assessment Report

Regulation Number:	5(2)(q)
Planning Inspectorate Scheme Reference	TR010056
Application Document Reference	7.4
Author:	A417 Missing Link

Version	Date	Status of Version
C01	May 2021	Application Submission

Table of contents

Figures

Tables

Executive summary

Purpose of report

This Scheme Assessment Report (SAR), produced as part of the Project Control Framework (PCF) Stage 2 (Option Selection), describes the development of solutions to the existing issues and constraints for the section of the A417 in Gloucestershire known as the Missing Link. The A417 forms a vital link to the M5 at Gloucester and the M4 at Swindon, together with the A419. The A417 Missing Link is a single-carriageway road near Birdlip between the Brockworth bypass and Cowley roundabout, and passes through the nationally important Cotswolds Area of Outstanding Natural Beauty (AONB). The study area includes a number of designated sites of historical, landscape and nature conservation interest.

PCF Stage 1 of the A417 Missing Link scheme involved the identification, sifting and appraisal of landscape led solutions for this route across the sensitive Cotswold escarpment. This process resulted in the 30 initial options being sifted to two, which were subsequently taken forward to non-statutory public consultation held early 2018.

The SAR provides an overview of the results of the public consultation and summarises the results of the assessment work that has been undertaken since then, in order to recommend a preferred option for progression to PCF Stage 3 (Preliminary Design).

History of the scheme

The A417 Missing Link scheme has been under consideration for more than 20 years. By 1998, dual-carriageway improvements were completed to over 90% of the length of the A417 / A419 - M4 / M5 link. The A417 section near Birdlip in Gloucestershire was not improved as part of those works. Between 2001 and 2003 the Highways Agency carried out a study to identify the environmental constraints centred on the existing route and to identify if options were available to improve this section of road with acceptable environmental impacts. The results were published in 2003 supporting a surface on-line dualling option.

The development of this option, now named the “the Modified Brown Route”, continued until 2006, when it was being prepared for public consultation. However, during this development stage, the route was classified as being of regional, rather than national importance and was not included in the National Roads Programme. It was classified as being within the ‘longer than ten years’ plan and the scheme’s progress faltered. In 2008, development work on lower cost solutions was carried

out. This concluded that there were no lower cost options which would provide long-term safety and congestion benefits between Cowley and Brockworth. Further workshops and small-scale studies were conducted between 2010 and 2014 with no significant progress being achieved.

In December 2014, the Department for Transport (DfT) published the Road Investment Strategy (RIS1) setting out a five year £15.2 billion investment programme (2015-20) for improvements to the strategic road network throughout England. The approach to RIS1 delivery is set out in Highways England's Delivery Plan (2015-20). The A417 Missing Link is one of 15 new schemes identified in the Delivery Plan for development in RIS1 and delivery in the next Road Investment Strategy period (RIS2 2020-2025).

Challenges and opportunities

The A417 Missing Link is wholly within the Cotswolds AONB, with no option to move the road outside the AONB whilst keeping the existing connections between urban, rural and employment centres. The existing situation of the road requires an intervention which must address challenges and opportunities that cannot be achieved through improvements to alternative strategic routes.

The key challenges and opportunities that the A417 Missing Link scheme will address are:

- **Landscape –** the existing road runs through the AONB creating severance in a high value landscape in a visible position at the top of the Cotswold escarpment. Sympathetic design, including route alignment, form of road and earthworks, and application of appropriate landscape and ecological measures that respond to the local area and address fragmentation, offer opportunities to contribute to changes in view and deliver effective integration and compatibility with the landscape character of the location.
- **Environment –** the area surrounding the A417 Missing Link has a number of designated sites which are of national significance for their scientific, environmental and heritage value. The scheme will provide opportunity for enhancement of these sites. Additionally, there is one Air Quality Management Area at Birdlip roundabout which could be mitigated through the scheme.
- **Traffic –** the A417 / A419 provides an essential link to the M5 at Gloucester and the M4 at Swindon, two of the top growth areas in the region. It also acts as an important connector between regions, providing an alternative to popular routes such as the A34 / M40, and forming an important travel route between the south coast and the

West Midlands. This section of the A417 is the only single-carriageway section of an otherwise high-quality continuous dual-carriageway route. It is frequently congested, with long delays causing poor journey times and reliability compared to the rest of the A417 / A419.

- **Safety –** high volumes of traffic, poor forward visibility and steep gradients contribute towards a particularly poor safety record on the existing single-carriageway section of the A417. Accident severity is particularly high on this section, with the number of killed and seriously injured casualties (KSIs) much higher than the national average for this category of road. The scheme has the opportunity to significantly improve safety on this section of road by increasing forward visibility and reducing the steep gradients on Crickley Hill.
- **Local and regional economy –** enhancing the route is expected to deliver local and regional economic benefits and provide new opportunities for growth for local communities and the wider Gloucestershire region.

Scheme objectives

Four scheme objectives have been developed through close collaboration with stakeholders, please see Table 0.1 below.

Table 0.1: Scheme objectives for the A417 Missing Link

A417 scheme objectives			
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 Area of Outstanding Natural Beauty and to minimise negative impacts of the 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.

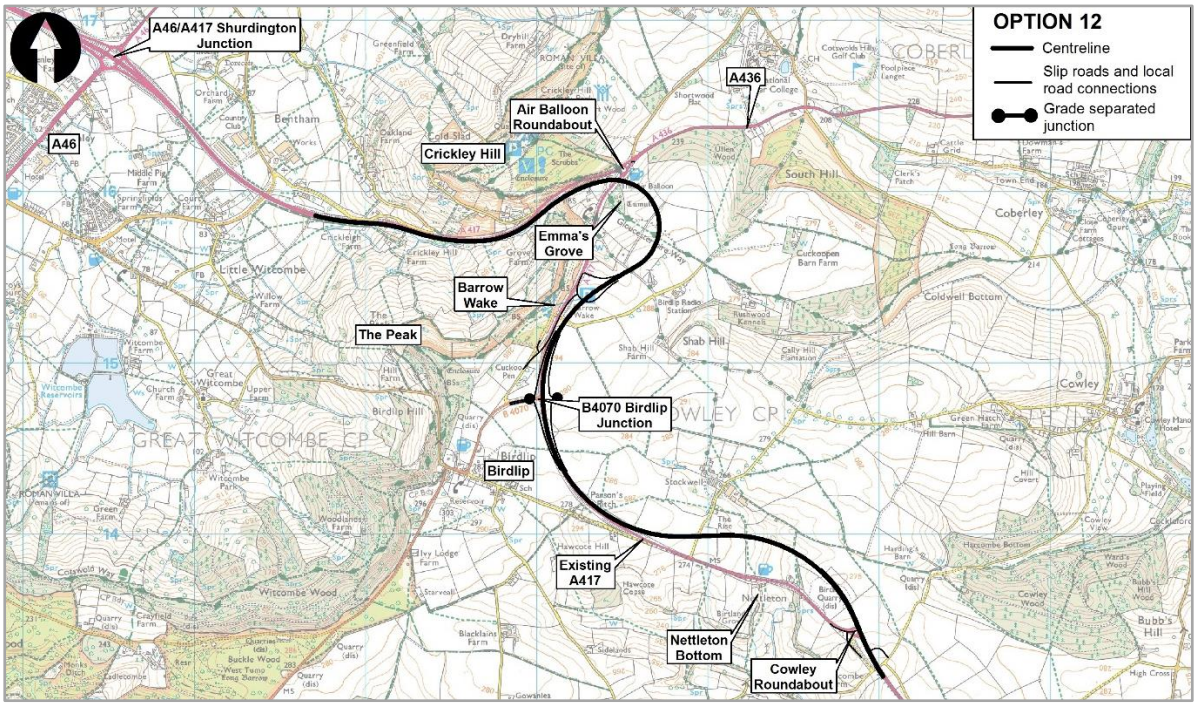
In the options identification stage, 30 route options were identified and sifted against these objectives and associated sub-objectives (Please see Table 3.1 for further detail).

PCF Stage 1 – options identification

The outcome of PCF Stage 1 was that surface routes Option 12 and Option 30 were recommended for non-statutory public consultation and further development. Both routes were considered affordable (within the £250 million to £500 million cost range), and deliverable, with both options delivering significant traffic and safety improvements on the existing road by providing a free flowing link and reducing gradients on Crickley Hill. The routes are shown below.

Option 12 is a surface route (historically known as the Modified Brown Route), with a mixture of widening of the existing road and construction of new sections of road, broadly following the route of the existing road whilst bypassing Nettleton Bottom.

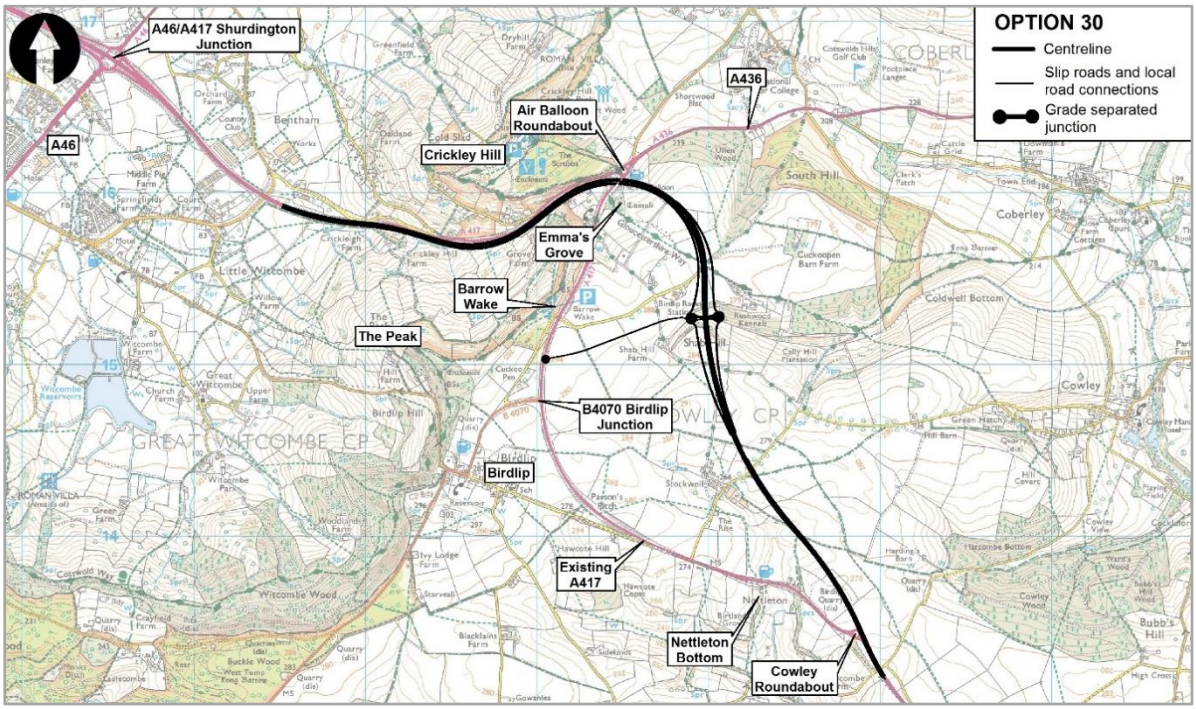
Figure 0.1: Option 12



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

Option 30 is a surface-level route and is characterised by mostly new construction. The existing road on Crickley Hill would be widened and the road would take a new route to the east, re-joining the existing A417 near Cowley roundabout. The existing road between Air Balloon and Cowley roundabout would be returned to the ownership of Gloucester County Council.

Figure 0.2 PCF Stage 1 - Option 30



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

Public consultation outcome

A non-statutory public consultation on proposals for the A417 Missing Link was carried out between 15 February and 29 March 2018. Almost 2,000 responses were received in total, and responses showed that public opinion is greatly supportive of Option 30. Those who identified their support for Option 30 amounted to 72% of all respondents, with an additional 8% stating their preference for Option 12.

Comments received informed a set of key issues for the public and stakeholders which were considered in the further option development at Stage 2, including:

- Environmental and geological impacts on nearby sites, including Crickley Hill and Barrow Wake Site of Special Scientific Interest (SSSI), and Emma's Grove Scheduled Monument
- Landscape considerations, in particular the minimising of the visual impact of the scheme in the Cotswolds AONB
- Access to the new road from the local network, including from the A436, the B4070, and various local communities
- Effects on local businesses and amenities
- Public Rights of Way, including their preservation and interaction with the scheme

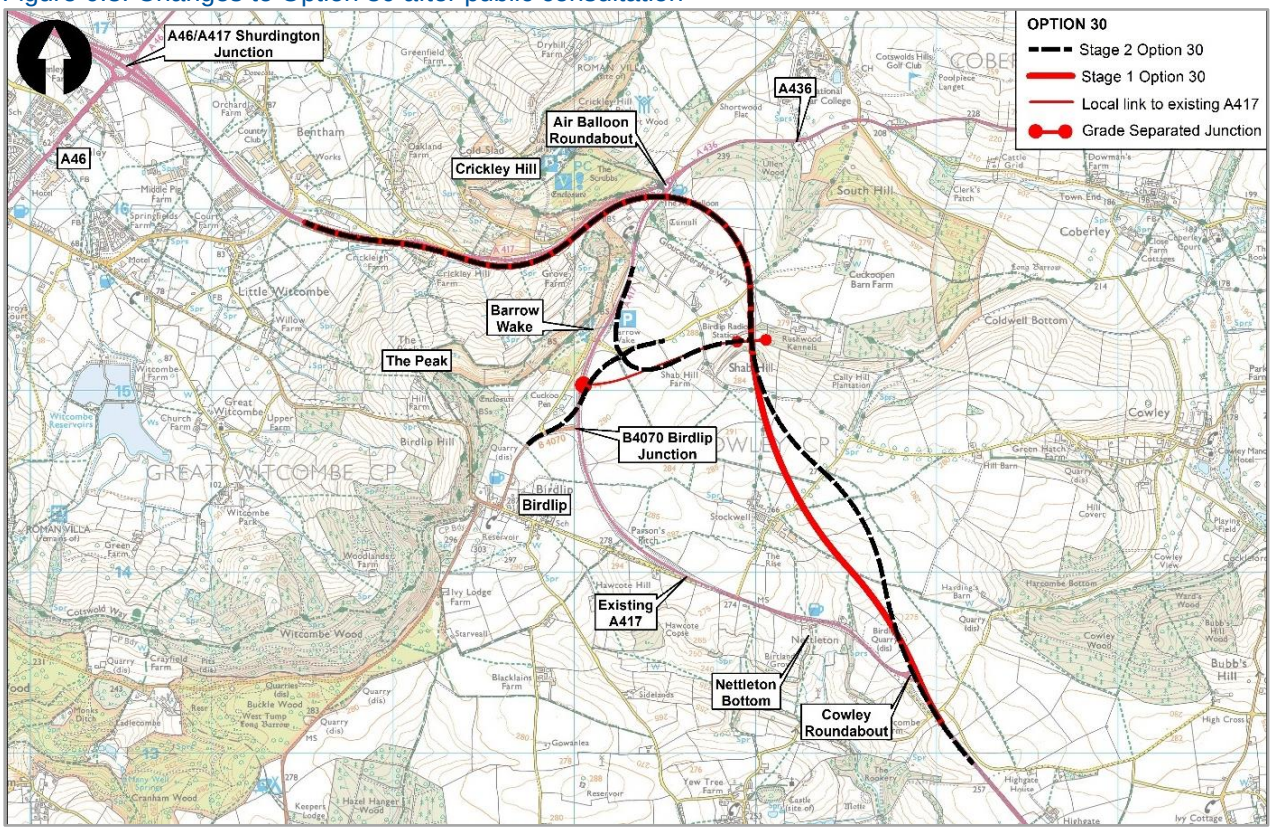
Route development

Option 12 was developed as a landscape led design in the previous studies undertaken between 2003 and 2006 for the Highways Agency, by minimising new road construction in the AONB. Following a landscape study during PCF Stage 1 and the comments gathered during the public consultation, several amendments were made to Option 30 to bring it to the same level of design as Option 12:

- Route amended near Stockwell for a better landscape fit
- The Link Road to Barrow Wake simplified and altered to enable a currently severed SSSI to be reconnected
- Gradient on Crickley Hill and through to Shab Hill junction further reduced from 7.5% to 7.0%
- Additional Cowley Junction added to provide direct access to Brimpsfield and Cowley, also allowing the existing A417 carriageway to be removed or repurposed from the access to Stockwell Farm up to the Birdlip junction

These amendments are shown below in Figure 0.3.

Figure 0.3: Changes to Option 30 after public consultation



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

Safety assessment

Due to the steep topography and various constraints of environmental assets, both options require a vertical gradient above the desirable maximum set out in highway design standards. However, both options would reduce the existing 10% maximum gradient on Crickley Hill, with Option 12 having a maximum of 8.4% and Option 30 having a maximum of 7%.

Both options contain departures from highway design standards. The majority of the departures from standard identified for each option (22 for Option 12, and 11 for Option 30) are as a result of environment, heritage and community constraints. Although opportunities to reduce or remove the design features are limited, all departures from standard will be reviewed in future stages of design, with the goal of removing or reducing them to improve the overall quality of the proposed route.

Through the removal of the existing single-carriageway section of the A417, both options would be expected to have a positive improvement upon road safety and contribute to the Highways England target of reducing the number of people killed or seriously-injured on the strategic road network.

Traffic assessment

Both options are forecast to reduce journey times along the A417 in both directions compared to the Do Minimum scenarios (if no changes were to be made to the route). Option 30 provides the better journey times along the A417, which reflects the more direct route alignment in that option.

Traffic travelling between the A436 and the A417 would see increased journey times, however this is offset by the benefits of reduced journey times on the A417 route. This increase is a result of the layouts of both options removing the direct connection between the existing A417 and A436 (currently at the Air Balloon roundabout). Option 30, which provides the least direct connection between these two roads, results in longer journey times when compared to Option 12. However, both options are anticipated to improve journey time reliability.

The improved journey times are forecast to lead to an increase in traffic along the A417 corridor in both options. To the south of the A417 Highwayman Inn junction, the maximum flow increase compared to the Do Minimum is forecast to occur in Option 30, with average annual traffic increasing by 21% once the road opens. Increases in Option 12 compared to the Do Minimum are lower but still equate to 14% in the opening year.

The forecast increases in traffic in the vicinity of the scheme are a result of background growth, in addition to the redirection of traffic from various alternative routes (both local and strategic), coupled with some re-routed trips that are taking advantage of the improvements to the route.

Environmental assessment

The environmental impacts of the scheme have been assessed in accordance with the requirements presented in the Infrastructure Planning (EIA) Regulations 2017 based on typical environmental mitigation being implemented prior to scheme specific mitigation measures being designed. Table 0.2 provides a summary of the residual environmental impacts following best practice mitigation for each discipline in the construction and operational stages. Table 0.2 highlights that, at present, there is limited variation in terms of overall residual environmental impacts between Option 12 and Option 30. Option 12 and Option 30 are recording the same level of significance in relation to air quality, cultural heritage, landscape, geology and soils, materials, noise and vibration, population and human health, and climate. However, the scale of significance within these significance scores may vary. There is slight variation in terms of overall residual environmental impact for biodiversity and road drainage and the water environment between the options with Option 30 reporting potentially less adverse impacts. Where significance scores are not specified, this is due to the methodologies used for those disciplines not allowing for grades of

significance to be determined at this stage; an impact is only classified as significant or not significant but not slight, moderate or large.

Table 0.2 Summary of overall residual environmental impacts with best practice mitigation

	Option 12		Option 30	
	Construction	**Operation**	**Construction**	**Operation**
Air quality	Not Significant	Not Significant	Not Significant	Not Significant
Cultural heritage	Large Adverse to Moderate Adverse	Large Adverse to Moderate Beneficial	Large Adverse to Moderate Adverse	Large Adverse to Moderate Beneficial
Landscape	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse
Biodiversity	Large Adverse to Moderate Adverse	Moderate Adverse	Large Adverse to Slight Adverse	Moderate Adverse
Geology and soils	Moderate Adverse	n/a	Moderate Adverse	n/a
Materials	Neutral to Moderate Effect	n/a	Neutral to Moderate Effect	n/a
Noise and vibration	Significant Adverse	Significant Adverse to Significant Beneficial	Significant Adverse	Significant Adverse to Significant Beneficial
Population and human health	Moderate Adverse	Moderate Beneficial	Moderate Adverse	Moderate Beneficial
Road drainage and the water environment	Very Large Adverse to Moderate Adverse	Very Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse
Climate	Not Significant	Not Significant	Not Significant	Not Significant

Compliance with the National Policy Statement for National Networks

At this stage, neither option can be distinguished from each other in terms of its comparable risk of non-compliance against the policy requirements set out within the National Policy Statement for National Networks (NPSNN) for the following topics: air quality; landscape and visual impact; noise and vibration; and road drainage and the water environment.

It is considered that Option 12 presents a greater risk of non-compliance than Option 30 against the relevant policy requirements of the NPSNN in respect of material assets and waste; and biodiversity, specifically impacts on SSSIs, irreplaceable habitats including ancient woodland, potential ancient woodland and veteran trees, and other protected species and habitats. Option 30, on the other

hand, presents a greater risk of non-compliance than Option 12 against the policy requirements of the NPSNN relating to cultural heritage, geology and soils, population and human health, and climate.

Further assessment and the development of scheme-specific mitigation, enhancement and compensation measures will ensure that adverse effects identified at PCF Stage 2 are eliminated or reduced as far as practicable for the preferred route.

Economic assessment

Cost estimates have been prepared for both scheme options. The estimated costs for both schemes have changed from the PCF Stage 1 estimates. For Option 12 there is a net increase due to a large increase in the cost of disposal of excess excavated material, despite reduced volumes being assumed. For Option 30, a significant reduction in excess material has been achieved, above that which was identified for Option 12. When this is combined with revised engineering assumptions on structural features, this achieves a significant net reduction in cost for Option 30. Table 0.3 summarises the costs for each option assessed. The costs include allowances for risk and contingencies and are presented in 2016 prices, to give the most up-to-date indication of the scheme cost.

Table 0.3: Most likely order of magnitude option estimates, 2016 Q1 price base

Option	Stage 2 Most likely OME
Option 12	£474,000,000
Option 30	£438,000,000

Source: Highways England (August 2018) and COBA manual (July 2017)

In line with the DfT's WebTAG guidance an economic assessment has been undertaken for both of the A417 Missing Link scheme options at PCF Stage 2. The assessment has considered the following:

- Transport User Benefits (TUBA)
- Accidents (COBALT)
- Journey time reliability
- Construction impacts (QUADRO)
- Air quality impacts
- Noise impacts
- Greenhouse gas emissions
- Wider economic impacts

The overall economic impacts of the scheme, expressed in their value in pounds, are summarised in the Analysis of Monetised Costs and Benefits (AMCB) table. The AMCB is shown in Table 0.4. As per WebTAG all costs and benefits reported in this section are in 2010 prices, discounted to 2010, to enable a consistent comparison between government expenditure of different types.

Table 0.4: Analysis of monetised costs and benefits (£000s)

Item	Option 12	Option 30
Accidents (not assessed by TUBA)[1]	67,903	65,255
Roadworks (not assessed by TUBA)[2]	-10,335	-10,215
Greenhouse gases (not assessed by TUBA)[3]	-36,495	-37,080
Noise (not assessed by TUBA)[4]	961	1,196
Air quality (not assessed by TUBA)[5]	-588	-963
Economic efficiency: consumer users (commuting)	34,061	38,915
Economic efficiency: consumer users (other)	14,509	17,235
Economic efficiency: business users and providers	111,436	158,717
Wider public finances (indirect taxation revenues)	72,774	73,812
Present value of benefits **(PVB)**	254,226	306,871
Broad transport budget present value of costs **(PVC)**	**295,057**	**272,506**
OVERALL IMPACTS		
Net present value (NPV)	-40,831	34,365
Initial benefit to cost ratio (BCR)	**0.86**	**1.13**
Reliability benefits	64,143	68,700
Wider economic benefits	50,722	63,621
Adjusted BCR	**1.25**	**1.61**

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. [1] from COBALT, [2] from QUADRO, [3] WebTAG Unit A3 Chapter 4, [4] WebTAG Unit A3 Chapter 2, [5] WebTAG Unit A3 Chapter 3.

The economic assessment has shown that, of the two options under consideration at PCF Stage 2, Option 30 provides the greatest amount of economic benefits at a lower cost, as shown by its benefit to cost ratio (BCR) of 1.61. When the economic assessment is considered with the large adverse impact on landscape and other environmental factors such as biodiversity and the historic environment, the two options are given Value for Money ratings. It is judged that Option 30 will likely be 'Low' value for money, whilst Option 12 is likely to deliver 'Poor to Low' value for money. This difference reflects the higher benefits offered by Option 30 relative to the similar impacts of the two options as in Table 0.2.

The recommended preferred route

Option 30 has greater support from the public, as shown by the results of the non-statutory public consultation. From an engineering perspective it provides a higher quality road for all road users.

Although both routes are similar in most respects from an objective environmental assessment and appraisal, Option 30 would divert the strategic road network away from the Cotswolds escarpment, presenting potential for further landscape and environmental design development during the continued development of the preferred route.

It is considered, based on the current assessments, that Option 12 is more likely to comply with the relevant policy requirements within the NPSNN than Option 30 relating to cultural heritage, geology and soils, population and health and climate.

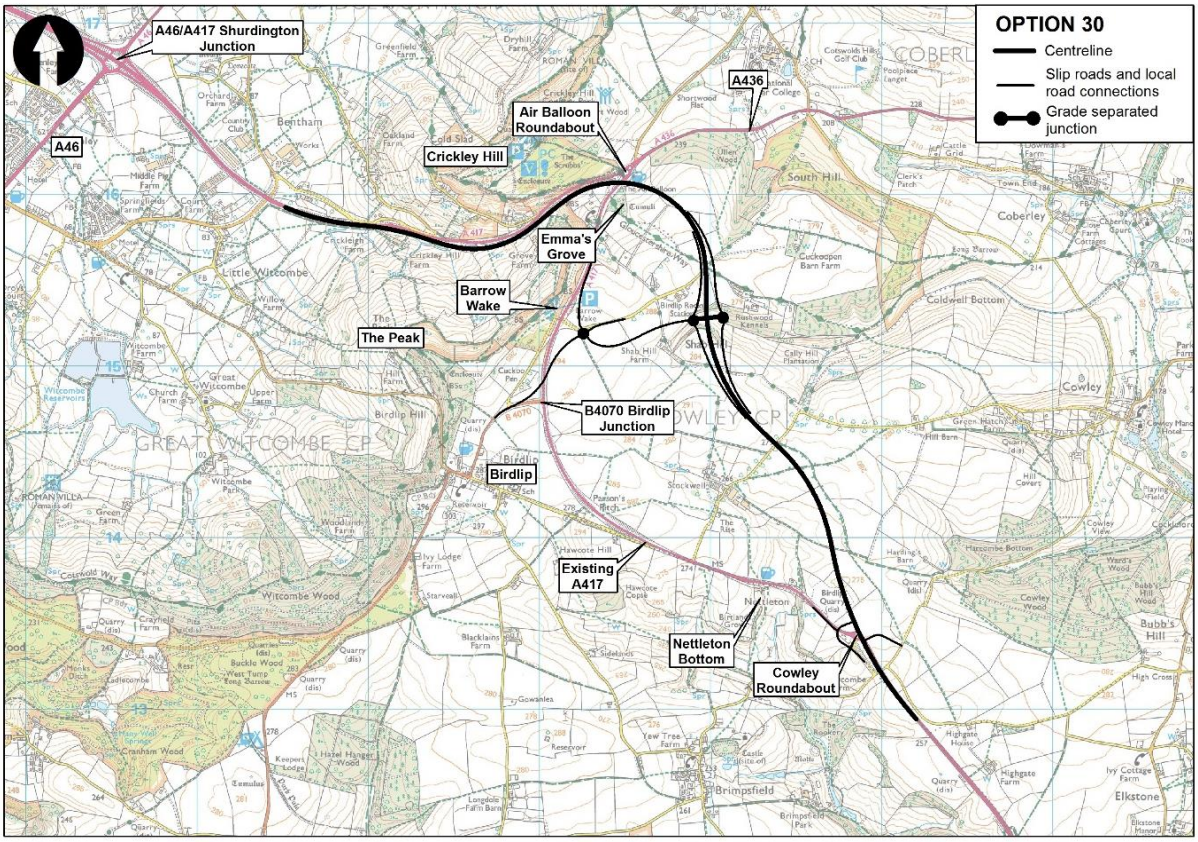
On the other hand, Option 30 is more likely to comply with the policy requirements of the NPSNN than Option 12, in the areas of material assets and waste; and biodiversity, specifically impacts on SSSIs, irreplaceable habitats including ancient woodland, potential ancient woodland and veteran trees, and other protected species and habitats.

Option 30 is lower cost, gives greater benefits and provides better value for money to the taxpayer compared with Option 12, whilst also delivering a more direct route, and more reliable journeys on the strategic route.

Option 30 is recommended as the preferred route, as the route able to best deliver on the scheme objectives based on the PCF Stage 2 assessment and appraisal of the route options and with strong public support. Option 30 is shown below in Figure 0.4.

Delivery of the project will be subject to confirmation of funding within the second road investment strategy, which will cover the period between 2020-2025 and is due to be published towards the end of 2019.

Figure 0.4: Option 30



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

1. Introduction

1.1. Purpose of this report

1.1.1. This Scheme Assessment Report (SAR) outlines the assessment of options for the section of the A417 in Gloucestershire, known as the Missing Link.

1.1.2. The objectives of this SAR are listed below:

- Provide a summary of the scheme's history and explains the existing condition along the study area
- Summarise the options identification process detailed in the scheme's Technical Appraisal Report (TAR)
- Summarise the Report on Public Consultation
- Present the development of route options taking into consideration feedback from the public consultation
- Report on the appraisal of route options, including policy, engineering, safety, traffic, economic, cost, operational, technology and maintenance, environmental, social and distributional impact assessments and appraisals
- Recommend a preferred route

1.1.3. At the conclusion of PCF Stage 2, Highways England makes a recommendation of a Preferred Route to the Secretary of State (SoS) for Transport. The SoS considers the recommendation and decides which option is chosen as the Preferred Route, which will be made public in a 'Preferred Route announcement' (PRA).

1.1.4. PCF Stage 3 (preliminary design) will follow PRA, where the Preferred Route will be developed in more detail and the scheme will undergo further public consultation before submission of a Development Consent Order (DCO) during PCF Stage 4 (statutory procedures and powers). The DCO will be examined by the Planning Inspectorate who will then make a recommendation on the scheme, after which the Secretary of State will make a decision on whether to grant or refuse development consent. Pending approval, construction can be commenced.

1.2. Structure of this report

1.2.1. This report is structured into the following chapters:

Chapter 1: Introduction – Gives an overview of the purpose of the report and

summarises the scheme's background.

Chapter 2: Existing conditions and need for the scheme – Gives a statement of the problem, description of the existing conditions and summary of the consequences of doing nothing.

Chapter 3: Planning factors – Provides a description of the Scheme Brief from Highways England, capturing the Client Scheme Requirements (CSRs) and relevant local and national policy.

Chapter 4: Option identification, sifting and appraisal (PCF Stage 1) – Summarises the Technical Appraisal Report with a brief description of the option identification process and a summary of the alternative options considered.

Chapter 5: Public consultation summary – Summarises the Report on Public Consultation.

Chapter 6: Stage 2 engineering and safety assessment – Provides an assessment of the developed route options as engineering solutions with summaries of the completed safety assessments.

Chapter 7: Traffic assessment – Summarises the traffic modelling and analysis that has been undertaken and the relative benefits of the developed route options.

Chapter 8: Economic assessment – Summarises the economic analysis that has been undertaken and the relative economic benefits of the developed route options.

Chapter 9: Environmental assessment and design – Gives an assessment of the developed route options against their impacts on noise, air quality, greenhouse gases, landscape, townscape, historic environment, biodiversity and the water environment.

Chapter 10: Appraisal summary – Summarises the positive and negative aspects of the developed routes, taking into consideration all the above assessments and presents the Appraisal Summary Tables.

Chapter 11: Conclusions and recommendations – Summarises the relative merits of each of the route options and provides a recommendation of a Preferred Route.

1.3. Scheme context

1.3.1. In 2014, the Department for Transport (DfT) announced its five-year investment programme for making improvements to the Strategic Road Network (SRN) across England. More than 100 schemes were identified as part of this Road Investment Strategy, one of which is the A417 Missing

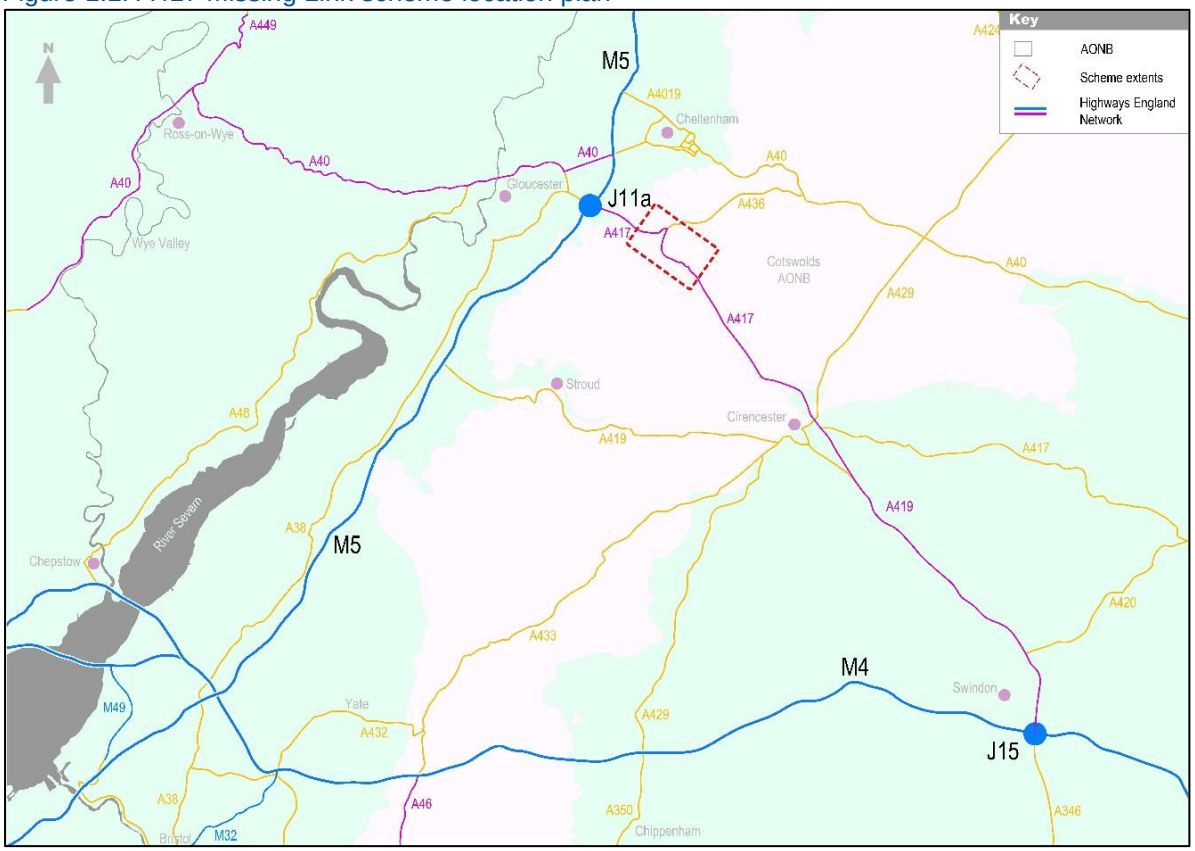
Link in Gloucestershire. This is in recognition of the fact that this area relies heavily on the connectivity provided by the strategic road network to other parts of the UK for jobs, tourism and the economy.

1.3.2. The A417 Missing Link is a section of single-carriageway road near Birdlip, between the Brockworth bypass and Cowley roundabout, running through the nationally important Cotswolds Area of Outstanding Natural Beauty (AONB). The study area includes a number of designated sites of historical, landscape and nature conservation interest.

1.3.3. Together, the A417 and A419 make up one of the south-west's most important road corridors, helping people get to work, school, visit friends, have fun and get to places in an emergency. They link the M5 at Gloucester (junction 11A) to the M4 at Swindon (junction 15) and provide vital connections to the towns of Cheltenham and Cirencester. The A417 / A419 are an important part of helping south-west businesses to connect with markets and opportunities in the Midlands and north and attract investment for Gloucestershire and its neighbours by linking them to London and the South-East.

1.3.4. Most of the route is a free flowing dual-carriageway, but there is one section that is not. Known as the Missing Link, this stretch of around three miles 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.

Figure 1.1: A417 Missing Link scheme location plan



Source: Mott MacDonald Sweco Joint Venture

1.3.5. 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. Some motorists divert onto smaller local roads to avoid tailbacks, causing difficulties for neighbouring communities. Poor visibility and steep gradients are another issue, contributing to the disproportionately high number of serious and fatal accidents that are seen along this stretch of road.

1.3.6. Upgrading this section of A417 to dual-carriageway in a way that is sensitive to the surrounding Cotswolds AONB will help unlock Gloucestershire's potential for growth, support regional plans for more homes and jobs and improve life in local communities by reducing queueing traffic, rat-running, and road accidents.

1.3.7. 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 is needed to improve safety, ease congestion and pollution, and support the economy and local communities.

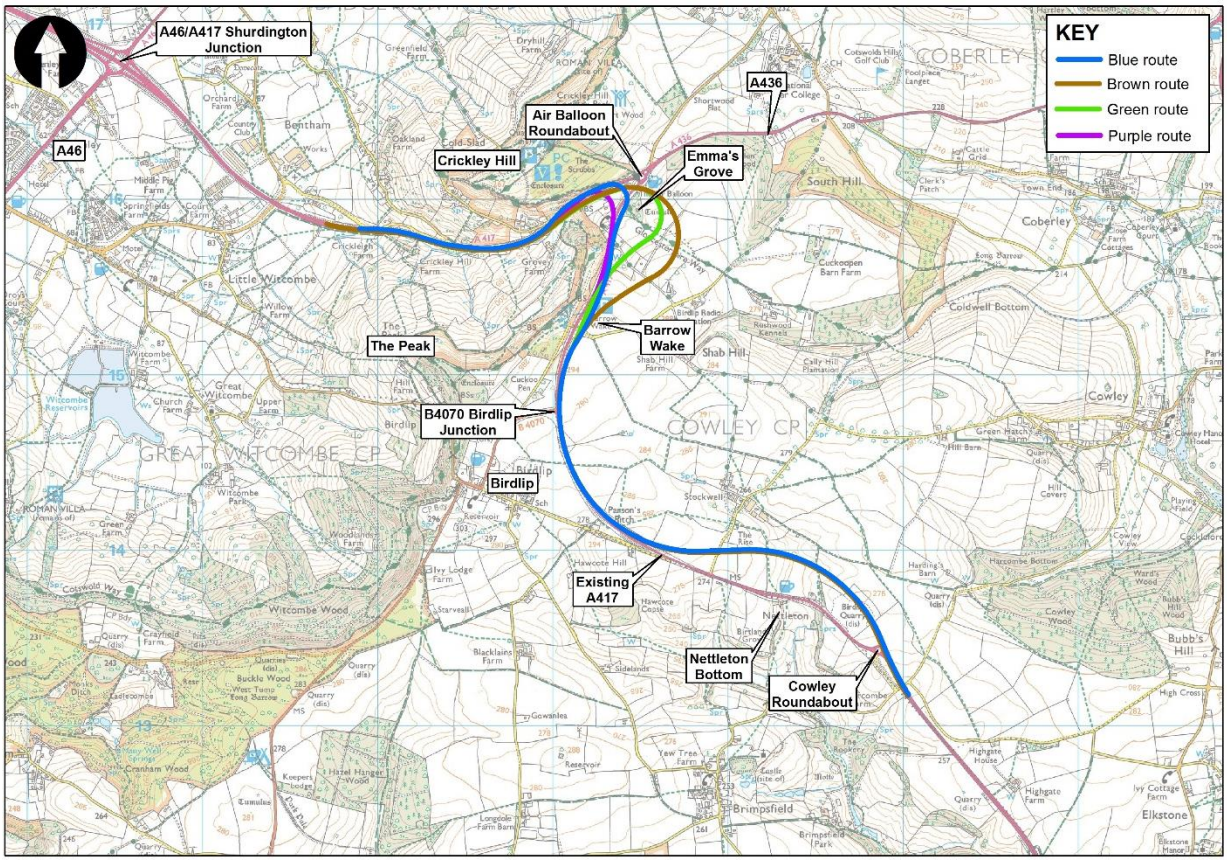
1.4. Scheme history

1.4.1. The A417 Missing Link scheme has been under consideration for more than 20 years. By 1998, dual-carriageway improvements were completed to over 90% of the length of the A417 / A419 link. This single-carriageway section near Birdlip in Gloucester was not improved as part of those works. However, it is maintained by the Design, Build, Finance and Operate (DBFO) Company and has subsequently been referred to as the A417 Missing Link.

1.4.2. In 2001, the Highways Agency appointed consultants to undertake a study to identify the environmental assets within a study area centred on the existing route alignment, prepare a constraints map and identify if options were available to improve this section of road which would have acceptable environmental impacts. The results were published in 2003 supporting a surface on-line dualling option. Further development of a tunnel option was abandoned due to an estimated cost of £1 billion and a holding objection in respect of ground water contamination from the Environment Agency.

1.4.3. In September 2003, Highways Agency held a value management workshop with representatives of statutory environmental bodies including the Environment Agency, Countryside Agency and English Heritage. This looked at three groups of schemes; off-line, tunnel and on-line. From this point, four on-line routes were developed (Blue, Purple, Green and Brown, as shown in Figure 1.2).

Figure 1.2: Highways Agency on-line solutions (2003)



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

1.4.4. A site meeting between the Highways Agency and the Countryside Agency (precursor to the Cotswold Conservation Board) in October 2003 dismissed the Blue and Purple route options as the engineering and operational challenges they presented were too great. Subsequently, the Green option was found to have significant impacts on the landscape in comparison to the Brown route, particularly at Emma's Grove. This presented opportunities for improvement to the A417.

1.4.5. The Brown Route was further developed, particularly the vertical alignment and the extent of ground modelling on the plateau, in an effort to:

- Reduce the impact on Birdlip
- Balance a 'cut and fill' surplus
- Mitigate concerns over safety in negotiating the tight 'loop' bend

1.4.6. The resulting route became known as the Modified Brown Route.

1.4.7. In 2004 the Environment Agency, Countryside Agency and English Heritage were all content for the Modified Brown Route to be included into the Roads Programme.

1.4.8. Whilst the surface option scheme was being progressed, the route was classified as being of regional importance rather than national importance in 2005. Funding for the scheme would have to be awarded through the South West Region's funding allocation. The South West Regional Assembly requested that the Highways Agency examine the possibility of a lower cost solution.

1.4.9. The Highways Agency carried out a review of off-line schemes, quick-win solutions and junction improvements. The conclusion was that there were no realistic schemes that could achieve a significant improvement other than the full dualling of the route between Cowley roundabout and Brockworth bypass. This review also considered and rejected developing the Modified Brown Route in a phased approach funding through private finance, and the option of doing nothing.

1.4.10. The Stage 2 SAR was prepared in March 2006 and concluded that the Modified Brown Route should be taken forward as the solution.

1.4.11. This scheme was prepared for public consultation in 2006. However, the consultation did not take place as the scheme was not included in the Roads Programme. It was identified within the 'longer than ten years' plan and therefore consultation and further development was not progressed.

1.4.12. In 2008, the Highways Agency again reviewed the opportunities to provide a lower cost scheme. It was concluded that there were no lower cost solutions which would be capable of providing long-term benefits to safety, congestion and environment along the A417 between Cowley roundabout and Brockworth bypass. The work confirmed the A417 Modified Brown Route as the only viable solution.

1.4.13. In 2010, the Highways Agency led workshops identifying short-term, low-cost measures to improve the route. These measures included:

- Facilitating the removal of broken down vehicles and providing laybys
- A version of Active Traffic Management that could include speed detection loops, Automatic Number Plate Recognition (ANPR), control room connectivity, emergency refuges, Traffic Officers and post mounted Vehicle Message Signing (VMS)
- CCTV cameras to provide real time video; initially being connected to the Regional Control Centre with access rights to other parties
- Strategic signing on the M4 and M5 could be implemented by the Regional Control Centre when an incident was positively confirmed via CCTV

- Restricting Heavy Goods Vehicle's to lane 1 on lengths of 2+1 lane layout and around Air Balloon roundabout where the capacity of lane 2 might be increased

1.4.14. Further measures that focussed on enhancements to the Air Balloon roundabout for the improvement of safety and congestion were established to:

- Restrict turning movements – A417 from Swindon to A436
- Segregated left turn from the A436 arm to the southbound A417
- Geometric improvement to the roundabout configuration
- A436 link to Birdlip junction

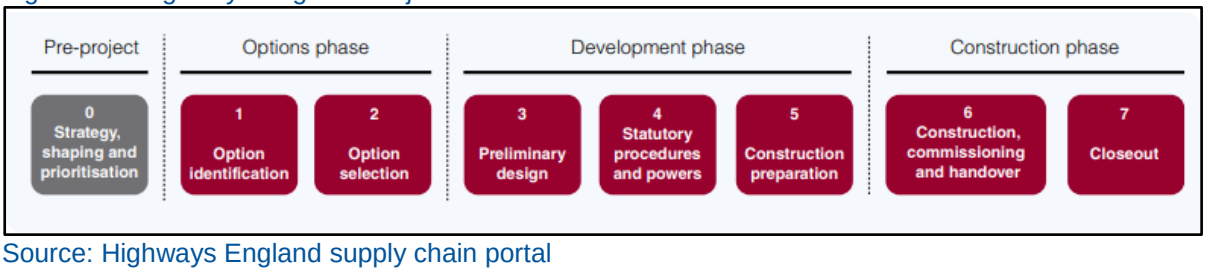
1.4.15. However, none of the measures highlighted above were implemented for the A417 Missing Link.

1.4.16. In 2014 the Highways Agency conducted a further study of the potential for low cost (less than £50 million) improvement options to solve the congestion that exists on the A417 Missing Link, focussing particularly on the Air Balloon roundabout. This study identified two options for grade-separation of the Air Balloon junction. Neither of these options were taken forward due to concerns over buildability.

1.4.17. In 2014, the DfT announced its five-year investment programme for making improvements to the SRN across England. More than 100 schemes were identified as part of this Road Investment Strategy, one of which was the A417 Missing Link between the Brockworth bypass and Cowley roundabout in Gloucestershire.

1.4.18. In 2015, Mott MacDonald Sweco Joint Venture (with sub-consultant WSP | Parsons Brinckerhoff) were appointed to develop the pre-project Strategy, shaping and prioritisation of the A417 Missing Link scheme, illustrated in Figure 1.3 below as the start of the Highways England PCF. PCF Stage 0 was completed in September 2015, concluding that a highways scheme was the most viable transport solution and that a major roads project should be initialised.

Figure 1.3: Highways England Project Control Framework



Source: Highways England supply chain portal

1.4.19. Highways England commissioned Mott MacDonald Sweco Joint Venture to progress the Options Phase for the scheme (PCF Stages 1 and 2), starting in September 2016. This Scheme Assessment Report represents the conclusion of the Options phase, leading to the Preferred Route Announcement and the subsequent Development phase.

2. Existing conditions and need for the scheme

2.1. Introduction

2.1.1. This chapter outlines the existing conditions of the A417 Missing Link study area, in particular the current route between Cowley roundabout and the Brockworth bypass. Additionally, it addresses the need for the scheme, with reference to the existing traffic issues and Do Nothing consequences.

2.1.2. The surrounding area of the existing A417 route contains a mix of agricultural land, woodland and common land. The nearest village is Birdlip which is situated approximately midway between Cowley roundabout to the south-east and Brockworth bypass to the north-west. Spread either side of the existing A417 route are farms, private properties, private enterprises and Crickley Hill Country Park which is situated west of the Air Balloon roundabout. The study area is shown in Figure 2.1.

Figure 2.1: Aerial imagery of the A417 Missing Link study area

Source: GiGi GIS Portal. Crown Copyright 2016 100030649

2.2. Statement of the problem

Traffic

2.2.1. The following paragraphs provide details of the existing traffic conditions on the A417 section known as the Missing Link. Where traffic flows and direction of travel are discussed below, “northbound” refers to journeys from Cowley roundabout to Brockworth Bypass (Cirencester to Gloucester), and “southbound” refers to journeys from Brockworth Bypass to Cowley roundabout (Gloucester to Cirencester).

Traffic characteristics on the A417 Missing Link

2.2.2. Average daily traffic flows (measured between November 2015 and October 2016) on the Missing Link section 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 (21,000 vehicles) and as a result, delays regularly occur on these links.

2.2.3. The Air Balloon roundabout is a key junction due to its connection of the A436 to the A417 and is a main cause of congestion in the area. The morning peak is characterised by slow moving and queuing traffic on all approaches. Northbound traffic in the morning peak is typically slow moving from as far south as Cowley roundabout, another location where queueing traffic is a common occurrence. Conditions in the evening peak are similar to the morning, except that the A417 southbound approach to the Air Balloon roundabout typically experiences fewer delays and queuing. The A436 approach to the Air Balloon roundabout also experiences delays and queues, which are an issue in the evening peak in particular.

2.2.4. The A417 / A419 route between Swindon and Gloucester is used by local and long-distance traffic with a wide range of origins and destinations, which stretch across south-east and south-west England, the West Midlands, and South Wales.

2.2.5. Examples of long-distance journeys, for which the full A417 / A419 route between the M4 and M5 is usually part of the quickest strategic route, include:

- London (including Gatwick and Heathrow airports) and the major channel ports at Folkestone / Dover to Gloucester and on to south Herefordshire (Hereford and Ross-on-Wye)

- M4 corridor west of London (Slough / Reading / Swindon) to Gloucester and on to south Herefordshire (Hereford) and south Worcestershire (Worcester)
- Solent area (Southampton / Portsmouth including ports) to Gloucester and on to Worcestershire, Herefordshire and south Shropshire (Ludlow)
- Dorset coast (Bournemouth) and Salisbury to Gloucester and the West Midlands / north-west England / North Wales

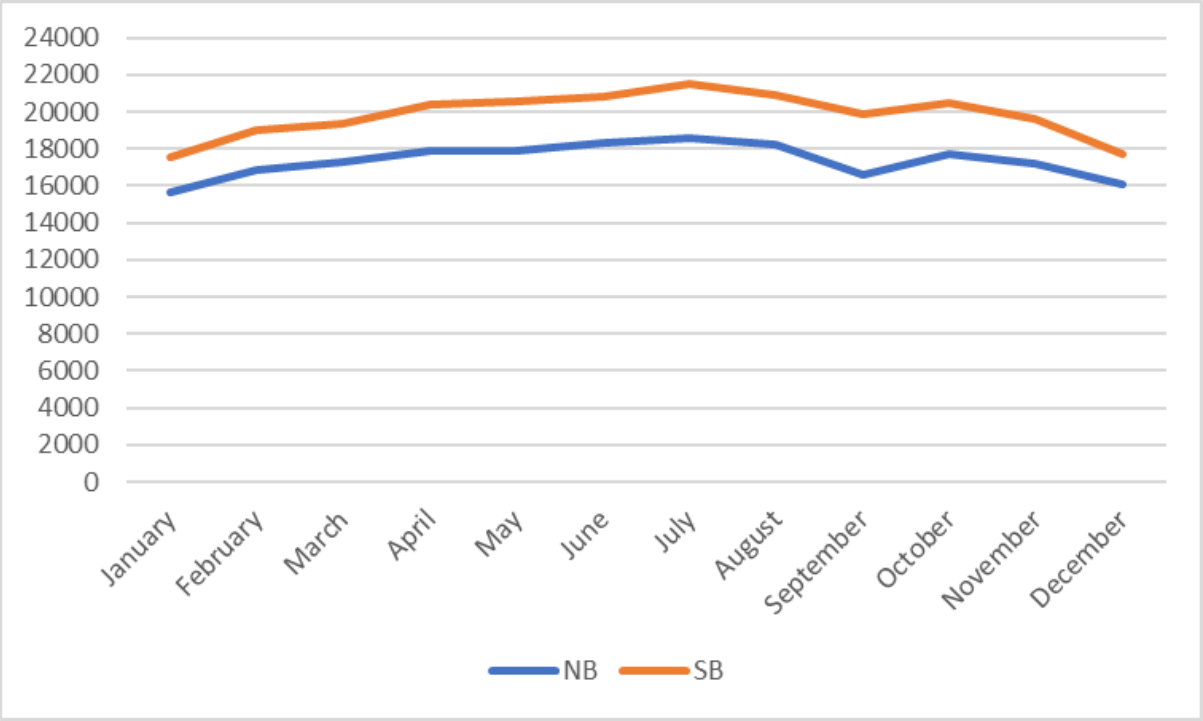
2.2.6. In addition to the long-distance journeys listed above, the western part of the Missing Link (A417 at Crickley Hill) is used for the following journeys via the A436:

- North London / Hertfordshire / Buckinghamshire (Aylesbury) and south Oxfordshire (Oxford) to Gloucester and on to Herefordshire and parts of mid-Wales (Powys)
- South Wales (M4 corridor) and south-west England (M5 corridor through to Devon and Cornwall) to the Cotswolds, north Oxfordshire, Bedfordshire and Northamptonshire

Traffic flow variations

2.2.7. Figure 2.2 shows the distribution of daily traffic volumes, by direction, on the Crickley Hill section of the A417 across the year (between November 2015 and October 2016). The data presented is the 7-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). The dip in traffic flow in September 2016 is coincident with scheduled night-time maintenance works on the A417 during the month.

Figure 2.2: A417 Crickley Hill daily traffic flows, by direction and month



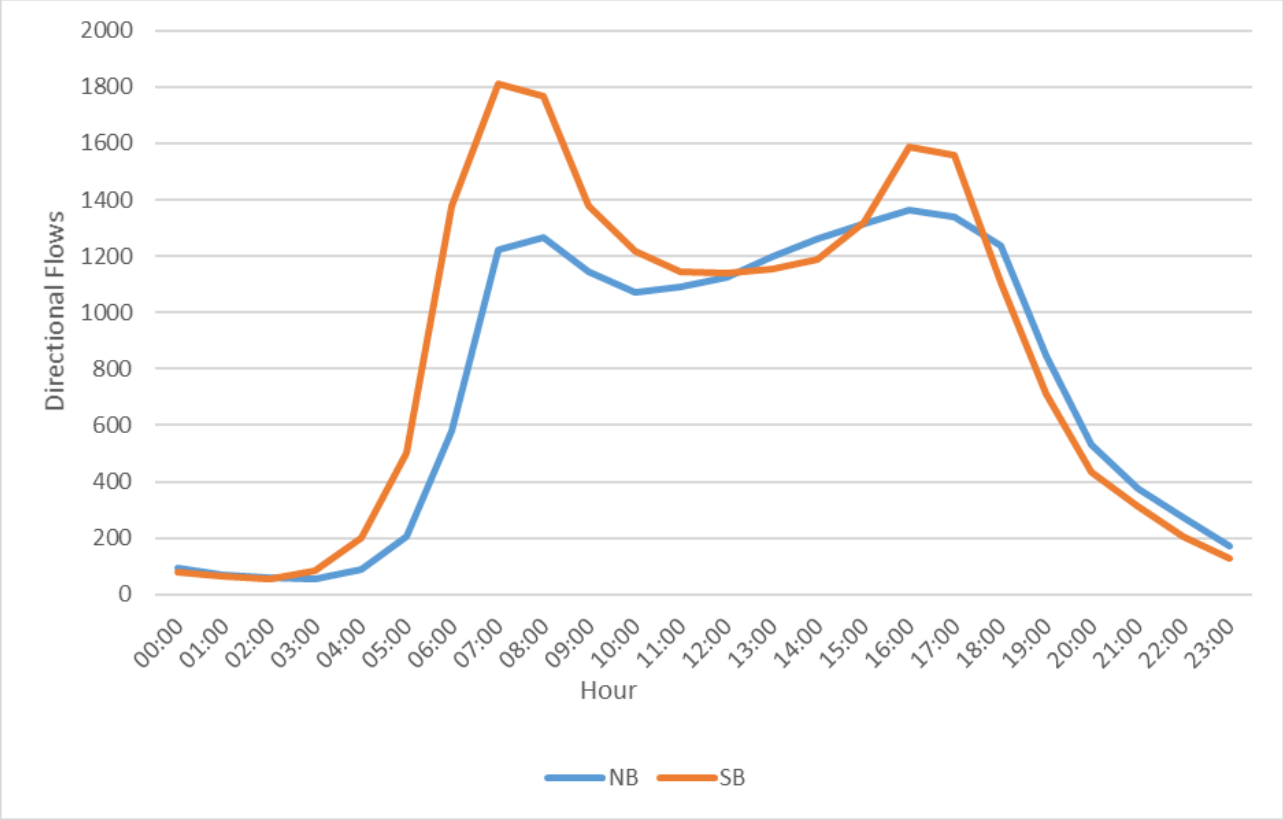
2.2.8. The figure shows a relatively moderate seasonal variation of traffic volumes across the year. Peak traffic levels occur in June and July, while the lowest flows occur in December and January.

2.2.9. Notable directional variations in total daily traffic volumes are apparent, with northbound flows on Crickley Hill typically 10-15% lower than the southbound direction. The variation in directional flows is reflective of congestion along this section of the A417 route. Northbound traffic on the A417 experiences delays for much of the day, while southbound traffic typically experiences less delay, and journey times are more consistent throughout the day.

2.2.10. As a result of the larger delays typically encountered by northbound traffic, 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 A417 at Birdlip and travel along Birdlip Hill and Ermin Way through the village of Little Witcombe. This traffic rat-running through villages causes difficulties for local communities.

2.2.11. Figure 2.3 shows the hourly weekday traffic flows, by direction, in February 2016 on Crickley Hill.

Figure 2.3: A417 Crickley Hill weekday traffic flows, by direction and hour (February 2016)



2.2.12. The above figure clearly identifies morning and evening peak periods for southbound traffic, but the peaks for northbound traffic are far less pronounced with relatively little variation in flows in the 12-hours between 07:00 and 19:00. The northbound peak flows are also lower than the southbound flows. This is likely to be reflective of a lack of northbound capacity along the Missing Link, particularly at the Air Balloon roundabout and on Crickley Hill, which restricts the volumes of traffic travelling northbound on this section of the A417, in particular during peak hours.

Congestion and stress

2.2.13. To summarise the performance of the single-carriageway section of the A417 the Congestion Reference Flow (CRF) and link 'stress factor' in the existing situation on Crickley Hill have been calculated using methodology outlined in the Design Manual for Roads and Bridges (Volume 5, Section 1, Part 3 TA 46/97).

2.2.14. The CRF is an estimate of the daily volume of traffic at which a road is likely to be congested in the peak periods on an average day. It provides a measure of the performance of a link, excluding the impact of junctions. The 'stress' factor is simply the ratio of the Annual Average Daily Traffic (AADT) flow over the CRF, with ratios exceeding 0.85 typically indicating

that the link in question will experience congestion and disruptions in flow during peak periods.

2.2.15. Table 2.1 identifies the CRF and 'stress' factor on the Crickley Hill section of the A417. With a 'stress' factor in excess of 0.85, it can be concluded that this single-carriageway section of the road is likely to experience congestion during the peak periods – this accords with observations in the local area.

Table 2.1: A417 Crickley Hill CRF and stress factor – existing conditions (2015)

Section	CRF	AADT (2015)	Stress Factor
A417 Crickley Hill	39,683	37,170	0.94

Impact on other routes

2.2.16. The constrained capacity, and resulting delays, on the Missing Link section of the A417 encourages traffic to find alternative routes on minor roads and through local villages.

2.2.17. The most highly trafficked local rat-runs are the routes via Elkstone towards Cheltenham and via Birdlip Hill towards Gloucester. Whilst these are the busiest local rat-runs in terms of total traffic flows, other rat running routes are understood to be used, including a route via Brimpsfield and Birdlip villages.

2.2.18. Throughout large parts of a typical day, traffic flows on these local roads are very low but during the peak hours when the A417 is particularly congested, flows increase markedly. This type of traffic flow profile in which the peaks are very pronounced is typically observed on roads used by rat-running traffic.

2.2.19. Two examples of daily traffic profiles are provided in Figure 2.4 for the minor road south of Elkstone and in Figure 2.5 for the minor road between Cowley roundabout and Brimpsfield. Both figures present average weekday traffic flows from an Automatic Traffic Count (ATC) undertaken in November 2016 and clearly demonstrate the pronounced peaks in traffic on these local roads.

Figure 2.4: Elkstone weekday traffic profile, by direction and hour

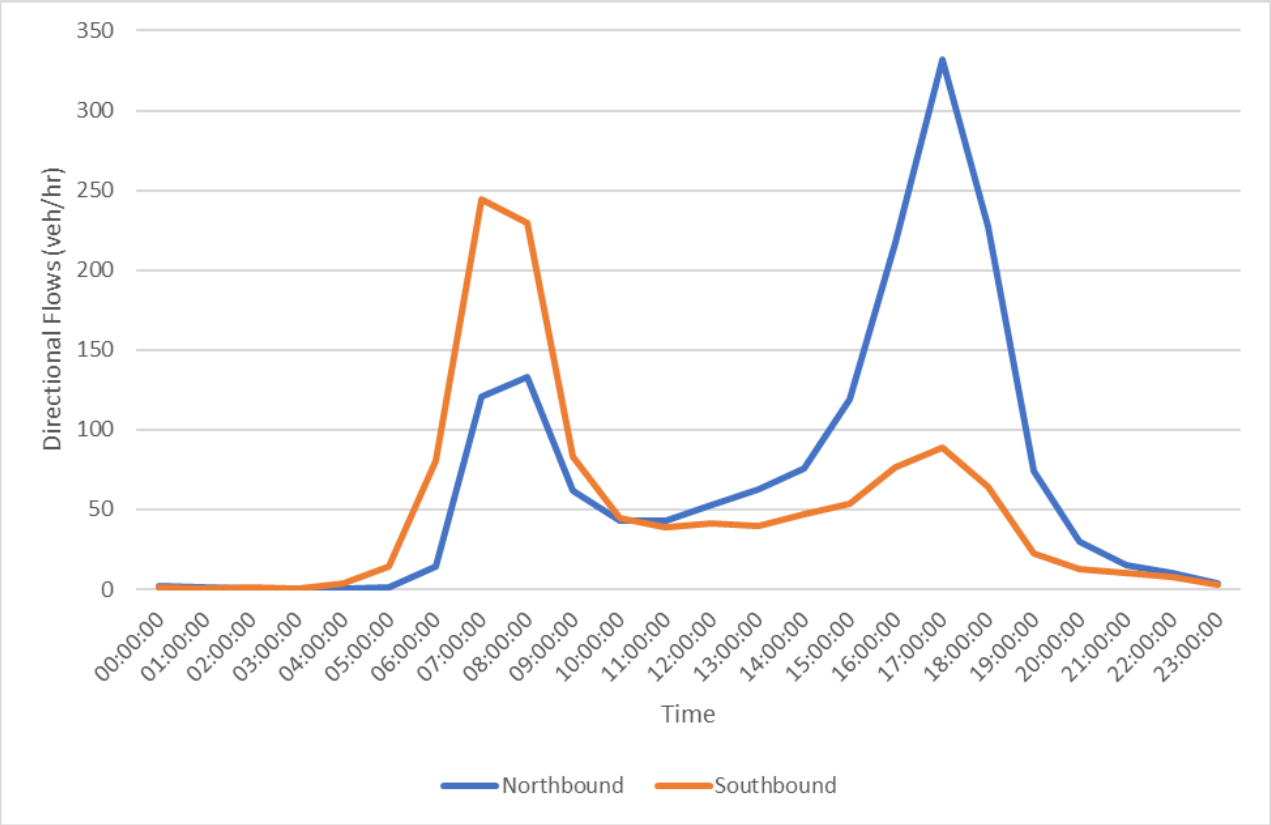
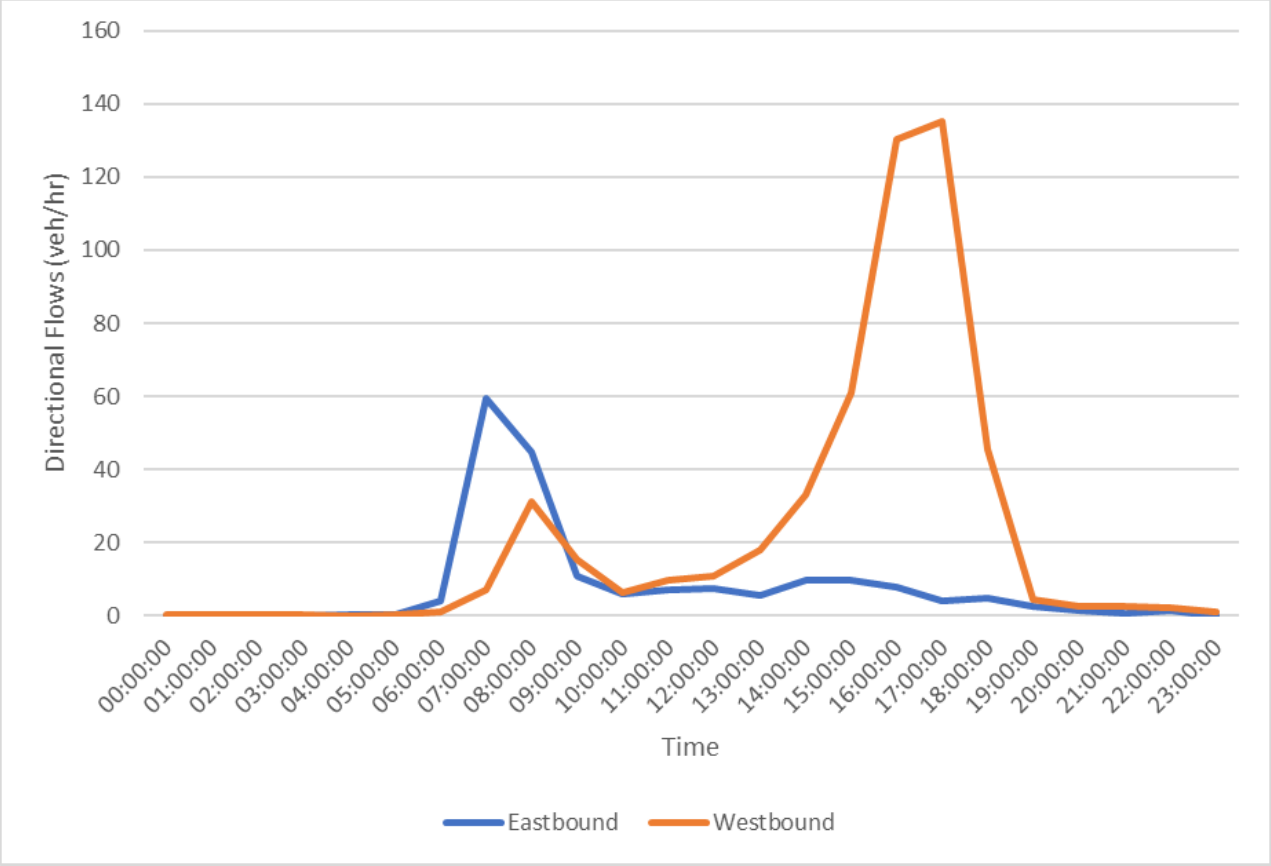


Figure 2.5: Brimpsfield weekday traffic profile, by direction and hour



2.2.20. The route via Brimpsfield, and particularly the section between Cowley roundabout and Brimpsfield village, is a very narrow lane with limited opportunities for opposing vehicles to pass one another. Throughout large parts of the day, total flows are lower than ten vehicles per hour in each direction but increase to nearly 140 for two hours between 16:00 and 18:00. Such traffic volumes are clearly unsuitable for such a narrow lane.

2.2.21. Table 2.2 summarises the proportion of total weekday traffic that occurs in the busiest hour and also the busiest three-hour period on the three rat-run routes discussed above. In addition, the equivalent values are presented for the section of the A417 south of Air Balloon for comparison purposes.

Table 2.2: Summary of traffic flow profiles in peak hours and periods

Location	Direction	% of total weekday traffic in:	
		Busiest hour	Busiest three-hour period
Birdlip Hill	Eastbound	16.2%	34.9%
	Westbound	14.6%	37.1%
Elkstone	Northbound	20.3%	47.4%
	Southbound	20.2%	46.1%
Brimpsfield	Eastbound	31.8%	61.5%
	Westbound	26.1%	60.1%
A417 (south of Air Balloon)	Northbound	7.5%	20.9%
	Southbound	8.2%	22.7%

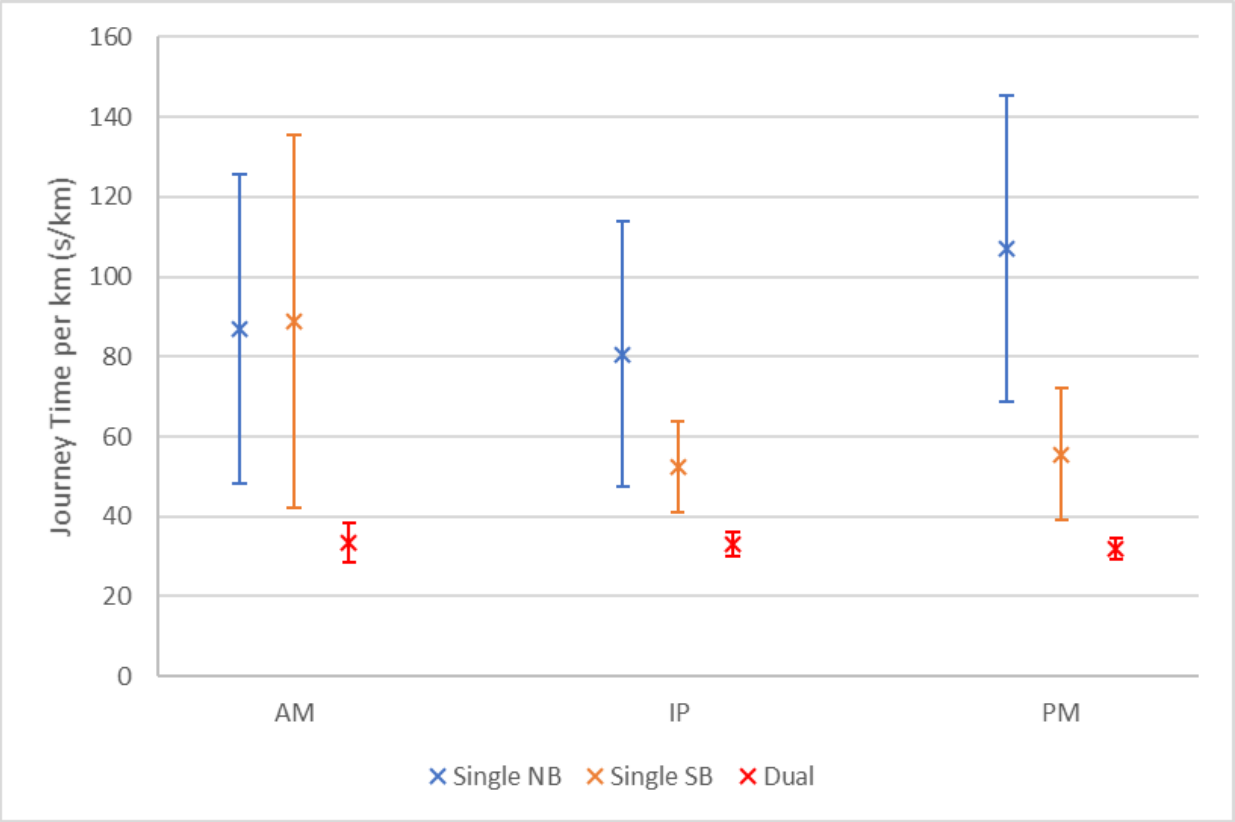
2.2.22. In comparison to the relatively ‘flat’ flow profiles observed on the A417, the peaks in traffic flows on the local rat-run routes are far more pronounced.

Journey times and reliability

2.2.23. Trafficmaster journey time data for the period from September 2014 to the end of August 2015 has been processed for the existing single-carriageway section of the A417. In addition, the data has been processed for an existing dual-carriageway section near Cirencester for comparison purposes.

2.2.24. Figure 2.6 presents the observed average journey times (in seconds per kilometre), by period, for the respective sections. The variability in journey times (in this case the standard deviation) are also indicated on the figure for each section and each period.

Figure 2.6: A417 Average journey times and variability



2.2.25. The figure illustrates that journey times on the single-carriageway sections are typically at least two or three times slower than the dual-carriageway section near Cirencester. The single-carriageway sections are also subject to significantly more variability than the dual-carriageway.

2.2.26. The northbound single-carriageway section is typically slower than the southbound equivalent, which is likely to be a result of the lower capacity in this direction at both the Air Balloon roundabout and on Crickley Hill.

Accidents

2.2.27. The high volumes of traffic, poor forward visibility and steep gradients contribute towards a particularly poor safety record on the existing single-carriageway section of the A417. Accident severity is particularly high on this section, with the number of killed and seriously injured casualties (KSIs) being much higher than the national average for this category of road.

2.2.28. Personal Injury Accident (PIA) data have been obtained for the latest five-year period (01/05/2013 to 30/04/2018) for the existing single-carriageway section of the A417 between Brockworth bypass and Cowley roundabout.

2.2.29. Figure 2.7 identifies the location and severity of these PIAs (only PIAs on the existing single-carriageway section are shown). Table 2.3 summarises the number of accidents and casualties throughout the five-year period.

Figure 2.7: Location of personal injury accidents

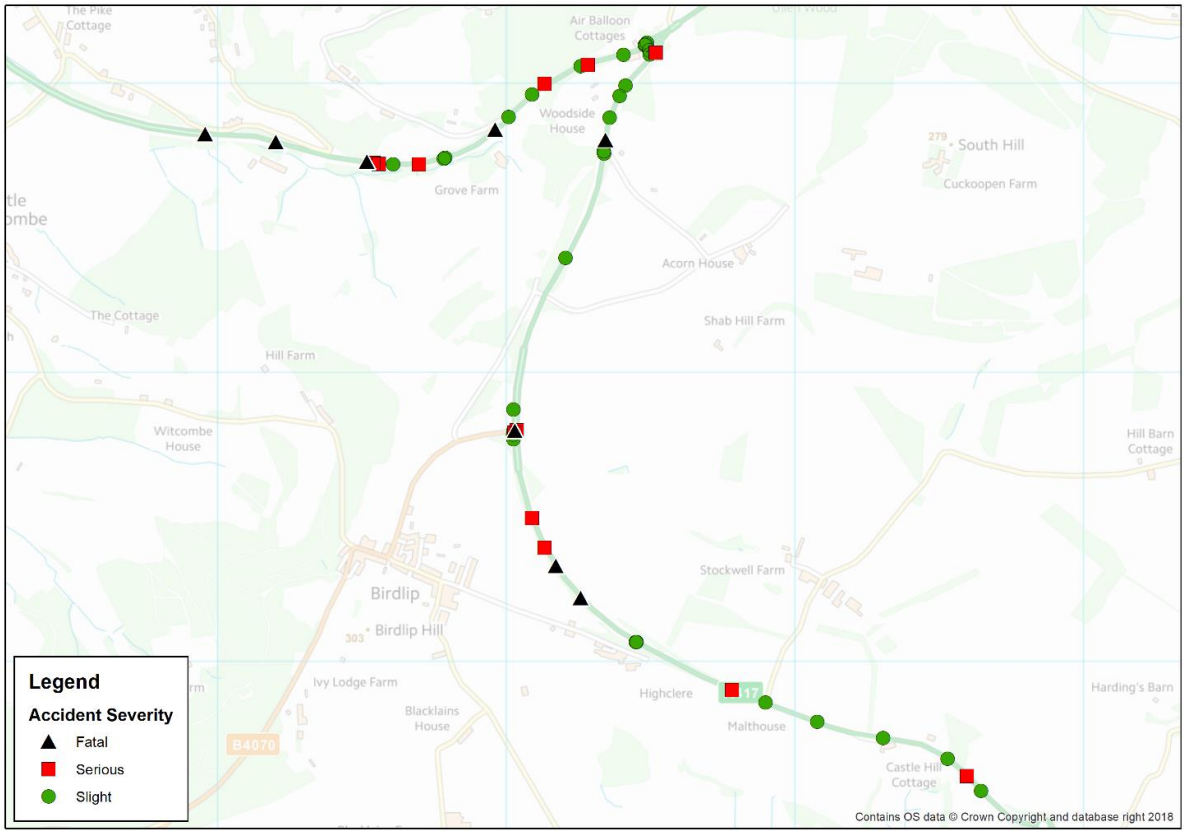


Table 2.3: Accidents and casualties by severity and year

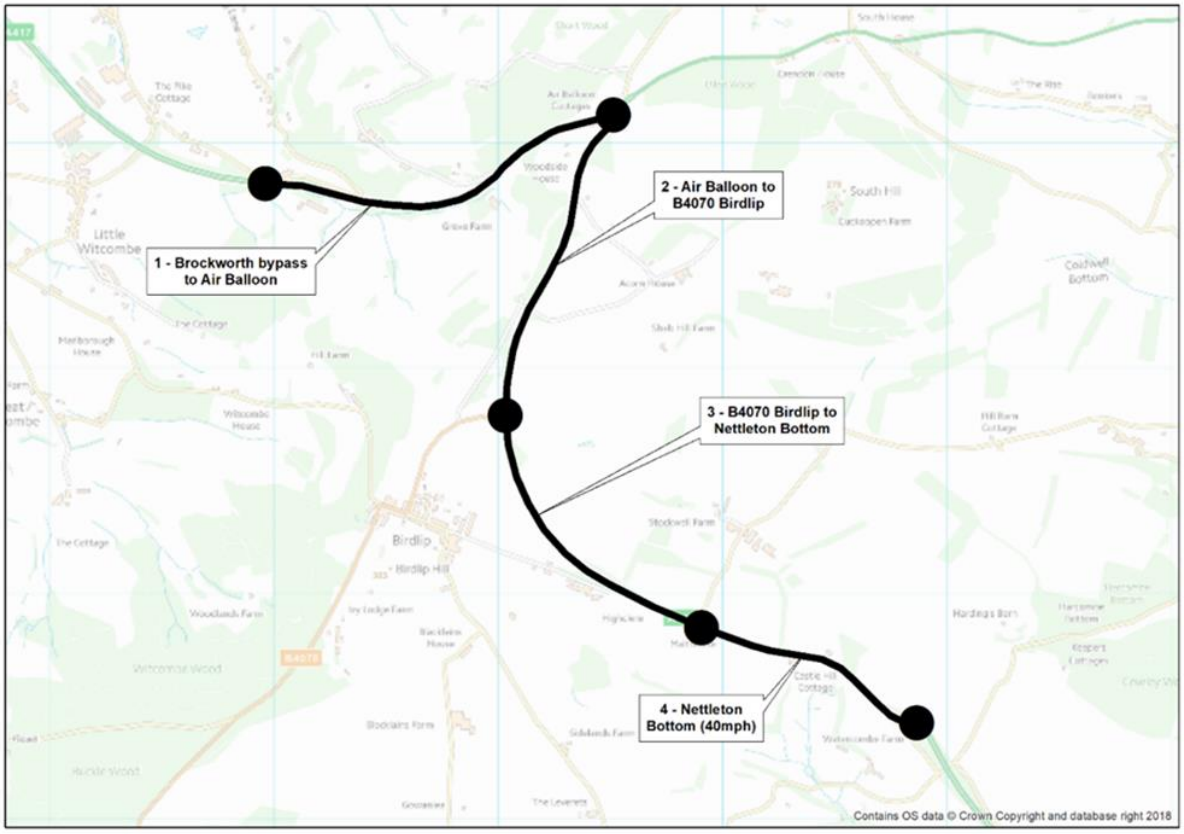
	Accidents				Casualties			
Year*	Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
2013/14	4	2	9	15	5	3	16	24
2014/15	0	1	6	7	0	1	8	9
2015/16	0	4	5	9	0	6	14	20
2016/17	1	3	5	9	1	5	14	20
2017/18	3	2	4	9	4	3	9	16
Total	**8**	**12**	**29**	**49**	**10**	**18**	**61**	**89**

* a year covers the period from 1 May to 30 April inclusive

2.2.30. In the five-years to the end of April 2018, there were 49 PIAs, including eight fatal and 12 serious accidents. The 49 accidents resulted in a total of 89 casualties, of which ten were fatalities and a further 18 were seriously injured.

2.2.31. The existing single-carriageway section has been further split into the sub-sections shown in Figure 2.8 to further demonstrate the PIAs along the route.

Figure 2.8: A417 Accident sections



2.2.32. The observed casualty rates (number of casualties per PIA) on each of the four sub-sections are presented in Table 2.4.

Table 2.4: Casualty rates per PIA by severity, by A417 section (May 2013 – April 2018)

Section	Total PIAs	Number of casualties				Casualties per PIA			
		Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
Brockworth bypass to Air Balloon	19	4	9	17	30	0.211	0.474	0.895	1.579
Air Balloon to B4070	14	3	3	22	28	0.214	0.214	1.571	2.000
B4070 to Nettleton Bottom	10	3	5	9	17	0.300	0.500	0.900	1.700
Nettleton Bottom (40mph)	6	0	1	13	14	0.000	0.167	2.167	2.333
TOTAL	**49**	**10**	**18**	**61**	**89**	**0.204**	**0.367**	**1.245**	**1.816**

2.2.33. Numerous KSIs have occurred on three of the four sub-sections. The only section experiencing no fatal accidents is through Nettleton Bottom, which is shorter and has a lower speed limit (40mph) than the other sub-sections.

2.2.34. The casualty rates observed on the A417 are significantly higher than the national average for single-carriageway roads, particularly for fatal and serious casualties. This is summarised in Figure 2.9 which presents the observed casualty rates per PIA on the A417 against the national average for equivalent road types.

Figure 2.9: Number of casualties per PIA

2.2.35. Table 2.5 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 (49) but assuming national average casualty rates.

Table 2.5: Casualties per PIA by severity – local and national comparison

	Total PIAs	Casualties			
		Fatal	Serious	Slight	Total
Observations (May 13 - Apr 18)	49	10	18	61	89
National Average	49	1	10	64	75

2.3. Existing highways network

Highway network

2.3.1. The existing A417 between Cowley roundabout and Brockworth bypass is a single-carriageway section on the 53 kilometres A419 / A417 route between junction 15 of the M4 and junction 11a of the M5, which is part of the Strategic Road Network. There are key connections with the A436 at the Air Balloon and the B4070 that connects to Birdlip.

2.3.2. The alignment of the existing route does not meet current standards with steep gradients present along most of the A417 Missing Link. Gradients are up to 10% on Crickley Hill, 7% on Birdlip Hill and up to 10% at Nettleton Bottom. Birdlip Hill forms the steep downhill approach to the Air Balloon roundabout.

2.3.3. The existing A417 varies in lane provision and speed limit between the extents of the route proposals:

- Starting at the Brockworth bypass end, the A417 is Dual 2 Lane All Purpose (D2AP) trunk road with a de-restricted (70mph) speed limit
- At the foot of Crickley Hill the dual-carriageway changes to a Wide Single-Carriageway Climbing Lane Section (WS2) with a 60mph speed limit extending to the Air Balloon roundabout
- Heading south from the Air Balloon roundabout the WS2 continues up to Barrow Wake where the A417 changes to a single-carriageway (S2) whilst maintaining the 60mph speed limit
- Through Nettleton the speed limit drops to 40mph in each direction and then reverts to 60mph and the single-carriageway provision continues to Cowley roundabout
- As part of the exit from / approach to Cowley roundabout, the A417 is once again a D2AP with a de-restriction speed limit

2.3.4. Between the extents of the proposals, at Cowley roundabout and the Brockworth bypass on the existing A417, the road type is of the following classification by approximate percentage:

- D2AP 16%
- WS2 48%
- S2 36%

Junctions

2.3.5. There are five junctions on this section of the A417:

- Major / minor junction (simple T junction) with local road to Cold Slad
- Air Balloon roundabout (A417 and A436)
- Major / minor junction (single lane dualling) with B4070 to Birdlip
- Major / minor junction (simple T junction) with local road to Cowley via Stockwell
- Cowley roundabout (A417 and local road to Cowley and Brimpsfield)

Minor accesses

2.3.6. There are nine minor accesses along this section of the A417 providing access to:

- Private properties on Crickley Hill, opposite the local road to Cold Slad
- The Air Balloon public house car park, one on the western exit to the roundabout and one on the southern approach
- A private property southbound from the Air Balloon roundabout
- Private fields southbound from the Air Balloon roundabout
- The Golden Heart Inn at Nettleton Bottom
- A private property at Nettleton
- Birdlip Quarry at Nettleton
- Private fields opposite Birdlip Quarry

A436 and B4070 road types and speed limits

2.3.7. The A436 is a single-carriageway road with a speed limit of 50mph. However, at the approach to, and exit from, the Air Balloon roundabout the speed limit is 60mph for a distance of approximately 150m.

2.3.8. The B4070 is a single-carriageway road with a speed limit of 60mph and is the approach road to the A417 from Birdlip.

Public Right of Way network

2.3.9. There are 15 footpaths, two bridleways and one byway open to all traffic that connect to the existing A417. In addition, there is one National Trail (Cotswold Way) and one Regional Trail (Gloucestershire Way) that cross the existing A417.

2.3.10. No pedestrian crossing facilities are currently provided (all crossings are uncontrolled and at-grade) and this has resulted in severance of the Public Right of Way (PRoW) network due to the high traffic volumes or speeds on the existing A417.

Maintenance and repair

2.3.11. This section of the existing A417 is currently operated and maintained by a Design Build Finance Operate (DBFO) Contractor. The DBFO contract ends in 2026 and therefore the DBFO Contractor has carried out all major maintenance it considers necessary before hand back. Some further maintenance work may be required as part of inspection and hand back process.

2.3.12. This section of the A417 has been reported to have a history of large snow drifts that have been up to 3m in depth. Residents in the area have been severely impacted and the Local Authority has previously installed snow fencing. In addition, the steep nature of the existing A417 means that ice has been a major issue on Crickley Hill.

2.3.13. Traffic management for maintenance requires lane closures or full road closures as this section is single-carriageway. Traffic management for maintenance has restrictions all year due to the high volumes of traffic and is generally not permitted during the winter period due to risk of adverse weather.

2.3.14. There are two laybys that could be used by the DBFO Contractor for temporary lay down of equipment and vehicles while undertaking maintenance activities.

Road lighting

2.3.15. Road lighting is currently only provided at the Air Balloon and Cowley roundabouts.

Road drainage

2.3.16. The existing A417 from Little Witcombe to the Air Balloon roundabout is kerbed on both sides. There are road gullies primarily along the southbound kerb line with kerbs offsetting into the verge area to accommodate the gullies at various locations. For the section of the carriageway close to the Air Balloon roundabout, the road gullies are located along the northbound kerb line with similar kerb offset arrangement. From assessment made from the Highways Agency Drainage Data Management System (HADDMS), there appears to be drainage pipes located in the verge to collect the surface water from the road gullies. However, the outfalls for the surface water drainage system cannot be identified in the record.

2.3.17. The carriageway from the Air Balloon roundabout to the Cowley roundabout is also kerbed on both sides but with gullies present only on one side in different lengths of the road presumably following the road cross fall along the different sections of the carriageway. From the information available, there appears to be soakaway / ditches with or without filter drains located in the verge at various locations on both sides of the carriageway for collecting the surface water from the road gullies. This suggests that the surface water run-off for this section of the road may be discharged through infiltration.

2.3.18. A previous drainage strategy report prepared in 2005 for the A417 Cowley to Brockworth bypass improvement project has also been reviewed. The report identifies that there are 16 main discharge locations along the A417 trunk road between the Cowley roundabout and the Brockworth bypass. Approximately 46% of the surface water run-off from this section of the A417 discharges via a series of infiltration ditches and soakaways, with the remaining 54% discharging into open watercourses.

Public utilities

2.3.19. Enquiries were conducted to determine the location of public utilities within the scheme area. Several statutory undertakers were found to have equipment in the area and following further investigations, four statutory undertakers were identified to have equipment that may require protection or diversion depending on the scheme option chosen; these included:

- Openreach
- Gigaclear
- Severn Trent Water

- Western Power Distribution.

2.3.20. Most of the affected utilities are located on Crickley or by the Air Balloon roundabout.

2.4. Environmental

2.4.1. The following section summarises the existing environmental constraints within the study area in relation to the proximity of the specific options and shown in Appendix A - Environmental constraints plan. The options are described in Chapter 6.

Air quality

2.4.2. There is one air quality management area (AQMA) within the study area, Birdlip AQMA, which is located adjacent to the existing Air Balloon roundabout and was designated in 2008 for exceedances of the NO_2 annual mean (which is 40µg/m³) at 68.1µg/m3.

2.4.3. The air quality study area for the scheme is within the boundaries of Gloucestershire County Council, and the district councils of Cheltenham Borough Council, Cotswold District Council, Stroud District Council and Tewkesbury Borough Council.

2.4.4. Cotswold District Council diffusion tube monitoring shows a mixture of exceedances and concentrations within 1µg/m^3 of the annual mean objective for NO_2 across the diffusion tube monitoring sites from 2014 - 2017, including within the Birdlip AQMA.

2.4.5. Diffusion tube monitoring is also undertaken within Gloucestershire County Council, Tewkesbury Borough Council and Cheltenham Borough Council. There are also diffusion tubes located around a section of the M5 within the affected road network (ARN) that are within the Stroud District Council administrative area. There were no measured exceedances at any of these tubes in 2017 and concentrations were generally observed to be decreasing.

2.4.6. A six-month air quality monitoring survey was undertaken by Highways England from January to June 2016. The results from monitoring were bias adjusted and annualised in accordance with the Department for Environment, Food and Rural Affairs Local Air Quality Management Technical Guidance 2016 (TG16). This monitoring survey concluded that NO_2 concentrations within the vicinity of the scheme options are generally well below the annual mean NO_2 air quality objective. The only monitoring

location in exceedance of the annual mean NO_2 objective was at the house opposite the Air Balloon pub within the Birdlip AQMA. The concentration at this site was 41.7µg/m^3. This area is already known to exceed the annual mean objective as demonstrated in Costwold District Council diffusion tube monitoring, and the presence of the Birdlip AQMA.

Cultural heritage

2.4.7. There are seven nationally designated Scheduled Monuments within one kilometre of the options. These are Crickley Hill camp, Dryhill Roman villa, three bowl barrows known as Emma's Grove Round Barrows, Brimpsfield Castle mound, Brimpsfield Castle, moat and fishpond at Bentham Manor, and two bowl barrows, known as Crippet's Wood round barrows.

2.4.8. Approximately 33 nationally listed buildings are located within one kilometre of the options, including one grade I listed building (Church of St Michael at Brimpsfield), numerous grade II listed buildings and one grade II* listed building. These are designated under the Planning (Listed Buildings and Conservation Areas) Act 1990. One Registered Park and Garden has been identified within the extent of the scheme options (Cowley Manor (grade II* listed)).

2.4.9. There are also many records of archaeological events and finds within one kilometre of the scheme options.

Landscape and visual

2.4.10. The study area falls within the Cotswolds Area of Outstanding Natural Beauty (AONB), which is nationally designated under the Countryside and Rights of Way Act 2000 for the purpose of conserving and enhancing the natural beauty of the area. The landscape character assessment of the AONB divides the landscape of the study area into the following character areas:

- Vale
- Scarp
- High Wold (two parts to north and south of the existing A417)
- High Wold Valley (two areas to north and south)

2.4.11. The topography of the landscape varies, with the escarpment forming a dominant feature. The well wooded nature of the area covers the rising landform as it climbs steeply from the neighbouring wolds. Away from woodland blocks, scattered trees pepper the grassland slopes towards more low-lying ground where linear belts of trees and shrubs and

hedgerows define land parcels. Whilst generally rural in character, transport links traversing the landscape introduce detracting features to the landscape. The A417 is the dominant transport feature, although it appears well screened from some areas.

2.4.12. In addition, a Contiguous Upper Scarp Landscape Corridor was identified through the Landscape and Visual Impact assessment work undertaken to date. It encompasses an interconnected landscape network comprising many of the most important and valuable parts of the landscape, including the areas that are most important in determining the character, appearance and value of the Cotswold escarpment. These also include areas of cultural and ecological value and important recreational links. Preservation of its integrity and connectivity is critical to the character and function of the nationally protected landscape. Its severance by the existing route of the A417 harms its current character, value and recreational function.

Biodiversity

2.4.13. Internationally designated sites located within the study area include:

- Cotswold Beechwoods Special Area of Conservation (SAC) (430m to the west of Option 12 and 320m to the west of Option 30)
- Wye Valley and Forest of Dean Bat Sites SAC (22km west of Option 12 and Option 30)

2.4.14. Nationally designated sites located within the study area include:

- Crickley Hill and Barrow Wake Site of Sites of Special Scientific Interest (SSSI) (partially within footprint of Option 12 and immediately adjacent to Option 30)
- Bushley Muzzard, Brimpsfield SSSI (330m west of Option 12 and 460m west of Option 30)
- Knap House Quarry, Birdlip SSSI (270m west of Option 12 and 180m west of Option 30)
- Cotswold Commons and Beechwoods SSSI (430m to the west of Option 12 and 320m to the west of Option 30)
- Leckhampton Hill and Charlton Kings Common SSSI (1.64km north of Option 12 and 1.5km north of Option 30)

2.4.15. Regionally designated sites located within the study area (please note that Gloucestershire County Council refer to Local Wildlife Sites as ‘Key Wildlife Sites’) include:

- Gloucestershire Wildlife Trust Reserves (two sites within 1km of Option 12 and Option 30)
- Key Wildlife Sites (seven sites within 1km of Option 12 and Option 30)

2.4.16. Habitats identified as irreplaceable under the National Policy Statement for National Networks (NPSNN) including ancient woodland and veteran trees include:

- Ullen Wood ancient woodland
- Potential ancient woodland at Emma's Grove
- A veteran tree at Air Balloon

2.4.17. Some ground truthing has been carried out for the Phase 1 habitat surveys, and detailed protected species surveys are currently being undertaken. These surveys commenced in May 2018 and it is anticipated that the results will be available for reporting in March 2019.

2.4.18. Various priority habitats have been recorded within the options' Zone of Influence (ZoI), consisting of: semi-natural broadleaved woodland, plantation woodland, scattered broadleaved trees, scrub, unimproved calcareous grassland, semi-improved calcareous grassland, semi-improved neutral grassland, semi-improved species-poor grassland, improved grassland, marshy grassland, hedgerows, standing water and running water.

2.4.19. Habitat suitability for protected species within the options' study areas consist of suitable habitats for badger, bats, dormouse, otter and water vole, birds, great crested newt, reptiles and terrestrial invertebrates.

2.4.20. Surveys have confirmed the presence of nine species of bat, badger, otter, adder, grass snake, common lizard and slow worm within the study areas of both Option 12 and Option 30. Additionally, great crested newts have been recorded within 500m of Option 12.

Geology and soils

2.4.21. According to the British Geological Survey (BGS) mapping, the topography and landform of the area reflects the underlying geology, which is dominated by the Cotswold escarpment and dip-slope. The bedrock of the area is characterised by rocks of the Jurassic period comprising (from oldest to youngest) the Lias Group, the Inferior Oolite Group and the Great Oolite Group. The escarpment is a significant feature on the landscape defined by the Jurassic Limestone Outcrop at the crest and the scheme is located on the escarpment. The top of the escarpment is underlain by the

Great and Inferior Oolite Groups (the Inferior Oolite is the main scarp-forming rock in this area of the Cotswolds) which dip gently to the south-east. Lower down the escarpment, the Lias Group lies below the Oolite Groups, however it is largely buried by ancient mass movement and instability deposits.

2.4.22. BGS information and previous ground investigation (GI) reporting indicates that the majority of the study area does not appear to be underlain by superficial deposits. A tract of Cheltenham Sand and Gravel is shown to be underlying the western part of the proposed scheme, towards the junction between the A417 and A46, and between Little and Great Witcombe at the base of the escarpment. In addition, Option 12 is shown to be underlain by a small area of Alluvium to the north-west of Cowley roundabout.

2.4.23. Both scheme options cross the area of landslide deposits associated with the Cotswold escarpment. A range of mass movements have disrupted the Cotswolds strata including landslides, cambering, gulls, valley bulging and solifluction caused initially by periglacial processes during the mid-Pleistocene (and understood to have also been active more recently through reactivation of these features).

2.4.24. In terms of hydrogeology, the Great Oolite Group and Inferior Oolite Group are classified as Principal Aquifers[1]. The Charmouth Mudstone Formation, Whitby Mudstone Formation, Bridport Sand Formation, Dyrham Formation and Marlstone Rock Formation are classified as a Secondary (undifferentiated) Aquifer[2]. A groundwater divide is understood to be present in the vicinity of the Cotswold escarpment, with aquifers draining to the Thames Catchment to the east (River Churn and its tributaries) and the River Severn to the west (via River Frome and Horsbere Brook)[82]. However, the exact location of this divide is unknown. The scheme is likely to straddle both the Thames and Severn catchments.

2.4.25. Most groundwater abstraction takes place from the Great and Inferior Oolite further down-dip to the south and east and there is therefore very little data available for boreholes within the study area. Groundwater levels (and saturated aquifer thickness) will be locally influenced by spring discharges and baseflow faults can create additional movement pathways or provide barriers to flow. There are also a number of surface water

[1] www.magic.defra.gov.uk, Multi Agency Geographic Information for the Countryside website, accessed 27/07/18.
[2] https://data.gov.uk/dataset/ef2399f1-acf4-45a7-abf3-c7369c0c8640/aquifer-designation-map-superficialdeposits accessed 16/07/18.

extractions from the Frome and Churn, including a major public water supply abstraction from the River Frome at Chalford.

2.4.26. There are a number of discharge consents within the area including:

- Sewage and trade discharges to underground strata at the Air Balloon Public House
- Crickley Cottages
- Birdlip Wastewater Treatment Works
- Hardings Barn (Cowley)
- A sewage discharge to a tributary of the Horsbere Brook at Greycote & Willow Farm (Little Witcombe)

2.4.27. Several post-1988 Agricultural Land Classification (ALC) surveys[3] have been undertaken within the study area of the two route options (between Crickley Hill and Brockworth either side of the A417). Within the extents of the surveyed area it was confirmed that the majority of the land is Grade 3b, with smaller pockets of Grade 3a Best and Most Versatile (BMV) land. A very small amount of Grade 4 land is also present. Provisional ALC maps (MAFF, 1976)[4] indicate that the majority of land within the study area for the scheme is Grade 3 (which is either Grade 3a (Good quality) or Grade 3b (Moderate quality) land) with a small amount of Grade 4 (Poor quality) ALC land present.

2.4.28. Crickley Hill and Barrow Wake SSSI is partly designated as a site of geological interest and is intersected by both scheme options. This is due to the rock exposures along the southern slopes of Crickley Hill which make up a key Jurassic locality showing a major section in the Lower Inferior Oolite. The site is also designated as a Geological Conservation Review site.

2.4.29. Within 500m of the scheme options there are three designated sites of geological interest:

- Knap House Quarry, Birdlip SSSI is designated due to exposures of Middle Jurassic sediments belonging to the Alenian and Bajocian Stages
- Bushley Muzzard SSSI is an area of marshland which may be impacted by changes in groundwater levels / quality and drainage

[3] Natural England (2015) Agricultural Land Classification (ALC) Grades – Post 1988 Survey (polygons) [online] available at: https://data.gov.uk/dataset/c002ceea-d650-4408-b302-939e9b88eb0b/agricultural-land-classification-alc-grades-post-1988-surveypolygons.
[4] www.magic.defra.gov.uk, Multi Agency Geographic Information for the Countryside website, accessed 27/07/18.

- Cotswold Commons and Beechwoods SSSI includes areas of calcareous pastures (resulting from the underlying limestone bedrock) and disused limestone mines are understood to be present in the area

2.4.30. In terms of potential contamination sources, no records have been found where any region within 500m of the study area has been determined as contaminated land under Section 78R of the Environmental Protection Act (EPA) 1990. However, some areas have been identified as potential sources of contamination. These sources include:

- Areas of potentially infilled land (predominantly former quarries)
- A small agricultural machinery operation located at Grove Farm where fuel and lubricating oils may be stored, and localised areas of raised land are present
- Birdlip Quarry that is currently used as a trials bike practice venue (motorised vehicles)
- A coach hire company and a number of other farm buildings where contamination associated with fuel and oil spills are a possibility (for example a tank at Stockwell Farm)

Material assets and waste

2.4.31. Aggregates produced across Gloucestershire include crushed rock from Carboniferous and Jurassic limestone, sand and gravel mostly made up of sharp sand with small amounts of soft sand, and recycled aggregates from construction, demolition and excavation wastes. The landbank for crushed rock was 24.32 million tonnes at the end of 2016, which indicates that reserves may be available to meet projected demand for just under 17 years. For sand and gravel the landbank was 4.41 million tonnes at the end of 2016, with the remaining length of this landbank being close to six years[5]. Therefore, in terms of the trend in the amount of remaining permitted reserves, in Gloucestershire, these continue to be in decline and now equate to an overall fall of 15% from 2012.

2.4.32. In terms of waste generation, the latest data from the Environment Agency[6] indicated that Gloucestershire produced over 2.4 million tonnes of waste in 2016. England produced over 200 million tonnes of waste in 2016, which was managed in 6,382 permitted waste facilities. With respect to construction and demolition waste, the Environment Agency[6] recorded that no inert construction and demolition waste was deposited in landfill in

[5] Gloucestershire County Council 6th Local Aggregate Assessment 2016.
[6] Environment Agency (2017) Waste Management for England 2016.

Gloucestershire. The ENV23 – Statistics on Waste[7] outlined that 107,557,676 tonnes of non-hazardous construction and demolition waste was generated in England in 2014, of which 91.4% of the non-hazardous waste was recovered.

2.4.33. There are no authorised or historic landfills within the boundary of the scheme extents. There are currently four operational landfills in Gloucestershire:

- Three non-hazardous sites (Hempsted in Gloucester, and Wingmoor Farm West and Wingmoor Farm East near Bishop's Cleve, Tewkesbury Borough)
- One hazardous site (Wingmoor Farm East near Bishop's Cleeve, Tewkesbury Borough)

2.4.34. There are also 19 permitted inert landfill - restoration facilities (including quarries) receiving construction and demolition waste within Gloucestershire[8]. There are 29 permanent, permitted inert waste recycling and recovery facilities in Gloucestershire.

Noise and vibration

2.4.35. Baseline noise in the immediate vicinity of the existing A417 is characterised by traffic noise and as distance increases from the A417 traffic, noise levels reduce but traffic noise remains audible within the majority of the study area. Where the proposed alignment leaves the A417 corridor, background noise levels are likely to be more dominated by local sources, although depending on weather conditions traffic noise may still be audible.

2.4.36. There are six noise Important Areas (nIAs) located within the extent of the scheme options on the existing A436 and A417. These are:

- Three nIAs adjacent to Crickley Hill
- One nIA adjacent to the Air Balloon roundabout and one adjacent to Ullen Wood
- One nIA adjacent to Birdlip Quarry

[7] Defra (2018) ENV23 – UK Statistics on Waste [online] available at: https://www.gov.uk/government/statistical-data-sets/env23-uk-waste-data-and-management (last accessed August 2018).
[8] Gloucestershire County Council (2010) Waste Core Strategy: Technical Paper WCS-A Waste Data (Update 2010) http://www.gloucestershire.gov.uk/media/8107/technical_evidence_paper_wcs-a_data_2010_update-43159.pdf (last accessed August 2018).

2.4.37. Crickley Hill and Barrow Wake SSSI is located within the study area of both scheme options. There are six Key Wildlife Sites and the Cotswold Beechwoods SAC is also located within both scheme option study areas. Other noise sensitive receptors are predominantly residential dwellings.

Population and human health

2.4.38. Video surveys were undertaken at 31 locations within the vicinity of the scheme[9] to obtain a daily count of walkers, cyclists and horse riders (WCH). The survey locations included a mixture of Public Right of Ways (PRoW) and local roads. The counts took place in September 2017 and were undertaken over a period of 14 hours (between 06:00 and 20:00).

2.4.39. In general, a high number of WCH were observed throughout the study area, with a total of 1,472 WCHs counted, though numbers varied substantially from site to site.

2.4.40. Tewkesbury Borough Council's Local Plan, Cotswold District Council's Local Plan and Gloucestershire County Council's Local Plan show there are no areas of development land within the study area of both scheme options at present. However, as the plan is yet to be adopted in the case of Tewkesbury Borough Council, policies may be subject to change and should continue to be reviewed at subsequent stages.

2.4.41. The area encompassing the scheme is rural; there are several residential farms adjacent to the existing A417 and the proposed route. Birdlip has a relatively large number of residential properties, mostly accessed via the B4070. There are also several residential properties on the eastern side of Birdlip, close to Parson's Pitch. There are also nine business properties within the study area, particularly along the existing A417. There are approximately 44 individual farm businesses within the study area[10] for Option 12 and 53 within the study area for Option 30[10].

2.4.42. Several areas of community land and community resources fall within 250m of both scheme extent comprising:

- 417 Bike Park
- Crickley Hill Country Park
- Ullenwood Bharat Cricket Club

[9] Refer to Section 2.10 of the Walking, Cycling and Horse Riding Assessment Report, Mott MacDonald Sweco Joint Venture (November 2017) document reference HE551506-MMSJV-HGN-000-RP-CH 00001.
[10] This is based on a review of known landholders within the 250m study area using Land Registry information and OS aerial imagery (2017).

- Barrow Wake (a scenic viewpoint)
- Barrow Wake car park
- Gloucestershire Way (a national long-distance footpath)
- The Cotswold Way (National Trail)
- Barrow Wake Common Land

2.4.43. In addition, St John Chrysostomom Greek Orthodox Church, located on Dog Lane (approximately 155m north of the A417) falls within 250m of Option 30.

2.4.44. Birdlip Primary School falls just outside of the 250m study area for Option 12.

2.4.45. Health profiles show that cause of death due to respiratory disease in both Badgeworth and Ermin wards is below the national average. The emergency admission rate for Chronic Obstructive Pulmonary Disease (COPD) is below the national average for the Ermin ward, but higher than the national average for Badgeworth ward, although this difference is not significant. The health profile figures for Ermin ward are lower than those for the Badgeworth ward.

2.4.46. Badgeworth ward has a lower proportion of children when compared to district, regional and national averages, whilst the proportion of children in Ermin ward is also slightly lower than district, regional and national averages, but is slightly higher when compared to Badgeworth ward. The proportion of young people (aged between 16 and 24) in Badgeworth ward and Ermin ward are in line with one another and also with Tewkesbury and Cotswold district averages. They are, however, lower when compared to South-West and national averages. The proportion of older people in Ermin ward is in line with the Tewkesbury and South-West averages, slightly higher than the national average and lower than the Cotswold average.

2.4.47. In terms of the working age population, Badgeworth ward has a lower proportion of this group compared to Ermin ward. The national average is higher than Badgeworth and in line with Ermin. The proportion of older people in Badgeworth ward is considerably higher than the national average. The proportion of population in Badgeworth ward with a limiting long-term health problem or disability is largely in line with both the South-West and national averages. The figure for Ermin ward is considerably lower than the Badgeworth ward and lower than both the South-West and national averages.

2.4.48. There are several areas of community land, including public open space, located within the study area of both Option 12 and 30. Such areas provide space for physical activity for people living close to the scheme and further afield.

2.4.49. The Cotswold district has a population of 87,509, of whom 51,218 (59%) are of working age (16-64 years old). Children (aged under 16 years) make up 16% of the population, and older people (over 64 years) make up 25%. The proportion of children is slightly lower than the national average of 19%, whilst the proportion of older people is higher than the national average of 18%. [11]

2.4.50. The proportion of economically active people in the Cotswold district is higher than the regional (south-west) and national averages at 83% (compared to 81% and 78% respectively). Employment in Cotswold is above the regional and national averages at 82% (compared to 78% and 75% respectively) and unemployment is slightly lower than the regional and national averages at 2% (compared to 3% and 4% respectively).

2.4.51. Eighteen of Cotswold's Lower Super Output Areas (LSOAs) are amongst the least deprived in England, and none are in the 20% most deprived in England. Overall, Cotswold ranks as the 267th most deprived of the 326 districts in England[12]

2.4.52. The district of Tewkesbury has a population of 90,332 of whom 53,800 (60%) are of working age (16-64 years old). Children (aged under 16 years) make up 19% of the population, and older people (over 65 years) make up 22%. The proportion of children is the same as the national average, whilst the proportion of older people is higher than the national average of 18%.[13]

2.4.53. The proportion of economically active people in Tewkesbury is considerably higher than the regional (south-west) and national average at 87% (compared to 81% and 78% respectively). Employment in Tewkesbury is above the regional and national average at 85% (compared to 78% and 75% respectively) and that unemployment is in line with the regional and national average at 3% (compared to 3% and 4% respectively).

[11] Office for National Statistics (2018): 'Population estimates – local authority based by single year of age 2017'.
[12] Gloucestershire County Council (2015): 'The English Indices of Deprivation 2015 Cotswold District Summary'.
[13] Office for National Statistics (2018): 'Population estimates – local authority based by single year of age 2017'.

2.4.54. Tewkesbury has two LSOAs that fall within the 20% most deprived in England.[14] Tewkesbury is also the fourth most deprived district in Gloucestershire and ranks as the 262nd most deprived of the 326 districts in England.[15]

Water environment

2.4.55. There are four Water Framework Directive (WFD) surface waterbodies within the study area:

- Horsbere Brook - source to conference of the River Severn
- Frome - source to Ebley Mill
- Churn (source to Perrot's Brook)
- Norman's Brook – source to conference Hatherley Brook

2.4.56. There are three WFD groundwater bodies within the study area:

- Burford Jurassic
- Severn Vale – Jurassic Limestone Cotswolds Edge South
- Severn Vale – Secondary combined

2.4.57. The scheme options are located within 500m of Flood Zones 2 and 3 for the River Frome at the eastern extents of the study area.

2.4.58. The scheme options skirt one Source Protection Zone 3 (SPZ) for a public water supply abstraction located 500m from the scheme.

2.4.59. The Environment Agency's online Flood Map for Planning[16] shows that the scheme options are not within an area benefitting from flood defences nor are they within designated flood storage areas.

Climate

2.4.60. The UK greenhouse gas (GHG) emissions in 2016 had decreased by 41% from 1990 levels. In 2016, UK net CO_2 (carbon dioxide) emissions were estimated at 379 million tonnes, a decrease of 6% in comparison to 2015 levels[17]. In 2016, 26% of UK GHG emissions were from the transport

[14] Gloucestershire County Council (2015): 'Understanding Tewkesbury Borough'.
[15] Gloucestershire County Council (2015): 'The English Indices of Deprivation 2015 Tewkesbury District Summary'.
[16] Environment Agency (2018) Flood Map for Planning. Available at https://flood-map-for-planning.service.gov.uk/, accessed 31/07/2018.
[17] 2016 UK Greenhouse Gas Emissions, Final Figures, Department for Business, Energy and Industrial Strategy, 2018.

sector, becoming the largest contributor, with emissions of 126 $MtCO_2e$ (million tonnes of carbon dioxide equivalent) in 2016.

2.4.61. Gloucestershire County Council CO_2 emissions were estimated to be at 3.7 million tonnes in 2015 with A roads contributing to 14% of this[18].

2.4.62. High-level climate observations for the Midlands[19] (for Met Office data, Gloucestershire is considered to be in the Midlands region) over a 30-year averaging period of 1981-2010 are presented in Table 2.6.

Table 2.6: Climate baseline for Midlands region

Climatic conditions	Climate observations
Temperature	Mean daily minimum temperatures can range from 0°C to 1.5°C in winter, whilst summer daily maximum temperatures are in the region of 22°C.
Rainfall	Atlantic depressions or convection are the source of the majority of rain in the Midlands, particularly in autumn and winter where Atlantic Lows are more vigorous. Annual rainfall in the Cotswolds averages at 800mm. Monthly rainfall is variable but is highest in the winter months. The number of days with rainfall totals greater than 1mm are 30-35 days in winter, dropping to an average of 20-25 days in summer.
Wind	The Midlands is one of the more sheltered parts of the UK. The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter half of the year when mean speeds and gusts are strongest at approximately 10 knots.
Sunshine	Average annual sunshine totals are between 1400 and 1600 hours. Industrial pollution can reduce sunshine amounts however since a decline in heavy industry, there has been an increase in sunshine duration over the industrial midlands.
Air frost	The average number of days with air frost varies from 40 to 60 days per year.

Source: Met Office Regional Climate Data

2.5. Do Nothing consequences

Combined and cumulative effects

2.5.1. Combined and cumulative effects result from multiple actions on receptors over time and are generally additive or interactive (synergistic) in nature. They can also be considered as effects resulting from incremental changes

[18] 2005 to 2015 UK Local and Regional CO2 Emissions, Department for Business, Energy and Industrial Strategy, 2017.
[19] Midlands Climate, The Met Office, 2016.

caused by other past, present or reasonably foreseeable actions together with the project, identified as:

- Combined effects from a single project (the interrelationship between different environmental factors)
- Cumulative effects from different projects (with the project being assessed)

2.5.2. For combined effects, the baseline is obtained from the preceding environmental disciplines.

2.5.3. The 'other developments' for consideration in this assessment have been identified using Cotswold District Council's Local Plan (2011-2031) (Adopted August 2018), Gloucester, Cheltenham and Tewkesbury Joint Core Strategy 2011-2031 (Adopted December 2017), the Traffic Team's Uncertainty Log, and Planning Inspectorate (PINS) Programme of Projects. Furthermore, 'other developments' have been identified by investigating developments on the Cotswold District Council and Tewkesbury Borough Council planning portals. The developments identified to be included within the cumulative effects assessment are contained within Table 2.7.

Table 2.7: 'Other Developments' identified for cumulative effects assessment

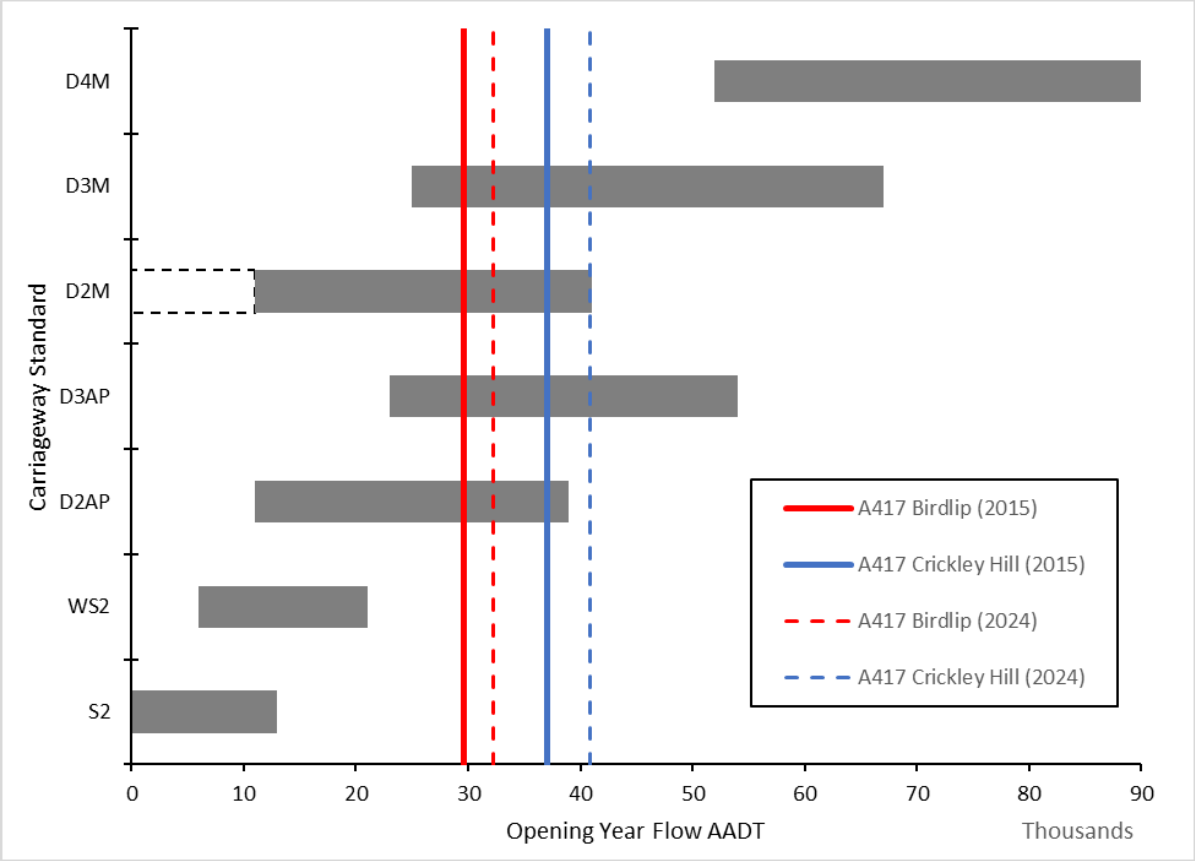
Proposed 'other' development	Description of the 'other development'
Tewkesbury Borough Council: 18/00410/APP	**Other development:** Land at Perrybrook, Brockworth **Site Address:** Perrybrook, Brockworth **Development Description:** Outline application for a mixed-use development of up to 1,500 dwellings, including extra care housing, community facilities including A1, A2, A3, A4 and A5 local retail shops (totalling 2,500m^2), B1/B8 employment uses (totalling 22,000m^2), D1 health facilities and formal and informal public open space (including means of access).
Cotswold District Council: 18/01615/FU	**Other development:** Land at Ullenwood Court, Ullenwood **Site Address:** Ullenwood Court, Ullenwood, Gloucestershire. **Development Description:** Residential re-development consisting of 26 residential (C3) units and associated works.

Traffic flow ranges

2.5.4. The following analysis is based on the A417 Missing Link PCF Stage 2 traffic model.

2.5.5. The Design Manual for Roads and Bridges (DMRB) recommends traffic flow ranges for new rural links based on the Annual Average Daily Traffic (AADT) flows. Figure 2.10 presents the indicative range of traffic flows within which different carriageway standards are likely to be economically justified, alongside 2015 observed and forecast 2024 Do Minimum (without scheme) AADTs for two single-carriageway sections of the existing A417.

Figure 2.10: Opening year AADT flow ranges for different carriageway standards



2.5.6. The 2015 observed daily traffic flows on the Crickley Hill and Birdlip sections of the A417 are around 37,000 and 30,000 respectively, volumes that are already in excess of the recommended maximum for a wide single-carriageway climbing lane section (WS2) road. In the 2024 Do Minimum scenario, the flows are forecast to increase to nearly 41,000 on Crickley Hill and to over 32,000 on the Birdlip section and are therefore clearly in exceedance of the maximum flow for WS2 roads.

Congestion and stress

2.5.7. As traffic flows along the A417 increase in the future, the performance of the single-carriageway section of the route will continue to deteriorate. To illustrate this point, the Congestion Reference Flow (CRF) and 'stress' factors (see paragraph 2.2.13) on Crickley Hill in the 2024 and 2039 Do Minimum scenarios are presented in Table 2.8.

Table 2.8: A417 Crickley Hill CRF and stress factor – Do Minimum scenarios

Section	CRF	AADT		Stress Factor	
		2024	2039	2024	2039
A417 Crickley Hill	39,683	40,900	46,300	1.03	1.17

2.5.8. The forecast 'stress' factors on Crickley Hill start exceeding 1.00 in 2024, which indicates that the link will experience substantial congestion and delays in the peak periods.

2.5.9. It is worth noting that the CRF and 'stress' measures relate only to the performance of a road link and do not account for capacity constraints at junctions. The capacity constraints presented by the at-grade junctions, and the Air Balloon roundabout in particular, will be significant and additional to the constraints associated with over-capacity links on this route.

2.6. Alternative routes

2.6.1. The National Policy Statement for National Networks (NPSNN) identifies that planning of the Strategic Road Network should encourage routes that avoid National Parks, the Broads and Areas of Outstanding Natural Beauty.

2.6.2. The existing A417 carriageway between Cirencester and Brockworth is located entirely within the Cotswolds AONB. As such there is no possible realignment or improvement of the A417 link which avoids the AONB. If alternative routes were available away from the existing A417 corridor, they would be by either alternative modes of transport, or via alternative routes using the strategic road network.

Alternative modes of transport

2.6.3. An assessment has been made of the potential for modes of transport other than highway being suitable to address the problems identified on the single-carriageway section of the A417. The outcome of this study has shown that while a package of alternative mode initiatives could potentially

complement the proposed highway scheme, these alternative measures could not realistically provide an effective solution on their own.

2.6.4. Together, the A417 and A419 make up one of the south-west's most important road corridors. The 33 mile (53km) long route links the M5 at Gloucester (junction 11a) to the M4 at Swindon (junction 15) and is used by a combination of local and long-distance traffic with a wide range of origins and destinations, which stretch across south-east and south-west England, the West Midlands, and South Wales.

2.6.5. The strategic nature of the A417 / A419 corridor is reflected in the dominance of longer distance trips on the route, with average journey lengths of cars currently travelling on the Crickley Hill section exceeding 75 miles (120 km). Over 70% of cars on this section are undertaking journeys of 30 miles (50 km) or further.

2.6.6. Locally, the A417 also provides vital connections to the towns of Cheltenham and Cirencester. The 3 mile (4.8km) section between Brockworth bypass and Cowley roundabout is the final remaining single carriageway section of the otherwise dual-carriageway A417 / A419 route.

2.6.7. The remaining single-carriageway section of the A417 experiences significant problems with traffic congestion as well as having a particularly poor safety record. These issues, and their associated knock-on impacts, would be effectively addressed by the proposed A417 Missing Link scheme.

2.6.8. A key purpose of the proposed highway scheme is to alleviate congestion and delays, which are caused by the demand for travel on the highway network exceeding capacity. The proposed highway scheme addresses this problem directly by providing additional capacity (i.e. increasing supply), which reduces the level of link 'stress' on the route. It also provides a considerably safer modern dual-carriageway that will directly address the poor safety record of the existing route. Theoretically, other modal interventions could address the congestion problem by reducing demand for road travel. However, while reducing highway demand may contribute to fewer accidents (by reducing traffic volumes), such interventions would not address the inherent road safety issues associated with the existing route (i.e. road alignment, steep gradients, poor forward visibility, at grade junctions etc).

2.6.9. Notwithstanding the lack of an alternative mode solution to the inherent safety problems on the A417, to achieve the same level of congestion relief (i.e. an equivalent level of link 'stress') as that provided by the

proposed A417 Missing Link scheme, an alternative mode approach would need to reduce highway demand on the existing route by over 15,000 person trips per day (by 2039). Alternative modal interventions could reduce traffic demand on along the A417 to a degree but attaining a reduction of this magnitude is unlikely to be a realistic prospect without widespread, transformational change in existing public transport infrastructure.

2.6.10. Considering the dominance of medium and longer distance trips currently on the A417 route, the alternative mode most likely to encourage modal shift away from road travel is rail, with non-motorised or local public transport modes (e.g. local bus services) unlikely to be able to achieve anything other than a minor reduction in car travel on the route.

2.6.11. Given the diffuse pattern of users of the existing route, with origins and destinations distributed over a wide area, it is clear that any intervention would need to focus on local, regional and national trip making in order to be effective. Concentrating only on relatively local movements, for example, between Cheltenham and Swindon would only impact on a small fraction of the existing A417 traffic. Of this small fraction of the A417 traffic, improvements to the rail provision would only entice some users onto the rail network with the net result to traffic reductions on the A417 being further watered down. This is illustrated in further detail below.

2.6.12. The line between Swindon, Gloucester and Cheltenham (the South Cotswolds Line) provides the most direct rail alternative to the A417 / A419 highway route and currently operates an hourly service in each direction. While station to station journey times between Swindon and Gloucester (approximately 50-55 minutes) are comparable to car travel times, when station access / egress times are considered, journey times by rail are typically uncompetitive for most journeys. At around 70 minutes, station to station journey times between Swindon and Cheltenham Spa stations are typically slower by rail than by road.

2.6.13. In summary, rail services along the A417 / A419 corridor between Swindon, Gloucester and Cheltenham are generally uncompetitive compared to road travel when service frequency and journey times are considered. This is reflected in existing patronage levels on the line, with broad estimates indicating that a maximum of around 8,000 passengers per day use the line between Gloucestershire and Swindon (due to its commercially sensitive nature, passenger demand data is not readily available and therefore the above estimate has been derived from published peak hour passenger ‘load factors’ and 2019 passenger capacities on the line).

2.6.14. Network Rail has identified the potential to improve journey times on the South Cotswolds line by up to five minutes by amending calling patterns at intermediate stations. While improvements would deliver some modal shift from car to rail, this would be expected to be very modest in comparison to the scale of mode shift necessary to mirror the decongestion benefits associated with the proposed highway scheme. Given the existing levels of rail use, even a doubling of existing rail passenger demand on the line, which would not be feasible without a transformational change in the competitiveness of rail services and a significant increase in rail capacity, would only equate to around one half of the modal shift needed to replicate the levels of congestion relief provided by the proposed highway scheme.

2.6.15. It is also worth reiterating that, due to the diffuse pattern of trips currently using the A417, improvements on the South Cotswolds Line would only impact a small proportion of existing road users. Such improvements would offer little or no benefits to most users of the A417.

2.6.16. Given the above and considering the need to address both the existing levels of congestion and delay, as well as the poor safety record of the single-carriageway section of the A417, it has been concluded that a highways scheme represents the most suitable solution to the existing problems. Therefore, alternative modes of transport are not viable alternatives to the construction of a highways scheme within the Cotswolds AONB.

2.6.17. Highways England will work with Gloucestershire County Council to identify opportunities to improve connectivity for pedestrians, cyclists and horse riders and to ensure Gloucestershire County Council's public transport network is accommodated as the scheme develops.

The strategic road network

2.6.18. The A417 / A419 is a strategic connection between the M5 and the M4. Taking the example of a journey between the M5 near Gloucester and the M4 near Newbury, alternative routes using the existing strategic road network could be considered for long-distance journeys. Two such routes are identified in Table 2.9 below.

Table 2.9: Routes from the M5 near Gloucester, to the M4 near Newbury

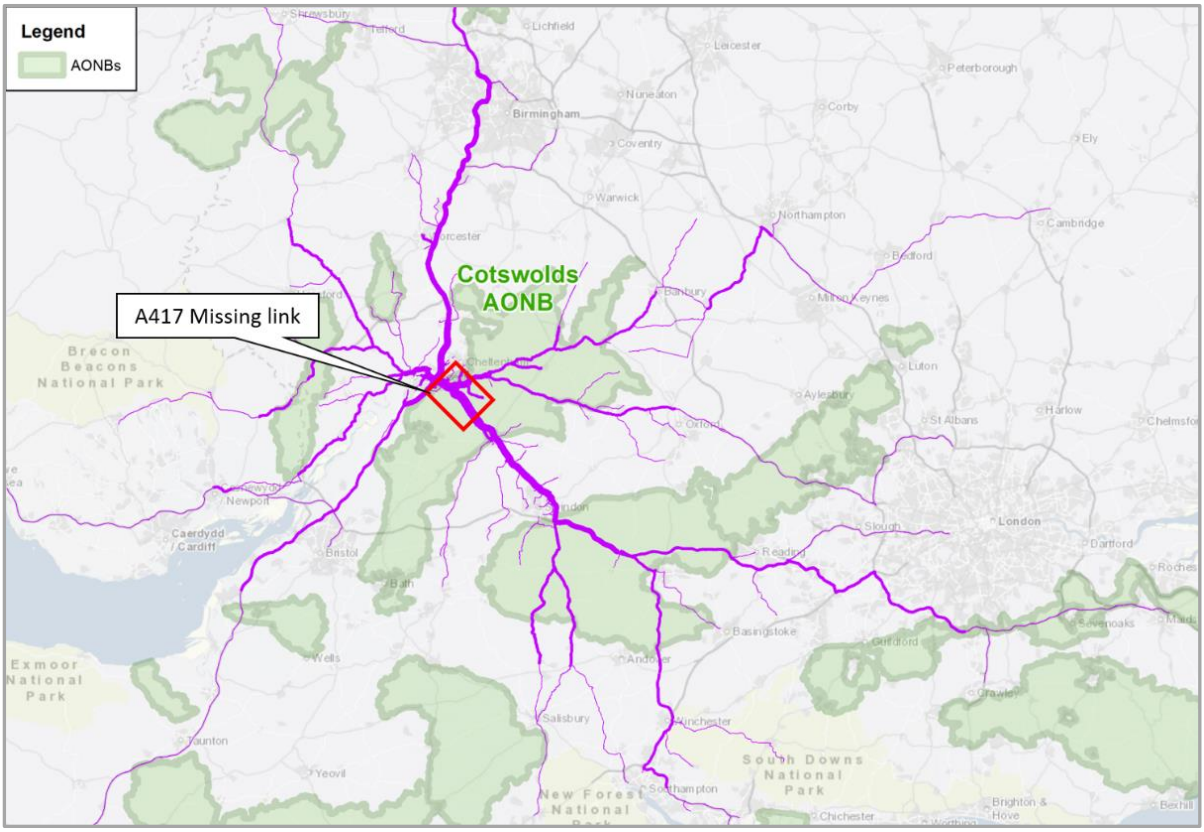
Route	Length	Additional length to the A417 / A419	Notes
A417/A419, then M4 eastbound	54 miles	N/A	The route passes through the Cotswolds AONB

Route	Length	Additional length to the A417 / A419	Notes
M5 southbound, then M4 eastbound	88 miles	34 miles	The route passes through the Cotswolds AONB (M4 to the north of Bath)
M5 Northbound, then M42 northbound, then M40 southbound, then A34 southbound, then M4 eastbound	128 miles	74 miles	The route passes through the North Wessex Downs AONB (A34 to the south of Oxford)

2.6.19. Taking the options for journeys above as an example, the alternative routes using the strategic road network would have substantial increases in costs for road users. For the alternative routes to be attractive enough to be used the A417 route would have to be extensively down-graded and the alternatives upgraded to attract and manage the traffic. Both identified alternatives would require additional capacity added to the strategic road network in either the Cotswolds AONB or the North Wessex Downs AONB.

2.6.20. The example of alternative routes above is most relevant for long-distance, north to south journeys. Figure 2.11 shows the routes of journeys using the Crickley Hill section of the A417 Missing Link, with thicker purple lines showing a greater number of journeys.

Figure 2.11 Catchment area and routes of trips using existing A417 Crickley Hill, with AONB boundaries



2.6.21. The figure shows that there is a significant east to west component to the journeys, and that a large amount of the journeys are between the Swindon and the Gloucester / Cheltenham areas. Due to the relatively short distance between the two centres, it is unrealistic for road users to divert to an alternative route on the strategic road network.

Conclusion

2.6.22. The National Policy Statement for National Networks (NPSNN) identifies that routes that avoid National Parks, the Broads and Areas of Outstanding Natural Beauty should be encouraged. In the context of the A417 Missing Link it has been shown that although this would be a desirable outcome, there is no viable alternative which would achieve the scheme objectives to the construction of a new highways scheme between Brockworth Bypass and Cowley Roundabout either through alternative modes of transport or alternative routes on the strategic road network.

2.7. Need for the scheme

2.7.1. The A417 Missing Link experiences high levels of congestion, poor journey time reliability, and a disproportionately high number of traffic incidents which are more severe than comparable roads.

2.7.2. Performance is hindered by the capacity limitations on the single-carriageway sections, with limited forward visibility, steep gradients, multiple minor accesses and two at-grade roundabouts restricting the flow of traffic. This variation in the standard of road from the connecting sections of the A417 contributes to the number of severe traffic incidents and the poor reliability of the route, particularly in winter conditions.

2.7.3. The Air Balloon roundabout is the location of an AQMA where a contributing factor to the designation in that location is the queuing traffic at the roundabout. The existing strategic road network severs a number of Public Rights of Way and other access routes used by walking, cycling and horse riding users.

2.7.4. Traffic growth forecast for a Do Nothing option would exacerbate all of these existing factors, and increase the disruptions caused by an intervention.

2.7.5. There is no alternative transport option that could address these factors together, either within the study area or in the wider strategic network. Therefore there is a need for a highway solution to the A417 Missing Link within the Cotswolds AONB.

3. Planning factors

3.1. Introduction

3.1.1. The scheme is defined as a Nationally Significant Infrastructure Project (please refer to section 3.3) and will seek development consent under the provisions of the Planning Act 2008.

3.1.2. This chapter will provide a comprehensive overview of the legislation and planning policy which is relevant to the scheme, setting out the relevant European Directives, UK legislation and national policy that will need to be complied as part of an application for development consent.

3.1.3. The Client Scheme Requirements (CSR) for the A417 Missing Link at Air Balloon scheme have been developed by Highways England and the Department for Transport, and are aligned with the objectives and vision of Road Investment Strategy 1 (RIS1). The CSR provides high-level information which details transport challenges and issues relevant to the scheme, scheme objectives, project outputs and value for the scheme.

CSR objectives

3.1.4. The specific CSR objectives are to:

- Improve the operation and efficiency of the existing transport networks
- Support economic growth
- Improve connectivity and community cohesion
- Make safety improvements for customers and operational staff
- Deliver capacity enhancements to the strategic road network (SRN)
- Seek to protect and enhance the quality of the surrounding environments for sustainable transport. Minimise the environmental impact of construction, operating, maintaining and improving the network

3.1.5. Throughout the design and delivery stages, the scheme will ensure that customers and communities are fully considered; specifically, this will include:

- Understanding the needs of all customers (including vulnerable users), stakeholders and partners
- Responding to those needs such that the end product delivers an improved customer experience

- Assessing the impact of works on road users and communities, minimising disruption and delivering appropriate mitigating measures. This assessment should look at issues through customers' eyes

Highways England organisational objectives

3.1.6. Organisational objectives are indicated below:

- During construction, the effect on the customer impact Key Performance Indicators (KPI) should be taken into account and close dialogue held with the Regional Intelligence Units (RIU), Operations Directorate (OD) and Gloucestershire County Council to consider traffic delay
- During design, close working with OD to consider future maintenance requirements to ensure the scheme is maintainable in a safe manner
- Current known maintenance requirements are picked up in construction of the scheme and that following completion there is a minimum five-years' maintenance free period to protect customer expectation
- All asset data to be handed over within a reasonable timescale following agreed handover to maintenance
- Act in a manner which it considers best calculated to minimise the environmental impacts of operating, maintaining and improving its network and seek to protect and enhance the quality of the surrounding environment
- Conform to the principles of sustainable development

3.1.7. The Highways England Licence document sets out key requirements that must be complied with by the Licence holder as well as statutory guidance. In complying with Section 4.2 (g) and its general duty under Section 5(2) of the Infrastructure Act 2015 to have regard for the environment, the Licence holder must:

- Ensure that protecting and enhancing the environment is embedded into its business decision-making processes and is considered at all levels of operations.
- Ensure the best practicable environmental outcomes across its activities, while working in the context of sustainable development and delivering value for money.
- Consider the cumulative environmental impact of its activities across its network and identify holistic approaches to mitigate such impacts and improve environmental performance.

- Where appropriate, work with others to develop solutions that can provide increased environmental benefits over those that the Licence holder can achieve alone, where this delivers value for money.
- Calculate and consider the carbon impact of road projects and factor carbon into design decisions and seek to minimise carbon emissions and other greenhouse gases from its operations.
- Adapt its network to operate in a changing climate, including assessing, managing and mitigating the potential risks posed by climate change to the operation, maintenance and improvement of the network.
- Develop approaches to the construction, maintenance and operation of the Licence holder's network that are consistent with the government's plans for a low carbon future.
- Take opportunities to influence road users to reduce the greenhouse gas emissions from their journey choices.

3.2. Key stakeholder objectives

3.2.1. The Cotswolds Area of Outstanding Natural Beauty (AONB) is the largest of 38 AONBs in England and Wales, and the second largest protected landscape in England after the Lake District National Park. In view of its special landscape character, there is a clear need to balance economic and social benefits of an improved road against potentially negative environmental impacts.

3.2.2. The integrated project team have worked closely with key stakeholders represented on the scheme steering group including Gloucestershire County Council, Cotswolds Conservation Board, National Trust, Gloucestershire Local Nature Partnership, Gloucestershire Wildlife Trust and G-First LEP to develop a scheme specific vision statement, four scheme specific objectives and a number of sub-objectives.

3.2.3. The scheme specific vision statement, four scheme specific objectives and associated sub-objectives are identified in Table 3.1 including how they cascade down from the Client Scheme Requirements (CSRs).

Table 3.1 A417 Scheme objectives and sub-objectives

Department for transport road investment strategy
A417 Missing Link at Air Balloon improvement – connection of the two dual-carriageway sections of the A417 near Birdlip in Gloucestershire, taking account of both the environmental sensitivity of the site and the importance of the route to the local economy.

Client Scheme Requirements					
Improve the operation and efficiency of the existing transport network	Support economic growth	Improve connectivity and community cohesion	Safety improvements for customers and operational staff	Deliver capacity enhancements to the strategic road network	Enhance and protect the quality of the surrounding environment while conforming to the principles of sustainable transport
Scheme vision					
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 visitors' enjoyment of the area; improving local communities' quality of life; and contributing to the health of the economy and local businesses.					
Scheme design principles					
Any solution involving a new road must ensure that the scheme is designed to meet the character of the landscape, not the other way round. Any scheme should bring about substantial benefits for the Cotswolds landscape and environment as well as people's enjoyment of the area. Any scheme must have substantially more benefits than negative impacts for the Cotswolds AONB.					
A417 scheme objectives					
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 minimise negative impacts of the 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.	
A417 scheme sub-objectives					
1	Road safety will be improved by designing to current standards and better separating strategic and local traffic.	The scheme will have an identity which reflects, conserves and enhances the character of the local landscape.	The scheme will enhance community cohesion by improving local connectivity and accessibility by helping to separate strategic and local traffic.	The scheme will contribute towards national transport policies that support economic growth.	

2	The scheme will be designed to provide greater road traffic capacity, improved network resilience and better journey time reliability for strategic and local journeys.	The scheme will improve landscape and ecological connectivity through landscape and habitat restoration and creation.	The scheme will reduce rat-running on local roads through provision of a more reliable strategic route with improved capacity, thereby enhancing the amenity of local settlements.	The scheme will complement Development Plans published by local authorities in the region to support regional and local economic growth and prosperity.
3	The scheme will enhance operational efficiency, improve maintenance safety and support best value whole-life cost benefits.	The horizontal and vertical alignments of the scheme will pay due regard to the nature of the local landform.	The scheme will contribute towards community and recreational opportunities through improved provision for motorised and non-motorised users.	The scheme will contribute to the health of the local visitor economy through improved access and visitor experience of the Cotswolds AONB.
4	The scheme will consider appropriate relaxations or departures from highways standards to minimise the environmental impact of the road without compromising safety.	The siting and form of structures, cuttings, embankments and landscape mounding will reflect local topography and landform.	The scheme will minimise road noise by applying sensitive noise mitigation measures where required.	The scheme will minimise disruption to local economic interests and businesses during both construction and operation.
5		The design of structures will be of lasting architectural quality.	The scheme will minimise light pollution through sensitive structural, junction, and lighting design and sign illumination.	The scheme will restore redundant highways land to agricultural, public access, community or nature benefit uses where appropriate.
6		The scheme will avoid significant interruption to groundwater flows or negative impacts on the aquifer, springs and watercourses.	The scheme will improve air quality by reducing pollution from traffic congestion.	The scheme will support the development and employment of local skills in its construction.
7		The scheme will avoid or, where absolutely necessary, minimise the direct loss of National Trust land, other areas owned and managed for conservation, open access land and country parks and at the same time minimise intrusion upon such land.	The scheme will improve continuity of access to the Public Rights of Way network, the Cotswold Way National Trail and the Gloucestershire Way.	The scheme will seek sustainable opportunities to use locally sourced construction materials to support the local economy.
8		The scheme will enable enhanced preservation of heritage assets and their settings and adopt designs that reflect and enhance the historic character of the area.		

3.3. Legislative framework

3.3.1. Key legislative frameworks, both supranational and national, have been identified and outlined below. The identified frameworks encompass both land use planning and environmental legislation and must be complied with in order to gain development consent. International, European and national legislation regarding specific environmental topics is provided in Appendix B.

European legislation

Environmental Impact Assessment Directive (2014/52/EU)

3.3.2. In order to gain development consent, Member States must identify and act on all measures necessary to ensure that projects likely to have significant effects on the environment by their nature, size or location are subject to an Environmental Impact Assessment (EIA). The scheme is likely to be categorised as Annex II development within the EIA Directive.

National legislation

The Planning Act 2008

3.3.3. The scheme is defined as a Nationally Significant Infrastructure Project (NSIP), under section 14 (1) (h) and section 22 of the Planning Act 2008 (PA 2008) (as amended by The Highways and Railway (Nationally Significant Infrastructure Project) Order 2013) (Ref 1) by virtue of the fact that:

- It comprises the construction of a highway
- The highway to be constructed is wholly in England
- The Secretary of State is the highways authority for the highway; and
- The speed limit for any class of vehicle on the highway is to be 50 miles per hour or greater, and the area for the construction of the highway is greater than 12.5 hectares

3.3.4. The Planning Act 2008 sets out the process for the consideration of applications for development consent. Statutory consultation is required as part of an application before submitting to the Secretary of State. Once the application is submitted, the Planning Inspectorate has up to 28 days to decide whether or not the application is accepted for examination.

3.3.5. Section 104 of the Act prescribes which policy documents will be considered as material considerations in the determination of applications referenced as nationally significant infrastructure, these include:

- Any National Policy Statement which has effect in relation to the type of development
- Any appropriate marine policy document
- Any local impact reports
- Any matters prescribed in relation to the type of development to which the application relates to
- Any other relevant matters which the Secretary of State believes are relevant and important to the Secretary of State's decision

3.3.6. As the proposed scheme is for the construction and alteration of a highway in England, the application will be considered primarily against the National Policy Statement for National Networks (NPSNN) (see section 3.4 for further details).

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

3.3.7. The EIA Regulations set out the process of environmental impact assessment for nationally significant infrastructure development and relate specifically to the *Planning Act 2008.* The EIA Regulations (The Infrastructure Planning (EIA) Regulations 2017) set out the procedures to be followed when undertaking environmental impact assessments associated with nationally significant infrastructure development. The objective of EIA is to provide high level assessment of all potential impacts associated with specified development on the environment and to consider any appropriate mitigation that could limit or eliminate its environmental impact.

The Highway and Railway (Nationally Significant Infrastructure Project) Order 2013

3.3.8. The Highway and Railway (Nationally Significant Infrastructure Project (NSIP)) Order 2013 made amendments to the Planning Act 2008 to ensure that highway-related development is only considered a NSIP where it exceeds specific limits or is likely to have a significant effect on the environment. As stipulated within the Planning Act 2008 Section 2, as amended by The Highway and Railway NSIP Order 2013, the relevant thresholds for highways schemes to be considered as NSIPs are outlined below:

- The construction or alteration of a motorway, is 15 hectares
- The construction or alteration of a highway, other than a motorway, where the speed limit for any class of vehicle is expected to be 50 miles per hour or greater, is 12.5 hectares
- The construction or alteration of any other highway is 7.5 hectares

3.3.9. Option 12 would be 47 hectares and Option 30 would be 57 hectares, and therefore would both exceed the thresholds of The Highway and Railway NSIP Order 2013 for the construction or alteration of highways, as permitted under Section 2 of the Planning Act 2008.

3.4. National policy

National Policy Statement for National Networks

3.4.1. The NPSNN sets out the need for, and government's policies to deliver NSIPs on the national road network in England.

3.4.2. The NPSNN sets out the government's vision and strategic objectives for delivering national network that meet the country's long-term needs; supporting a prosperous and competitive economy and improving overall quality of life. The strategic objectives are to deliver networks which:

- Have the capacity and connectivity and resilience to support national and local economic activity and facilitate growth and create jobs.
- Support and improve journey quality, reliability and safety.
- Support the delivery of environmental goals and the move to a low carbon economy.
- Join up our communities and link effectively to each other.

3.4.3. Drivers of need for the development of the national road network have been issued, specifically identifying a need to address road congestion, construct efficient and resilient networks to better support social and economic activity, and to provide a network that is capable of stimulating and supporting economic prosperity.

3.4.4. Without improving the national road network, including its operational performance, it will be difficult to support further economic growth, employment and housing which will ultimately lead to constraints in economic growth and a reduction in quality of life.

3.4.5. Chapter 3 of the NPSNN identifies that in order to be sustainable and to improve people's quality of life, the need for development must be seen in the context of the Government's wider policies on economic performance,

environment, safety, technology, sustainable transport and accessibility, as well as journey reliability and the experience of road - rail users. Wider policies relate to:

- Environmental and social impacts – national road networks should be designed to minimise social and environmental impacts and improve quality of life. In delivering new schemes, the Government expects applicants to avoid and mitigate environmental and social impacts in line with the principles set out in the National Planning Policy Framework (NPPF) and the Government's planning guidance.
- Emissions – government policy supports Ultra Low Emission Vehicles (ULEVs); and predicts that road development on aggregate levels of emissions is likely to be very small.
- Safety – the government's vision and approach to road safety expects schemes to take opportunities to improve road safety by introducing modern and effective safety measures where proportionate.
- Technology – innovative transport technologies can potentially revolutionise travel, improving safety and journey reliability, and reducing costs and environmental impacts associated with scheme construction and operation.
- Sustainable transport – as part of the government's commitment to provide a range of sustainable travel options, applicants are expected to incorporate diverse transport modes in addition to road improvement schemes. This includes investing in developing an inclusive and high-quality cycling and walking environment for walkers, cyclists and horse riders (WCH).
- Accessibility – the most inclusive and accessible transport network should be incorporated into the scheme design, to provide a range of opportunities and choices for its users to access jobs, services and people.
- Road tolling and charging – it is government policy not to introduce national road pricing to manage demand on the strategic road network.

3.4.6. Chapter 4 of the NPSNN focuses on the assessment principles which are applied to NSIP development as it would progress towards achieving Development Consent Order (DCO) status and acquiring planning consent. The statutory framework for deciding NSIP applications, as stipulated within the NPSNN, is set out in Section 104 of the Planning Act.

3.4.7. In considering any proposed development, and when weighing its adverse impacts against its benefits, the Examining Authority and the Secretary of State will take into account:

- Its potential benefits, including the facilitation of economic development, including job creation, housing and environmental improvement, and any long-term or wider benefits
- Its potential adverse impacts, including any longer-term and cumulative adverse impacts, as well as any measures to avoid, reduce or compensate for any adverse impacts

3.4.8. Chapter 5 of the NPSNN outlines the possible impacts that would be relevant to any type of national networks infrastructure and sets out how these impacts should be considered. The sections include:

- Air quality
- Carbon emissions
- Biodiversity
- Waste management
- Civil and military aviation and defence interests
- Coastal change
- Dust, odour, artificial light, smoke, steam
- Flood risk
- Land instability
- The historic environment (this includes impacts on World Heritage Site)
- Land use including open space, green infrastructure, and greenbelt
- Noise and vibration
- Impacts on transport networks
- Water quality and resources

3.5. Other relevant policy and strategy

National Planning Policy Framework

3.5.1. The NPPF[20] was first published on 27 March 2012 and revised on 24 July 2018. It sets out the government's planning policies for England and how these are expected to be applied.

3.5.2. The NPPF presents a consolidated national framework for planning policies concerning sustainable development in the realm of town and country planning, setting out economic, environmental and social principles and priorities. The framework acts as guidance for local planning

[20] Department for Communities and Local Government (March 2018) *National Planning Policy Framework* [on-line] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740441/National_Planning_Policy_Framework_web_accessible_version.pdf (last accessed October 2018).

authorities and decision-makers, both in drawing up locally-prepared plans and making decisions about planning applications, which are determined in accordance with the development plan.

3.5.3. The framework does not contain specific policies for NSIPs. These are determined in accordance with the decision-making framework set out within the Planning Act 2008 (as amended) and relevant national policy statements for major infrastructure, as well as other matters which are relevant. These may include matters set out within the NPPF.

Road Investment Strategy

3.5.4. Formulated by the Department for Transport (DfT), the Road Investment Strategy (RIS1) for the 2015-16 to 2019-20 road period[21] sets out a strategic long-term case for improving the strategic national network within England. Under Section 3 of the Infrastructure Act 2015, the Secretary of State and Highways England are required to comply with the strategy and fulfil the objectives set out within.

3.5.5. The RIS has targeted eight specific performance areas for its long-term aspirations, these are:

- Making the network safer
- Improving user satisfaction
- Supporting the smooth flow of traffic
- Encouraging economic growth
- Delivering better environmental outcomes
- Helping cyclists, walkers and other vulnerable users of the network
- Achieving real efficiency
- Keeping the network in good condition

3.5.6. Within the Road Investment Strategy: Investment Plan, the A417 Missing Link scheme was identified as one of the key investments on the strategic road network.

3.6. Local policy

3.6.1. Local policies of relevance to the scheme include the Cotswold Local Plan (2011-2031), the Gloucester, Cheltenham and Tewkesbury Joint Core

[21] Department of Transport (2015) Road Investment Strategy: for the 2015/16-2019/20 Road Period [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408514/ris-for-2015-16-road-period-web-version.pdf (last accessed October 2018).

Strategy (2011-2031) and the Draft Tewkesbury Borough Plan (2011-2031).

3.6.2. The Cotswold Local Plan was adopted by Cotswold District Council on 3 August 2018.

3.6.3. The Gloucester Cheltenham Tewkesbury Joint Core Strategy will be a key part of the development plan for the area. The Strategy was adopted by each of the boroughs in December 2017.

3.6.4. Tewkesbury Borough Plan is still in the process of being adopted by Tewkesbury Borough Council. The draft version provides site options for future development and draft policies for those areas not covered by national guidance or the Joint Core Strategy.

3.6.5. Although the plans do not contain policies specific to the A417 Missing Link scheme, there are policies within each that may be considered relevant to the scheme (Table 3.2).

Table 3.2: Local plan policies

Local plan policies			
	Cotswold Local Plan	**GCT Joint Core Strategy**	**Draft Tewkesbury Local Plan**
Air quality	Policy EN1 Built, Natural and Historic Environment	Policy SD3: Sustainable Design and Construction	Policy ENV1 Special Landscape Areas
	Policy EN15 Pollution and Contaminated Land	Policy SD14: Health and Environmental Quality	
		Policy INF1: Transport Network	
Cultural heritage	Policy EN1: Built, Natural and Historic Environment	Policy SD7: The Cotswolds Area of Outstanding Natural Beauty	Policy HER1 Development within or in Close Proximity to a Conservation Area
	Policy EN10: Designated Heritage Assets		
	Policy EN11: Historic Environment: Designated Heritage Assets - Conservation Areas	Policy SD8: Historic Environment	Policy HER4 Buildings and Features of Local Historic, Industrial Archaeological or Architectural Interest
	Policy EN12: Historic Environment: Non-designated heritage assets		
Landscape and visual effects	Policy EN4: The Wider Natural and Historic Landscape	Policy SD6: Landscape	Policy ENV1 Special Landscape Areas
	Policy EN5: Cotswolds Area of Outstanding Natural Beauty Policy	Policy SD7: The Cotswolds Area of Outstanding Natural Beauty	Policy ENV2 Landscape Protection Zones
	EN6: Special Landscape Areas		Policy ENV3 Locally Important Open Spaces

Local plan policies			
	Cotswold Local Plan	**GCT Joint Core Strategy**	**Draft Tewkesbury Local Plan**
Geology and soils	Policy EN1 Natural and Historic Environment	Policy SD3: Sustainable Design and Construction	Policy ENV4 Key Wildlife Sites, Strategic Nature Areas and Regionally Important Geological / Geomorphological Sites
	Policy EN8: Biodiversity and Geodiversity: Features, Habitats and Species	Policy SD9: Biodiversity and Geodiversity	
	Policy EN9: Biodiversity and Geodiversity: Designated Sites	Policy SD14: Health and Environmental Quality	
	Policy EN15: Pollution and Contaminated Land		
Biodiversity	Policy EN1: Built, Natural and Historic Environment	Policy SD9: Biodiversity and Geodiversity	Policy ENV4 Key Wildlife Sites, Strategic Nature Areas and Regionally Important Geological / Geomorphological Sites
	Policy EN7: Trees, Hedgerows and Woodlands	Policy INF3: Green Infrastructure	Policy ENV5 Ponds
	Policy EN8: Biodiversity and Geodiversity: Features, Habitats and Species		Policy ENV6 Orchards
	Policy EN9: Biodiversity and Geodiversity: Designated Sites		

Local plan policies			
	Cotswold Local Plan	**GCT Joint Core Strategy**	**Draft Tewkesbury Local Plan**
Materials		Policy SD3: Sustainable Design and Construction	
Noise and vibration	Policy EN15 Pollution and Contaminated Land	Policy SD3: Sustainable Design and Construction	Policy ENV1 Special Landscape Areas
		Policy SD14: Health and Environmental Quality	
		Policy INF1: Transport Network	
Population and human health	Policy INF2: Social and Community Infrastructure	Policy SD14: Health and Environmental Quality	Policy TRAC1 Cycle Network & Infrastructure
			Policy TRAC2 Pedestrian Accessibility
	Policy INF7: Green Infrastructure	Policy INF4: Social and Community Infrastructure	Policy RCN1 Outdoor Playing Space
			Policy RCN3 Horse Riding Facilities

Local plan policies			
	Cotswold Local Plan	**GCT Joint Core Strategy**	**Draft Tewkesbury Local Plan**
Road drainage and water environment	Policy EN15: Pollution and Contaminated Land	Policy SD3: Sustainable Design and Construction	Policy SD3 – Sustainable Design and construction
	Policy EN14: Managing Flood Risk	Policy INF2: Flood Risk Management	Policy INF2 Flood Risk Management
Climate	Policy EN1: Built, Natural and Historic Environment	Policy SD3: Sustainable Design and Construction	Policy SD4: Sustainable Design and Construction
	Policy EN14: Managing Flood Risk		

Cotswold AONB management plan

3.6.6. The Cotswold AONB Management Plan[22] (2018 – 2023) is a policy document, setting out the vision, outcomes and policies that would be applied to the management of the AONB. The management plan was adopted by the Cotswold Conservation Board on the 20 September 2018. Table 3.3 summarises the policies of adopted management plan that are relevant to the scheme.

Table 3.3: Summary of the Cotswold AONB management plan policies

Cotswold AONB Management Plan (2018-2023)	
Policy CE1: Landscape	1. Proposals that are likely to impact on, or create change in, the landscape of the Cotswolds AONB, should have regard to, be compatible with and reinforce the landscape character of the location, as described by the Cotswolds Conservation Board's Landscape Character Assessment and Landscape Strategy and Guidelines. 2. Proposals that are likely to impact on, or create change in, the landscape of the Cotswolds AONB, should have regard to the scenic quality of the location and its setting and ensure that views - including those into and out of the AONB – and visual amenity are conserved and enhanced.
Policy CE11: Major Development	1. Proposals for major development in the Cotswolds AONB and in the setting of the AONB, including site allocations in Local Plans, must comply with national planning policy and guidance and should have regard to – and be compatible with – the guidance on major development provided in Appendix 9 of the Cotswolds AONB Management Plan. 2. Any major development proposed in the Cotswolds AONB, including major infrastructure projects, should be 'landscape-led', whereby it demonstrably contributes to conserving and enhancing the natural beauty of the Cotswolds AONB and, where appropriate, to the understanding and enjoyment of its special qualities. This should include fully respecting and integrating the special qualities of the AONB into the planning, design, implementation and management of the development, from the very beginning of the development's inception. 3. The A417 Missing Link scheme should be an exemplar of the 'landscape-led' approach outlined this policy.
Policy CE12: Development Priorities and Evidence of Need	1. Development in the Cotswolds AONB should be based on robust evidence of local need arising from within the AONB. Priority should be given to maintaining and enhancing local community amenities and services and improving access to these amenities and service.
Policy CE6: Historic Environment and Cultural Heritage	1. The historic environment and cultural heritage of the Cotswolds AONB, both designated and undesignated should be conserved and enhanced through effective management.

[22] Cotswold Conservation Board (2018) Cotswold Area of Outstanding Beauty Management Plan 2018-2023 [online] available at: https://www.cotswoldsaonb.org.uk/wp-content/uploads/2018/10/Cotswolds-AONB-Management-Plan-2018-2023.pdf (last accessed October 2018).

Cotswold AONB Management Plan (2018-2023)	
Policy CE7: Biodiversity	1. Biodiversity in the Cotswolds AONB should be conserved and enhanced by establishing a coherent and resilient ecological network across the Cotswolds AONB and in its setting. 2. Proposals that are likely to impact on the biodiversity of the Cotswolds AONB should provide a significant net-gain in biodiversity, particularly with regard to the species and habitat.
Policy CE10: Development and Transport - Principles	1. Development and transport in the Cotswolds AONB and in the setting of the AONB should have regard to – and help to deliver – the purposes of conserving and enhancing the natural beauty of the AONB and increasing the understanding and enjoyment of the AONB's special qualities. They should also contribute to the economic and social well-being of AONB communities.

4. Option identification, sifting and appraisal (PCF Stage 1)

4.1. Introduction

4.1.1. The following section provides an overview of the Project Control Framework (PCF) Stage 1, Option identification sifting process, associated assessment and stage conclusions. For full details refer to the Technical Appraisal Report found at https://highwaysengland.citizenspace.com/he/a417-missing-link/supporting_documents/A417%20Technical%20Appraisal%20Report.pdf.

4.2. Sifting methodology

4.2.1. A four-step process (Table 4.1) was followed to identify options for a solution to the A417 Missing Link and then reduce those options down to a number of routes for full assessment, and to inform the choice of routes to be taken forwards for public consultation.

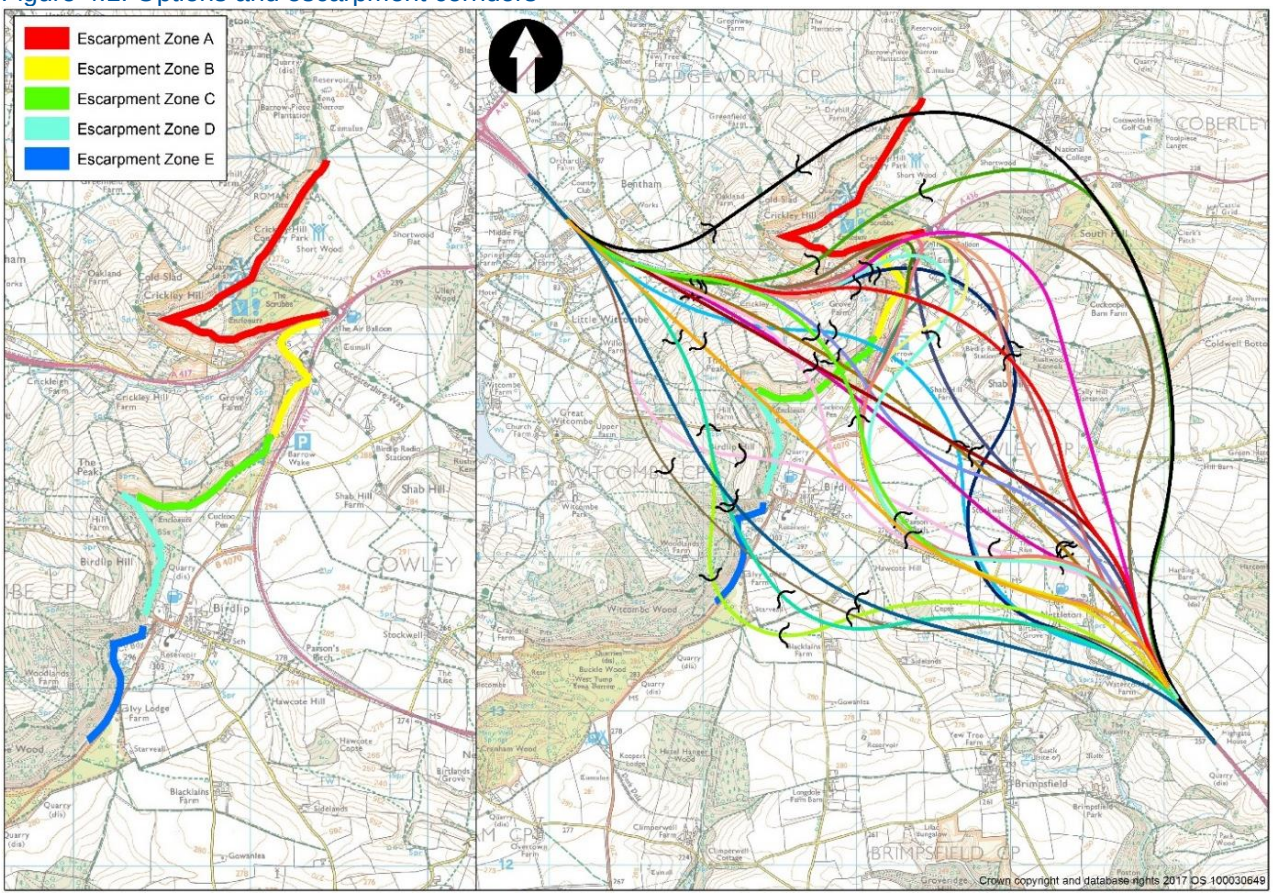
Table 4.1: Sifting methodology steps

Sifting steps	Assessment work
Step 1	Development and categorisation of options as described in section 4.3.
Step 2	Engineering assessment of viability of options, see section 4.4.
Step 3	Assessment of remaining routes using Early Assessment and Sifting Tool (EAST) Plus methodology, see section 4.5.
Step 4	Assessment of highest scoring routes on value for money and affordability, see section 4.6.

4.3. Step 1 – Initial option identification

4.3.1. The A417 Missing Link on the Cotswold escarpment has been the subject of a number of studies since 2001. These past studies were used as a source of route options as well as routes generated at a value management workshop held on the 5 October 2016 between Highways England (with their suppliers) and stakeholders. This process generated 30 initial options, a combination of surface and tunnel route options, as shown in Figure 4.1 below.

Figure 4.1: Options and escarpment corridors



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

4.3.2. The initial 30 options were categorised into five escarpment corridors, A, B, C, D and E, based on where the surface or tunnel options run across and down the escarpment.

4.4. Step 2 – Engineering assessment

4.4.1. To ensure that options to be progressed offer an improvement to the geometry of the existing route, the routes were assessed against the relevant current design standards for tunnels and dual-carriageways.

4.4.2. Ten of the initial 30 options were removed during this stage, with 20 progressing to step 3.

4.5. Step 3 – Early assessment and sifting tool plus assessment

4.5.1. The Early Assessment and Sifting Tool (EAST) Plus methodology used for this stage of the sifting is a version of the standard Department for Transport (DfT) tool for early stage sifting. The standard EAST tool is used to qualitatively assess each option against a series of questions and criteria. The tool was modified for the A417 to provide a ranking between options, and to include additional criteria to represent the scheme specific objectives developed

collaboratively with stakeholders to reflect a landscape-led approach to scheme development.

4.5.2. The results of this assessment were used to take a broad range of options through for appraisal. The top scoring options from escarpment corridor B, C, D and E were taken forward. The three routes within escarpment corridor A scored poorly, particularly against environmental objectives, and were therefore discounted. In the place of a route from escarpment corridor A, the top scoring surface route was progressed. The five options taken for full assessment at this step were options 3, 21, 24, 29 and 30.

4.6. Step 4 – Value for money and affordability assessment

4.6.1. In autumn 2017, a cost range for the scheme was set at £250 million to £500 million. At the same time, the results of the economic appraisal on Options 3, 21, 24 and 29 showed that tunnel options were going to provide poor value for money, with a high cost exceeding the cost range for the scheme. In comparison, the surface route (Option 30), provided positive value for money and was within the cost range.

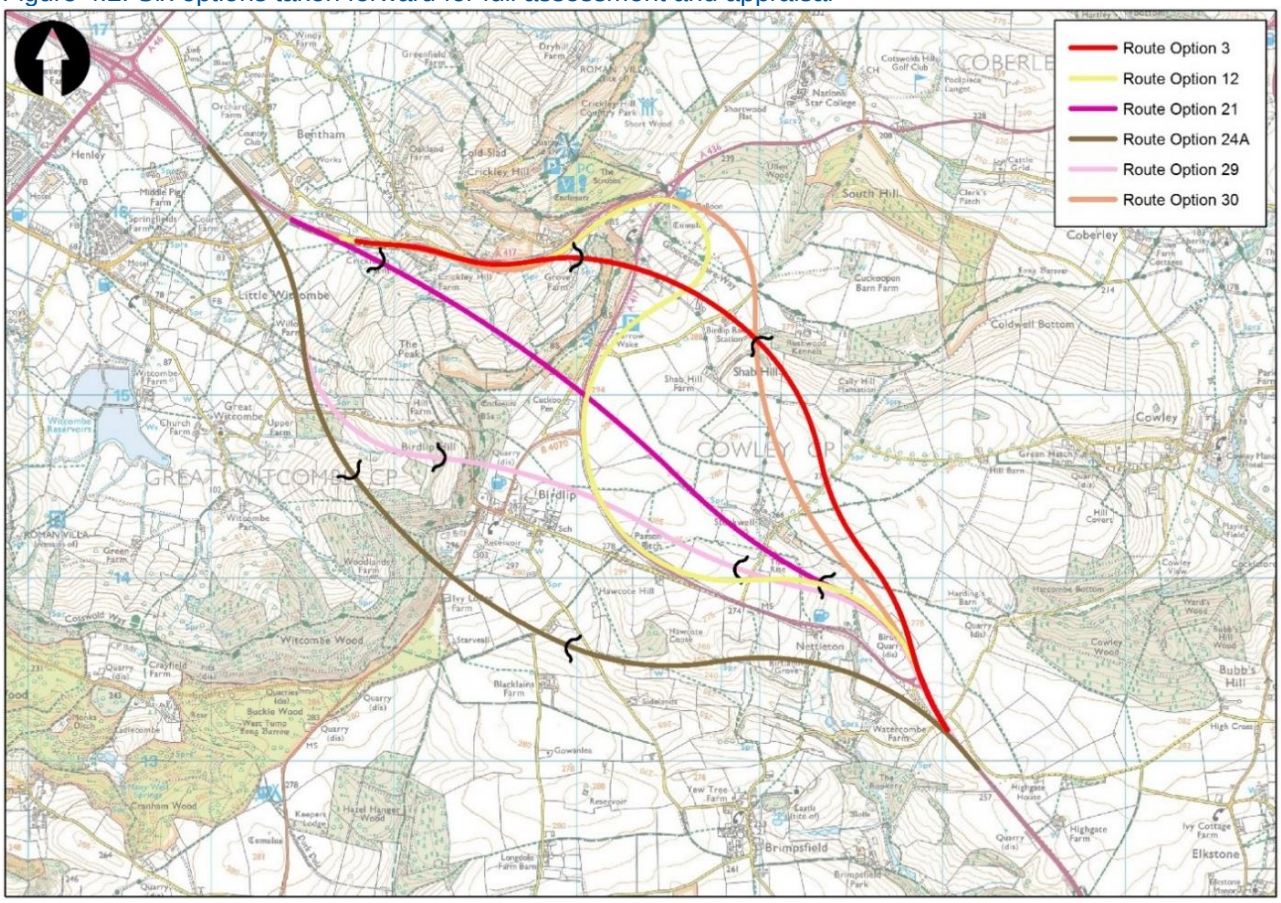
4.6.2. To ensure that a second affordable route was progressed from PCF Stage 1, the next best performing surface route from the first three steps of the sifting was taken forward for full assessment and appraisal. This route was Option 12, a route from historic studies which was formerly known as the Modified Brown Route.

4.6.3. As a result of the four sifting steps, six options, Options 3, 12, 21, 34, 29 and 30 were fully assessed and appraised to inform the choice of options to be taken to public consultation.

4.7. Full assessment and appraisal

4.7.1. The six options taken forward for full assessment and appraisal are shown below in Figure 4.2.

Figure 4.2: Six options taken forward for full assessment and appraisal



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

Option estimates

4.7.2. Commercial estimates were prepared following development of the options. These order of magnitude estimates are given in Table 4.2 below.

Table 4.2: Most likely order of magnitude option estimates, 2016 / Q1 price base

*all prices in millions	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
TOTAL	£875	£465	£1,625	£1,210	£1,240	£485

Traffic analysis

4.7.3. A regional traffic model with coverage of the south-west of Britain, taking in South Wales, the West Midlands and Southern England to the west of London was adapted for use on the scheme.

4.7.4. The traffic model's forecast is that all options would reduce delays and improve journey times along the A417. The greatest journey time savings are forecast to occur in Option 21, due to the direct alignment provided by this tunnel option. The forecasts for Option 12, which has a less direct alignment compared to the

other options and includes a section with a mandatory 50mph speed limit, provides the smallest journey time improvement along the A417 of all six options, though still shows a significant reduction in journey times compared to the existing route.

Economic analysis

4.7.5. The economic appraisal of each option followed the guidance set out in WebTAG, DfT's transport appraisal guidance. The method estimates the economic impacts of the scheme based on the efficiency of the journey for the road user, costs or benefits to the environment and the impact of accidents and road works. When reliability and wider economic benefits are included in the analysis, an adjusted Benefit to Cost Ratio (BCR) can be calculated; these are given in Table 4.3 below.

Table 4.3: Adjusted BCRs for the six options

Item	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Adjusted BCR	0.79	0.68	0.47	0.54	0.56	1.04

4.7.6. The tunnel options (Options 3, 21, 24 and 29) all had high benefit values, but their high costs caused them to have poor BCRs. Options 12 and 30, the surface routes, had lower benefits but their significantly lower costs gave them higher BCRs compared to the costlier tunnel options. Option 30 was the only route to offer positive value for money (greater than 1), meaning the returns were estimated to be greater than the cost.

Safety assessment

4.7.7. A road safety assessment of the six routes was completed based on the engineering development of the routes at the early stage following option sifting. All six options gave rise to safety considerations which would need to be addressed as part of the further development of the project. Option 12 was the option presenting the biggest challenges in safety due to differences between the horizontal and vertical alignment design and the Design Manual for Roads and Bridges (DMRB) requirements. All the proposed options would be expected to improve road safety, reducing the number of people killed or seriously injured on the route.

4.7.8. From a Construction (Design and Management) Regulations 2015 (CDM 2015) perspective, the tunnel options would require specialised construction and management techniques introduced as early as practicable to mitigate risks at the design stage. All six options are notable for the quantity of earth movements required within the construction area and outside of it, and this was identified as a key point of safety management.

Environmental assessment

4.7.9. The potential environmental impacts of the six options were appraised in accordance with WebTAG guidance to a scoping level, and to a simple level appropriate to the stage. Consultation with statutory environmental bodies took place throughout the stage.

4.7.10. The appraisal and assessment at this stage covered impacts on the landscape, historic environment (archaeology, listed buildings and scheduled monuments), human environment (noise and air quality) and habitats and wildlife.

4.7.11. Across the areas assessed, Option 21 was found to generally outperform the other options due to the length of the route within a tunnel, and the route avoiding sensitive areas. All options were identified to have net benefits in noise reduction compared to the existing route, however in all other areas the options showed disbenefits.

4.7.12. Consultation has been undertaken with statutory environmental bodies (SEBs) as the scheme has progressed. This includes input into the development of scheme objectives, the identification of opportunities and constraints and discussions over key scheme issues.

4.7.13. Of the tunnelled solutions, Options 24 and 29 were found to perform less well across all measures than Options 3 and 21. Between the two surface options, there was little difference in the appraisal results. Option 12 was identified to outperform Option 30 in noise reduction, while Option 30 was found to have lower air quality disbenefits.

Social assessment

4.7.14. Social impacts of the six options were appraised in accordance with WebTAG guidance. Social assessment and appraisal addressed the impacts of the scheme on commuters and the public, through journey time and reliability, physical activity, accidents and accessibility among other areas.

4.7.15. The routes largely performed at a similar level within the social appraisal area. The key differentiator between the routes in this area was the reduced journey time for commuters. Relative to the current route, the six options were found to deliver significant benefits in terms of net present value. The tunnel options were identified as delivering greater benefits than the surface routes, with Option 30 delivering significantly greater benefits than Option 12 from the surface routes.

Additional environmental assessment

4.7.16. To supplement the appraisal of potential environmental and social impacts of the routes, several additional studies were completed to support the conclusions and any further work with regards to preferred route selection. The additional studies described below were produced to aid discussions with environmental stakeholders.

4.7.17. The Sustainable Decision Model (SDM) is a tool that provides a qualitative assessment of sustainability performance. The results of the model in PCF Stage 1 showed Option 21 had the highest sustainability performance, with all tunnel options outperforming the surface options. Between the two surface options, Option 12 showed the lowest performance.

4.7.18. Opportunity mapping was undertaken for the scheme to identify measures that go above the standard mitigation required to avoid adverse environmental impacts. A series of workshops were held to inform the exercise, attended by the A417 integrated project team and environmental stakeholders, including the Cotswolds Conservation Board, National Trust and Wildlife Trusts. The opportunities identified would provide improved biodiversity connectivity, as well as enhanced recreational and cultural access within the Cotswolds Area of Outstanding Natural Beauty (AONB).

4.7.19. A landscape monetisation assessment was prepared, alongside the qualitative WebTAG appraisal. This assessment placed a value on the landscape types within the scheme extents and quantified the impact of each option. The valuation findings showed that all options had sizeable disbenefits; Option 21 had the smallest disbenefits, and Options 12 and 30 had the largest disbenefits.

4.7.20. Following consultations with stakeholders such as the Cotswolds Conservation Board, a landscape study was undertaken for the scheme to appraise the options for the A417 Missing Link. The overarching purpose of the study was to ensure that the earliest stages of route selection paid due regard to the nationally designated landscape context (the Cotswolds AONB). The study responded to the identified need within the scheme vision for a landscape-led highways improvement scheme. An important aspect of the study was to focus on the identification of how well different highway alignment options might generate opportunities for broader scale as well as localised landscape enhancements. The study identified Crickley Hill as being the only suitable route for a surface option to ascend the escarpment, as is the case with both Option 12 and Option 30. Engineering and geological feasibility had also proved strong justifications for Crickley Hill being identified as the most suitable route to ascend the escarpment. The study also made several recommendations for landscape-led improvements on the options.

Appraisal summary

4.7.21. Appraisal Summary Tables (ASTs) were produced for each of the six options to collate all of the assessments against the criteria of Economy, Environmental, Social and Public Accounts.

4.7.22. Comparison between the ASTs for each option showed that the tunnel options, Options 3, 21, 24 and 29 outperformed the surface options in most of the economy, environmental and social measures.

4.7.23. This was balanced against an estimated cost substantially higher than either surface route, which took the tunnel routes above the upper limit of the cost range (£500 million). After a value for money appraisal to estimate the economic impact of the options was completed, the surface options outperformed the tunnel options and Option 30 outperformed Option 12.

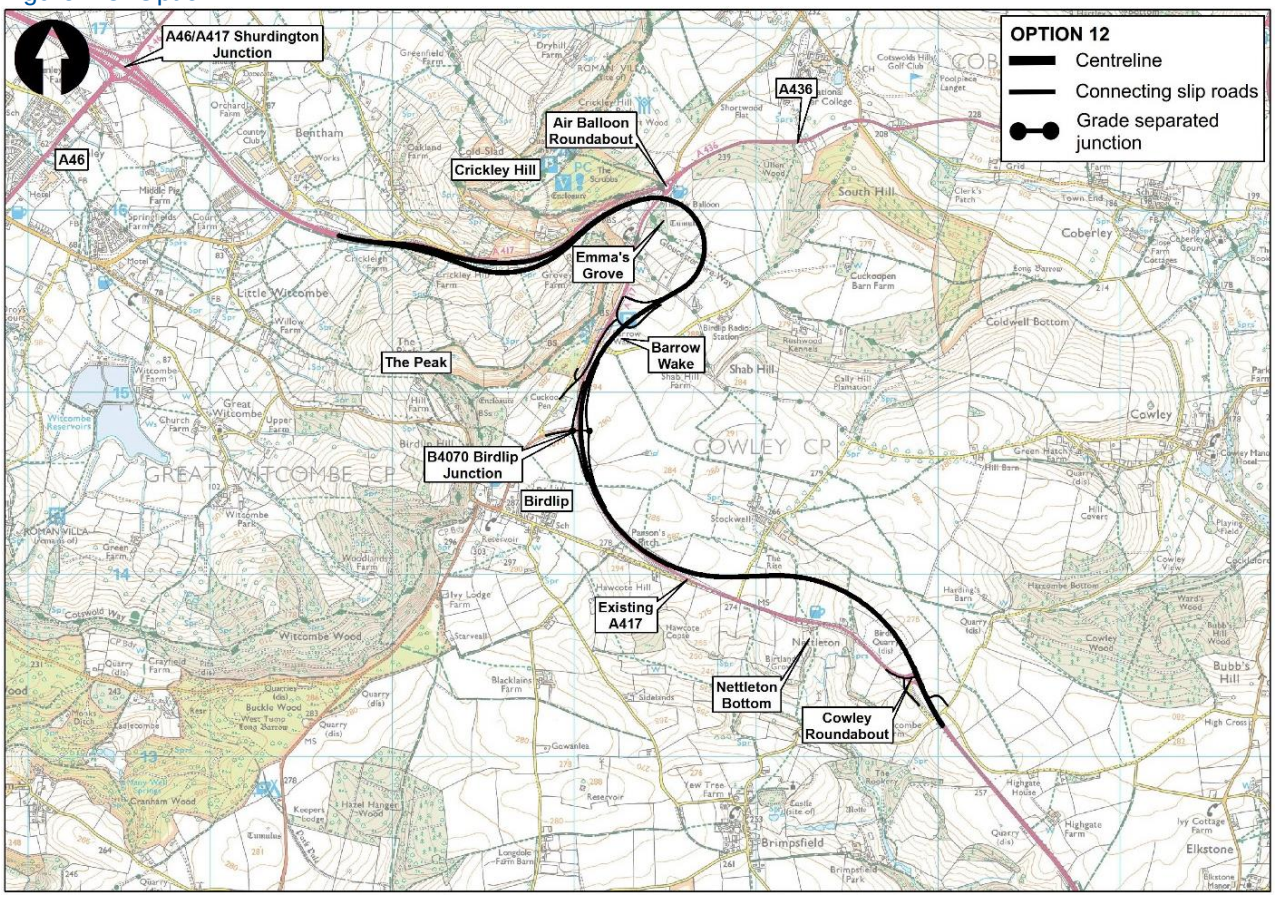
4.8. PCF Stage 1 Conclusions

4.8.1. All tunnel options assessed (Options 3, 21, 24 and 29) were shown to give poor value for money for the taxpayer. The most significant factor causing this was the high estimated costs of the tunnel options, all of which were estimated to cost significantly more than the upper limit of the cost range of £500 million. Despite their high monetised and intangible benefits demonstrated in the appraisal work, these routes could not be recommended for further development.

4.8.2. The two surface routes, Option 12 and Option 30, were then recommended to be taken forwards for public consultation and further development. Both routes are considered affordable (within the £250 million to £500 million cost range), and deliverable, with both options delivering significant improvements on the existing situation. These routes are shown below in Figure 4.3 and Figure 4.4, and summarised as:

- Option 12 – Surface route (historically known as the Modified Brown Route), with a mixture of on-line widening and off-line construction broadly following the route of the existing road whilst bypassing Nettleton Bottom.

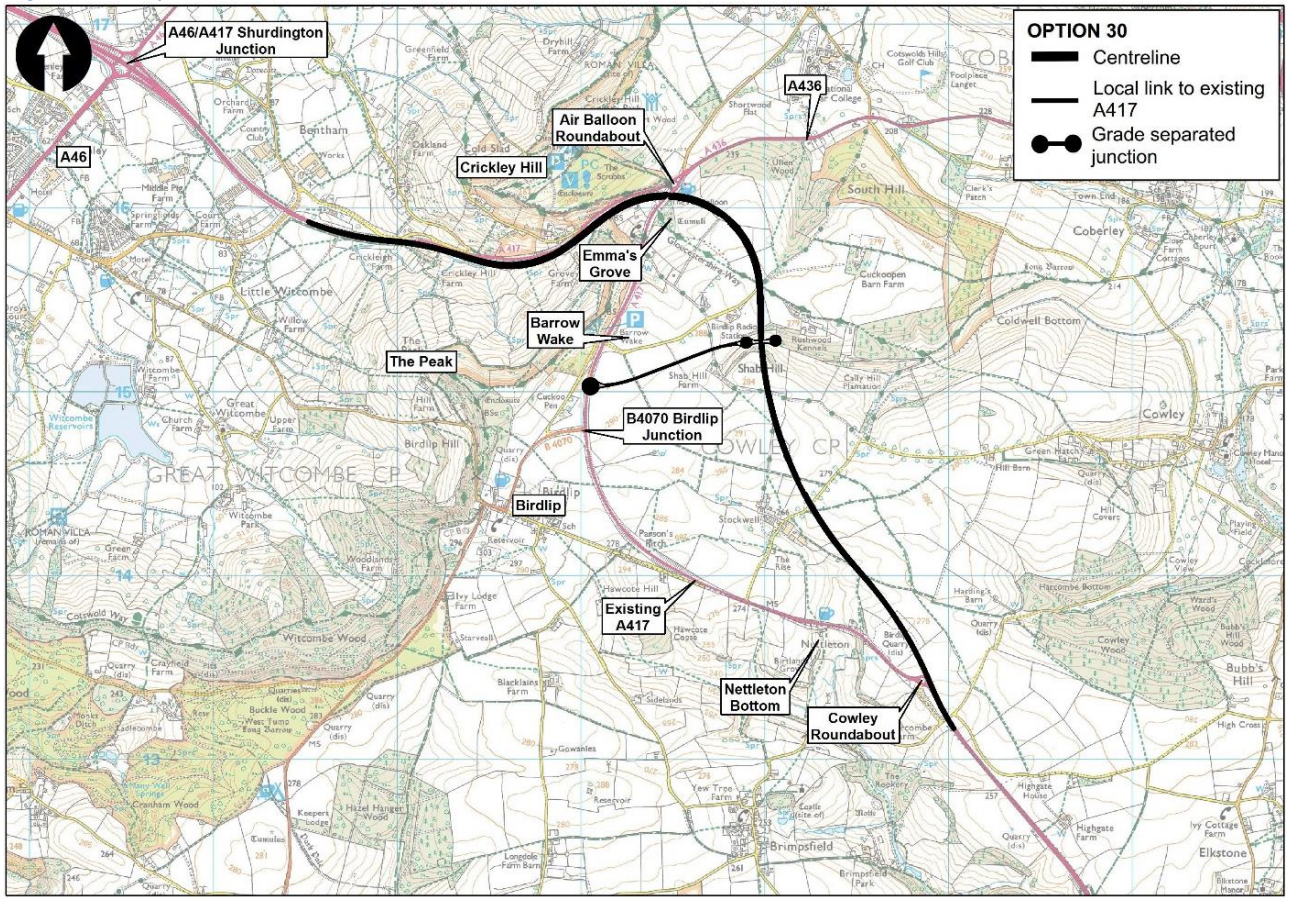
Figure 4.3: Option 12



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

- Option 30 – Surface route, majority off-line construction with on-line widening along Crickley Hill before diverging to the east of the existing route and re-joining at Cowley.

Figure 4.4: Option 30



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

5. Public consultation summary

5.1. Introduction

5.1.1. Public consultation on proposals for the A417 Missing Link was carried out between 15 February and 29 March 2018. This chapter summarises the consultation and the key issues raised that have informed the choice of preferred route. The public consultation is documented in full in the 'A417 Missing Link: Report on Public Consultation'.

5.2. Scheme proposals presented for consultation

5.2.1. Two proposed options were presented to the public as part of the non-statutory consultation, as shown in Figure 5.1 (Option 12) and Figure 5.2 (Option 30).

Figure 5.1: Option 12 as illustrated in the Public Consultation Booklet

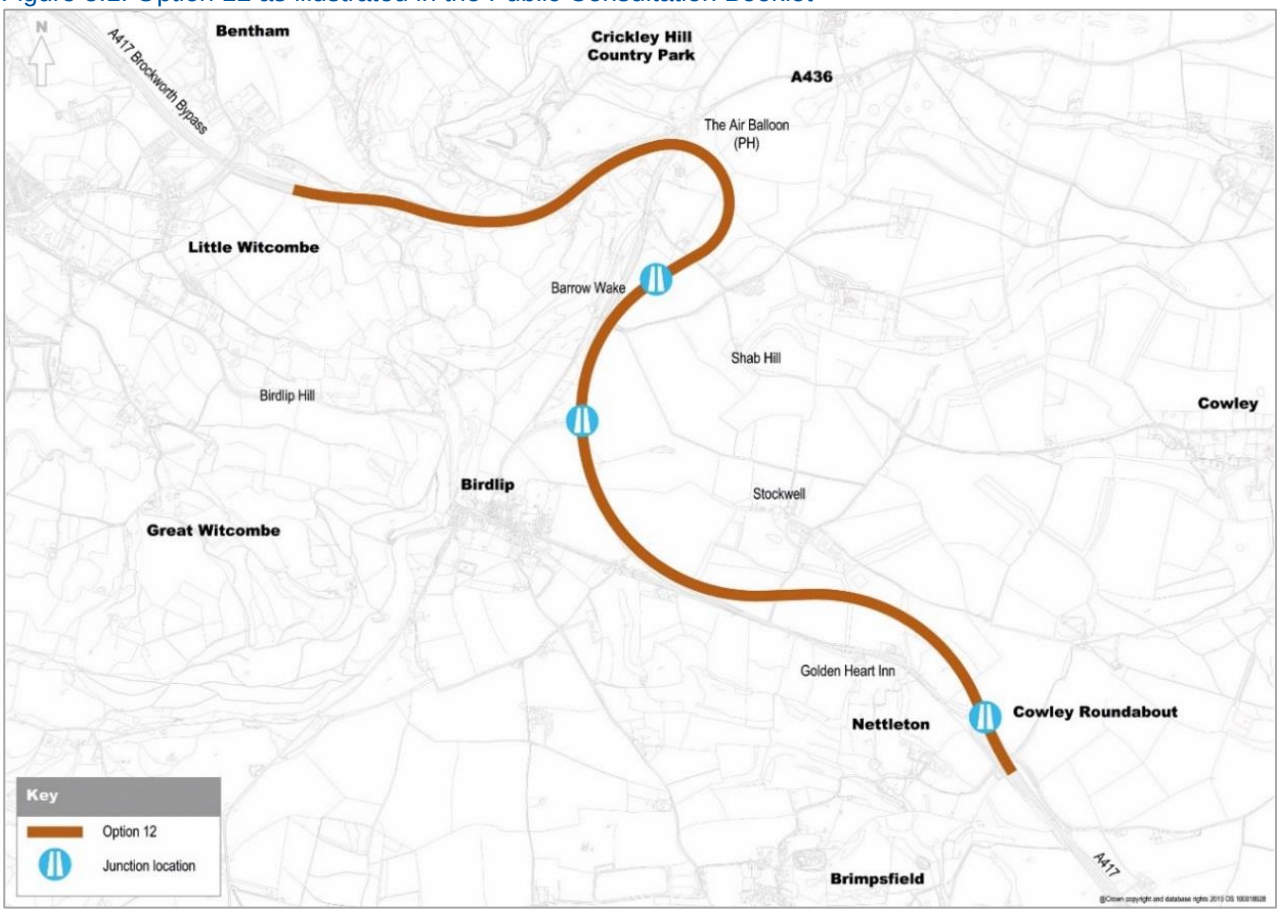
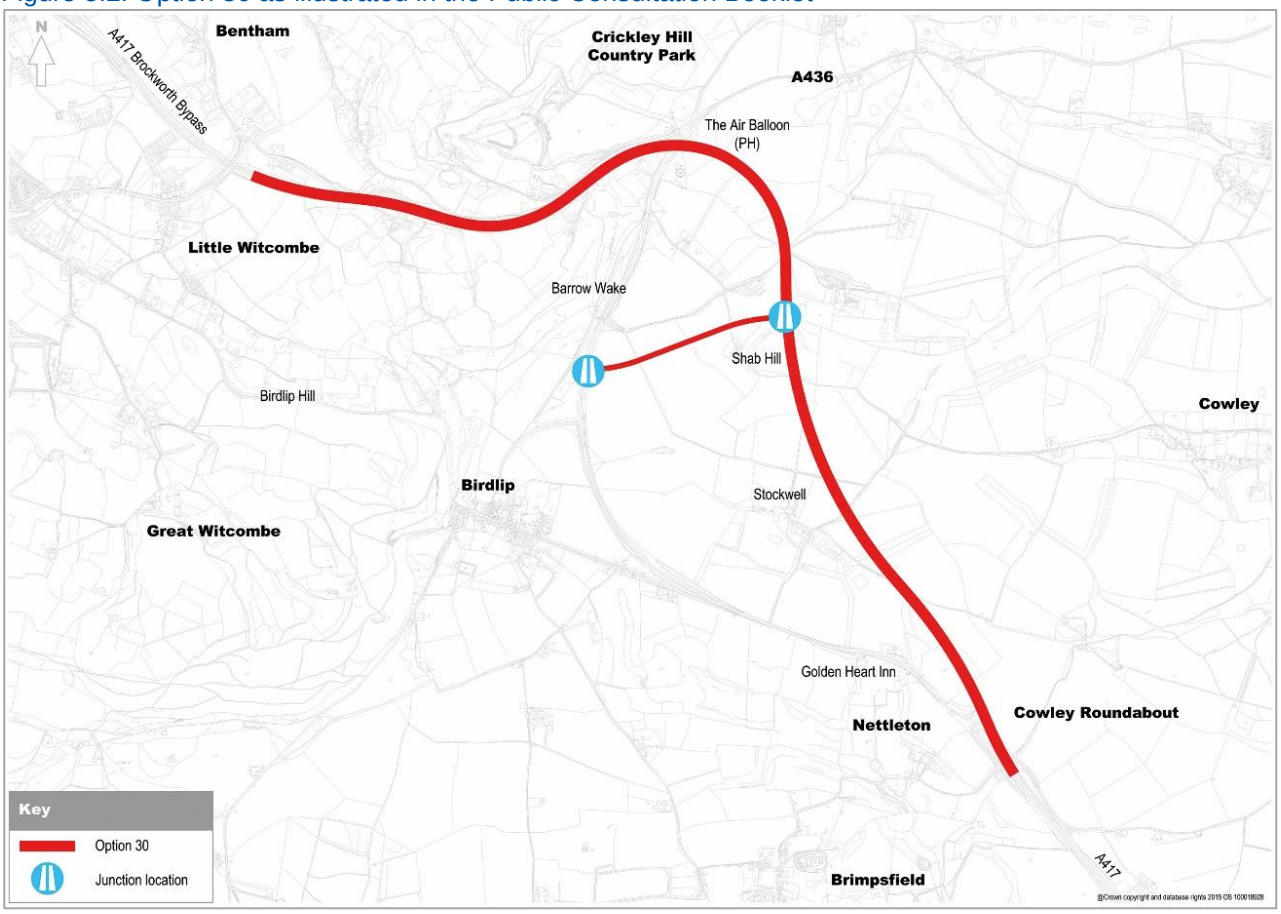


Figure 5.2: Option 30 as illustrated in the Public Consultation Booklet



5.2.2. The proposals were explained in a Public Consultation Booklet, through which views were invited on the two options. The Public Consultation Booklet is available at: https://highwaysengland.citizenspace.com/he/a417-missing-link/supporting_documents/A417%20Public%20Consultation%20Brochure.pdf.

5.3. Consultation arrangements

5.3.1. Consultation on the scheme proposals was held over a six-week period from 15 February to 29 March 2018.

5.3.2. A variety of activities were undertaken to raise awareness of the consultation. These included mailings, leaflet distribution, media events and advertising on social media. Public exhibitions (or events) were held on six occasions at different venues to give people an opportunity to view information about the scheme and speak with members of the project team, as well as to provide comments on the scheme proposals.

5.3.3. During consultation, Highways England invited feedback via a range of channels:

- By completing and handing in a feedback form at the public exhibitions, or returning them by post using the FREEPOST address, FREEPOST A417 MISSING LINK CONSULTATION
- By completing and submitting the feedback form online via Citizen Space (https://highwaysengland.citizenspace.com/he/a417-missing-link/)
- By downloading the feedback questionnaire on the scheme website, completing it and sending it via email to the scheme email address A417missinglink@highwaysengland.co.uk
- By emailing A417missinglink@highwaysengland.co.uk
- By sending a letter to the FREEPOST address, FREEPOST A417 MISSING LINK CONSULTATION

5.3.4. The feedback form asked the following six questions:

1. To what extent do you agree with our proposed Option 30?
2. Do you have any comments to make in relation to Option 12?
3. As part of identifying route options, Highways England assessed over 30 options, including six as part of the further appraisal work. Do you have any comments on any of the other options included in the assessment?
4. Is there anything further you would like us to consider in relation to improving the A417 Missing Link?
5. How did you hear about this consultation?
6. Do you have any feedback on this consultation - events, information provided, advertising etc?

5.4. Consultation response

5.4.1. Almost 2,000 responses were received in total. A breakdown of these are shown in Table 5.1 below.

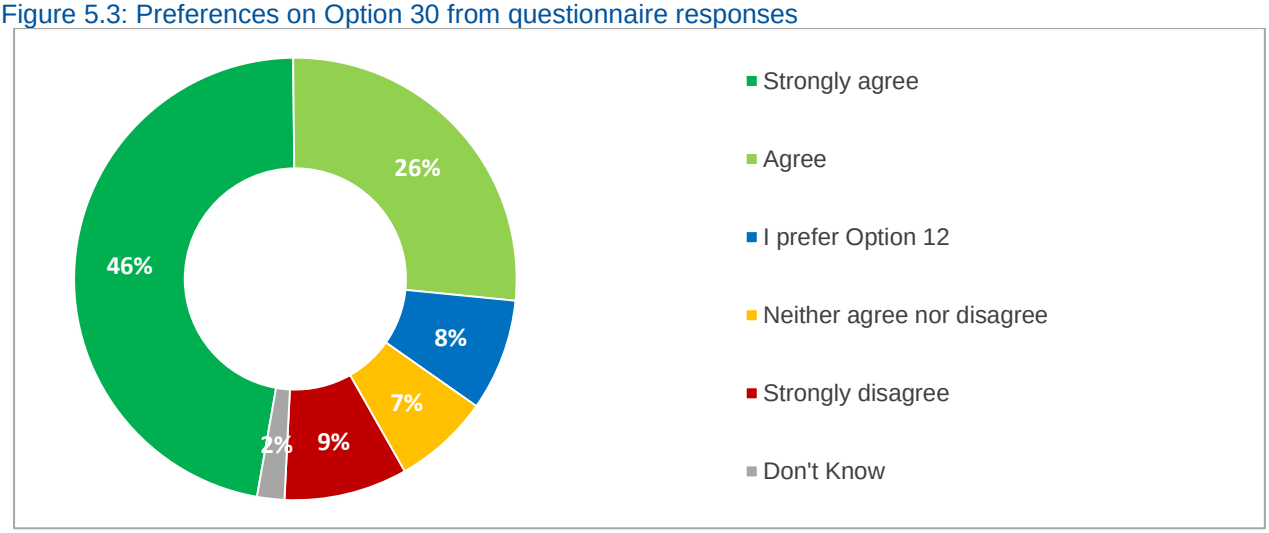
Table 5.1: Number of consultation responses received by format

Response format	Number of responses received
Questionnaire responses (via the consultation webpage or by hand)	1,913
Emails and letters	38
Total	**1,951**

Questionnaire responses: Question 1 (To what extent do you agree with our proposed Option 30?

5.4.2. The responses to Question 1 showed that public opinion is greatly supportive of Option 30. Those who identified their support for Option 30 amounted to 72% of all respondents, with an additional 8% stating their preference for Option 12. Figure 5.3 below provides more detail.

Figure 5.3: Preferences on Option 30 from questionnaire responses



5.5. Key issues

5.5.1. Respondents were also invited to include comments to support their opinions of the two proposed options, the discounted options and the scheme proposals in general. These comments were collated and subsequently analysed, the process of which is detailed in the 'A417 Missing Link: Report on Public Consultation'.

5.5.2. Taking into account all comments, whether expressing support for or opposition to the scheme, three main categories emerged:

- Matters that will be taken into consideration as part of the continuing development of the scheme
- Matters that have informed the further appraisal and assessment of Options 12 and 30, leading to the choice of Option 30 as the preferred route
- Comments about options that were considered and dismissed at earlier stages of the scheme's development, either during the appraisal of the shortlisted options or as part of the earlier options sifting process, as set out in the Technical Appraisal Report (TAR).

5.5.3. Comments which informed the choice of the preferred route were separated into key issues for the public and stakeholders, relating to the choice of Option 12 or Option 30. These key issues are summarised below:

- Landscape considerations, in particular the minimising of the visual impact of the scheme in the Area of Outstanding Natural Beauty (AONB)
- Environmental and geological impacts on nearby sites, including Crickley Hill and Barrow Wake Sites of Special Scientific Interest (SSSIs), and Emma's Grove Scheduled Ancient Monument (SAM)
- Traffic delays and disruption during construction of the scheme
- Public Rights of Way, in particular national trails (such as the Cotswold Way and Gloucestershire Way), and their preservation and interaction with the scheme
- Impacts on local communities such as Birdlip, Stockwell, Brimpsfield and Cowley
- Access to the new road from the local network, including from the A436, the B4070, and various local communities
- Cost and value for money of the scheme
- Effects on local businesses and amenities

5.5.4. These considerations from consultation have been reviewed alongside the findings of further assessment work undertaken during and since consultation, as set out in this report. This review has informed the choice of preferred route.

6. Stage 2 engineering and safety assessment

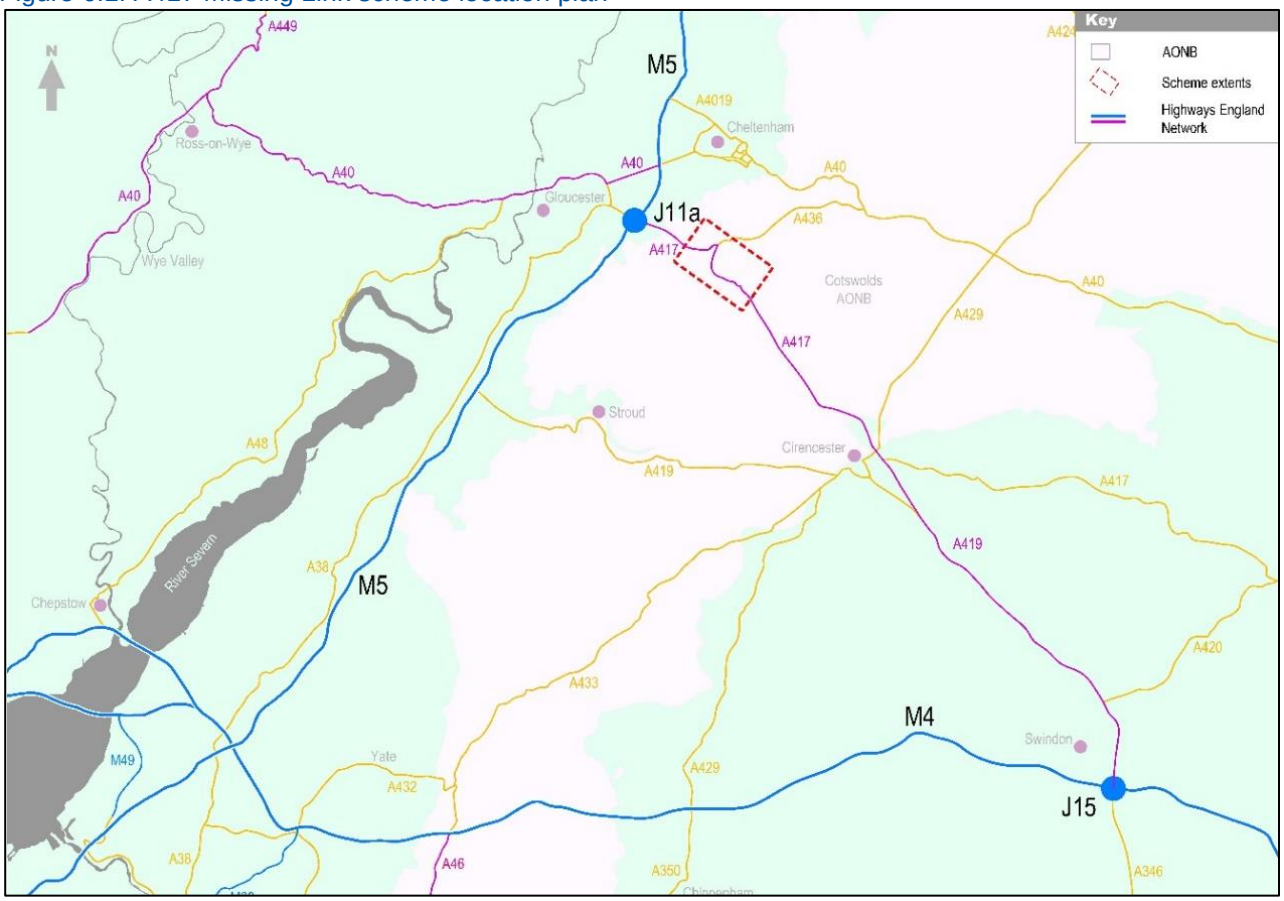
6.1. Introduction

6.1.1. Six options were taken forward in Project Control Framework (PCF) Stage 1 for further appraisal to determine which of the proposed options were to be presented at public consultation. The six options comprised four tunnel and two surface options. Following the sifting process, the two options taken forward to public consultation were:

- Option 12
- Option 30

6.1.2. This chapter describes these two route options as assessed at Stage 2. The design details described (e.g. junction arrangements, heights of embankments and depths of cuttings) are outline designs adopted for the purposes of like-for-like comparison of the route options. These outline details would be subject to change as the chosen preferred route is developed further to optimise its design which will include measures to further improve its benefits, mitigate its impacts and to improve safety. Where references are made to chainages along either option, these can be looked up on the layouts in Appendices C and D.

Figure 6.1: A417 Missing Link scheme location plan



Source: Mott MacDonald Sweco Joint Venture

6.2. Stage 2 option development

6.2.1. Both options were identified during the option identification process in PCF Stage 1. Option 12 was a route identified from previous studies (previously the "Modified Brown Route"), whilst Option 30 was a newly identified route.

6.2.2. Option 12 was developed to a level of outline design consistent with PCF Stage 3 design for consultation in the previous studies undertaken between 2003 and 2006 for the Highways Agency. The option was developed in collaboration with the Environment Agency, Countryside Agency and English Heritage to have minimal impact on the sensitive environmental sites and the designated landscape. The level of development of Option 12 led to the need to review Option 30 to ensure an appropriate comparison was being made between the routes.

6.2.3. A Landscape Study was completed in PCF Stage 1 to review how a highways scheme can be accommodated within the Cotswolds Area of outstanding Natural Beauty (AONB). The study identified Crickley Hill as being the only suitable route to ascend the escarpment with a surface solution, as is the case with both

Option 12 and Option 30. The study also made recommendations for landscape-led improvements to Option 30, including:

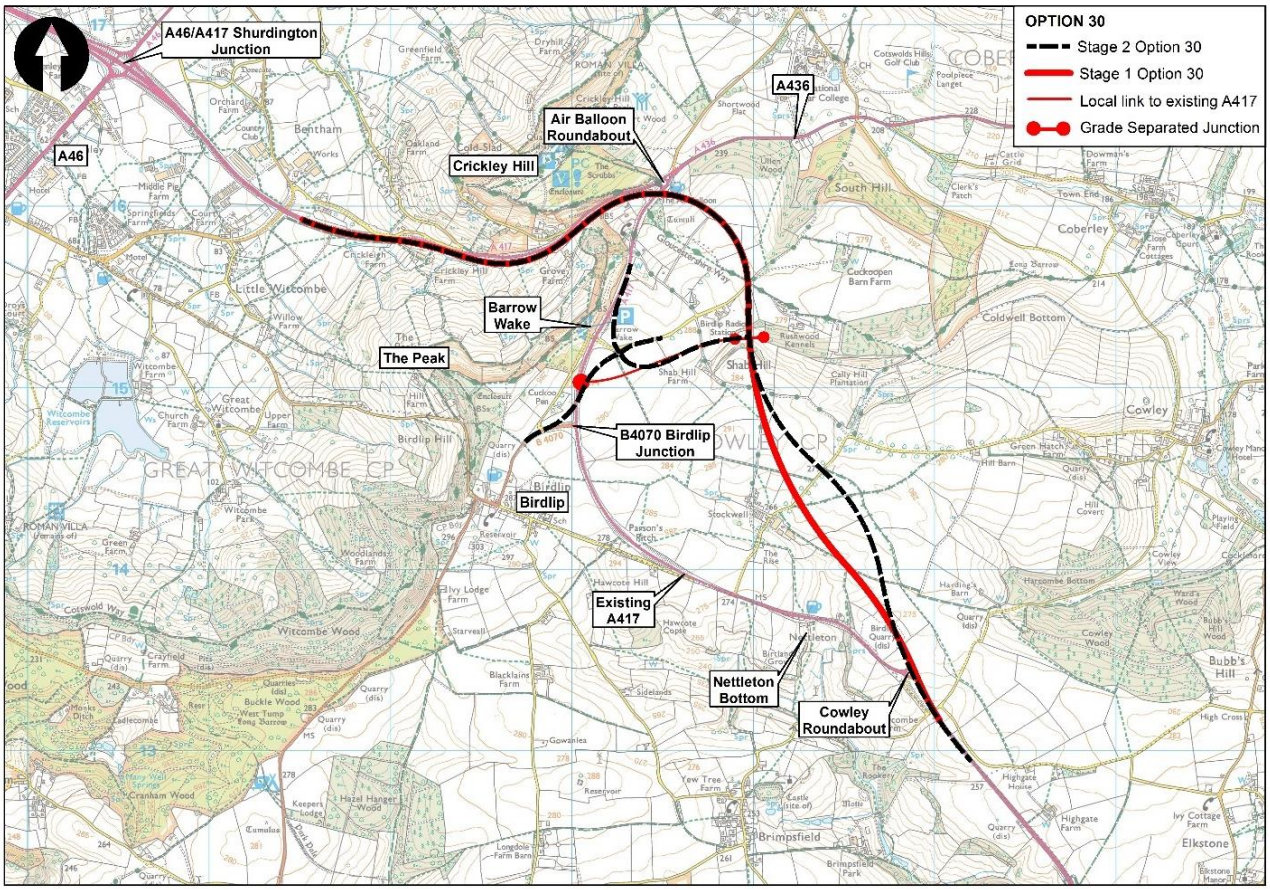
- That the route to the east of Stockwell be revised to better fit the topography
- That the link road between Shab Hill and the existing A417 carriageway be amended to improve fit with the landscape and connection to local roads

6.2.4. As a result of these recommendations, and other opportunities identified through consultation, the amendments below were made to Option 30 for Stage 2 assessment:

- Horizontal Alignment near Stockwell - The mainline geometry was amended to fit more closely with the existing landscape. The alternative alignment has shifted the carriageway approximately 230m east of Stockwell Farm compared to the previous version of Option 30.
- Link Road to Barrow Wake - The link road between the existing A417 (at Barrow Wake) and the new grade-separated junction at Shab Hill was realigned together with the repositioning of the roundabout connecting the existing routes to the link road. This change simplifies the existing highway layout and enables the existing A417 to be removed at Barrow Wake (between the Birdlip connection and link towards the A436). This includes the existing structure below the A417 which provided vehicle access from the B4070 to properties including Rushwood Kennels and Birdlip Radio Station. This amendment also enables the Sites of Special Scientific Interest (SSSI) at Barrow Wake to be reconnected (currently severed by the existing A417).
- Alignment on Crickley Hill and through to Shab Hill Junction - Amended vertical profile on the mainline to further reduce the maximum gradient from 7.5% to 7.0%.
- Cowley Junction, left in / left out - Provision of left in / left out junction at Cowley to provide direct access to Brimpsfield and Cowley. This allows the existing A417 carriageway to be removed or repurposed from the access to Stockwell Farm to the Birdlip junction. With the removal of existing carriageway associated with this solution and the link road to Barrow Wake there is the potential for approximately two kilometres of existing carriageway to be removed.
- Junction arrangement at A436 / Leckhampton Hill identified as a traffic signal controlled junction.

6.2.5. The changes to Option 30 between PCF Stage 1 and Stage 2 are shown in Figure 6.2 below, and the resulting route described in the following sections.

Figure 6.2: Changes to Option 30 after public consultation



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

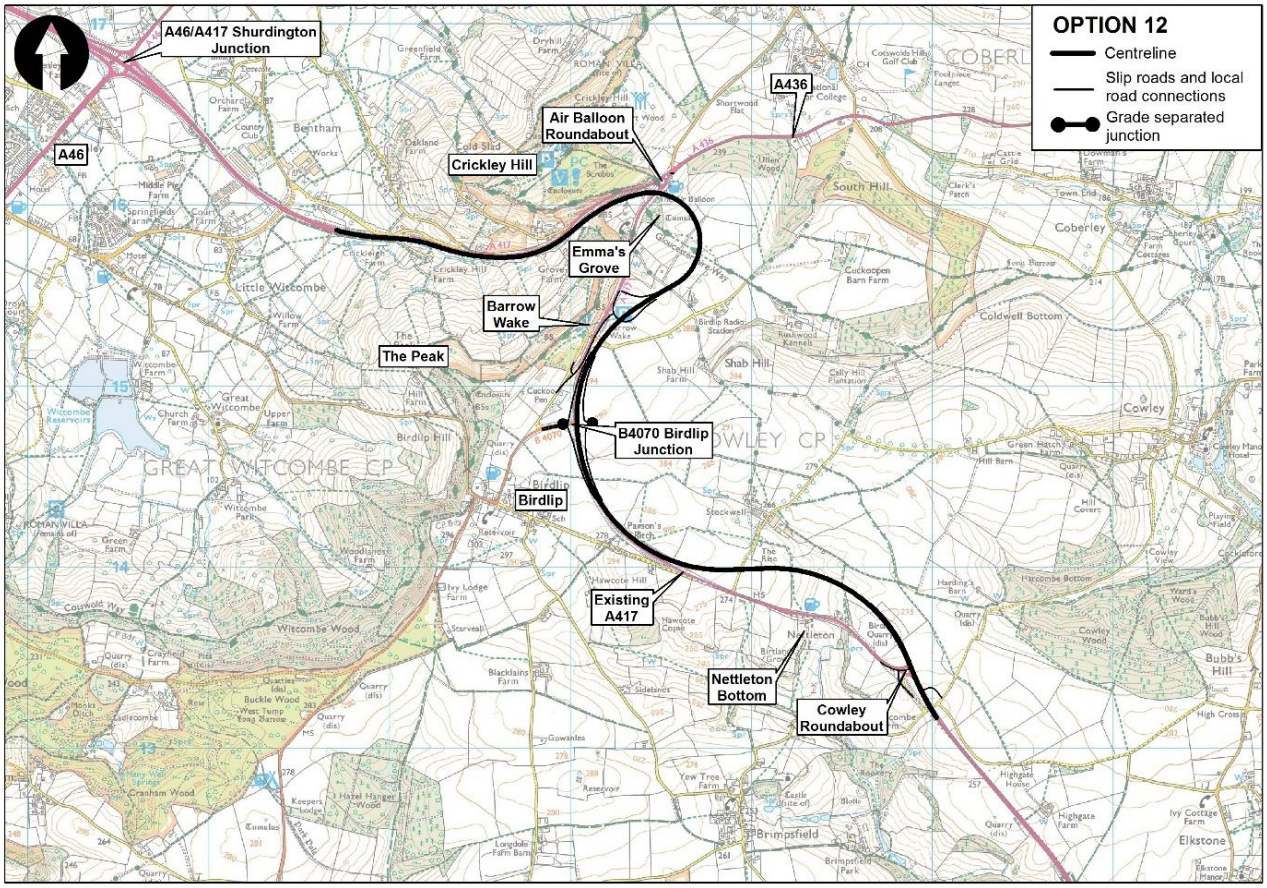
6.3. Description of Option 12

Description of route

6.3.1. The following route description commences at the Brockworth bypass and continues in a southerly direction along the route to its tie-in just south of Cowley roundabout.

6.3.2. Option 12 is a surface dual-carriageway proposal approximately 6.4 kilometres in length. It utilises the existing A417 corridor for 1.3 kilometres with an off-line widening of the existing road. The proposed route leaves the existing route 600m prior to the Air Balloon junction before transitioning into a 270m radius right-hand curve. The proposed route then transitions into a broad left-hand curve to re-connect to the existing route corridor near Barrow Wake and remains in the existing route corridor for approximately 1.1 kilometres. Nearby the existing Stockwell junction, the proposed route transitions to a right-hand curve to bypass Nettleton Bottom, 200m to the north of the existing route, before re-joining the existing A417 south of Cowley roundabout. See Figure 6.3 below and Appendix C.

Figure 6.3: Option 12



Source: Mott MacDonald Sweco Joint Venture

6.3.3. The deepest section of cut along the route is located at chainage 1600, at the vicinity of the existing Air Balloon roundabout, and it is approximately 20m deep. The route has a climbing lane provision for the southbound carriageway which is approximately 3.8 kilometres in length, providing three lanes in the southbound direction and two in the northbound direction for this length.

Option rationale and constraints

6.3.4. At the time of development, between 2001 and 2006, consultations with the statutory environmental bodies on the various constraints determined that the route should stay centred on the existing A417 route alignment therefore maximising the re-use of the existing carriageway into the final solution to avoid the various environmental constraints. The exceptions are:

- The 255m radius bend (four steps below desirable minimum) which is required to negotiate the 150° turn near Air Balloon and maintain a free flow alignment
- The southern section that avoids difficult topography at Nettleton Bottom

6.3.5. The off-line section through Nettleton provides an opportunity for the existing carriageway to be removed. However, due to the existing access to the Golden Heart Inn and the unclassified road to Stockwell, only the section of existing carriageway from the Stockwell junction heading west for approximately 0.4 kilometres could be removed.

6.3.6. The 270m radius section (or Loop) to the east of Air Balloon and Emma's Grove Scheduled Monument is off-line, and the existing A417 from Barrow Wake to Air Balloon will be used to connect the A436 traffic onto the newly dualled A417 carriageway. Therefore, there is no opportunity to remove the existing carriageway in this location.

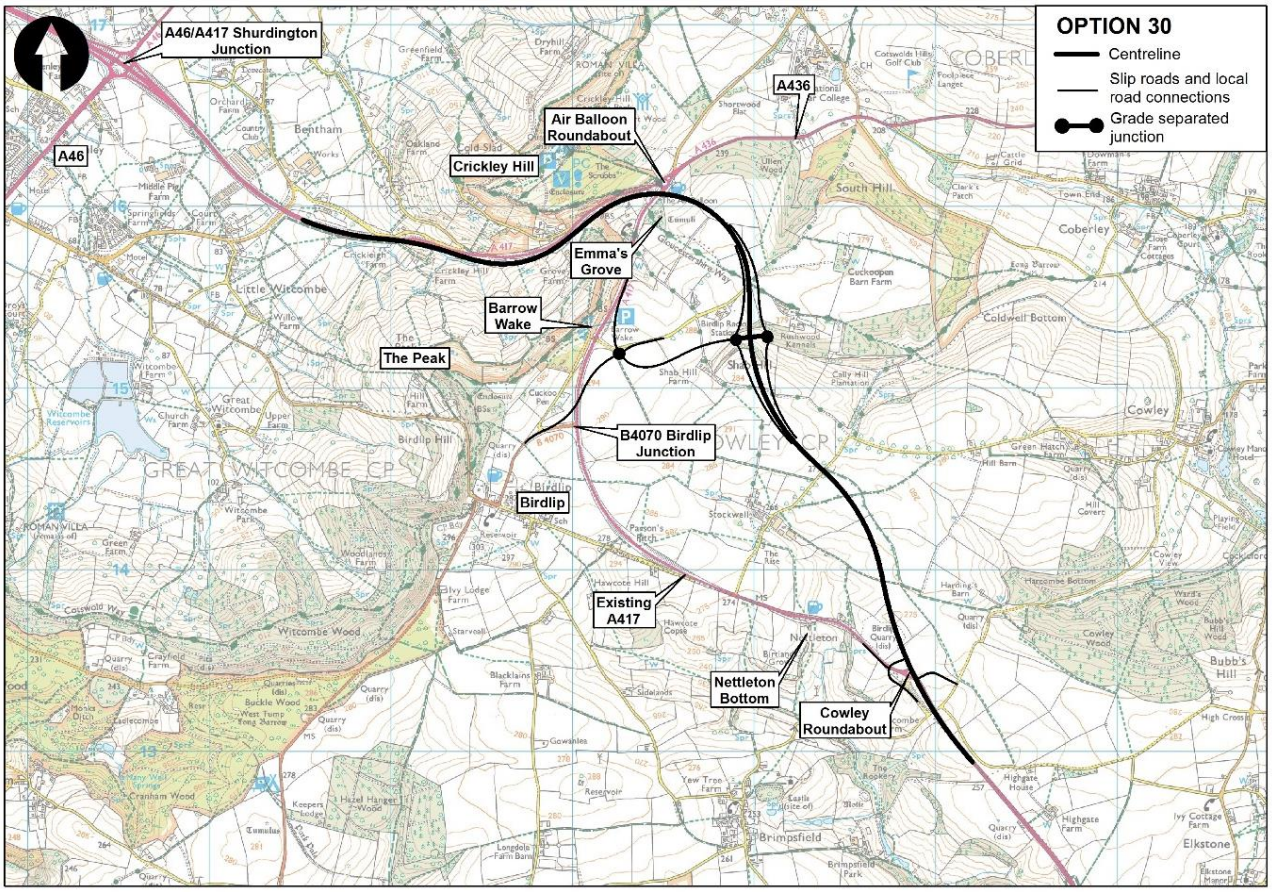
6.4. Route Option 30

Description of route

6.4.1. The following route description commences at the Brockworth bypass and continues in a southerly direction along the route to its tie-in just south of Cowley roundabout.

6.4.2. Option 30 is a surface dual-carriageway solution to the A417 Missing Link. The mainline of Option 30 is approximately 5.6 kilometres long, which includes the utilisation of the existing A417 for approximately 0.5 kilometres. The proposed route maintains the existing A417 corridor with widening, for a further 1 kilometre southbound up Crickley Hill. It leaves the corridor prior to the existing Air Balloon junction. The route transitions to a right-hand radius of 510m (two steps below the desirable minimum standard), before passing through a point approximately 160m east of Birdlip Radio Station and continuing on a left-hand radius of 1,020m to a point 450m north of Stockwell Farm. The alignment then proceeds on a right-hand radius of 1,020m to the north-east of Stockwell before transitioning to a left-hand radius of 2,040m to the point of tie-in with the existing A417. See Figure 6.4 below and Appendix D.

Figure 6.4: Option 30



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

6.4.3. The deepest section of cut along the route is located at chainage 1800, at the vicinity of the existing Air Balloon roundabout, and it is approximately 28m deep. The route has a climbing lane provision for the southbound carriageway which is approximately 4.2 kilometres in length, providing three lanes in the southbound direction and two in the northbound direction for this length.

Option rationale and constraints

6.4.4. The proposed A417 is to be a rural dual 2 lane all purpose (D2AP) road with a climbing lane on Crickley Hill. It is intended to produce a high speed, free flowing road consistent with the adjacent dual-carriageway sections.

6.4.5. Option 30 has been developed to avoid the following:

- Crickley Hill Farm (listed building)
- Grove Farm (buildings and working business)
- The SSSIs at the top of Crickley Hill (although the Barrow Wake SSSI may be impacted during construction)
- Ullen Wood
- Shab Hill Farm

- Birdlip Radio Station
- Cuckoopen Farm
- Rushwood Kennels
- Stockwell Farm Buildings

6.4.6. Avoiding the SSSIs and Ullen Wood was particularly challenging and has resulted in the use of the 510m bends, a two-step below desirable minimum horizontal curve.

6.5. Highway design, relaxations and departures from standards

6.5.1. Both Option 12 and Option 30 include a number of relaxations (permitted reductions to desirable minimum parameters given in the standards) and departures from standard in order to avoid the constraints detailed above.

6.5.2. For determining desirable minimum parameters, a design speed 120kph (band B) was used. The band is identified by how constrained the design is in terms of its route, width, the topography and the number of connections to it. More permitted reductions to the desirable minimum standard are permitted for band B alignments.

6.5.3. The proposed highway alignment design is summarised for the two routes in Table 6.1 below:

Table 6.1 Highway design summary

Item	Option 12	Option 30
Horizontal alignment - Crickley Hill	Follows existing alignment whilst improving on horizontal elements not to current standards	Follows existing alignment whilst improving on horizontal elements not to current standards
Horizontal alignment - Off-line “Air Balloon” section	270m radius curve (four steps below desirable minimum, departure from standard)	Two sequential 510m radius curves (two steps below desirable minimum, permitted relaxation)
Horizontal alignment – section to Cowley	Use of desirable minimum curves to Nettleton Bottom, one step below desirable minimum curve to bypass Nettleton Bottom (permitted relaxation)	Use of desirable minimum curves to the tie-in with the existing A417 near Cowley
Vertical alignment	One step below desirable minimum vertical curves or better have been used (permitted relaxation)	Desirable minimum vertical curves used
Gradient climbing Crickley Hill	The maximum gradient on Crickley Hill is 8.4% for 500m (departure from standard)	The maximum gradient on Crickley Hill is 7% which is permitted relaxation

Item	Option 12	Option 30
Climbing lane provision	Climbing lane provided for slow-moving traffic up Crickley Hill	Climbing lane provided for slow-moving traffic up Crickley Hill
Forward visibility (mainline)	Several sections have visibility that is below the 295m desirable minimum stopping sight distance (SSD) to the low object (permitted relaxation, away from junctions)	Several sections have visibility that is below the 295m desirable minimum stopping sight distance (SSD) to the low object (permitted relaxation, away from junctions)
Shab Hill junction	*Not required in Option 12*	Combinations of below desirable minimum stopping sight distance and horizontal curvature (combination causes departure from standard)
Birdlip junction	Combinations of below desirable minimum stopping sight distance and vertical curvature (combination causes departure from standard)	*Not required in Option 30*
Cowley junction	To-standard	Reduced visibility on approach to junction below permitted minimum (departure from standard)
Total number of departures from standard	**22**	**11**

6.5.4. Of the departures identified above for each option (22 for Option 12, and 11 for Option 30), the majority are a result of the compromises required to respect the environment, heritage and community constraints avoided by each option. Although opportunities to reduce or remove the design features are limited, all departures from standard will be reviewed in future stages of design, with the goal of removing or reducing them to improve the overall quality of the proposed route.

6.5.5. Where departures from standard cannot be removed through design, they may require mitigation to reduce their perceived impacts. Required departures will be risk assessed and formal applications for approvals submitted during future stages of development. It is considered at the current stage of development that the identified departures for Option 30 would be acceptable, but that Option 12 would require extensive mitigation before acceptance could be achieved.

6.6. Structures

6.6.1. An indicative structures design was undertaken at PCF Stage 1 and updated for the revised cost estimates completed during PCF Stage 2. The proposed structures for the two options are summarised in Table 6.2 below:

Table 6.2 Structures summary

Type	Option 12	Option 30
New Bridge	Overbridge to carry the A436 carriageway over the new A417 alignment	Overbridge to carry the A436 carriageway over the new A417 alignment
New Bridge	Overbridge carrying the Gloucestershire Way footpath over the A417	Overbridge for non-motorised users (NMU) route / farm track over the A417
New Bridge	Overbridge for farm track over the A417 (Radio Station bridge)	Multiple span underbridge carrying the A417 over a grade-separated junction
New Bridge	Underbridge carrying the A417 dual-carriageway over the slip road	Underbridge carrying the A417 over Cowley Lane
New Bridge	Underbridge carrying the A417 dual-carriageway over a minor road (Barrow Wake underbridge)	Underbridge carrying the A417 over a farm track
New Bridge	Underbridge carrying the A417 dual-carriageway over the new Birdlip junction	Overbridge for farm track over the link road connecting the new grade-separated junction and the existing A417 single-carriageway
New Bridge	Underbridge carrying the A417 dual-carriageway over a footpath	Green bridge over both the existing and proposed A417 carriageways would link the landscape on either side of the existing road corridor. This would provide a route for wildlife migration and accommodate a diversion of the Cotswold Way NMU route
New Bridge	Overbridge carrying Cowley Lane over the A417	
New Bridge	Overbridge carrying walking, cycling and horse riding routes over the A417	
New Bridge	Green bridge over both the existing and proposed A417 carriageways would link the landscape on either side of the existing road corridor. This would provide a route for wildlife migration and accommodate a diversion of the Cotswold Way NMU route	

Type	Option 12	Option 30
Retaining walls	Major retaining walls would be required in conjunction with a steepened slope along the deep cutting in the vicinity of the existing Air Balloon roundabout, up to a maximum combined wall / slope height of approximately 20m	Major retaining walls would be required in conjunction with steepened slopes along the deep cutting in the vicinity of the existing Air Balloon roundabout, up to a maximum combined wall / slope height of approximately 28m
Existing structures	Barrow Wake Underbridge on the existing A417 may be impacted by the new Birdlip junction arrangements	Barrow Wake Underbridge on the existing A417 could be removed under the proposal for Option 30

6.6.2. The number, form and type of structures as set out above will continue to be refined as the option selected as the preferred route is developed in future stages.

6.6.3. Although Option 12 requires more structures than Option 30 as assessed at this stage, the difference in form means that there is little to differentiate the two schemes on this point.

6.7. Junction and local roads strategy

6.7.1. A junction and local road strategy for the two route options (for Stage 2 assessment) was developed at a high level and in accordance with the following principles:

- Major junction treatment:
  - One major junction for traffic to use the A436, B4070, and to access the local area, such as Birdlip village. There was no demand for another major junction
- Minor road treatment and junctions:
  - One access to minor local roads connecting to smaller settlements, via provision near the existing Cowley roundabout at the southern end of the scheme. All other local roads are intended to be diverted to use either the proposed major or minor junction
- Access treatment:
  - No accesses are to be provided onto the new dual-carriageway as alternative arrangements from the local road network can be found. The exception is on Crickley Hill where currently Grove Farm (Crickley Hill Tractors) which may require an access onto the A417 due to its isolated nature and challenging topography

6.7.2. The assumptions across both options are as follows:

- The location for the major junction is on top of the escarpment, thereby reducing gradient issues and minimising the length of the A436 diversion
- Full grade-separation to TD 22 (Layout of Grade Separated Junctions) is proposed for the major junction due to the anticipated traffic flows
- A “left in / left out” major / minor junction to TD 42 (Geometric Design of Major/Minor Priority Junctions) is provided for the proposed Cowley junction

6.8. Earthworks

6.8.1. Both options require a major cutting through the top escarpment, near Emma’s Grove and the Air Balloon, to improve the existing gradients. Much of the cutting is through Cotswold limestone and therefore it may be possible to use steepened slopes with benching for the cutting slopes. This would give a similar appearance to the section of the A417 through the Churn Valley near Cirencester. Otherwise, for this stage of assessment, cutting slopes have been assumed to be 1:2 (vertical:horizontal) or approximately 26° at this location.

6.8.2. For this stage of assessment, embankment slopes have been assumed to be 1:3 (vertical:horizontal) or approximately 18° away from the major cutting above.

6.8.3. The scheme aims to minimise generation of waste and maximise on-site use in keeping with the Waste Framework Directive; however there is significant surplus material due to the extensive cutting. Option 12 has a material surplus nearly double that of Option 30 (1,425,000m^3 and 760,900m^3 respectively).

6.8.4. It is anticipated that good quality limestone will be excavated from the cutting and available for a range of uses on and off-site. These uses are likely to include dry stone walling and suitable material for use in construction. Any material would require processing to enable its reuse.

6.8.5. Further details of the re-use of material will be determined on completion of the ground investigation to be undertaken at the next stage of assessment after selection of a preferred route. However Option 30 would have less challenges in achieving a balance in material.

6.9. Carriageway lighting

6.9.1. The provision of lighting would be subject to a detailed risk assessment by a road safety engineer, consistent with the industry standard procedure for the introduction of lighting on a scheme. At this early stage in the scheme development, and for the purpose of assessment ahead of the lighting appraisal, lighting assumptions have been adopted that are in accordance with design standards and common dual-carriageway lighting practice throughout the UK.

6.9.2. It is assumed that the mainline and local roads would be unlit for all route options. Roundabouts, junctions and their approaches on slip roads are also assumed to be unlit for all route options. At this stage, having considered sustainability issues and the potential impacts on the landscape character of the Cotswolds AONB, lighting has been excluded in the scheme design.

6.9.3. The detailed lighting assessment would be undertaken at the next stage of assessment after selection of a preferred route.

6.10. Public Rights of Way

6.10.1. A walking, cycling and horse riding (WCHR) assessment report has been produced, that identifies the existing non-motorised users (NMU) network and its operation across the study area and sets the objectives for the NMU in the design development going forward. This included engagement with the numerous stakeholders, including local councils and the various user groups.

6.10.2. NMU crossings of the proposed route options have been indicatively designed and priced as being segregated from motorised vehicles travelling along the A417 mainline, either over or under the new carriageway. Where possible existing NMU routes would be maintained, but where this is not feasible, they would be diverted along a suitable alternate route. NMU provisions would maintain or enhance connectivity for users, particularly between Barrow Wake and Crickley Hill Country Park.

6.10.3. The proposals for the A417 Missing Link scheme would be assessed in full against the objectives identified within the WCHR assessment report, at a number of stages through the project.

- Preliminary design - following the completion of preliminary design, prior to the PCF Stage 1 Road Safety Audit
- Detailed design - following the completion of detailed design, prior to the Stage 2 Road Safety Audit
- Post-construction - following completion of construction. This should accompany the Stage 3 Road Safety Audit, and should be completed prior to the undertaking of any Stage 4 Road Safety Audit

6.10.4. The proposals for the A417 Missing Link scheme would be assessed in full against the objectives identified within the WCHR assessment report, at a number of stages through the project. At present with the proposals developed at this stage, there is insufficient detail to differentiate the effect of either Option 12 or Option 30 on WCHR users.

6.10.5. As the proposals are developed in future stages of design, Highways England will continue to proactively engage with the local Highway Authority and WCHR

user groups to seek opportunities that complement and enhance the existing WCHR network. These opportunities would be developed taking account of current best practice the benefits of the scheme where they provide the most value.

6.11. Impact on existing utilities

6.11.1. The scheme affects the following statutory undertakers, with the main impact of the scheme on Crickley Hill and near the existing Air Balloon roundabout:

- Openreach
- Gigaclear
- Severn Trent
- Western Power Distribution

6.11.2. An assessment has been carried out on the level of impact of existing utilities and budget estimates (C3 estimates) for the total statutory undertaker's diversionary costs have been prepared as shown below in Table 6.3.

Table 6.3: Statutory undertaker's diversionary costs

Option	Total statutory undertaker's diversionary cost
Option 12	£2,411,200
Option 30	£1,085,800

6.11.3. The lower budget estimate for Option 30 is predominately due to reduced increased impact on telecommunications equipment; existing equipment located on Crickley Hill and near Stockwell is generally not affected, unlike Option 12.

6.12. Constructability

6.12.1. Given the traffic volumes, the strategic importance of the route, the lack of suitable diversion routes nearby and the government's aim to reduce disruption to roads users, it is vital that the existing network remains operational during construction.

6.12.2. For Option 30, construction is predominately off-line whilst Option 12 is predominately on-line widening. This makes Option 30 easier to construct.

6.12.3. The key construction challenge for both options is the construction phasing in the vicinity of the Air Balloon roundabout. The topography, nearby Scheduled Monument of Emma's Grove and SSSIs at Barrow Wake and Crickley Hill, and the need to maintain a permanent traffic route means construction of the proposed A436 bridge would be extremely challenging.

6.12.4. Both route options would require temporary traffic management at various times and locations for a number of purposes including:

- Construction works in the vicinity
- Plant to cross the highway
- Access and egress to site compounds

6.12.5. Detailed temporary traffic management proposals have not yet been developed but it is anticipated that lane width reductions and temporary speed limits would be required at each tie-in location.

6.12.6. There may also be the need for short-term temporary closures and diversions of the A417, local roads and Public Rights of Way (PRoW) to allow tie-ins with the new infrastructure to be constructed. Where appropriate and possible these are likely to take place during the night. As part of the construction operation there would also be a need to move materials from one part of the site to another and to import materials and plant to site.

6.12.7. All temporary traffic management proposals and permitted access routes would be incorporated into a Traffic Management Plan which would be agreed with the relevant highway authority, Gloucestershire County Council for local roads and the maintainer for the existing A417.

6.13. Option estimates

6.13.1. Following the further engineering review of Option 12 and Option 30, the two options were assessed by Highways England's Commercial Division to produce the most likely Order of Magnitude (OME) estimates given below in Table 6.4. These estimates are based on 2016 Q1 prices.

Table 6.4: Most likely order of magnitude option estimates, 2016 Q1 price base

Option	Stage 2 Most likely OME
Option 12	£474,000,000
Option 30	£438,000,000

6.13.2. The estimated costs have increased for Option 12 and decreased for Option 30 since the PCF Stage 1 estimates were prepared. For Option 12, this is primarily due to an increase in indirect works costs associated with increased rates for disposing of excess earthworks material, despite a significant reduction in the assumed volumes. For Option 30 the net decrease is due to revised assumptions on retaining wall lengths and height, and changes in assumptions on the Shab Hill and Gloucestershire Way structures. Both estimates included

revised assumptions on future procurement methodology, limiting cost increase on Option 12 and adding to the reduction for Option 30.

6.14. Technology and maintenance assessment

6.14.1. A high-level technology and maintenance assessment has been completed based on the outline designs of Option 12 and Option 30. The results of this assessment are presented in the following sections.

Technology

6.14.2. The A417 Missing Link scheme is not expected to adopt technology to support operational regimes which manage traffic and provide current information to drivers.

6.14.3. Whilst the A419 / A417 route has been identified as a potential expressway, this scheme is not intending to provide facilities for an expressway as the design of an expressway needs to be carried out over wider length of the road network; ideally the whole of the A419 / A417 route.

Maintenance

6.14.4. As this scheme is in the early stages of development, the design of various assets has not commenced and will vary depending on the route option identified as the preferred route. An initial maintenance and repair strategy statement report has been produced that identified likely new assets and their possible location regardless of route option. There are no identified departures relating to the maintenance and repair strategy of any assets on the proposed route options.

6.14.5. The scheme would seek to introduce new maintainable assets and carry out asset renewal so there is limited repair works in the short to medium term due to the design life of those assets.

6.14.6. The key maintenance issues identified during the early stages of the scheme:

- Mainline alignment (horizontal radii that are below desirable minimum standards)
- Mainline alignment stopping sight distance (SSD) below desirable minimum in junction approaches
- Climbing lane
- Earthworks design is to adopt naturally graded slopes (assumed to be 1:3 throughout) if possible
- Cut slopes designed at steeper slopes (steeper than or equal to 1:2)
- Culverting / diverting Horsbere Brook and controlling groundwater

- Green bridge – an unusual asset to maintain
- Varying structural arrangements employed (i.e. two spans, three spans, four spans) depending on specific circumstances for each individual structure (i.e. skew, span length)
- Winter maintenance

6.14.7. The only distinguishing aspect between the two options identified at this stage is the increased number of geometric departures associated with Option 12, which increases the risks for maintenance activities. Option 12 includes a 270m radius curve on an 8% gradient with a mandatory 50mph speed limit in the vicinity of Air Balloon. It is anticipated that the risk to maintainers will be greatly increased in this location due to the reduced forward visibility. It is likely that Option 12 would require additional closures to conduct routine maintenance activities than Option 30.

6.15. Safety assessment - Impact on road user

Assessment methodology

6.15.1. A safety assessment has been undertaken for both route options with reference to the road safety targets contained within the Highways England Delivery Plan. It then considers the effective construction traffic management that will be required to deliver the project. The remainder of the section reviews the potential implications for operational safety of the two alignments; Option 12, and Option 30.

6.15.2. The road safety element has assessed the following aspects:

- Overall alignments
- General highway design features
- Junction strategy
- Tie-in points
- Tunnel options
- Severance and implications for the local highway network

6.15.3. This assessment reviews the design from a road safety perspective. Observations and recommendations are made about road safety aspects for consideration in future design development.

Implications of the proposals

6.15.4. The Missing Link consists of a single-carriageway trunk road with two at-grade roundabout junctions. Existing highway features include:

- At-grade local junctions
- Residential and field accesses
- Laybys
- Access to the Air Balloon Public House via a slip road on the northbound approach to Air Balloon roundabout and a short right turn lane on the southbound departure from the roundabout
- Access to the Golden Heart Public House in Nettleton via a short service road consisting of the former alignment of the A417

6.15.5. The proposed route options would eliminate most or all of these highway features. In addition, the horizontal and vertical alignments and associated forward visibility would be significantly improved relative to the existing situation.

6.15.6. Both route options would remove traffic from the majority of the existing A417 carriageway between Cowley and Brockworth bypass. However, both options continue to utilise the existing A417 as part of the local highway network providing access to the A436 and Cheltenham for all motorists through the re-use of Birdlip Hill. As such, much of the existing A417 highway features would remain in this location including a residential access to Crickley Ridge and climbing lane heading south. However, the level of risk and therefore the likely number of collisions associated with these features may reduce due to lower traffic flows on the section of re-used carriageway.

Road safety review

Overall alignment

6.15.7. The horizontal alignment of both route options includes curves that are less than the desirable minimum for a 120kph design speed.

6.15.8. Option 12 includes a number of curves that are notably below the desirable minimum with one that is four steps below. The 270m radius curve is proposed on a crest curve of varying gradient between 5-7%. A 50mph speed limit is proposed for this section of the A417. Whilst this will go some way to mitigate the issues it is accepted that further measures will also be needed. The following measures will be considered in further detail as the design progresses:

- VMSs located at the beginning of the downhill section warning road users of their approaching speed and a tight left hand bend
- Average speed cameras to enforce road user speed
- Hard-wired road studs to encourage good lane discipline installed around the bend
- A widened central hatch area between the two downhill lanes to encourage road users to remain in their lane within the high risk area

- Split level carriageway between the up and downhill sections to reduce the risk of a crossover incident

6.15.9. The maximum gradient used on Option 12 is 8.4% for a length of 430m on Crickley Hill, which is above the desirable maximum for an all-purpose trunk road of 4%, and greater than the absolute maximum of 8%. This therefore requires a departure from standard.

6.15.10. Option 30 includes a number of curves that are below the desirable minimum with two sequential 510m curves that are two steps below desirable minimum. The first is located on Crickley Hill with the second being used to avoid the constraints of Emma's Grove scheduled monument. The 510m radius curve is in combination with a 7% vertical gradient and crest curve. There is no reduction in speed limit proposed for Option 30 due to the curves being permitted relaxations to the standards.

6.15.11. The maximum gradient used on Option 30 is 7.0% for a length of 1.8 kilometres on Crickley Hill and Emma's Grove, which is above the desirable maximum for an all-purpose trunk road of 4%, but less than the absolute maximum of 8%. This therefore does not require a departure from standard.

6.15.12. Stopping sight distance requirements and provisions would be considered further in the next stage on the preferred route. Although the preference would be to avoid departures wherever possible, departures could be acceptable with appropriate mitigation especially on the approach to junctions.

6.15.13. Both options include the provision of a climbing lane on the A417 southbound up Crickley Hill to the top of the crest.

6.15.14. As identified within Table 6.1, Option 12 results in 22 departures and Option 30 has 11 departures. Therefore, Option 30 is a more suitable solution due to its higher quality geometry used in the route alignment.

Junctions

6.15.15. The location and form of the junctions will be finalised during the next stage of design development after selection of a preferred route. The following paragraphs identity the current junction locations and forms for each of the options under consideration.

6.15.16. Option 12 will include three new junctions and amendments to an existing junction will be provided within this option:

- A grade-separated dumb-bell junction mid-way along the new A417 providing a junction with the B4070

- North facing on / off-slips approximately 500m north of the grade-separated junction
- A left in / left out junction arrangement in both directions in the vicinity of the existing Cowley roundabout at the point at which the new A417 alignment ties-in with the existing dual carriageway
- Modifications to the existing A436 / Leckhampton Hill junction will also be undertaken to provide a new roundabout junction

6.15.17. The north facing on / off-slips and the proposed grade-separated junction are located at the top of a vertical crest curve and are approximately 500m apart. The horizontal and vertical curvature combined with the close proximity of these junctions would adversely affect the driveability by increasing driver workload due to the number of manoeuvres and decisions to be taken within a short length of carriageway.

6.15.18. The mitigation factors as described in 6.15.11 would need to be installed to reduce the hazards identified above.

6.15.19. The access arrangements for road users heading south from the A436 towards Cirencester via the A417 via the grade-separated junction for Option12 presents a confusing route. This may increase the risk of driver hesitancy and risk of collisions. The proposed arrangement introduces unnecessary conflict points. Careful consideration to the management of traffic through signage and road markings would be required during the development of the route option to reduce the anticipated confusion to drivers and reduce driver workload.

6.15.20. The following new junctions and amendments to existing junctions will be provided within Option 30:

- A grade-separated dumb-bell junction mid-way along the new A417 alignment
- A left in / left out junction arrangement on the A417 near the location of the existing Cowley roundabout
- An at-grade roundabout linking into the existing A417 to the north of the existing B4070 junction at Barrow Wake
- Modifications to the existing A436 / Leckhampton Hill junction will also be undertaken including junction signalisation

6.15.21. The position of the proposed grade-separated junction at the top of a 7% gradient raises concerns relating to an increased risk of collisions between slow moving vehicles continuing along the A417 and vehicles attempting to leave at the new junction. It also may increase the risk of entry speeds for vehicles joining the A417 in the westbound direction. The final form of the Shab Hill junction will be determined during the next stage of design development

considering the risks associated with vehicles joining and leaving the mainline carriageway at the crest of the gradient.

6.15.22. The proposed at-grade roundabout linking into the existing A417 at Barrow Wake is located on a steep gradient which may cause safety issues for road users. The location and layout of this junction will be reviewed during the development of the route option.

6.15.23. Post-construction, all A436 traffic for both options would continue to use the existing A417 south of the Air Balloon roundabout. The existing Air Balloon roundabout will be removed and the junction between Leckhampton Hill and the A436 would be modified to form a signal controlled junction.

6.15.24. The final choice of junction layout at each location would take account of traffic flows and turning movement proportions to minimise the risk of collisions. The junction layouts may also pose problems for vulnerable users wishing to proceed on the local road network who are required to negotiate the junction. The needs of these users would be considered at the next design stage.

6.15.25. Amendments to, and mitigation measures for the current junction locations could be implemented to address many of these concerns in future design development.

Tie-in points

6.15.26. The carriageway standard of the route options would be similar to the existing A417 at tie-in points at each end of the scheme for both options.

6.15.27. The proposed link road for Option 30 will tie-in with the existing A417 via a new at-grade roundabout and associated connections to the existing A417 and B4070.

6.16. Impact during construction, maintenance, operation and demolition

6.16.1. The Construction (Design and Management) Regulations 2015 (CDM 2015) set out the legal minimum requirements for management of design, construction and maintenance phases of the project, to ensure that the requirements of the Health and Safety at Work Act (1974) are considered by duty holders. Actions taken to reduce or eliminate hazards and risks during the design phase are recorded in the Designers Hazard Elimination and Management Record.

6.16.2. During PCF Stage 2 Option Selection, the duty holders under CDM are:

- Client – Highways England

- Principal Designer – Mott MacDonald (on behalf of the Mott MacDonald Sweco Joint Venture)
- Principal Contractor – not appointed, (but the existing site is operated by the Design Build Finance Operate (DBFO) company)

6.16.3. During the options identification, selection and development stages there is considerable scope to design out and eliminate hazards and reduce risk to the personnel who will use the highway as a place of work during its lifetime. Items that can be considered to reduce risk to those using the site as a place of work are, but not limited to, the items below.

Construction phase

6.16.4. The proposed options include significant off-line sections of the alignments. This allows some of the works to be carried out in an 'off-line' site, with no members of the public transiting through the site. The site would need to access the public highway network, and once the preferred route is known, temporary site accesses and compounds can be designed. The current roundabouts on the A417 would be suitable locations for accesses that would reduce the risk to the workforce as they join the public highway.

6.16.5. Of the two options, Option 12 utilises more of the existing carriageway. In addition to Crickley Hill which both routes use, Option 12 also utilises approximately 1 kilometre length of on-line widening near Birdlip village in addition to changes to the level of the existing carriageway. Construction of the off-line carriageway elements would take place first to allow traffic to use the existing road during construction, before traffic is switched to the new construction to allow the existing road to be modified. Despite any such phasing, construction works would be taking place in close proximity to live traffic and precautionary measures such as the use of varioguard and average speed cameras to reduce the speed of the live traffic should be considered.

6.16.6. The construction and phasing near the Air Balloon roundabout will be particularly challenging for Options 12 and 30. The three main challenges to overcome as the design progresses would be:

- Maintaining the existing traffic movements
- Constructing the cutting for the dual-carriageway
- Providing sufficient working space to construct the overbridge to connect the A436 to the existing

6.16.7. Both options involve substantial movements of spoil to create cuttings and junction earthworks. Reduction in the movement of fill within site, (i.e. reusing

the excavated fill within the site extents), would reduce the total distance covered by plant moving materials through the site.

6.16.8. Due to the off-line location of the majority of the sites, structures would be constructed without the live traffic passing through. This gives the contractor the opportunity to construct structures at existing ground levels and then dig out beneath. Alternatively, the contractor may propose to construct structure decks at ground level and then lift into place. Therefore, there are options to eliminate the majority of 'working at height' hazards through best design practice. Option 12 contains more elements of on-line works than Option 30, especially around the existing and proposed Birdlip junction. However, Option 12 is anticipated to be more disruptive to existing road users than Option 30.

6.16.9. Statutory undertakers' apparatus crosses the site and temporary disconnection of these utilities is unlikely to be approved for the duration of the construction phase. Therefore, the designer and contractor will need the highest level of accuracy in determining the location of apparatus to reduce the risk of striking utilities during construction. The design team have worked with the current statutory undertakers' returns and will work closely with the providers as the design progresses, to ensure a safe and efficient process for maintaining, and if necessary, diverting any affected apparatus.

Maintenance phase

6.16.10. After the construction phase the highway will be handed over to the maintenance organisation. An initial maintenance and repair strategy statement report has been produced (see Section 6.14) and this is to be developed in collaboration with the maintenance organisation.

6.16.11. In addition to the key maintenance issues described in Section 6.14 above, safe access for maintenance and repair needs to be developed. Detailed traffic management arrangements have not been identified at this stage of the scheme development, however the following elements of the concept designs potentially affect traffic management arrangements:

- Less than desirable minimum radius radii horizontal bends
- Junction approaches with reduced stopping sight distance
- Position of major junction in relation to less than desirable minimum radius horizontal bends
- Gradients of more than 4%

6.16.12. For the trunk road, the assumed safe means of access to features in the verge and central reserve is through the implementation of lane closures or from

maintenance laybys. There are no existing or proposed hardshoulders that could be used for maintenance activities.

6.16.13. For the local road network, the assumed safe means of access to features in the verge is from the adjacent traffic lane though the implementation of a lane closure or from maintenance laybys.

6.16.14. No specific locations have been identified for maintenance laybys.

6.16.15. The use of remotely operated temporary traffic management signs and fixed taper points has not yet been considered during this stage.

6.16.16. No specific provision for Emergency Crossing Points (ECP) on the dual-carriageway has been identified during this stage. It is assumed ECPs are to be provided and therefore maintenance measures for these facilities will be required.

6.17. Summary and conclusions

6.17.1. The two options follow a similar route up Crickley Hill but follow different alignments as they reach the top of the escarpment. Option 12 generally follows the existing A417 but includes a bypass for Nettleton Bottom, whilst Option 30 takes a more direct route to the southern tie-in. Otherwise, both options follow broadly similar principals.

6.17.2. Due to the topographical and various environmental constraints, both options require a vertical gradient above the desirable maximum and use of horizontal bends near the Air Balloon that are below desirable minimums. For Option 12, the bend is four steps below desirable minimum and two design speed steps tighter than for Option 30. As a result, several departures are required for each option; Option 12 requires 22 departures whilst Option 30 requires 11 departures. In comparison to Option 12, Option 30 provides the greater opportunity to design out departures as the design develops.

6.17.3. Through the removal of the existing single-carriageway section of the A417, both options would be expected to have a positive impact upon road safety and contribute to the Highways England target of reducing the number of people killed or seriously injured on the strategic road network.

6.17.4. The higher number of departures and steeper vertical alignment associated with Option 12 mean the risks associated with the operational and maintenance safety would be higher than Option 30 even after mitigation is applied for both options.

6.17.5. Both options would give rise to safety considerations that would have to be addressed in the further development of the scheme, including steep gradients. Mitigating measures would be applied to address safety matters. Of the two options, Option 12 presents the greater challenges to overcome and would require the most mitigation measures.

6.17.6. Neither of the route options have any significant technology requirements; expressway requirements have not been considered as part of the scheme.

6.17.7. There would be no significant difference between the maintenance and repair requirements for the two route options. However, it is anticipated that the risk to maintainers will be increased for Option 12 due to the horizontal and vertical alignments associated with the proposed route.

6.17.8. From a CDM 2015 perspective, both the options are notable for the quantity of earth movements required within the construction area and outside of it, and this will be a key point of safety management.

7. Traffic assessment

7.1. Introduction

7.1.1. The A417 Missing Link traffic model was developed for the purposes of assessing scheme options, as well providing inputs to the environmental appraisal, highway and junction design, economic assessment and distribution impact assessment.

7.1.2. The traffic model used at Project Control Framework (PCF) Stage 2 was developed from the PCF Stage 1 traffic model, which in turn was developed from Highways England's South West Regional Traffic Model (SWRTM).

7.1.3. This chapter provides a summary of the traffic modelling methodology adopted in PCF Stage 2, including an overview of the SWRTM and development undertaken at PCF Stage 1. An overview of the forecast performance of both scheme options is also provided within this chapter.

7.2. Traffic modelling methodology

Key features of the model

7.2.1. The A417 base traffic model is representative of average weekday (Monday to Friday) traffic for March 2015.

7.2.2. The modelling system follows the WebTAG based approach, comprising of:

- Trip end model – used for estimating the number of trips generated / attracted by a specific zone
- Demand model – used for estimating how travellers will 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

7.2.3. The highway assignment model has been developed in SATURN software and covers a single average hour across four time-periods in a March weekday. The modelled time periods are:

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

7.2.4. Only the three day-time periods are subject to calibration and validation, with the OP model simply providing an alternative method to factoring from modelled periods to daily levels.

7.2.5. 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

7.2.6. The Employers' Business and Other trips are also split into home based and non-home based purposes.

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

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

South West Regional Traffic Model

7.2.9. Highways England 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 represent an average weekday in March 2015.

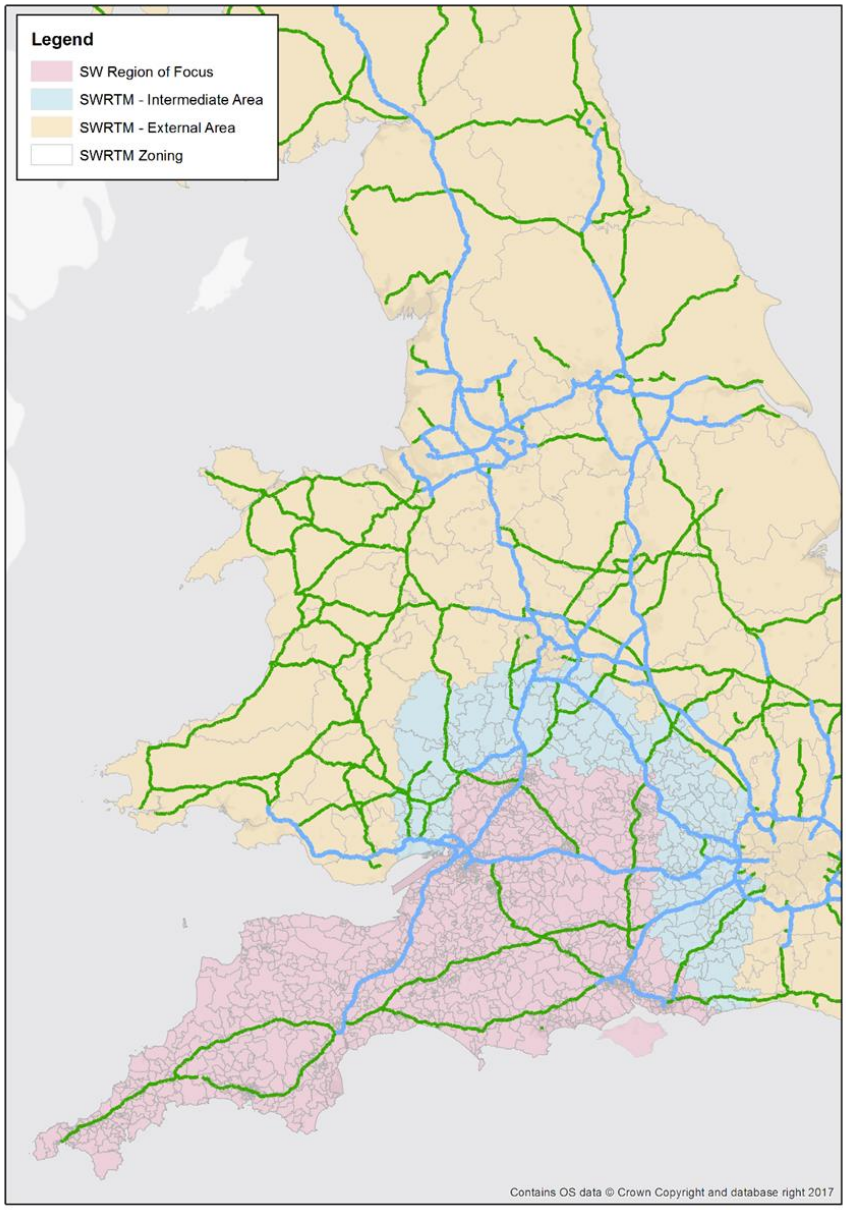
7.2.10. The A417 Missing Link is a RIS scheme within the geographical area of South West RTM (SWRTM). The coverage of the SWRTM is illustrated in Figure 7.1, which identifies the various modelled areas that are defined below.

7.2.11. 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 provide 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.

7.2.12. 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 trunk roads.

7.2.13. 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 7.1: SWRTM Network coverage



Development of the PCF Stage 1 traffic model

7.2.14. The SWRTM Design Freeze 2 (DF2) base model was used as the initial basis for the A417 PCF Stage 1 traffic model. Key changes made when developing the A417 traffic model from the SWRTM are described in the following paragraphs, and included the following:

- Simplification of detailed coding outside of the main study area
- Enhancement of the local network and zone system within the main study area to provide more detailed representation of local routes
- Additional observed local data (journey times and traffic counts) used to allow the model calibration and validation to be focused on the A417 study area

7.2.15. The main study area for the A417 traffic model was defined at PCF Stage 1, with SWRTM initial assignments used to identify the potential traffic impacts of an A417 improvement scheme. From these initial tests using the SWRTM it was noted that, in addition to local reassignment, the main strategic effect of a Missing Link scheme was likely to be reassignment onto the A417 from the M5 / M4 and also from the M40 / A34 route.

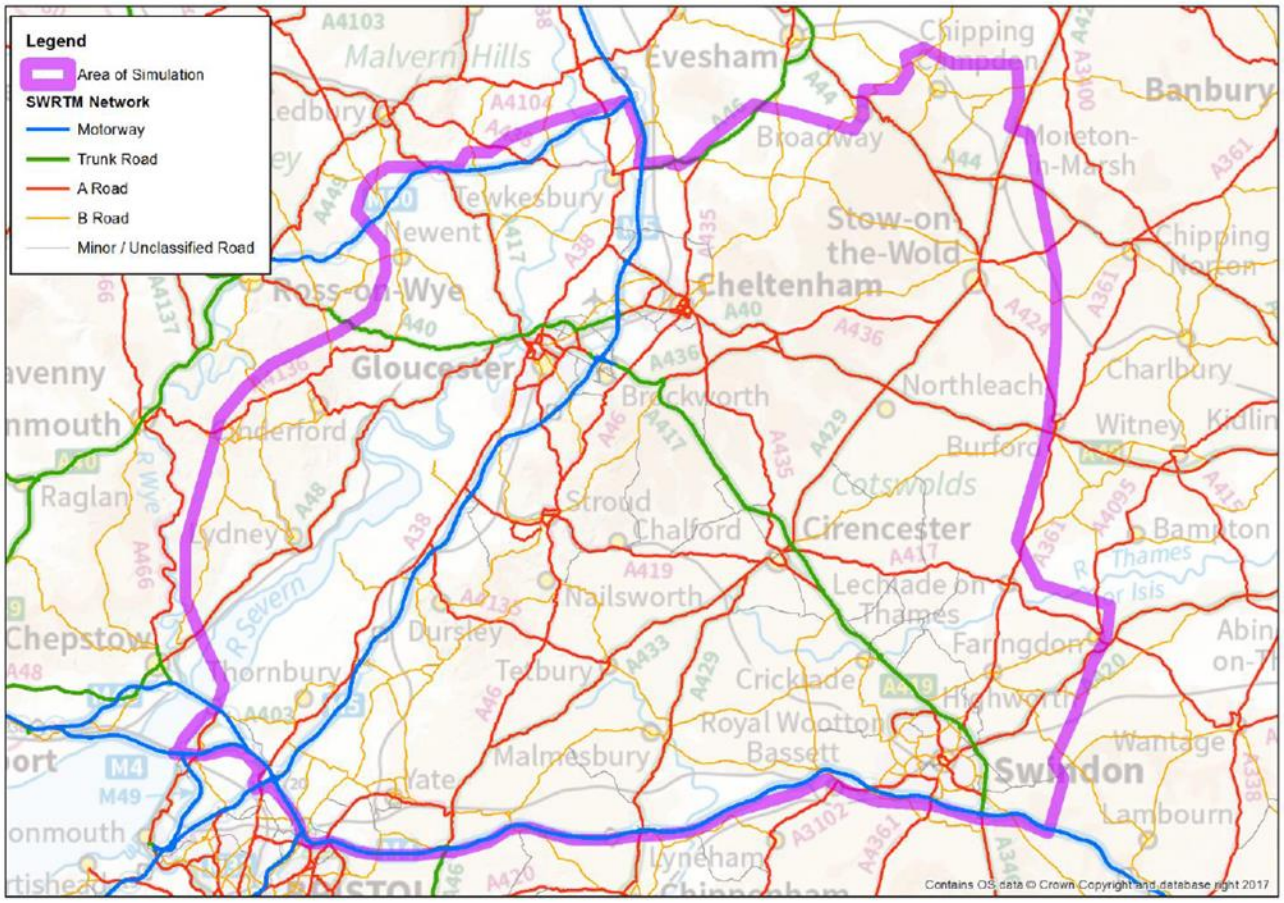
7.2.16. Whilst the affected M4 / M5 sections are included within the SWRTM RoF, the length of the M40 / A34 alternative route over which reassignment is anticipated to occur lies outside the SWRTM RoF and is not coded in detail. At PCF Stage 1 the M40 / A34 route was retained as fixed speed coding and it was accepted 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.

7.2.17. In defining the A417 study area, consideration was also given to retaining the full detail of the SWRTM in order to try and maximise the capture of benefits in the appraisal. However, having such a large detailed modelled area would significantly increase the risk of noise in the assignments becoming an issue in the appraisal of the scheme.

7.2.18. In light of the above, the boundary of the detailed modelled area in the A417 PCF Stage 1 model was unchanged from the SWRTM to the north and west but the area was significantly reduced compared to the RTM to the south and east. To the south, the detailed area extends to include M5 junction 16 (south of the M4 / M5 Almondsbury interchange) and includes the M4 to junction 15 south-east of Swindon. To the east, the boundary of the detailed area broadly follows the Gloucestershire county boundary.

7.2.19. The extent of the detailed modelled area, which is also known as the 'simulation area', at PCF Stage 1 is shown in Figure 7.2. All areas outside of this detailed modelled area were converted to, or retained as, fixed speed coding.

Figure 7.2: A417 Missing Link traffic model simulation area



7.2.20. The largest urban areas within the A417 detailed modelled area were retained as fixed speed coding at PCF Stage 1. This included Cheltenham, Gloucester and Stroud near to the scheme, and Swindon further afield.

7.2.21. Having defined the area of detailed modelling the development of the A417 traffic model subsequently involved enhancing the SWRTM near the proposed scheme 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.

7.2.22. A selection of SWRTM model zones were disaggregated to enable, in conjunction with additional network detail, more accurate loading of traffic in the local area. The PCF Stage 1 model included 1,914 zones, an increase of 13 compared to the SWRTM.

7.2.23. Additional local traffic count data, over and above that included in the SWRTM, were also incorporated into the calibration and validation of the model to better represent local traffic movements.

7.2.24. The PCF Stage 1 base year traffic model generally calibrated and validated well against observed data, including journey times and individual link flows. There were some locations, generally in close proximity to Cheltenham and Gloucester, where comparisons between modelled and observed flows at an aggregate screenline level (i.e. where counts are grouped together to capture traffic movements over a wider area) fell outside the intended targets. However, on the whole, it was concluded that the PCF Stage 1 model provided a robust basis from which future year forecasts and options testing could be developed.

7.2.25. The model was subsequently used as the basis of the PCF Stage 1 traffic forecasts, which were prepared for four future years (2024, 2031, 2039 and 2051), and for each of the six scheme options under consideration at the time.

Development of the PCF Stage 2 traffic model

7.2.26. The PCF Stage 2 traffic model builds on the work undertaken at the previous stage, with further enhancements made to the model with the aim of improving the representation of urban areas near the scheme.

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

7.2.28. The zone system in these urban areas has been refined at PCF Stage 2 to enable more accurate loading of traffic in the model. The PCF Stage 2 model now includes 1,940 zones, an increase of 26 from PCF Stage 1.

7.2.29. As mentioned previously, the detailed coding within the SWRTM contained ‘islands’ of fixed speed coding covering large urban areas. These included several areas within the A417 detailed modelled area (Swindon, Cheltenham, Gloucester, Bishops Cleeve, Stroud and Nailsworth). At PCF Stage 1, these urban areas were retained with fixed speed coding. To better represent delay and route choice in the PCF Stage 2 model, network coding in these urban areas (with the exception of Swindon) has been enhanced to provide a more detailed and responsive representation of the highway network.

7.2.30. As outlined above, in addition to local reassignment, a Missing Link scheme is also expected to result in reassignment onto the A417 from the M5 / M4 and also

from the M40 / A34 route. This was confirmed to be the case in the forecasts undertaken at PCF Stage 1.

7.2.31. While the affected M5 / M4 sections were coded in detail in the PCF Stage 1 model, the M40 / A34 route was retained as fixed speed coding. It was accepted that journey time benefits arising from a reduction in traffic on this route would not be captured in the appraisal.

7.2.32. The M40 / A34 route has also not been included within the detailed modelled area in the PCF Stage 2 model due to the length of this alternative route, its relative remoteness from the main modelled area and the substantial data requirements. However, in order to improve the responsiveness of this route to changes in demand, speed flow curves have been introduced along its length in the PCF Stage 2 model.

7.2.33. In light of the above, the extent of the detailed model area remains unchanged from PCF Stage 1 but the key longer distance alternative routes (M40 / A34, M42 and M5 north) are now coded with speed flow curves.

7.2.34. The calibration and validation results for the PCF Stage 2 base model represent a clear improvement against those achieved at PCF Stage 1, particularly with regards to flows at the aggregate screenline level. The improvement in the PCF Stage 2 results reflects the additional work undertaken at this stage and particularly the improved representation of the urban areas of Cheltenham, Gloucester, Cirencester and Stroud in the model. It has therefore been concluded that the PCF Stage 2 base traffic model provides a robust basis for the appraisal of the scheme options.

PCF Stage 2 traffic forecasting methodology

7.2.35. Traffic forecasts have been prepared for the current estimated opening year for the scheme, 2024, and the scheme design year, 2039. 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. This is consistent with the forecasting approach adopted at PCF Stage 1.

7.2.36. Forecasts have been undertaken for the two options (Do Something scenarios) under consideration at PCF Stage 2, as well as a scenario without the scheme (Do Minimum scenario).

7.2.37. 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:

- 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) v7.2 growth factors as a constraint on trip growth for cars and rail
- Application of growth of freight traffic from Department for Transport (DfT) Road Traffic Forecasts 2018 (RTF18)
- Application of forecast traffic growth at the primary airports and seaports within the south-west region

7.2.38. The transport supply (i.e. transport network) 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.

7.2.39. In addition, the PCF Stage 2 forecasts include the removal of toll charges on the Severn Crossings.

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

- Do Minimum forecasts – these use forecast year trip matrices and the future transport network that excludes the proposed scheme options
- Do Something forecasts – these use forecast year trip matrices and the future transport network changes, including the proposed scheme options

7.2.41. The traffic forecasts have been undertaken using a variable demand modelling approach that is consistent with that applied in the development of the SWRTM and at PCF Stage 1. The responses to changes in travel costs that are represented by the variable demand model include trip redistribution, mode choice and time period choice.

7.3. Analysis of scheme performance

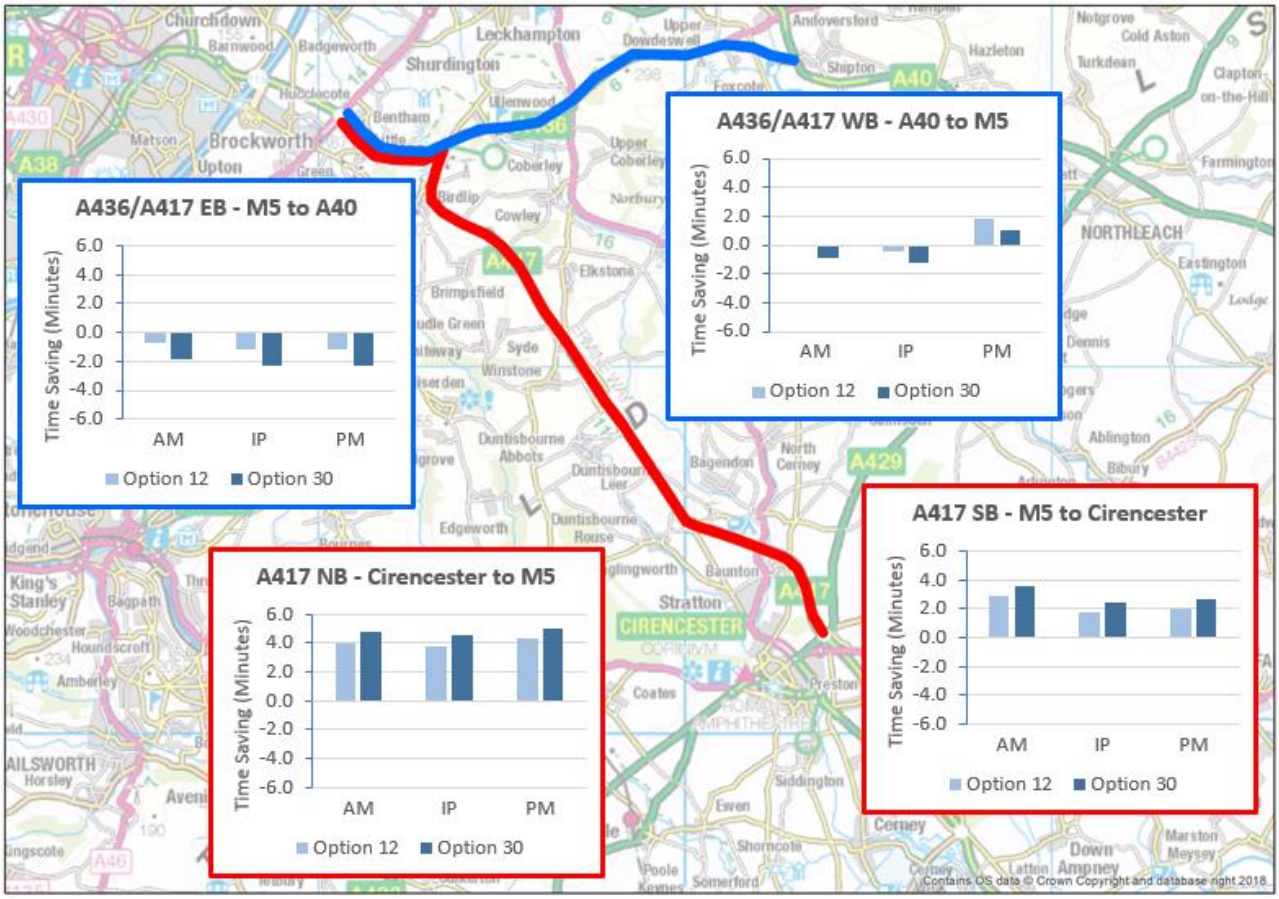
Journey times

7.3.1. To illustrate the impact of the scheme options on forecast journey times, the modelled journey times have been extracted from the various scenarios for the following routes, which are also shown in Figure 7.3.

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

7.3.2. Figure 7.3 summarises the journey time savings against the Do Minimum scenario for both options for the 2024 forecast year.

Figure 7.3: Forecast journey time savings (2024)



7.3.3. Both options are forecast to reduce journey times along the A417 in both directions compared to the Do Minimum scenarios. Option 30 provides the better journey times along the A417, which reflects the more direct route alignment in that option. Given the large amounts of existing delays experienced by northbound traffic, the largest journey time savings are forecast to be achieved in that direction.

7.3.4. In the opening year (2024) forecasts for Option 30, northbound journey times reduce by more than 4.5 minutes in the AM and inter-peak periods, and by slightly more than 5 minutes in the PM peak. Option 12 northbound savings are lower but still exceed 4 minutes in both the AM and PM peak periods.

7.3.5. The journey time savings on the A417 are not as great in the opposite (southbound) direction, but in Option 30 still equate to around 3.5 minutes in the AM peak and 2.5 minutes in the other periods. In Option 12 the southbound reductions are slightly under 3 minutes in the AM peak, and 2 minutes in the PM peak.

7.3.6. Journey times on the A436 route are generally forecast to increase compared to the Do Minimum scenario with both options. The longer journey times forecast to occur along this route is reflective of the scheme layouts, with the direct

connection between the existing A417 and A436 (currently at the Air Balloon roundabout) being removed in both options. Option 30, which provides the least direct connection between these two roads, results in longer journey times when compared to Option 12.

7.3.7. In the existing situation, westbound traffic typically experiences greater delay at the Air Balloon roundabout than the eastbound equivalent traffic on this A417/A436 route. Westbound delays are also typically more significant in the evening peak period. As such, both scheme options improve westbound journey times in the evening peak, with Option 12 reducing journey times compared to the Do Minimum in this period by nearly 2 minutes in 2024. Option 30 reduces westbound journey times by around 1 minute in the evening peak in 2024. Impacts on westbound journey times in the other periods are more mixed, with Option 30 forecast to increase these journey times (compared to the Do Minimum in 2024) by around 1 minute in both the AM and the IP periods. Option 12 also increases westbound journey times in the PM peak (by nearly 30 seconds) but has a largely neutral effect in the other periods.

7.3.8. Eastbound journey times are forecast to increase in all periods with both scheme options. Option 30 provides the slowest eastbound journey times and, when compared to the 2024 Do Minimum scenario, adds nearly 2 minutes to journey times in the AM peak and nearly 2.5 minutes in both other periods. Option 12 eastbound journey times increase by around 1 minute in all three periods.

Traffic flows

7.3.9. Forecast Annual Average Daily Traffic (AADT) flows at key locations, both near the scheme and on longer distance routes, are presented on plans included in Appendix E. Each location shown on the plans is allocated a reference ID. Separate plans are produced for each scheme option with AADTs shown for the Do Minimum and Do Something scenarios for both the 2024 opening year and the 2039 design year. The 2015 base year flows are also presented on the plans. The location reference ID shown in the AADT plans are also included in the following tables to enable the locations to be cross-referenced.

7.3.10. Table 7.1 summarises forecast AADT flows along the A417 in the vicinity of the scheme. Flows on the existing A417 alignment and on the proposed link between the new and old alignments (in Option 30 only) are also presented in the table.

Table 7.1: Forecast AADT Flows on A417

Location	Ref.	2015	2024			2039		
		Base	DM*	Opt 12	Opt 30	DM*	Opt 12	Opt 30
A417 south of the Highwayman	ID 1	33,400	37,100	42,400	44,900	43,300	51,300	53,900
A417 Crickley Hill	ID 6	36,900	40,900	45,900	46,500	46,300	56,700	57,200
A417 west of A46 / A417 junction	ID 9	50,700	60,500	65,100	65,600	70,800	77,700	78,300
Link between old and new A417 (Option 30)	ID 26	-	-	-	10,600	-	-	13,800
Existing A417 south of Air Balloon roundabout	ID 5	29,500	32,200	18,900	16,400	35,700	22,600	20,300

*Do Minimum

7.3.11. In both scheme options, flows on the mainline A417 are forecast to increase as a result of the Missing Link scheme. Compared to the Do Minimum scenario, opening year flows on the Crickley Hill section of the A417 are forecast to be 5,000 vehicles per day (vpd) greater with Option 12 and 5,600 vpd greater with Option 30. The more direct alignment and faster journey times that Option 30 provides compared to Option 12 contributes to the higher forecast flows on the A417 in the former option.

7.3.12. In both scenarios, 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, coupled with some redistributed trips that are taking advantage of the improvements to the route.

7.3.13. The greater flows on the A417 with Option 30 correspond to greater levels of reassignment from various alternative routes, providing significant reductions in traffic on local roads currently used as rat-runs. Table 7.2 identifies the forecast AADT flows on a selection of roads in the vicinity of the A417 Missing Link.

Table 7.2: Forecast AADT Flows on Other Roads

Location	Ref.	2015	2024			2039		
		Base	DM*	Opt 12	Opt 30	DM*	Opt 12	Opt 30
Elkstone	ID 2	3,800	4,000	3,300	2,900	4,400	3,300	2,700
Birdlip Hill	ID 7	5,300	6,500	4,000	3,900	9,200	4,300	4,600
Leckhampton Hill	ID 4	7,000	7,300	7,500	7,400	7,700	8,700	8,700
A436 at Ullenwood	ID 10	13,100	13,900	11,900	9,400	15,900	14,500	12,200
B4070 south of Birdlip	ID 14	5,200	5,500	6,600	6,700	5,900	7,500	7,700
A46 north Painswick	ID 11	5,700	6,300	5,900	5,800	7,200	6,800	6,700

*Do Minimum

7.3.14. Traffic flows on the main local rat-runs of Birdlip Hill and the route via Elkstone are forecast to reduce with both scheme options as local traffic reassigns onto the A417. In the opening year, flows on the Elkstone rat-run are forecast to reduce compared to the Do Minimum by 1,100 vpd with Option 30 and by 700 vpd with Option 12. Similarly, opening year flows on Birdlip Hill are forecast to reduce by nearly 40% with both options.

7.3.15. As well as local reassignment effects, both scheme options are forecast to encourage some reassignment from strategic routes including the A34 / M40, A419 via Stroud and A429 through the Cotswolds. The most significant of these impacts occurs on the A34 / M40 corridor, from where approximately 1,000 vpd are forecast to reassign onto the A417 / A419 corridor. These strategic effects are largely common to both options, but with greater reassignment generally occurring with Option 30.

7.3.16. The large reduction in delays at the existing Air Balloon roundabout is forecast to also lead to other local effects, including an increase in traffic on the B4070 between Stroud and Cheltenham. In the opening year flows at this location are forecast to increase by around 20% with both options. The increase on the B4070 is primarily a result of traffic reassigning from the A46 route via Painswick.

7.3.17. Changes in flows resulting from the scheme options are forecast to be less substantial on the M4 west of Swindon and on the M5 north of Bristol, which suggests minimal reassignment away from the M4 / M5 route.

7.3.18. Traffic flows on the A436 to the east of the Air Balloon roundabout are forecast to decrease compared to the Do Minimum for both Options 12 and 30. The reduction in traffic is a result of the modified arrangement for east-west traffic

routing between the A436 and the A417 / M5 (and vice versa). Both options will result in increases in journey length for this movement, with Option 30 being considerably the longer of the two options. In addition, while travel times are forecast to be more reliable when compared to the existing situation at the Air Balloon roundabout, both options lead to increased travel times outside of peak periods. With Option 30, flows on the A436 are forecast to reduce by almost a third compared to the Do Minimum. Corresponding reductions with Option 12 are forecast to be less significant and, in the opening year, equate to a reduction of 14% compared to the Do Minimum.

7.4. Conclusions

7.4.1. Both options are forecast to reduce journey times along the A417 in both directions compared to the Do Minimum scenarios. Option 30 provides the better journey times along the A417, which reflects the more direct route alignment in that option.

7.4.2. The benefits of reduced journey times on the A417 route are, at least in part, offset by increased journey times in both options for traffic travelling between the A436 and A417. The longer journey times forecast to occur along this route reflects the scheme layouts, with the direct connection between the existing A417 and A436 (currently at the Air Balloon roundabout) being removed in both options. Option 30, which provides the least direct connection between these two roads, results in longer journey times when compared to Option 12.

7.4.3. The improved journey times are forecast to lead to an increase in traffic along the A417 corridor in both options. To the south of the A417 Highwayman Inn junction, the maximum flow increase compared to the Do Minimum is forecast to occur in Option 30 with the AADT increasing by 21% in the opening year. Increases in Option 12 compared to the Do Minimum are lower but still equate to 14% in 2024.

7.4.4. The forecast increases in traffic in the vicinity of the scheme are a result of reassignment from various alternative routes, both local and strategic, coupled with some redistributed trips that are taking advantage of the improvements to the route.

8. Economic assessment

8.1. Introduction

8.1.1. This chapter provides an overview of the economic assessments undertaken for the A417 Missing Link scheme options at Project Control Framework (PCF) Stage 2. The results of the economic assessments are also presented.

8.2. Overview

8.2.1. The Department for Transport's (DfT's) WebTAG 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 both PCF Stage 2 A417 scheme options has followed the guidance set out in the following WebTAG Units:

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

8.2.2. Table 8.1 identifies the approach adopted to appraise the economic impacts of the A417 scheme options.

Table 8.1: Overview of economic assessments

Element	Assessment method
Transport economic appraisal	TUBA (Transport Users Benefit Appraisal) software (version 1.9.11)
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 2017 version 4.15.0.1)
Air quality	DfT's 'Local Air Quality Workbook' and 'Air Quality Valuation Workbook'
Noise impacts	Approach set out in WebTAG Unit A3 Chapter 2
Greenhouse gas emissions	Approach set out in WebTAG Unit A3 Chapter 4
Wider economic impacts	WITA (Wider Impacts in Transport Appraisal) software (version 1.2.1.2 beta)

8.2.3. The application of the above methods in the economic assessment of the scheme is set out in detail within the subsequent sub-sections.

8.2.4. The economic appraisal for the scheme has used the A417 Missing Link PCF Stage 2 traffic model. Traffic forecasts have been prepared for an estimated

opening year for the scheme, 2024, and the scheme design year, 2039. 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.

8.2.5. Forecasts have been undertaken for both scheme options and also for a Do Minimum scenario, in which no A417 Missing Link scheme is implemented.

8.3. Economic appraisal approach

Estimation of costs

8.3.1. Highways England has prepared cost estimates for both scheme options.

8.3.2. The expenditure profiles are based upon cost estimates for each financial year prepared in Q1 2016 prices and then inflated to outturn costs using Highways England projected construction related inflation. These costs have then been rebased to 2010 calendar year profiles for economic calculations, using the Gross Domestic Product (GDP)-deflator series as published in the WebTAG Databook. The costs exclude all recoverable VAT and all historic costs have been removed.

8.3.3. Operation and maintenance costs are presented in Table 8.2 as net values (i.e. the costs associated with maintaining the new road(s) less the cost of maintaining the existing alignment in the Do Minimum scenario). These costs have been calculated using values included within Part 2, Chapter 9 of the DfT's COBA manual (July 2017).

8.3.4. Table 8.2 summarises the costs for each option assessed. The costs include allowances for risk and contingencies and are presented in 2010 prices, undiscounted.

Table 8.2: Option cost summary (2010 prices, undiscounted)

Cost type	Option 12	Option 30
Preparation	£13,071,542	£12,659,307
Supervision	£6,974,566	£5,502,434
Works	£340,394,873	£310,739,414
Land	£19,365,541	£21,397,784
Operation & maintenance	£9,745,849	£9,947,558
TOTAL	**£389,552,371**	**£360,246,497**

Source: Highways England (December 2018 and January 2019) and COBA manual (July 2017)

Transport user benefits

8.3.5. The DfT's economic appraisal software TUBA version 1.9.11 has been used to calculate the transport user benefits for each option in accordance with published DfT guidance.

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

8.3.7. 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 options for a 60-year period from scheme opening (i.e. 2024 to the end of 2083). Both the benefits, and the scheme costs, are discounted by TUBA to the present value year (2010) in accordance with WebTAG Unit A1.1.

8.3.8. The traffic models have been built to represent a weekday in March and include an average AM peak hour (07:00-10:00), an average interpeak hour (10:00-16:00), an average PM peak hour (16:00-19:00), and an average off-peak hour (19:00-07:00). In the appraisal the results produced by the average-hour models for the single weekday in March have been factored up using annualisation factors to represent all hours during the year. These factors take into account monthly variations in flow as well as making allowance for weekends and bank holidays.

Accident benefits

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

8.3.10. The COBALT approach adopted for the A417 Missing Link scheme combines accidents on links and junctions together. The assessment has been limited to the area of detailed modelling within the SATURN traffic model as this area is considered to encompass the majority of the effects of the proposed scheme options.

8.3.11. Using the PCF Stage 2 base SATURN model as a starting point, a base COBALT network was prepared in Geographic Information System (GIS). In keeping with COBALT guidance, the SATURN highway network has been simplified in places to condense complex junction coding down to single nodes. In addition to the simplification of complex junction coding in the SATURN networks, it was also necessary to combine SATURN links, which are one-way only, such that a single link in COBALT 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 hardstrip. The speed limit was also allocated to each link in the COBALT network.

8.3.12. Observed accidents from a full 5-year period 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, is used by the software to derive observed accident rates on each of the COBALT links.

8.3.13. To account for the high number of seriously injured and fatal casualties on the existing single-carriageway sections of the A417, the assessments also include the application of observed accident severity splits and casualty rates on this section of the road.

8.3.14. Do Minimum COBALT networks were prepared from the base network by modifying the structure to accommodate the relevant Do Minimum scenarios. 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. Do Something (i.e. with scheme) networks were created from the Do Minimum networks in a similar way, with default accident rates being applied to the new scheme links.

8.3.15. COBALT forecasts the number of accidents and casualties in the Do Minimum and Do Something scenarios over the 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 WebTAG guidance. By comparing the Do Minimum and Do Something 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.

Journey time reliability

8.3.16. 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 will lead to improved journey time reliability along the A417 route.

8.3.17. Using Trafficmaster journey time data, the standard deviation of travel time (adopted as a measure of travel time variability) has been obtained for the existing single-carriageway section of the A417 and was compared with the reliability of travel time on an adjacent existing dual-carriageway section.

8.3.18. Reliability benefits have subsequently been monetised by applying the ‘rule of a half’ method using the travel time standard deviations, forecast traffic flows and

a forecast value of reliability per vehicle. As recommended in WebTAG Unit A1.3, the value of reliability (in £'s per hour) has been derived using WebTAG Values of Time and applying a 'reliability factor' of 0.4.

8.3.19. Opening year (2024) reliability benefits are calculated by applying the annualisation factors used in TUBA and are discounted to 2010 using standard discounting rates. The benefits were then calculated for the full 60-year appraisal period by applying an appropriate capitalisation factor to the 2024 opening year benefits.

Construction impacts

8.3.20. To quantify the impacts of scheme construction on transport users an economic assessment has been performed for both scheme options with QUADRO software (QUADRO 2017 v4.15.0.1).

8.3.21. The assumptions used in the appraisal are based on an assessment of the temporary traffic management arrangements that are considered to be necessary in order to construct each of the two scheme options. This includes the introduction of speed reductions and road closures (with diversions) at various times throughout the construction period.

Air quality

8.3.22. 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 (NPV) have been calculated based upon local and regional changes in air quality. Roads in the traffic model that meet the Design Manual for Roads and Bridges (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'.

Noise impacts

8.3.23. A noise appraisal has been undertaken in accordance with WebTAG Unit A3 Chapter 2. Net present values 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 respective option study areas required independent entries in the WebTAG Noise Worksheets for 'with' and 'without' scheme in both opening and design years.

8.3.24. 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 WebTAG methodology.

Greenhouse gases

8.3.25. A greenhouse gases (GHG) appraisal has been undertaken in order to determine the carbon dioxide equivalent (CO_2e) emissions for each option and derive the NPV of each option in terms of GHGs. This appraisal was undertaken based on the approach set out in WebTAG Unit A3 Chapter 4. Outputs from the A417 PCF Stage 2 traffic model were provided for each of the Missing Link scheme options. Data on vehicles flow, speed and % heavy duty vehicles (HDV) (HDV are a sum of heavy goods vehicles and buses) were available on an Annual Average Daily Traffic (AADT) basis for the Do Minimum and Do Something scenarios for the scheme options. The results were input into the DfT Greenhouse Gases Workbook (Version May-18) to generate the associated NPV for each of the options being considered.

Wider economic impacts

8.3.26. Wider economic impacts refer to economic impacts that are additional to the standard transport user benefits assessed by TUBA software. At PCF Stage 2 the wider economic impacts of the scheme options have been assessed using the DfT's WITA software (version 1.2.1.2 beta). WITA assesses the wider economic impacts of a scheme in accordance with the calculations and methodologies set out in WebTAG Unit A2.1.

8.3.27. The following wider economic impacts have been included in the appraisal undertaken at PCF Stage 2:

- Agglomeration impacts
- Labour supply impacts
- Output change in imperfectly competitive markets

8.3.28. 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 at the Missing Link, a scheme at this location will reduce travel costs and contribute towards increased agglomeration and labour supply impacts.

8.3.29. The wider economic appraisal is based on matrices of trips and costs extracted from the transport model for the four forecast years (2024, 2031, 2039 and 2051). Benefits calculated by WITA are then interpolated and extrapolated by the software to cover the whole appraisal period. However, WITA only allows for an appraisal period up to the year 2080 and therefore the wider economic impacts do not cover the full 60-year period (2024 - 2083) considered in the

economic appraisal of the A417 Missing Link scheme. As a result, the wider economic impacts calculated by WITA should be considered a slight underestimate.

8.3.30. Given the extent of the A417 model, which has 1,940 zones, and the memory limitations of the WITA software, it has been necessary to aggregate the traffic model inputs to WITA to a coarser zone system consisting of just 158 zones (referred to as 'WITA Analysis Zones'). The calculations undertaken by WITA are done at the level of WITA Analysis Zones.

8.3.31. Other inputs to WITA include economic data at the Local Authority District level. These have been derived from the WebTAG 'Wider Impacts Dataset' (July 2013) and include Gross Domestic Product (GDP) per worker across four industrial sectors, average wage per worker and the index of labour productivity. This dataset has also been used to compile other input data, including forecast growth in GDP per worker and economic parameters.

8.3.32. 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 traffic model. Outside of the area of detailed modelling, 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 A417 model (including the external areas), only results for the detailed modelled area are extracted and used in the economic appraisal of the scheme.

8.4. Economic assessment results

8.4.1. The overall monetised economic impacts of the scheme are summarised in the Analysis of Monetised Costs and Benefits (AMCB) table, which includes results from the TUBA, COBALT and QUADRO programs, as well as the assessments undertaken for journey time reliability, noise, air quality, greenhouse gases and wider economic benefits. The AMCB is shown in Table 8.3. As per WebTAG all costs and benefits reported in this section are in 2010 prices, discounted to 2010.

Table 8.3: Analysis of monetised costs and benefits (£000s)

Item	Option 12	Option 30
Accidents (not assessed by TUBA)[1]	67,903	65,255
Roadworks (not assessed by TUBA)[2]	-10,335	-10,215
Greenhouse gases (not assessed by TUBA)[3]	-36,495	-37,080
Noise (not assessed by TUBA)[4]	961	1,196
Air quality (not assessed by TUBA)[5]	-588	-963
Economic efficiency: consumer users (commuting)	34,061	38,915
Economic efficiency: consumer users (other)	14,509	17,235
Economic efficiency: business users and providers	111,436	158,717
Wider public finances (indirect taxation revenues)	72,774	73,812
Present value of benefits (PVB)	254,226	306,871
Broad transport budget present value of costs (PVC)	**295,057**	**272,506**
OVERALL IMPACTS		
Net present value (NPV)	-40,831	34,365
Initial benefit to cost ratio (BCR)	0.86	1.13
Reliability benefits	64,143	68,700
Wider economic benefits	50,722	63,621
Adjusted BCR	**1.25**	**1.61**

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. [1] from COBALT, [2] from QUADRO, [3] WebTAG Unit A3 Chapter 4, [4] WebTAG Unit A3 Chapter 2, [5] WebTAG Unit A3 Chapter 3.

8.4.2. Transport economic efficiency improvements, and travel time benefits in particular, provide the largest contribution to the overall benefits for both scheme options. Benefits associated with accidents, journey reliability and wider impacts are also significant in both options. In comparison to these benefits, the monetised impacts arising from environmental and construction impacts are relatively minor.

8.4.3. The present value of benefits over the 60-year appraisal period are £254 million for Option 12 and £307 million for Option 30. The greater levels of benefits achieved by Option 30 (around 20% higher than Option 12) reflect its more direct route alignment and larger journey time savings for A417 traffic.

8.4.4. Of the two scheme options being appraised, the greater benefits achieved by Option 30, coupled with its marginally lower costs, results in this option providing the better overall ratio of benefits to costs. Option 30 achieves an initial Benefit to Cost Ratio (BCR) of 1.13 and an adjusted BCR of 1.61 when reliability and wider economic benefits are included. This compares to an initial BCR of 0.86 and an adjusted BCR of 1.25 for Option 12.

8.5. Sensitivity tests – High and low growth

8.5.1. As per WebTAG 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.

8.5.2. 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 public transport reference matrices. The proportion of base demand to be added / subtracted was calculated using the following:

$$2.5\% \times \sqrt{(\text{forecast year} - \text{base year})}$$

8.5.3. 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 √ (2031-2015)).

8.5.4. Table 8.4 shows the AMCB for the high and low growth scenarios, alongside the equivalent values for the core scenarios for both scheme options.

8.5.5. At this PCF Stage, the economic impacts associated with accidents, roadworks, greenhouse gases, noise, air quality and journey time reliability 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 each option.

8.5.6. 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.

8.5.7. The benefits are slightly asymmetrical in both options with a skew towards low growth (meaning that 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 (for example, M4 junction 15, M5 junction 11a) that will 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 8.4: Analysis of monetised costs and benefits (£000s) – High and low growth

Item	Option 12			Option 30		
	Low	Core	High	Low	Core	High
Accidents (not assessed by TUBA)[1]	67,903			65,255		
Roadworks (not assessed by TUBA)[2]	-10,335			-10,215		
Greenhouse gases (not assessed by TUBA)[3]	-36,495			-37,080		
Noise (not assessed by TUBA)[4]	961			1,196		
Air quality (not assessed by TUBA)[5]	-588			-963		
Economic efficiency: consumer users (commuting)	25,471	34,061	34,541	31,070	38,915	37,558
Economic efficiency: consumer users (other)	9,276	14,509	13,530	14,628	17,235	15,336
Economic efficiency: business users and providers	91,155	111,436	125,950	135,059	158,717	175,421
Wider public finances (indirect taxation revenues)	63,715	72,774	73,538	64,708	73,812	70,700
Present value of benefits (PVB)	211,063	254,226	269,005	263,657	306,871	317,207
Broad transport budget present value of costs (PVC)	295,057			272,506		
OVERALL IMPACTS						
Net present value (NPV)	-83,994	-40,831	-26,052	-8,849	34,365	44,701
Initial benefit to cost ratio (BCR)	**0.72**	**0.86**	**0.91**	**0.97**	**1.13**	**1.16**
Reliability benefits	64,143			68,700		
Wider economic benefits	48,694	50,722	52,174	61,255	63,621	65,291
Adjusted BCR	**1.10**	**1.25**	**1.31**	**1.44**	**1.61**	**1.66**

Notes: All monetary values are expressed in 2010 prices, discounted to 2010. [1] from COBALT, [2] from QUADRO, [3] WebTAG Unit A3 Chapter 4, [4] WebTAG Unit A3 Chapter 2, [5] WebTAG Unit A3 Chapter 3.

8.6. Economic assessment conclusions

8.6.1. The economic assessment has shown that, of the two options under consideration at PCF Stage 2, Option 30 provides the greatest amounts of economic benefits and offers the best ratio of benefits to costs.

9. Environmental assessment, National Policy Statement for National Networks compliance and environmental design

9.1. Introduction

9.1.1. An environmental assessment has been undertaken in accordance with the requirements presented in the Infrastructure Planning (EIA) Regulations 2017 for each of the relevant environmental topics that are scoped into the assessment, as follows:

- Air quality
- Cultural heritage
- Landscape and visual effects
- Geology and soils
- Biodiversity
- Material assets and waste
- Noise and vibration
- Population and health
- Road drainage and the water environment
- Climate
- Cumulative effects

9.1.2. The output of the environmental assessment is to report the likely significance of effects using established significance criteria, as presented within the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5. This requires an assessment of the receptor or resource's environmental value (or sensitivity) and the magnitude of project's impacts (change).

9.1.3. The DMRB states that the approach to assigning significance of effect relies on reasoned argument, professional judgement and taking on board the advice and views of appropriate organisations. For some factors, predicted effects may be compared with quantitative thresholds and scales in determining significance.

9.1.4. Assigning each effect to one of the five significance categories (Neutral to Very Large) enables different environmental issues to be placed upon the same scale, to assist the decision-making process at whatever stage the project is at within that process. A summary of potential environmental effects is provided below.

9.1.5. In addition to the environmental assessment, a review of the scheme's potential compliance with the National Policy Statement for National Networks (NPSNN)

has been undertaken. A summary is provided below, with further detail on how each environmental topic conforms to the NPSNN provided in Appendix F.

9.2. Summary of potential environmental effects and NPSNN compliance

Air quality

Environmental assessment

9.2.1. The construction phase is expected to last approximately three years and could affect local air quality through the generation and subsequent deposition of construction dust arising from construction activities and vehicle movements. With the implementation of mitigation measures, such as avoiding double handling of materials and minimising height of stockpiles, air quality effects from the construction phase of all options are expected to be adverse but not significant.

9.2.2. Nitrogen dioxide (NO_2) concentrations have been predicted for human health and ecological receptors, listed in Table 9.1 and Table 9.2 respectively. Nitrogen oxide (NO_x) concentrations have been predicted for ecological receptors listed in Table 9.3 and Table 9.4.

Table 9.1: Human health receptors and NO_2 Annual Mean Concentration (µg/m^3) (Option 12)

Receptor Name/ (Receptor ID)	OS Grid Reference		NO_2 Annual Mean Concentration (µg/m^3) (Option 12)			
	X	Y	2015 Base Year	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Air Balloon Cottages (1)	393447	216120	45.4	26.9	14.3	-12.6
Air Balloon Cottages (2)	393464	216132	42.3	25.7	13.4	-12.3
Crickley Hill (3)	393104	215886	16.0	10.5	14.5	4.0
Crickley Court (4)	392022	215849	23.1	14.5	14.0	-0.5
Fernbank (5)	392881	215806	23.1	14.4	13.2	-1.2
Barrow Wake House (6)	393511	215622	11.3	7.8	9.7	1.9
The Rise (7)	394049	214120	9.1	6.4	7.6	1.2
Castle Hill Cottages (8)	394545	213635	20.9	12.9	6.6	-6.3
Lychett Cottage (9)	394313	216391	20.6	13.2	11.8	-1.4
Highgate Farm (10)	395605	212642	10.3	7.1	7.3	0.2

Receptor Name/ (Receptor ID)	OS Grid Reference		NO_2 Annual Mean Concentration (µg/m^3) (Option 12)			
	X	Y	2015 Base Year	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Lyefield Court (11)	396407	219832	28.9	19.8	17.9	-1.9
Leckhampton Road (12)	394788	219867	25.6	17.2	18.8	1.6
Chosen View (13)	390454	216691	21.6	15.2	14.8	-0.4
Wye Road (14)	389845	216035	18.6	13.1	12.6	-0.5
Abbey Way (15)	402206	202609	14.6	10.0	10.1	0.1
Brockworth Road (16)	389340	219105	26.6	18.9	19.1	0.2
Seven Springs (17)	396573	216877	14.3	9.4	8.9	-0.5
Corner Cottage (18)	392592	214369	15.0	10.3	10.5	0.2
Fosse Farm (19)	396926	210376	17.5	11.5	12.3	0.8
Woodbine Cottage (20)	389637	221834	32.9	23.8	24.2	0.4
Calcutt Manor (21)	411209	193319	36.0	23.4	24.1	0.7
Sunny Bank (22)	402028	205209	11.9	8.2	8.5	0.3
The Noake (23)	387793	217869	17.3	12.4	12.4	0.0
Sussex Gardens (24)	387916	217397	26.1	18.6	18.6	0.0

Table 9.2: Human health receptors and NO_2 Annual Mean Concentration (µg/m^3) (Option 30)

Receptor Name (Receptor ID)	OS Grid Reference		NO_2 Annual Mean Concentration (µg/m^3) (Option 30)			
	X	Y	2015 Base Year	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Air Balloon Cottages (1)	393447	216120	45.4	26.9	13.0	-13.9
Air Balloon Cottages (2)	393464	216132	42.3	25.7	12.3	-13.4
Crickley Hill (3)	393104	215886	16.0	10.5	14.6	4.1
Crickley Court (4)	392022	215849	23.1	14.5	14.4	-0.1
Fernbank (5)	392881	215806	23.1	14.4	13.5	-0.9
Barrow Wake House (6)	393511	215622	11.3	7.8	7.4	-0.4
The Rise (7)	394049	214120	9.1	6.4	6.0	-0.4
Castle Hill Cottages (8)	394545	213635	20.9	12.9	6.1	-6.8
Lychett Cottage (9)	394313	216391	20.6	13.2	10.9	-2.3

Receptor Name (Receptor ID)	OS Grid Reference		NO_2 Annual Mean Concentration (µg/m^3) (Option 30)			
	X	Y	2015 Base Year	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Highgate Farm (10)	395605	212642	10.3	7.1	7.1	0.0
Lyefield Court (11)	396407	219832	28.9	19.8	16.5	-3.3
Leckhampton Road (12)	394788	219867	25.6	17.2	19.3	2.1
Chosen View (13)	390454	216691	21.6	15.2	15.1	-0.1
Wye Road (14)	389845	216035	18.6	13.1	12.7	-0.4
Abbey Way (15)	402206	202609	14.6	10.0	10.2	0.2
Brockworth Road (16)	389340	219105	26.6	18.9	19.1	0.2
Seven Springs (17)	396573	216877	14.3	9.4	8.3	-1.1
Corner Cottage (18)	392592	214369	15.0	10.3	9.7	-0.6
Fosse Farm (19)	396926	210376	17.5	11.5	12.7	1.2
Woodbine Cottage (20)	389637	221834	32.9	23.8	24.2	0.4
Calcutt Manor (21)	411209	193319	36.0	23.4	24.5	1.1
Sunny Bank (22)	402028	205209	11.9	8.2	8.6	0.4
The Noake (23)	387793	217869	17.3	12.4	12.4	0.0
Sussex Gardens (24)	387916	217397	26.1	18.6	18.6	0.0

9.2.3. For Option 12 the highest predicted annual mean NO_2 concentrations in the Do Something scenario would occur at Receptor 20, the concentration at this receptor would increase by 0.4µg/m^3 to 24.2µg/m^3 in the Do Something scenario from 23.8µg/m^3 in the Do Minimum. This receptor is located approximately 25m west of the M5 and would experience an increase of approximately 2,200 Annual Average Daily Traffic (AADT) as a result of Option 12. For Option 30 the highest predicted annual mean NO_2 concentrations in the Do Something scenario would occur at Receptor 21, and the concentration would increase by 1.1µg/m^3 to 24.5µg/m^3 from 23.4µg/m^3 in the Do Minimum. This receptor is located approximately 7m from this section of the A419 close to Cricklade; this section of road would experience an increase of approximately 3,600 AADT as a result of Option 30.

9.2.4. For both options the greatest increase in annual mean NO_2 is predicted at Receptor 3:

- Option 12 - an increase of 4µg/m^3 from 10.5µg/m^3 in the Do Minimum scenario to 14.5µg/m^3 in the Do Something scenario
- Option 30 - an increase of 4.1µg/m^3 from 10.5µg/m^3 in the Do Minimum to 14.6µg/m^3

9.2.5. Option 12 would move the A417 approximately 30 metres closer to Receptor 3 and there would also be an increase in AADT of approximately 5,000 along the A417. Similarly, Option 30 would move the A417 closer to Receptor 3, and there is a predicted increase of approximately 5,700 AADT on this stretch of the A417 under Option 30. The predicted annual mean NO_2 concentration in both the Do Minimum and Do Something scenarios is below the annual mean objective of 40µg/m^3 for both options.

9.2.6. The greatest reductions in annual mean NO_2 concentrations are predicted to occur at the Air Balloon Cottages (Receptors 1 and 2, which are located within the Birdlip Air Quality Management Area (AQMA) and adjacent to the Air Balloon roundabout) for both Option 12 and Option 30:

- Option 12 - The concentrations reduce by 12.6µg/m^3 at Receptor 1 to give a Do Something concentration of 14.3µg/m^3 and by 12.3µg/m^3 at Receptor 2 to give a Do Something concentration of 13.4µg/m^3
- Option 30 - The concentrations reduce by 13.9µg/m^3 at Receptor 1 to 13.0µg/m^3 and by 13.4µg/m^3 at Receptor 2 to 12.3µg/m^3

9.2.7. These reductions occur because Option 12 would move the A417 30m from where it is currently located and away from the receptors and Option 30 would move the A417 35m away from where it currently is, and subsequently away from the receptors. Both options would alter the traffic flow from light congestion to free-flowing adjacent to this receptor, due to the removal of the roundabout.

9.2.8. All predicted annual mean concentrations of NO_2 are well below 60µg/m^3 and therefore no exceedances of the 1-hour NO_2 objective are predicted for both options.

Table 9.3: Annual mean NO_x concentrations at ecological receptors for Option 12

Receptor/ (Receptor ID)	Distance from nearest affected road (m)	OS Grid Reference		Annual mean NO_X concentration (µg/m^3)		
		X	Y	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Crickley Hill and Barrow Wake SSSI (Eco 1)	2	393423	216109	55.0	23.4	-31.6

Receptor/ (Receptor ID)	Distance from nearest affected road (m)	OS Grid Reference		Annual mean NO_X concentration (µg/m^3)		
		X	Y	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Crickley Hill and Barrow Wake SSSI (Eco 2)	55	393171	215940	14.5	23.0	8.5
Crickley Hill and Barrow Wake SSSI (Eco 3)	2	393219	215426	55.5	17.7	-37.8
Cotswold Commons and Beechwoods SSSI (Eco 4)	2	392432	214418	11.4	10.1	1.3
Cotswold Beechwood SAC (Eco 5)	2	392051	213620	13.7	15.2	1.5
Hucclecote Meadows SSSI (Eco 6)	10	387227	216392	30.5	30.4	-0.1
North Meadows and Clattinger Farm SAC (Eco 7)	90	409619	194826	8.2	8.3	0.1
Lineover Wood SSSI (Eco 8)	25	398696	218497	10.1	9.8	-0.3
Westwell Gorse SSSI (Eco 9)	2	421937	211278	11.8	11.8	0
Leckhampton Hill and Charlton Kings Common SSSI (Eco 10)	25	394461	217829	9.2	9.4	0.2
Bull Cross, The Firth and Juniper Hill SSSI (Eco 11)	2	387666	208597	8.0	8.6	0.6

Table 9.4: Annual mean NO_x concentrations at ecological receptors for Option 30

Receptor (Receptor ID)	Distance from nearest affected road (m)	OS Grid Reference		Annual mean NO_X concentration (µg/m^3)		
		X	Y	2024 DM[(a)]	2024 DS[(a)]	Change (DM to DS)
Crickley Hill and Barrow Wake SSSI (Eco 1)	2	393423	216109	55.0	21.1	-33.9
Crickley Hill and Barrow Wake SSSI (Eco 2)	55	393171	215940	14.5	23.3	8.8
Crickley Hill and Barrow Wake SSSI (Eco 3)	2	393219	215426	55.5	12.1	-43.4
Cotswold Commons and Beechwoods SSSI (Eco 4)	2	392432	214418	11.4	9.8	-1.6
Cotswold Beechwood SAC (Eco 5)	2	392051	213620	13.7	15.2	1.5
Hucclecote Meadows SSSI (Eco 6)	10	387227	216392	30.5	30.3	-0.2
North Meadows and Clattinger Farm SAC (Eco 7)	90	409619	194826	8.2	8.3	0.1
Lineover Wood SSSI (Eco 8)	25	398696	218497	10.1	9.3	-0.8
Westwell Gorse SSSI (Eco 9)	2	421937	211278	11.8	12.0	0.2
Leckhampton Hill and Charlton Kings Common SSSI (Eco 10)	25	394461	217829	9.2	9.3	0.1
Bull Cross, The Firth and Juniper Hill SSSI (Eco 11)	2	387666	208597	8.0	8.8	0.8

9.2.9. Concentrations of NO_x have been predicted at 11 locations identified across the nine ecological designations assessed. All predicted annual mean concentrations of NO_2 are well below 60µg/m^3 and therefore no exceedances of the 1-hour NO_2 objective are predicted for either option. In addition, no

designated sites are predicted to have NO_x concentrations above 30µg/m^3 and experience a change greater than 0.4µg/m^3, and therefore, no assessment of nitrogen deposition is required. However, for Hucclecote Meadows Sites of Special Scientific Interest (SSSIs), the annual mean NO_x concentration is predicted to exceed the NO_x critical level in the Do Something scenario. This receptor location experiences a reduction of 0.1µg/m^3 of NO_x between the Do Minimum and the Do Something scenario for Option 12 and a reduction of 0.2µg/m^3 for Option 30. Predicted NO_x concentrations at the remaining ecological receptor locations are all below the NO_x critical level of 30µg/m^3 in the Do Something scenario. The concentrations at Eco 1 and Eco 3 (receptor points within Crickley Hill and Barrow Wake SSSI) are predicted to be in exceedance of the NO_x critical level in the Do Minimum scenarios. The concentration at these receptors is predicted to reduce by 31.6µg/m^3 at Eco 1 and 37.8µg/m^3 at Eco 3 for Option 12 and 33.9µg/m^3 at Eco 1 and 43.4µg/m^3 at Eco 3 for Option 30 to below the 30µ/m^3 critical level. Both Options would move the A417 away from these receptors, and congestion would also reduce from light congestion to high speed at Eco 1. No exceedances of the 1-hour NO_2 objective are predicted for either option.

9.2.10. In order to mitigate against construction dust effects at receptors, the Contractor shall carry out construction works in accordance with the Best Practicable Means (BPM), as described in Section 79 (9) of the Environmental Protection Act 1990, to reduce emissions which may affect air quality. Requirement for operational mitigation would be determined as part of the on-going Air Quality assessment for the preferred option to be undertaken at Project Control Framework (PCF) Stage 3.

NPSNN accordance

9.2.11. At this stage, based on the current available information and the consideration of the predicted impacts from both options, both options are considered to comply with the relevant policy requirements set out within the NPSNN relating to air quality. Refer to Appendix F for further details.

Cultural heritage

Environmental assessment

9.2.12. Both scheme options have the potential to result in adverse effects on archaeological remains, historic buildings and historic landscapes. Gloucestershire County Council historic environment record (HER) has identified approximately 250 recorded heritage assets within the 1 kilometre study area, 30 of which are considered to be sensitive to the scheme. Preserving archaeological remains in-situ would be explored during the design process as

part of mitigation for the scheme. Best practice measures to limit adverse effects on heritage assets would be employed during construction through the implementation of a Construction Environment Management Plan (CEMP).

9.2.13. During the construction of both options, the most significant adverse effects would be those on Emma's Grove and its potential associated features and the Roman roadside settlement that was recorded at Birdlip Quarry. For Option 30 there would be additional significant adverse effects on the grade II listed Shab Hill Barn and Stockwell deserted medieval village.

9.2.14. Whilst the road is in operation, the setting of the Scheduled Monument at Emma's Grove would be at risk from additional sound and visual intrusion with both options. Additionally, both options would increase the size and capacity of the A417 around the area of Crickley Hill, potentially increasing the harm caused by noise, light and visual intrusion on the setting of the Scheduled Monument during the operation of the scheme. The context makes a valuable contribution to the value of this asset, and the high significance of the asset makes the effect on its setting a key consideration. For Option 30, even with best practice mitigation in place, the setting of Shab Hill Barn would be adversely altered. In this case, mitigation in the form of planting of trees and vegetation, which would help screen the asset to maintain their historic and rural setting, would be developed to reduce adverse effects as far as possible. Assets of local significance, such as the Air Balloon Public House, would also be adversely impacted by both options.

9.2.15. Both options would result in significant benefits for the grade II listed Milestone and Golden Heart Inn; the realignment of the road would improve the setting of these assets. In addition to this, there would be a slight beneficial effect on the setting of the scheduled sites of Brimpsfield Castle and Brimpsfield Castle mound, and the grade I listed Church of St Michael.

9.2.16. Mitigation measures will be developed for the preferred route and would seek to reduce adverse effects as far as possible during construction and operation. In addition to mitigation through the CEMP for construction during operation mitigation measures would include the lowering of the vertical alignment of the route including junctions wherever practicable, keeping it sensitive to the landform as much as possible with earth bunds and false cuttings as appropriate to keep it out of view reducing both visual and noise impacts on the setting of assets. During operation mitigation would also include the planting of trees and vegetation, which would help screen the assets to maintain their historic and rural setting. Mitigation will be further developed at the next stage.

NPSNN accordance

9.2.17. At this stage, based on the current available information, Option 30 has the potential to cause a larger number of adverse effects than Option 12 and is at greater risk of non-compliance with the requirements of the NPSNN. Should any significant impacts be identified at PCF Stage 3 following further assessment and design work, relevant policy requirements as set out within the NPSNN would need to be met. For further details, please refer to Appendix F.

Landscape and visual

Environmental assessment

9.2.18. Both Options 12 and 30 have the potential to cause significant adverse effects upon both landscape character and visual amenity. From the Brockworth bypass in the west, through Crickley Hill to Air Balloon, both options would share similar alignments. Over this section there would be subtle differences in highway arrangements. The significance of effect upon landscape character and visual amenity is considered comparable for both scheme options, and is predicted to be large adverse, at worst, due to considerable variance of the proposed schemes with the character of the landscape. The Crickley Hill section of the scheme is located within the most sensitive, escarpment landscape.

9.2.19. East and south of Air Balloon up to the Cowley junction, Option 12 has a route alignment that runs in part on-line, whereas Option 30 is fully off-line. Option 30 would be at considerable variance with the character of the landscape, given its direct effect on a large, open, arable landscape. Nevertheless, Option 12 would also degrade or diminish the integrity of a range of characteristic elements within the high wold, and the significance of effects arising from the off-line sections, like Option 30, are also considered to be large. This high wold landscape located within the Cotswolds AONB is intensively farmed and considered to be of relatively lower sensitivity when compared with the escarpment.

9.2.20. The effects on visual receptors of the two scheme options through the high wold landscape would also vary according to the specific alignment of each scheme. Both scheme options would give rise to significant visual effects, with Option 30 affecting a number of isolated dwellings and farmsteads. Option 12 has the potential to give rise to significant adverse effects on both isolated properties or farmsteads, and Birdlip village.

9.2.21. During construction a CEMP would detail specific mitigation measures to reduce adverse impacts which would include (but not be limited to):

- Establishing site compounds, haul road selection and material stores away from topographical high points and away from receptors or viewpoints
- The screening of plant or compounds using stored soils or through temporary screening planting

9.2.22. The design process during the next stage will be focused on both multi-disciplinary technical specialist input and consultation with stakeholders and the public to ensure adverse effects are mitigated or designed out for both construction and operation. Other operational mitigation would include planting and earthworks to reduce the long-term effect upon landscape character, by reflecting local topography and landform and thereby helping either option to respond positively to the context, and to settle within the surrounding landscape over time.

9.2.23. Further general approaches to mitigation design would be to include the lowering of the vertical alignment of the route including junctions wherever practicable, keeping it sensitive to the landform as much as possible. This could be strengthened with the use of earth bunds and false cuttings as appropriate, as well as planting to aid the integration of the scheme with the surrounding landscape. Mitigation will be further developed at the next stage.

NPSNN accordance

9.2.24. Both Options 12 and 30 have the potential to cause significant adverse effects upon both landscape and visual amenity and therefore at this stage it is not possible to distinguish between the relevant merits of either option in terms of their compliance with the requirements of the NPSNN. Should significant impacts be identified at PCF Stage 3 following further assessment and design work, relevant policy requirements as set out within the NPSNN would need to be met. For further details refer to Appendix F.

Biodiversity

Environmental assessment

9.2.25. Based on the current available baseline information and available information on the construction of the scheme options, the following potential impacts have been identified on biodiversity.

9.2.26. The majority of receptors have been assessed as likely to have negligible or slight adverse effects. However, the overall significance of effects on biodiversity as a result of Option 12 is likely to be Large Adverse during construction and Moderate Adverse during operation and the overall significance of effects of

Option 30 are likely to be Moderate Adverse during both construction and operation.

9.2.27. For Option 12 a larger overall significance is reported for construction due to the potential impacts on the wetland habitat at Bushley Muzzard SSSI:

- During the excavation of major earthworks
- Due to the permanent footprint of the new road within a deep cutting which may intersect the aquifer that supplies the site resulting in potential permanent and irreversible impacts to the SSSI

9.2.28. Option 30 would also have an impact on Bushley Muzzard, but it would not be as significant. On-going assessments of the local hydrology and the impacts of the cuttings will be undertaken to provide more confidence in the potential significant impacts.

9.2.29. Significant impacts (Moderate Adverse) are also currently assessed for bats during construction and operation due to habitat loss and fragmentation and potential direct impacts on individual bats, for both options. Further detailed bat surveys are on-going and additional surveys will be undertaken to provide a more robust baseline and a greater confidence in assessing the significance of potential residual impacts.

9.2.30. For both options Moderate Adverse effects on ancient woodland and veteran trees are also anticipated during construction due to a loss of habitats which are classed as irreplaceable. Option 12 has marginally more land-take from the possible ancient woodland at Emma's Grove and potentially has greater air quality impacts to Ullen Wood ancient woodland due to the location of the roundabout on the A436. Therefore, the significant effects are slightly worse than for Option 30. Land-take from ancient woodland and possible ancient woodland would be avoided as much as possible during the final design of the preferred route. If land-take from ancient woodland is unavoidable and deemed necessary for the scheme, then appropriate compensation land will be arranged.

9.2.31. At this stage in the design process it is not possible to outline a detailed migration strategy as the status of habitats and protected species affected by the proposals are currently unknown. The design of mitigation would follow the standard mitigation hierarchy of '*avoidance – minimisation – compensation – offsetting'* with the avoidance of significant effects undertaken as a priority. A landscape planting specification will be finalised:

- Once the status of protected and notable species is known
- The preferred route has been chosen
- The extent of vegetation clearance and earthworks are known

9.2.32. The Method Statement accompanying the Natural England licence application will specify the mitigation planting requirements, as well as other appropriate mitigation to ensure no long-term effects where the presence of European Protected Species (EPS) is confirmed through further surveys. Where there are no EPS constraints, but there are other factors requiring mitigation, such as protected species, designated habitats and policy requirements, the habitat loss is recommended to be offset through landscape mitigation planting to be detailed in the Ecological Mitigation Strategy.

NPSNN accordance

9.2.33. At this stage, based on the current available information, Option 30 has the potential to cause a lesser direct impact on SSSIs, ancient woodland, potential ancient woodland and other protected habitats and species than Option 12. Therefore, Option 12 is at greater risk of non-compliance against the relevant policy requirements of the NPSNN. The relevant requirements of the NPSNN would need to be satisfied where the scheme would lead to substantial harm to, or loss of, biodiversity assets. For further details, please refer to Appendix F.

Geology and soils

Environmental assessment

9.2.34. It is considered that both scheme options have the potential to result in significant construction stage adverse effects upon geology, soils and the associated environment.

9.2.35. The potential for residual significant adverse effects has been identified for geologically designated SSSIs for both Options 12 and 30. This includes impacts on geological features (Crickley Hill and Barrow Wake SSSI) through land-take and disturbance during construction of the road and associated structures leading to permanent loss or alteration of nationally important geological exposures. Mitigation measures for encroachment into, and loss of, areas of SSSI are limited for geology and soils features, as the loss is permanent, however, the scheme design would be sympathetic and minimise disturbance to geological outcrops where practicable. There are potential opportunities for the provision of improvements to these sites due to their proximity to the scheme. Further assessments at PCF Stage 3 will determine the provision of mitigation measures and enhancement opportunities in relation to geology and soils, taking into consideration views about management and information contained within the SSSI site citation concerning existing geological exposures. The scheme proposals would lead to the loss of a small area of the Crickley Hill and Barrow Wake SSSI. Scheme design would be sympathetic and minimise disturbance to geological outcrops where feasible. The proposed green bridge would extend

across the escarpment and lead to the loss of geological features. The principal mitigation for this would be to alter the location of the bridge slightly and ensure the bridge design would have minimal impacts on any areas of significant outcrop.

9.2.36. Both options also have the potential for significant impacts on geology and soils due to the generation of significant quantities of excavated virgin geological materials resulting in excess material.

9.2.37. The groundwater within the underlying Principal / Secondary Aquifer would be subject to potential significant adverse impacts during construction due to construction works being located over a Principal Aquifer, source protection zone (SPZ) 3 and Secondary Aquifer. Risks include:

- The creation of contamination pathways during foundation works
- Increased turbidity within the aquifer due to foundation and general construction operations
- Quality deterioration from injection of grouts or pastes into groundwater during foundation works
- Temporary reduction in groundwater levels with an associated reduction / cessation in spring flow due to dewatering and ground works during construction. This could lead to potential impacts on groundwater fed ecosystems (e.g. Bushley Muzzard SSSI), downgradient groundwater abstractions and river flows

9.2.38. To mitigate the risk of contamination of groundwaters the contractor would take precautions, in line with all associated pollution prevention guidelines and best practice, to ensure that pollution of the aquifer cannot occur and new pathways for contaminant migration are not established when working in areas where Made Ground or contaminated materials are present. Excavated materials would be managed in line with the requirements in the Outline Environmental Management Plan and eventual CEMP.

9.2.39. Option 30 has the potential to result in significant adverse effects on agricultural land as a national resource, due to the loss of Grade 3 land. At this stage it cannot be confirmed if this land is Grade 3a, which is best and most versatile (BMV) land or Grade 3b which is agricultural land of a lower sensitivity. Option 12 is unlikely to result in significant adverse effects on agricultural land, with less than 20 hectares of Grade 3 land predicted to be permanently removed. As mitigation for this there would be the inclusion of a Soils Management Plan within the CEMP which would ensure works are undertaken in accordance with appropriate guidelines such as Defra's Code of Practice for the Sustainable Use of Soils on Construction Sites and BS3882: 2015, particularly in areas where the

reinstatement of agricultural land would be required temporarily during construction.

9.2.40. Significant impacts are not anticipated during operation on geology or soils.

NPSNN accordance

9.2.41. However, a significant effect relating to geology and soils is anticipated for both schemes due to the alignment of each option, the significance of effect for Option 12 would be less than that of Option 30. At this stage, there is a lesser risk of non-compliance against the relevant policy requirements set out within the NPSNN associated with Option 12. Should any significant impacts be identified at PCF Stage 3 following further assessments and design work, the relevant requirements set out within the NPSNN would need to be met. For further details, please refer to Appendix F.

Material assets and waste

Environmental assessment

9.2.42. The construction of a new carriageway and associated structures, including roundabouts, culverts and bridges, would require the use of material resources. This has the potential to result in significant adverse effects associated with:

- The extraction, processing and transport of materials
- The manufacture of construction products
- Their subsequent transport to, and use on, construction sites

9.2.43. During construction, it is anticipated that the quantity of materials required for both scheme options would be considerable, especially steel, concrete and materials required for pavement construction. Best practice mitigation measures within construction documents, including the CEMP and Site Waste Management Plan, would reduce the effect on material resources. However, due to the uncertainty at this stage regarding the exact material quantities required it is concluded that there is the potential for significant effects on material resources during construction for both options.

9.2.44. Measures would be implemented to reduce the effects of material resource use and waste generation by the scheme during the construction phase. The principles of the waste hierarchy would be applied throughout the design phase and into construction, to move waste and material management practices as far up the hierarchy as practicable. This would minimise the need for disposal and maximise re-use and recycling opportunities.

9.2.45. Where waste must be taken to a recycling or disposal site, the contractor would ensure that the sites have the appropriate permits to ensure that environmental risks are reduced, such as damage to hydrological systems. In addition, the suitable facility would be located as close to the works as possible to minimise the impacts of transportation, in particular, the release of carbon emissions. The Contractor would identify the closest and relevant treatment and disposal sites. The Contractor would produce a CEMP, which would detail all mitigation measures to be adhered to on-site.

9.2.46. A Site Waste Management Plan would also be produced by the Contractor, prior to the start of construction. It would ensure that unavoidable waste is managed in accordance with the waste hierarchy and other relevant legislative requirements and would detail information on the waste carriers and waste management facilities that would be used.

NPSNN accordance

9.2.47. With the current available assessments, Option 30 would produce a reduced surplus of cut materials compared with Option 12 and therefore a lesser risk of non-compliance against the policy tests set out within the NPSNN relating to materials and waste is associated with Option 30 at this stage. Should any significant impacts be identified at PCF Stage 3, the relevant policy requirements set out within the NPSNN would need to be met. For further details, please refer to Appendix F.

Noise and vibration

Environmental assessment

9.2.48. Significant adverse noise and vibration effects have the potential to occur with either scheme option during construction depending on the specific location and programme of construction activities. It is expected that the implementation of mitigation measures during construction would reduce effects, so they would not be significant. It is anticipated that the limits for normal working hours and levels of noise at nearby properties would be agreed by the Contractor in advance with the local authority's Environmental Health Officer and incorporated into the CEMP for the preferred route. This would identify the series of measures to reduce the environmental effects during the construction period and would cover environmental and safety aspects affecting the interests of residents, businesses, all road users, and the general public, in the vicinity of the works.

9.2.49. Assessment results show that without implementation of either scheme option noise levels would increase at all receptors by a negligible amount due to increased traffic flows. Option 12 would generate noise level increases at three

receptors with magnitudes no greater than moderate in the opening year but would not generate any increases at receptors with magnitudes of moderate or greater in the future year. Option 30 would generate noise level increases at 11 receptors with magnitudes of moderate or greater in the opening year and would also generate increases at nine receptors with magnitudes of moderate or greater in the future year.

9.2.50. However, in the short-term both options would generate decreases in noise levels at a large number of receptors during both the opening and future years when compared against the Do Minimum scenario. For Option 12 this would include benefits to 136 dwellings and 23 other sensitive receptors through a predicted perceptible decrease in noise, and for Option 30 this would result in 92 dwellings and 32 other sensitive receptors experiencing a decrease in noise. Significant beneficial effects would be generated at 48 dwellings for Option 12 and 82 dwellings for Option 30.

9.2.51. Analysis shows a decrease in the total number of receptors exposed to noise levels above the Significant Observed Adverse Effect Level (SOAEL) and above the Lowest Observed Adverse Effect Level (LOAEL) in the short and long-term at a large number of properties for both options. Overall, Option 30 produces a greater number of noise reduction benefits in terms of a reduction of properties experiencing LOAEL and SOAEL during both day and night-time periods.

9.2.52. Both options would also generate adverse effects including increases in noise levels and increases in adverse effect levels. In the majority of instances, noise level increases at receptor properties would be negligible or minor (i.e. less than a 3dB increase in the short-term and less than a 5dB increase in the long-term). Option 12 would generate significant adverse noise effects during operation at two dwellings. Option 30 would generate significant adverse noise effects at four dwellings during operation.

9.2.53. In the long-term without implementation of either scheme option, noise levels within noise Important Areas (nIAs) would experience negligible increases due to increased traffic flow. Both Option 12 and Option 30 would result in decreases in noise levels at the majority of dwellings within nIAs, with the exception of three properties in Option 12 which would experience a negligible increase or no change. All predicted noise levels in nIAs for each option would however be lower than without the scheme in each instance.

9.2.54. In terms of mitigation the DMRB advises on reductions of sound from thin surface courses. For the purposes of this assessment it has been assumed that by the Design Year (2039) in the Do Minimum case, all existing trunk roads and motorways would be surfaced with thin surface course. Mitigation in the form of acoustic barriers and bunds would be investigated as part of the PCF Stage 3

assessment. In particular, mitigation would be investigated for receptors where the A417 and associated junctions would move closer due to changes in the road alignment.

NPSNN accordance

9.2.55. It is considered at this stage that neither option indicates greater compliancy with the policy tests set out within the NPSNN for noise and that further assessments are required at PCF Stage 3 to fully determine the impacts of the scheme. Should any significant impacts be identified at PCF Stage 3, the relevant policy requirements set out within paragraphs 5.195 and 5.196 of the NPSNN would need to be satisfied. For further details, please refer to Appendix F.

Population and human health

Environmental assessment

9.2.56. During the construction stage of both options, one residential property (Woodside House) and one business (The Air Balloon Pub) would be demolished. The loss of two properties makes up less than 0.001% of the total housing stock within Gloucestershire county, 0.005% of the total housing stock within Cotswold District Council and 0.005% of the total housing stock within Tewkesbury District Council. There is currently no industry standard or methodology that supports assignment of significance to this change, however the scale of change in available housing stock is very small. For Option 12, two residential properties would experience slight adverse and not significant effects due to land-take. For Option 30, one residential property and one business would be subject to slight adverse and not significant effects due to land-take. Both options would also require land-take from Barrow Wake, an area of Common Land owned by Gloucestershire County Council, although a slight adverse and not significant effect is predicted for both options.

9.2.57. Throughout the construction stage of both options, the scheme would intersect the Gloucestershire Way National Trail. Should the route be permanently interrupted, there is the potential for a moderate adverse and significant effect to arise. A moderate adverse and significant effect would also arise for Option 30 due to land-take at the Ullenwood Bharat Cricket Club.

9.2.58. During the construction period of both options, health could be impacted through any changes in local air quality. There is the potential for changes in both air quality and noise levels during the operation of both options.

9.2.59. Throughout the construction of both options, the local economy would experience minor beneficial, but not significant effects. The effects would relate

to a potential increase in employment opportunities and construction workers using local facilities, such as hospitality establishments. There may be a minor beneficial but not significant effect due to an increase in indirect employment opportunities during the operation of both options.

9.2.60. Three farms would experience moderate adverse and significant effects due to land-take during the construction of Option 12. For Option 30, four farms would be subject to moderate adverse and significant effects due to land take. Twelve farms would experience slight adverse and not significant effects due to land-take for Option 12. For Option 30, 16 farms would be subject to slight adverse and not significant effects.

9.2.61. Slight Adverse and not significant effects are predicted for community severance and journey length and time, amenity, and driver stress during construction for both options, due to potential diversions and closures of Walking, Cycling and Horse Riding (WCH) routes and the presence of construction material, machinery and vehicles.

9.2.62. Once in operation, a Moderate Beneficial and significant effect is anticipated for driver stress with the provision of a high quality free flowing dual-carriageway along the A417 Missing Link section, resulting in improved flows and speeds during peak periods both on the A417 and local road network.

9.2.63. Slight Adverse effects are predicted in operation for journey length and time, and amenity with permanent changes to WCH facilities having the potential to adversely affect WCH journeys. A Slight Adverse effect is also anticipated 15 years after opening for views from the road, with the scheme anticipated to screen a number of views for vehicle travellers from the road. A Neutral effect is anticipated for community severance with any adverse effects experienced in terms of journey length and amenity for pedestrians and others travelling to facilities balanced out by beneficial effects for motorised travellers using the road network to reach community facilities.

9.2.64. An on-balance adverse and significant effect relating to population and health has been predicted for both Options 12 and 30. Option 30 presents a greater risk of conflict with NPSNN policy due to the potential land-take at Ullenwood Bharat Cricket Club. Should a significant impact remain at PCF Stage 3 following further assessment and design work, the relevant policy requirements of the NPSNN would need to be satisfied. For further details, please refer to Appendix F.

Road drainage and the water environment

Environmental assessment

9.2.65. Both scheme options have the potential to cause adverse effects on surface water and groundwater receptors. Risks to groundwater receptors are of particular concern with respect to deep cuttings and earthworks within the aquifer for each scheme option, which may partially or fully intersect the saturated aquifer.

9.2.66. During construction both options have the potential for significant adverse effects on the Cotswolds Edge South groundwater body (Great and Inferior Oolite) due to deep cuttings and the Ground investigation (GI) acting as pathways for adverse effects. Earthworks, deep cuttings and dewatering within the following ground water bodies would also have the potential for significant adverse effects from both options impacting on the water supply and quality, economic value, conveyance of flow and biodiversity on the following groundwater bodies:

- Burford Jurassic (Great and Inferior Oolite)
- Severn Vale - Secondary Combined (Lias Group)
- Severn Vale – Jurassic Limestone Cotswolds Edge South (Great and Inferior Oolite).

9.2.67. Both options would have a significant adverse effect on the water supply and quality of Horsbere brook. During construction mitigation best practice measures would be included within the CEMP in accordance with Construction Industry Research and Information Association (CIRIA) Guidelines[23,24,25], and the Environment Agency's approach to groundwater protection[26] and groundwater protection guides[27].

9.2.68. During operation, barriers to water flow and groundwater seepage would result in potential significant adverse effects on both options to the following groundwater bodies resulting in impacts on water supply and quality economic value, conveyance of flow and biodiversity:

- Burford Jurassic (Great and Inferior Oolite)
- Severn Vale - Secondary Combined (Lias Group)

[23] Soubry, M. (2001) Bridge Detailing Guide. CIRIA C543.
[24] Murnane, E., Heap, A. and Swain, A. (2006) Control of water pollution from linear construction projects. Technical guidance. CIRIA C648.
[25] Charles, P. and Edwards, P. (2015) Environmental good practice on site guide (Fourth Edition). CIRIA C741.
[26] Environment Agency. (2017). Protect groundwater and prevent groundwater pollution. [online] Available at: https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution
[27] Environment Agency. (2017). Groundwater protection technical guidance. [online] Available at: https://www.gov.uk/government/publications/groundwater-protection-technical-guidance

- Severn Vale – Jurassic Limestone Cotswolds Edge South (Great and Inferior Oolite)

9.2.69. Mitigation measures specifically relating to run-off, flow and seepage would be incorporated into the design, which would reduce the levels of pollutants and provide protection to the local watercourses.

9.2.70. The assessment indicates that, with mitigation, neither scheme option is likely to result in any deterioration of the Water Framework Directive (WFD) status of the water bodies that the study area of the scheme falls within, nor would the scheme options affect the ability of the water bodies to achieve their relevant objectives under the WFD.

9.2.71. It is considered at this stage, with the current assessments available, that neither option indicates greater compliance with the NPSNN or performs better than the other in terms of environmental outcomes. Should any significant impacts be identified at PCF Stage 3 following further assessment and design work, the relevant policy requirements set out within the NPSNN would need to be met. For further details, please refer to Appendix F.

Climate

Environmental assessment

9.2.72. The carbon assessment encompasses two sub-topics: the effects on climate (effects of the scheme on climate change in terms of Greenhouse Gas (GHG) emissions from the scheme and mitigation potential), and vulnerability of the scheme to climate change (effects relevant to climate resilience and adaptation including the effects of climate change on the scheme and the contribution of the scheme to wider resilience).

Table 9.5: The estimated carbon emissions of each option over the relevant UK Government Carbon Budgets

Project Stage	Option 12 'Do Something' Scenario (tCO_{2e})	Option 30 'Do Something' Scenario (tCO_{2e})	Option 12 Net CO2 increase (tCO2e) (Do something – Do minimum)	Option 30 Net CO2 increase (tCO2e) (Do something – Do minimum)	Proportion of Carbon Budgets within relevant years
Construction of asset (2021-2024)	5,071	8,950	5,071	8,950	3rd Carbon Budget (2018-2022) (Total for one year of this budget - 509MtCO2e)

Project Stage	Option 12 'Do Something' Scenario (tCO_{2e})	Option 30 'Do Something' Scenario (tCO_{2e})	Option 12 Net CO2 increase (tCO2e) (Do something – Do minimum)	Option 30 Net CO2 increase (tCO2e) (Do something – Do minimum)	Proportion of Carbon Budgets within relevant years
	10,142	17,901	10,142	17,901	4th Carbon Budget period (2023-2027) (Total for two years of this budget - 780MtCO2e)
Operational life of asset (2025-onwards)	192,004,504	192,006,171	42,358	44,026	4th Carbon Budget period (2023-2027) (Total for 3 years of this budget - 1170MtCO2e)
	253,108,174	253,110,004	56,072	57,993	5th Carbon Budget (2028-2032) (Total for five years of this budget - 1,725MtCO2e)
Total	445,127,892	445,143,027	113,644	128,871	

9.2.73. Table 9.5 above presents the construction and operational carbon associated with both scheme options. Option 30 has been calculated as having 43% higher construction emissions than Option 12, due to the larger quantities of structural concrete and steel required for the retaining wall. The operational results for both options are very similar as the global (i.e. network-wide) level average speeds are very similar between the two options, primarily because the majority of the links in the model (>85%) are coded as 'fixed speed' links that are not responsive to changes in traffic flow. The results for Option 30 are marginally larger than Option 12 due to higher annual vehicle kilometres.

9.2.74. In terms of the vulnerability of the scheme to climate change during the three-year construction period, it is not expected that climate change would result in a change in the risk of severe weather, although the construction site may be vulnerable to extremes of weather, leading to a risk of delay in activities. Therefore, changes in climate are not expected to significantly affect construction of either of the options.

9.2.75. The scheme's vulnerability to climate change during operation is assessed based on the varied assets which make up the scheme, due to their diverse ability to withstand climatic conditions over a 60-year appraisal period. The

effects of climate change on scheme assets has been assessed as Not Significant for all the assets due to mitigation involving a CEMP. This would ensure that the construction of the scheme allows for adaptation to effects of changes in climate such as ensuring construction materials are covered to protect from weather impacts when stored and pro-active planning to minimise adverse effects.

NPSNN accordance

9.2.76. It is considered at this stage, with the current assessments available, that Option 12 would result in emissions of approximately 15,241tCO_2e for the construction lifecycle stages, and it would perform better than Option 30 in terms of environmental outcomes, which would result in emissions of approximately 26,852tCO_2e. If significant effects are identified at PCF Stage 3 following further assessment and design work, and if the need for the scheme is justifiable, the relevant policy requirements set out within the NPSNN would need to be met.

Cumulative effects

9.2.77. The assessment for combined effects involved the identification of effect interactions associated with Options 12 and 30, upon separate environmental receptors.

9.2.78. The combined effect during construction and operation for both Options 12 and 30 is anticipated to be Significant Adverse. This is due to combined impacts on cultural heritage, geology and soils, landscape, communities, the water environment and ecology.

9.2.79. The assessment of cumulative effects involved the identification of impacts likely to be caused by ‘other developments’ together with Options 12 and 30. There were two ‘other developments’ identified within the study area where there was an overlap in Zone of Influence (ZoIs). For both options the residual cumulative effects during construction and operation as a result of the ‘other developments’ with Options 12 and 30 would be anticipated to be Significant Adverse. This is due to the significant adverse effects reported from the scheme’s impact on cultural heritage, landscape and biodiversity. However, it should be noted that the ‘other developments’ do not contribute to this significant effect as it is due to the residual effects of Options 12 and 30.

9.3. Environmental design

9.3.1. The vision for the scheme is for a landscape-led highways improvement scheme that will deliver a safe and resilient free-flowing road while:

- Conserving and enhancing the special character of the Cotswolds Area of Outstanding Natural Beauty (AONB)
- Reconnecting landscape and ecology
- Bringing about landscape, wildlife and heritage benefits, including enhanced visitors' enjoyment of the area
- Improving local communities' quality of life; and contributing to the health of the economy and local businesses

9.3.2. The vision is translated into three design principles that govern all design development. These are:

- Any solution involving a new road should ensure the scheme is designed to meet the character of the landscape, not the other way around
- Any scheme should bring about substantial benefits for the Cotswolds landscape and environment as well as people's enjoyment of the area
- Any scheme should have substantially more benefits than negative impacts for the Cotswolds Area of Outstanding Natural Beauty

9.3.3. These design principles cascade into scheme objectives and sub-objectives, which have in turn been incorporated into a scheme Design Principles Register[28]. The register cross references relevant policy and guidance from the NPSNN, the Government's 25 year Environment Plan[29], the Cotswolds AONB Management Plan[30] and Highways England: The road to good design[31].

9.3.4. The Design Principles Register acts as a tool, integral to the development of the scheme options, to ensure the scheme has regard to good road design principles including those of Highways England and is consistent with policy and guidance. In particular, consideration will be given to the potential for good road design to create and enhance a sense of place and allow for places and communities to positively express identity and character where the scheme would be located. Therefore, a key aspect to the scheme design is aiming to achieve a context led, elegant approach to the highway design, responding sensitively to the landscape, biodiversity and heritage assets and characteristics of the area. The Design Principles Register also seeks to ensure that the scheme makes an important and positive contribution to many aspects of the

[28] A417 Stage 2 Design Principles Register HE551505-MMSJV-EGN-000-RP-LX-00015.
[29] Department for Environment, Food and Rural Affairs (Defra) (2018), A Green Future: Our 25 Year Plan to Improve the Environment [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf.
[30] Cotswolds Conservation Board (2018) Adopted Cotswolds AONB Management Plan [online] available at: https://www.cotswoldsaonb.org.uk/wp-content/uploads/2018/10/Cotswolds-AONB-Management-Plan-2018-2023.pdf.
[31] Highways England (2018) The road to good design [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/672822/Good_road_design_Jan_18.pdf.

environment, including improvements to landscape and ecological connectivity, and where possible, seeking to achieve net environmental gain.

9.3.5. Additionally, following consultations with stakeholders such as the Cotswolds Conservation Board, a landscape study was undertaken for the scheme to appraise the options for the A417 Missing Link. The overarching purpose of the study was to ensure that the earliest stages of route selection pay due regard to the nationally designated landscape context (the Cotswolds AONB). The study responds to the identified need within the scheme vision for a landscape-led highways improvement scheme. An important aspect of the study was to focus on the identification of how well different highway alignment options might generate opportunities for broader scale, as well as localised, landscape enhancements.

9.3.6. The landscape study was informed by acknowledgement of the evolving landscape and awareness of the landscape management and enhancement strategies that have been adopted by the Cotswolds Conservation Board and others to encourage and manage positive landscape change. The study will inform the design of the selected option, and continuous design development will take place to fulfil the objective of the scheme to be landscape led.

9.4. Consultation

9.4.1. There has been on-going consultation throughout the design process with relevant environmental stakeholders through Technical Working Groups meetings held bi-monthly and through other informal channels.

9.4.2. Historic England and Gloucestershire County Council's heritage team were consulted on 22 June 2017 to present the proposed options. Initial comments highlighted the archaeological importance of the landscape, which extends beyond the boundaries of the Scheduled Monuments. The limited archaeological investigations outside the Scheduled Monuments have revealed archaeological remains of potentially national significance and this must be considered in future evaluation.

9.4.3. Consultation in the landscape context has been undertaken with a number of stakeholder bodies, including the Cotswolds Conservation Board and the Gloucester Local Nature Partnership. This has resulted in a landscape-led approach to scheme development, as encapsulated in the Landscape Vision for the scheme, which has been confirmed as a landscape-led highways improvement scheme that will deliver a safe and resilient free flowing road while:

- Conserving and enhancing the special character of the Cotswolds AONB
- Reconnecting landscape and ecology

- Bringing about landscape, wildlife and heritage benefits, including enhanced visitors' enjoyment of the area; improving local communities' quality of life
- Contributing to the health of the economy and local businesses

9.4.4. With regards to biodiversity, specific consultation between Mott MacDonald Sweco Joint Venture and Natural England has been undertaken to aid in the development of an appropriate and robust mitigation strategy. Consultation with the National Trust, Gloucestershire Wildlife Trust, Gloucestershire Local Nature Partnership, Cotswolds Conservation Board, Gloucester County Council and the Woodland Trust has also been undertaken with respect to potential environmental (including ecological) enhancement opportunities that may be developed as part of the overarching mitigation and enhancement plan for the preferred route, once identified.

9.5. Conclusion

9.5.1. An environmental assessment has been undertaken in accordance with the requirements presented in the Infrastructure Planning (EIA) Regulations 2017. This assessment covered the following topics: Air quality, Cultural heritage, Landscape and visual effects, Geology and soils, Biodiversity, Materials and waste assets, Noise and vibration, Population and health, Road drainage and the water environment, Climate and cumulative effects. Table 9.6 below summarises the overall range of residual effects relating to each environmental topic area assessed in the construction and operation stages. These conclusions are based on typical best practice mitigation being implemented, and a PCF Stage 2 level of design and baseline environmental information available at this stage in the progression of the scheme. Table 9.6 highlights that, at present, there is limited variation in terms of overall residual environmental impacts between Option 12 and Option 30. Option 12 and Option 30 are recording the same level of significance in relation to air quality, cultural heritage, landscape, geology and soils, materials, noise and vibration, population and health and climate. There is slight variation in terms of overall residual environmental impact for biodiversity and road drainage and the water environment between options, with Option 30 reporting potentially less adverse impacts. However, the scale of significance within these significance scores may vary. Where significance scores are not specified, this is due to the methodologies used for those disciplines not allowing for grades of significance to be determined at this stage (i.e. an impact is only classified as significant or not significant but not slight, moderate or large).

Table 9.6 Summary of overall residual impacts with best practice mitigation

	Option 12		Option 30	
	Construction	**Operation**	**Construction**	**Operation**
Air Quality	Not Significant	Not Significant	Not Significant	Not Significant
Cultural Heritage	Large Adverse to Moderate Adverse	Large Adverse to Moderate Beneficial	Large Adverse to Moderate Adverse	Large Adverse to Moderate Beneficial
Landscape	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse
Biodiversity	Large Adverse to Moderate Adverse	Moderate Adverse	Large Adverse to Slight Adverse	Moderate Adverse
Geology and Soils	Moderate Adverse	n/a	Moderate Adverse	n/a
Materials	Neutral to Moderate Effect	n/a	Neutral to Moderate Effect	n/a
Noise and Vibration	Significant Adverse	Significant Adverse to Significant Beneficial	Significant Adverse	Significant Adverse to Significant Beneficial
Population and Human Health	Moderate Adverse	Moderate Beneficial	Moderate Adverse	Moderate Beneficial
Road Drainage and the Water Environment	Very Large Adverse to Moderate Adverse	Very Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse	Large Adverse to Moderate Adverse
Climate	Not Significant	Not Significant	Not Significant	Not Significant

9.5.2. A requirement for the preferred route at PCF Stage 3 is further design development, environmental assessment and the preparation of an environmental masterplan and environmental management plan, to include bespoke mitigation, enhancement and compensation where necessary. This further assessment and design development will ensure that adverse effects identified at PCF Stage 2 are eliminated or reduced as far as possible for the preferred route. The design principles will be integral to this development, as will on-going consultation to create an overall compensation, mitigation and enhancement plan.

9.5.3. Both routes are similar in most respects from an objective environmental assessment and appraisal. At this stage, neither option can be distinguished from each other in terms of their performance against the policy requirements of the NPSNN in the following topics:

- Air quality
- Landscape and visual effects
- Noise and vibration
- Road drainage and water environment

9.5.4. Based on the current assessments, it is considered that Option 12 would perform better than Option 30 against the relevant policy requirements of the NPSNN in respect of cultural heritage, geology and soils, population and health and climate. Option 30, on the other hand, would perform better than Option 12 against the policy requirements of the NPSNN relating to material assets and waste; and biodiversity, specifically impacts on SSSIs, irreplaceable habitats including ancient woodland, potential ancient woodland and veteran trees, and other protected species and habitats. For further details, please refer to Appendix F.

10. Appraisal summary

10.1. WebTAG Appraisal summary introduction

10.1.1. This chapter provides a summary of the WebTAG assessment and appraisal undertaken on two scheme options under consideration at PCF Stage 2. The assessments are summarised in WebTAG Appraisal Summary Tables (ASTs).

10.2. Economy

10.2.1. Chapter 8 summarised the economic assessment that has been undertaken on the two scheme options. The assessment has been undertaken in accordance with WebTAG guidance.

10.2.2. The results of the economic assessment of the scheme options are summarised in Table 10.1.

Table 10.1: Summary of economic results (£000s)

	Option 12	Option 30
Present value of costs (PVC)	295,057	272,506
Present value of benefits (PVB)	254,226	306,871
PVB + reliability & wider economic benefits	368,091	439,192
Initial Benefit to Cost Ratio (BCR)	0.86	1.13
Adjusted BCR	1.25	1.61

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

10.2.3. Option 30 is forecast to provide the greatest amount of benefits, with a PVB of £307 million (increasing to £439 million when reliability and wider economic benefits are included) over the 60-year appraisal period. Benefits achieved by Option 12 are lower at £254 million, or £368 million when reliability and wider economic benefits are included.

10.2.4. Of the two scheme options, the greater benefits achieved by Option 30, coupled with its marginally lower costs, results in this option providing the better ratio of benefits to costs. Option 30 achieves an initial BCR of 1.13 and an adjusted BCR of 1.61 when reliability and wider economic benefits are included. This compares to an initial BCR of 0.86 and an adjusted BCR of 1.25 for Option 12.

10.2.5. When the economic assessment is combined with non-tangible impacts including those on landscape, biodiversity, heritage and water environment, the two options are given Value for Money ratings. It is judged that Option 30 will likely be ‘Low’ value for money, whilst Option 12 is likely to deliver ‘Poor to Low’

value for money. This difference reflects the higher benefits offered by Option 30 relative to the similar impacts of the two options.

10.3. Environmental appraisal

10.3.1. Chapter 9 summarises the environmental assessment that has been undertaken for the two scheme options in accordance with the Design Manual for Roads and Bridges (DMRB).

Quantitative environmental results

10.3.2. Table 10.2 and paragraphs 10.3.3 to 10.3.5 provide a summary of the quantitative environmental appraisal undertaken for air quality, noise and greenhouse gases in line with WebTAG A3.1 guidance for the two scheme options.

Table 10.2: Summary of quantitative environmental results (£000s)

Environmental topic	Option 12	Option 30
Air quality	-588	-963
Noise	961	1,196
Greenhouse gases	-36,495	-37,080

Air quality

10.3.3. The overall outcome from the air quality appraisal indicates a negative impact for Options 12 and 30. The air quality results show some variation in monetised impacts between the scheme options, although these differences are considered to be relatively minor. Rather than being directly related to the local impacts associated with the specific route alignments, the variations primarily stem from differences in forecast traffic flows across the wider affected road network.

Noise

10.3.4. The outcome from the noise appraisal results demonstrate an overall benefit for both options. A reduction in traffic using the bypassed section of A417 and along some local minor roads contribute to an overall benefit in each instance. Option 30 is shown to provide a greater monetised noise benefit compared to Option 12. This is because of fewer households being forecast to experience an increase in day-time or night-time noise.

Greenhouse gases

10.3.5. Due to a rise in the number of vehicle kilometres travelled relative to the Do Minimum scenario in the Opening Year and Design Year and a change in speed, each of the options would lead to an increase in Greenhouse Gas (GHG)

emissions and therefore have a negative impact in monetary terms. The results from Options 12 and 30 are similar as the global (i.e. network-wide) level average speeds are very similar between the two options, primarily because the majority of the links in the model (>85%) are coded as 'fixed speed' links that are not responsive to changes in traffic flow. The results for Option 12 are marginally lower due to lower annual vehicle kilometres.

Qualitative environmental results

10.3.6. Table 10.3 and paragraphs 10.3.8 to 10.3.11 provide a summary of the qualitative environmental appraisal undertaken for landscape, historic environment, biodiversity and the water environment in line with WebTAG A3.1 guidance for the two options.

Table 10.3: Summary of qualitative environmental results

Environmental topic	Option 12	Option 30
Landscape	Large Adverse	Large Adverse
Townscape[32]	Not applicable	Not applicable
Historic Environment	Large Adverse	Large Adverse
Biodiversity	Large Adverse	Large Adverse
Water Environment	Very Large Adverse	Very Large Adverse

10.3.7. The WebTAG appraisal for Options 12 and 30 shows that both options perform very similarly at this stage of design with respect to environmental impacts.

Landscape

10.3.8. Both options sit within the Cotswolds Area of Outstanding Natural Beauty (AONB) and during their operation could increase visual disturbance along their route, as well as potentially cause fragmentation of the local landscape pattern. Therefore, a Large Adverse effect on landscape is predicted for Options 12 and 30.

Historic environment

10.3.9. Options 12 and Option 30 would have very similar impacts on the historic environment during their operation, with both options resulting in an adverse impact on the setting of Crickley Hill Camp Scheduled Monument and Emma's Grove Scheduled Monument. The two options would result in adverse impacts to the setting of grade II listed buildings, comprising Crickley Hill Farm for Option 12, and both Harding's Barn and Shab Hill for Option 30. There would also be

[32] Given the highly rural nature of the scheme and that the routes would not pass through developed settlements or village settlements, a townscape appraisal was not considered to be necessary for either option.

adverse impacts to archaeological remains, as well as to the Air Balloon Public House, an asset of local significance which would be demolished by both options. Considering both the adverse and beneficial effects of each option, a Large Adverse effect on the historic environment is anticipated.

Biodiversity

10.3.10. During operation the two options are predicted to result in a precautionary large adverse impact on bats. The scheme proposals could directly affect bat populations with reduced available habitat, habitat fragmentation and an increased likelihood of the species colliding with traffic, resulting in the mortality of bats. Option 12 has the potential to result in a Large Adverse effect on Bushley Muzzard Sites of Special Scientific Interest (SSSI), as this option could intersect the aquifer supplying the SSSI. Moderate adverse effects have been predicted on ancient woodland due to the loss and fragmentation of habitats at Emma's Grove for both options. The appraisal considers only standard mitigation at this stage. Taking into account the most adverse category, a Large Adverse effect is predicted for Options 12 and 30.

Water environment

10.3.11. Either option has the potential to adversely affect groundwater receptors during construction and operation. Both options would intersect the Great Oolite aquifer upgradient of Bushley Muzzard SSSI, potentially reducing water supply to this spring-fed wetland and resulting in habitat loss. The mainline cutting for both options close to the Air Balloon roundabout would also potentially divert groundwater from one catchment to another. The magnitude of impact on groundwater receptors is considered to be moderate adverse, and the importance of the receptor is very high, resulting in a highly significant impact on two or more water features. In the absence of ground investigation baseline data and detailed design and mitigation measures a Very Large Adverse effect is anticipated.

10.4. Social appraisal

10.4.1. Chapters 8 and 9 summarise the social assessment that has been undertaken for the two scheme options in accordance with the DMRB.

Quantitative social results

10.4.2. Table 10.4 below provides a summary of the quantitative environmental appraisal undertaken for commuting and other users, reliability impact on commuting and other users, and accidents in line with WebTAG A4.1 guidance for the two options. Refer to Chapter 8 for a more detailed discussion on the impacts on these topics.

Table 10.4: Summary of quantitative social results (£000s)

Environmental topic	Option 12	Option 30
Commuting and other users	48,600	56,200
Reliability impact on commuting and other users	28,900	29,800
Accidents	67,900	65,300

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

Qualitative social results

10.4.3. Table 10.5 and paragraphs 10.4.5 to 10.4.10 provide a summary of the qualitative environmental appraisal undertaken for physical activity, journey quality, security, access to services, affordability, severance and option and non-use values in line with WebTAG A4.1 guidance for the two options.

Table 10.5: Summary of qualitative environmental results

Environmental topic	Option 12	Option 30
Physical activity	Neutral	Neutral
Journey quality	Slight Beneficial	Slight Beneficial
Security	Neutral	Neutral
Access to services	Neutral	Neutral
Affordability	Moderate Adverse	Moderate Adverse
Severance	Neutral	Neutral
Option and non-use values	Neutral	Neutral

10.4.4. The WebTAG appraisal for Options 12 and 30 shows that both options perform very similarly at this stage of design with respect to social impacts.

Physical activity

10.4.5. Both options would result in the severance of some Walking, Cycling and Horse Riders (WCH) routes in operation, which could result in some journey length and time increases for WCH, although the provision of diversions and new crossings could improve amenity with safer crossings, therefore reducing effects. Whilst journey length increases could discourage some people from using these routes, adverse effects are likely to be offset by the potential health benefits of people travelling further and potentially being provided with safer crossings. As such, an on-balance Neutral effect is predicted on physical activity for Options 12 and 30.

Journey quality

10.4.6. Options 12 and 30 are predicted to result in an improvement to journey quality for travellers using the A417 in operation. New signage, reduced congestion and

an improved road surface would result in benefits to traveller care. Neutral impacts upon traveller views are anticipated for both options. For both options, travellers' stress would generally reduce with improvements to driver frustration, route uncertainty and fear of potential incidents, although a slight increase in frustration is possible along the A436, as travellers would have to travel slightly further. New safety provisions including a new suitable vehicle restraint system along the central reserve would reduce fear of potential incidents whilst new signage would slightly improve route uncertainty. Therefore, a Slight Beneficial effect is predicted on journey quality for both options.

Security

10.4.7. Options 12 and 30 are anticipated to result in a Neutral effect on security in operation, with no changes to public transport waiting facilities, interchange facilities or informal surveillance. WCH routes would be affected, and consideration of measures such as footbridges and underpasses has been given to retain connectivity and access for WCHs along the network. The potential provision of underpasses may adversely affect the personal security of pedestrians. The two options may also result in some changes to lighting at the Air Balloon junction, although no lighting is likely to be required at Cowley roundabout. Changes to landscaping are likely with new screening planting and cuttings provided, but this would not affect personal security.

Affordability

10.4.8. Both options would result in a Moderate Adverse effect on affordability in operation, with an overall increase in vehicle operating costs (VOCs) for either option. The increase in VOCs is partly driven by the redistribution of the highway improvement, with people choosing to travel further, and therefore incurring greater VOCs due to the reductions in travel time that the scheme brings. For most existing trips, the scheme would reduce VOCs, as the new alignment for Options 12 and 30 is more direct and less congested than the current route, although some local movements, such as between the A417 and A436, would experience increases in journey distance, and therefore costs.

Severance

10.4.9. An on balance Neutral effect is predicted on severance for Options 12 and 30 in operation. Slight increases in severance are predicted for pedestrians wishing to access community facilities in the study area with WCHs potentially required to travel further due to the diversion of existing routes. Slight increases in severance are also predicted for cyclists and horse riders travelling to community facilities in the study area with some hindrance to movements likely. However, these negative impacts would be offset by the slight relief in severance

for local communities such as Birdlip, Cowley, Coberley, Little Witcombe and Brockworth due to the rerouting of traffic from local roads onto the A417.

Access to services and option and non-use values

10.4.10. A Neutral effect on access to services or option non-use values is expected for Options 12 and 30, as there would be no effects on public transport accessibility and the scheme would not substantially change the availability of transport services in the study area.

10.5. Appraisal summary tables

10.5.1. ASTs have been produced for both scheme options to collate the assessments and appraisals summarised above and detailed within this report. The ASTs provide a summary of the appraisal under the main headings of:

- Economy
- Environmental
- Social
- Public accounts

10.5.2. The qualitative and quantitative impacts for both scheme options are provided in Table 10.6. Where there are both quantitative and qualitative impacts, the impact has been represented by the former. Copies of the full ASTs for both options are provided in Appendix G.

Table 10.6: Combined appraisal summary results

	Impacts	Option 12	Option 30
Economy	Business users and transport providers	£111.4 million	£158.7 million
	Reliability impact on Business users	£35.2 million	£38.9 million
	Regeneration	n/a	n/a
	Wider impacts	£50.7 million	£63.6 million
Environmental	Noise	£1.0 million	£1.2 million
	Air quality	PM10 NPV: -£0.2 million NOX NPV: -£0.4 million Total value of change in air quality: -£0.6 million	PM10 NPV: -£0.5 million NOX NPV: -£0.4 million Total value of change in air quality: -£1.0 million
	Greenhouse gases	-£36.5 million	-£37.1 million
	Landscape	Large adverse	Large adverse
	Townscape	n/a	n/a
	Historic environment	Large adverse	Large adverse
	Biodiversity	Large adverse	Large adverse
	Water environment	Very large adverse	Very large adverse
Social	Commuting and other users	£48.6 million	£56.2 million
	Reliability impact on commuting and other users	£28.9 million	£29.8 million
	Physical activity	Neutral	Neutral
	Journey quality	Slight beneficial	Slight beneficial
	Accidents	£67.9 million	£65.3 million
	Security	Neutral	Neutral
	Access to services	Neutral	Neutral
	Affordability	Moderate adverse	Moderate adverse
	Severance	Neutral	Neutral
	Option and non-use values	Neutral	Neutral
Public Accounts	Cost to broad transport budget	£295.1 million	£272.5 million
	Indirect tax revenues	-£72.8 million	-£73.8 million

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

11. Conclusions and recommendations

11.1. Introduction

11.1.1. This chapter summarises the assessment and appraisal work undertaken and concludes with a recommendation for the scheme to be taken forwards to PRA.

11.2. Need for the scheme

11.2.1. The existing A417 Missing Link experiences high levels of congestion, poor journey time reliability, and a disproportionately high number of traffic incidents which are more severe than comparable roads. Its performance is hindered by the limitations on the single-carriageway sections, with limited forward visibility, steep gradients, multiple minor accesses and two at-grade roundabouts restricting the flow of traffic. There is an Air Quality Management Area (AQMA) designated at the Air Balloon where a contributing factor is the queuing traffic at the roundabout. The existing road severs a number of Public Rights of Way and other access routes used by walking, cycling and horse riding users.

11.2.2. The traffic growth forecast for a Do Nothing option would exacerbate these existing factors, and increase the disruptions caused by an intervention. There is no alternative transport option which could address these factors together, either within the study area or in the wider strategic network, therefore there is a need for a highway solution to the A417 Missing Link within the Cotswolds Area of Outstanding Natural Beauty (AONB).

11.3. Project Control Framework Stage 1 outcome

11.3.1. The outcome of Project Control Framework (PCF) Stage 1 was that surface routes, Option 12 and Option 30 were recommended to be taken forward for public consultation and further development. Both routes were considered affordable (within the £250 million to £500 million cost range), and deliverable, with both options delivering significant improvements on the existing road.

11.4. Public consultation outcome

11.4.1. Public consultation on proposals for the A417 Missing Link was carried out between 15 February and 29 March 2018. Almost 2,000 responses were received in total, and responses showed that public opinion is greatly supportive of Option 30, with 72% of respondents identified their support for Option 30.

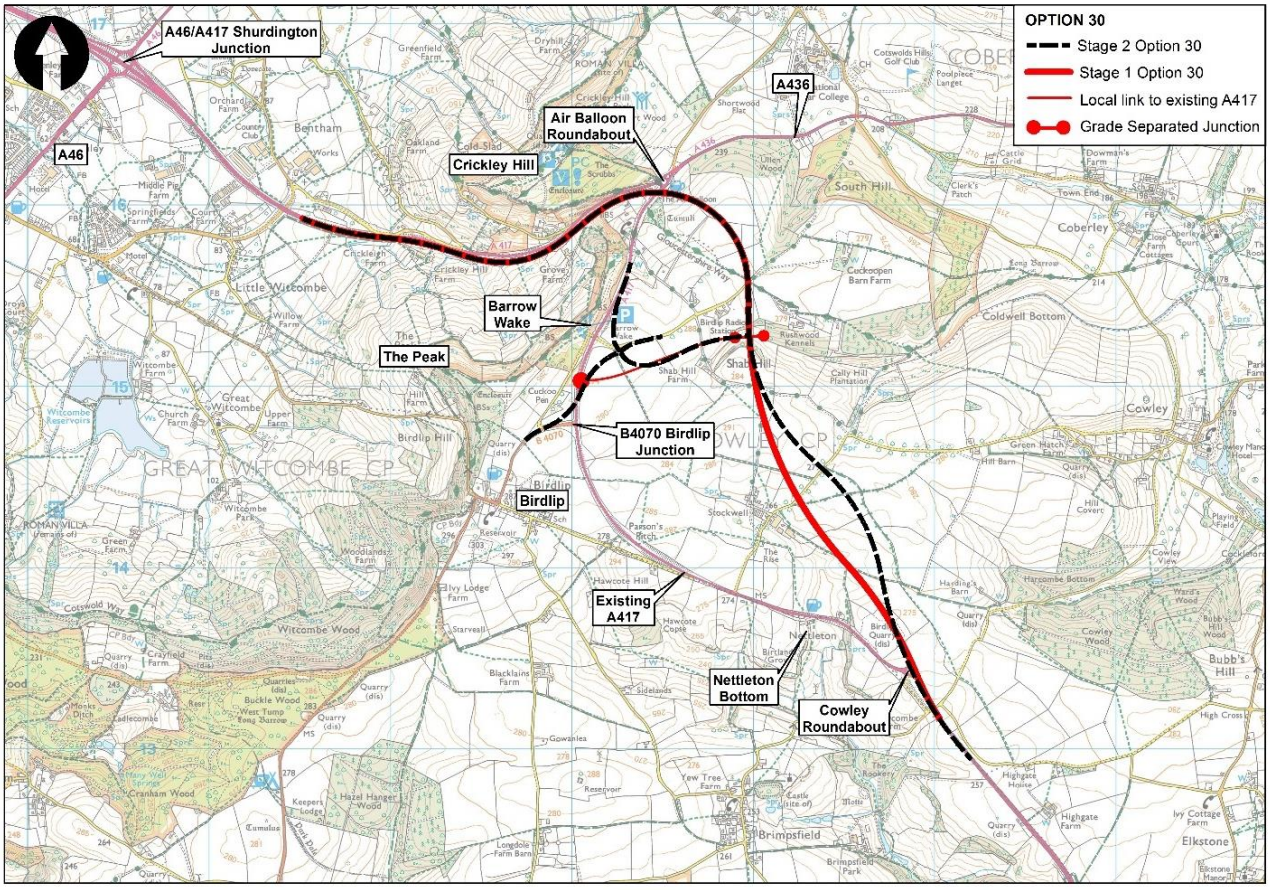
11.4.2. Comments received informed a set of key issues which were taken account of with the further option development at Stage 2, including:

- Environmental and geological impacts on nearby sites, including Crickley Hill and Barrow Wake Sites of Special Scientific Interest (SSSI), and Emma's Grove Scheduled Monument
- Landscape considerations, in particular the minimising of the visual impact of the scheme in the Cotswolds AONB
- Access to the new road from the local network, including from the A436, the B4070, and various local communities
- Effects on local businesses and amenities
- PRoW, including their preservation and interaction with the scheme

11.5. Engineering development and assessment

11.5.1. Option 12 was developed to be a landscape-led design in the previous studies undertaken between 2003 and 2006 for the Highways Agency. Following a landscape study during PCF Stage 1 and the comments gathered during the public consultation, several amendments were made to Option 30 to bring it to the same maturity of design as Option 12. The amended route is shown below in Figure 11.1.

Figure 11.1: Changes to Option 30 after public consultation



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

11.5.2. From an engineering perspective both Options 12 and 30 follow broadly similar principals; both options require a vertical gradient above the desirable maximum and use of horizontal bends near the Air Balloon that are below desirable minimums. As a result, several Departures from Standards are required for each option. Option 12 requires 22 Departures from Standards whilst Option 30 requires 11 Departures from Standards. The route alignment of Option 12 (and the associated Departures from Standards) mean that operational and maintenance safety would be worse than Option 30.

11.5.3. Through the removal of the existing single-carriageway section of the A417, both options would be expected to have a positive impact upon road safety and contribute to the Highways England target of reducing the number of people killed or seriously injured on the strategic road network.

11.5.4. Both options would give rise to safety considerations that would have to be addressed in the further development of the scheme, including gradients above the desirable maximum of 4%. Mitigating measures would be applied to address safety matters relating to these proposed gradients. Of the two options, Option 12 presents the greater challenges to overcome and would require the most mitigation measures, however both sets of proposals represent an improvement in gradient over the existing 10% maximum.

11.6. Cost estimates and benefit to cost ratios

11.6.1. Following the further engineering review of Option 12 and Option 30, cost estimates were produced for the two options in the form of the most likely Order of Magnitude (OME) estimates given below in Table 11.1. These estimates are based on 2016 Q1 prices.

Table 11.1: Most likely order of magnitude option estimates, 2016 Q1 price base

Option	Stage 2 Most likely OME
Option 12	£474,000,000
Option 30	£438,000,000

11.6.2. The cost estimates have been combined with the results from a refined regional traffic model for the updated growth assumptions. The Benefit Cost Ratio (BCRs) have subsequently been calculated in line with the Department for Transport's WebTAG methodology and are given below in Table 11.2.

Table 11.2: Analysis of monetised costs and benefits (£000s)

Item	Option 12	Option 30
Initial benefit to cost ratio (BCR)	0.86	1.13
Adjusted BCR	1.25	1.61

11.7. Appraisal summary tables

11.7.1. Appraisal Summary Tables (ASTs) with corresponding worksheets have been produced in accordance with the Department for Transport's Transport Analysis Guidance (WebTAG). The summary tables are reproduced in Appendix G of this report.

11.7.2. Comparison between the ASTs for the two options show the two options are objectively similar in terms of qualitative environmental and social impacts.

11.7.3. When comparing quantitative economic, environmental, social and public accounts impacts, Option 30 outperforms Option 12 overall as reflected in its higher BCR.

11.8. The recommended preferred route

11.8.1. Option 30 has greater support from the public, as shown by the results of the non-statutory public consultation. From an engineering perspective it provides a safer and higher quality road for all road users and road workers.

11.8.2. Both routes are similar in most respects from an objective environmental assessment and appraisal. At this stage, neither option can be distinguished from each other in terms of its compliance with the policy requirements set out within the National Policy Statement for National Networks (NPSNN) in the following topics: air quality; landscape and visual impact; noise and vibration; and road drainage and the water environment.

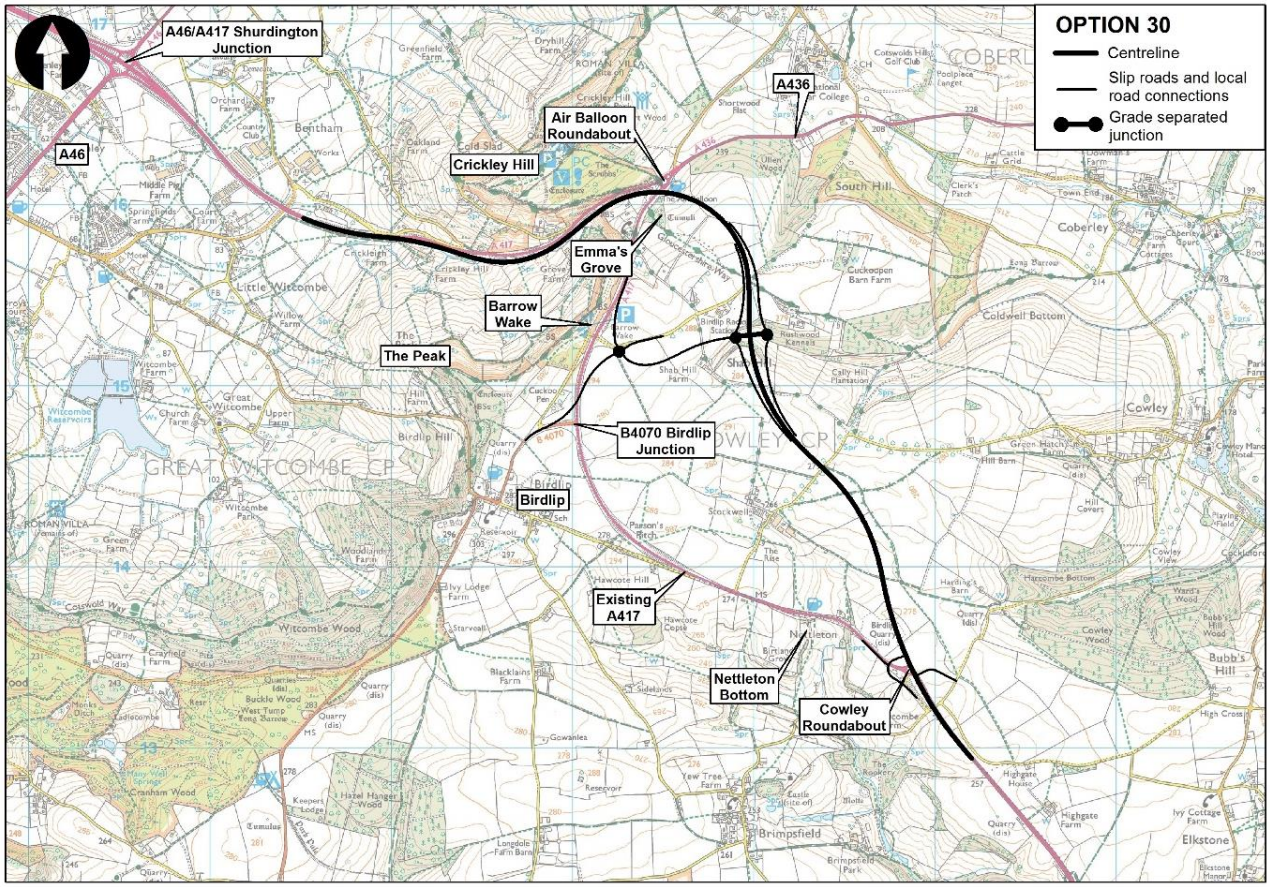
11.8.3. It is considered, based on the current assessments available, there is a lesser risk of non-compliance associated with Option 12 against the relevant policy requirements set out within the NPSNN than there is for Option 30 in respect of cultural heritage, geology and soils, population and health and climate.

11.8.4. On the other hand, there is a lesser risk of non-compliance associated with Option 30 against the policy requirements of the NPSNN than there is for Option 12 in respect of material assets and waste; and biodiversity, specifically impacts on SSSIs, irreplaceable habitats including ancient woodland, potential ancient woodland and veteran trees, and other protected species and habitats.

11.8.5. Option 30 is lower cost, gives greater benefits and provides better value for money to the taxpayer of the two solutions whilst also delivering a more direct route, and more reliable journeys on the strategic route. Additionally, Option 30 would divert the strategic road network away from the Cotswolds escarpment edge which presents opportunities for further landscape and environmental design development.

11.8.6. As the route able to best deliver on the scheme objectives based on the PCF Stage 2 assessment and appraisal of the route options and with strong public support, Option 30 is recommended as the preferred route and is shown below in Figure 11.2 and in detail in Appendix D – Option 30.

Figure 11.2: Option 30



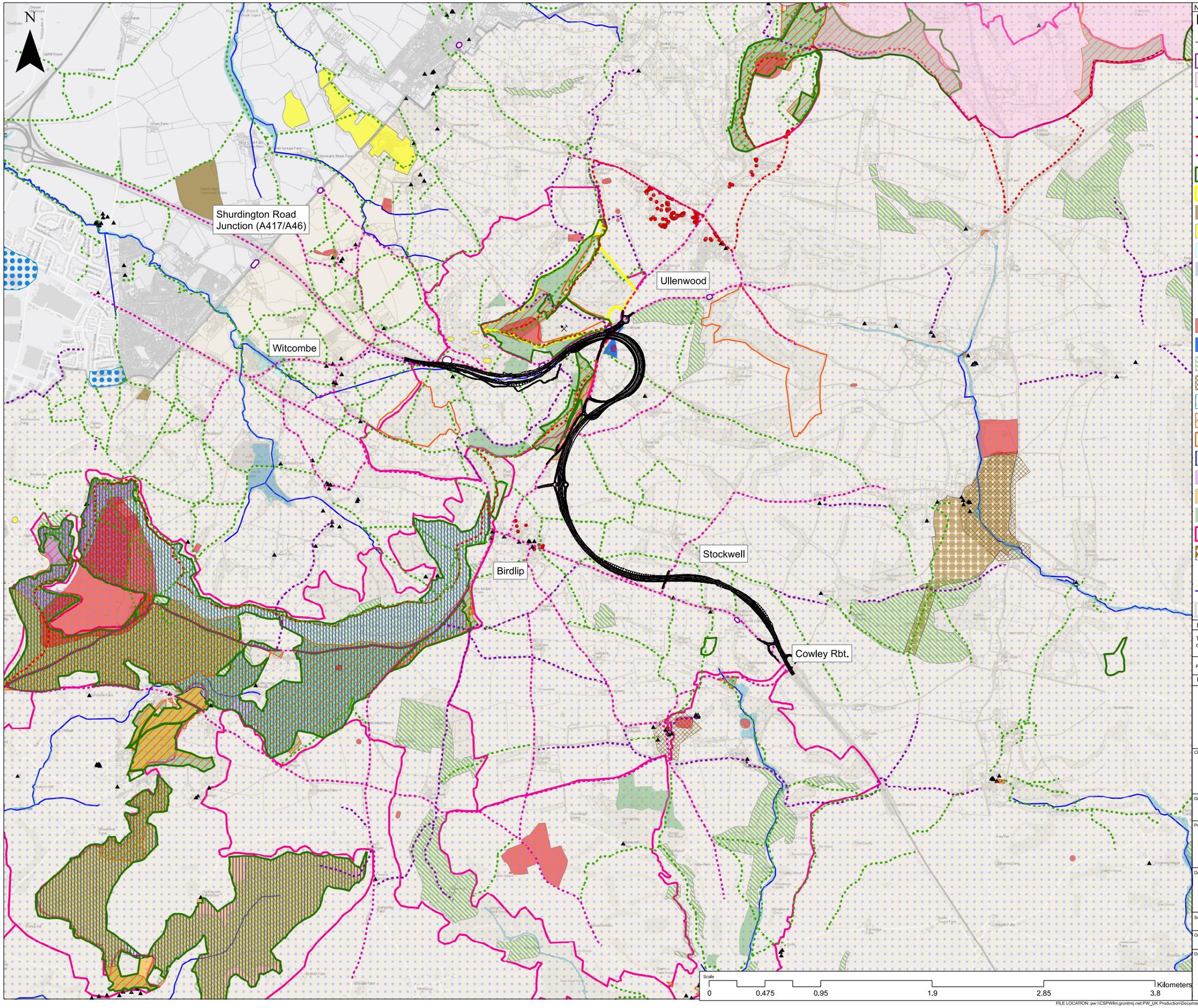
Source: GiGi GIS Portal. Crown Copyright 2016 100030649

11.8.7. The preferred route has been, and will continue to be, developed in collaboration with key stakeholders. Opportunities identified and explored with the key stakeholder group in late 2018 include alternative connection opportunities or the A436 to Shab Hill junction. These opportunities may provide:

- Improved journey times for the A436 traffic
- Greater opportunities to reconnect landscape and biodiversity assets
- The removal of existing infrastructure from the Cotswold escarpment

11.8.8. Delivery of the project will be subject to confirmation of funding within the second road investment strategy, which will cover the period between 2020-2025 and is due to be published towards the end of 2019.

Appendix A - Environmental constraints plan



Notes

Key to Symbols

- Option 12
- Noise Important Area
- AQMA
- Footpath
- Bridleway
- National Trail - Cotswold Way
- Cycle Paths
- Site of Special Scientific Interest
- Country Park
- Authorised Landfill
- Historic Landfill
- Flood Zone 2
- Flood Zone 3
- Listed Building
- Buried Archaeology
- Scheduled Monument
- Potential Ancient Woodland
- Ancient Woodland
- Conservation Area
- Local Development Area
- Registered Common Land
- Woodland Trust Tree Boundaries
- Special Area of Conservation
- Local Nature Reserve
- National Nature Reserve
- Open Access Land
- Strategic Nature Area (SNA)
- Registered Park & Garden
- Tree Preservation Orders
- Waterbodies
- Area of Outstanding Natural Beauty

Notes

The environmental constraints datasets were dowloaded January 2017. Updates to these datasets may be available and at an appropriate stage the constraints map will be amended.

Rev	Date	Amendment Details	Drw'n	Chk'd	App'd
P01	NOVEMBER 2018	1ST REVISION	SB	AM	BM

Mott MacDonald Sweco

Client: highways england

Drawing Status: FIT FOR INFORMATION

Suitability: S3

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: ENVIRONMENTAL CONSTRAINTS PLAN - OPTION 12

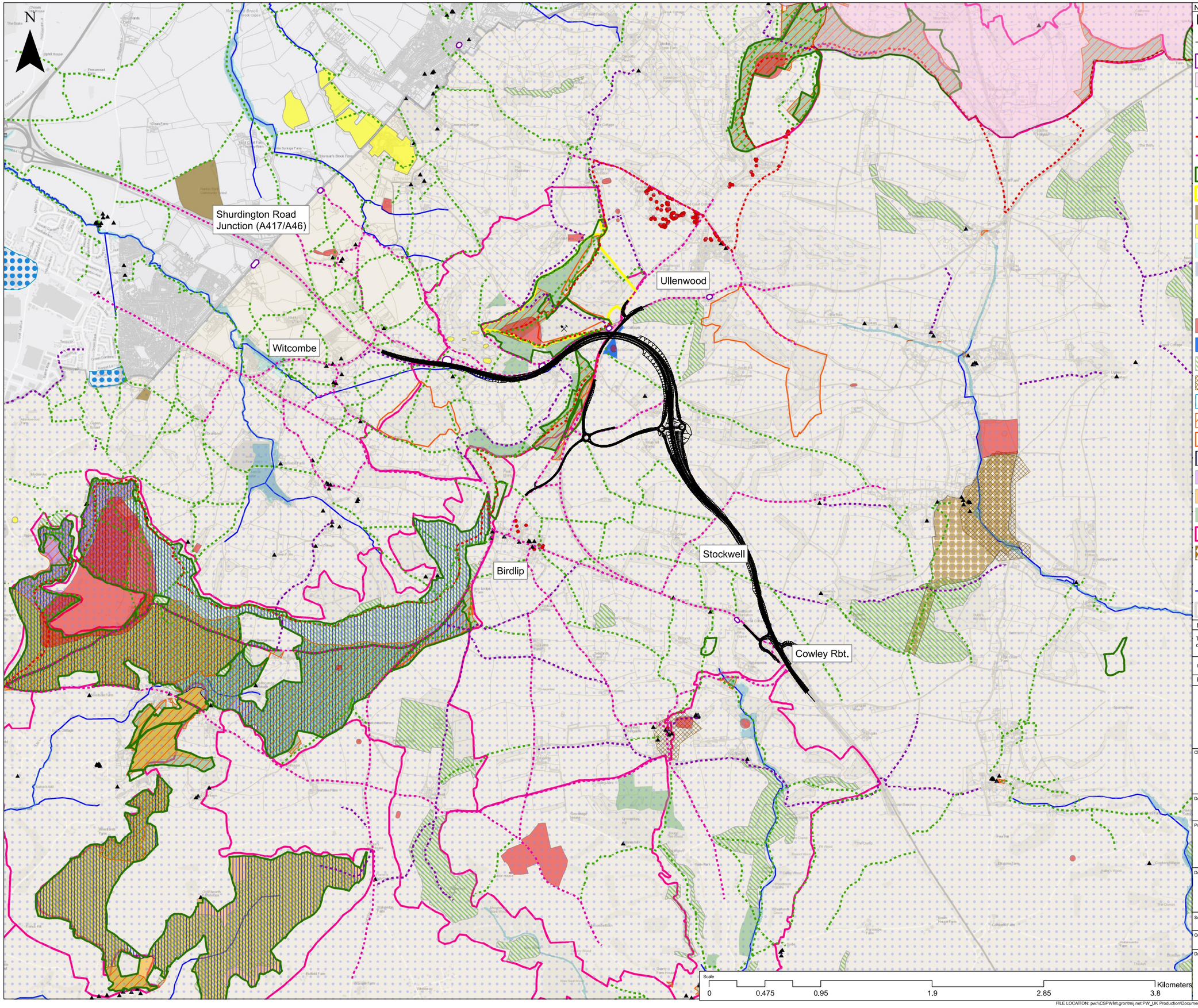
Scale	Designed	Drawn	Checked	Approved
1:15,000	E.RYDER	S.BUCKWELL	A.MASON	B.MULLEY
Original Size	**Date**	**Date**	**Date**	**Date**
A1	SEPTEMBER 2018	SEPTEMBER 2018	SEPTEMBER 2018	SEPTEMBER 2018

Drawing Number: HE PIN | Originator | Volume
551505 - MMSJV - EGN -
000 - DR - LX - 00005
Location | Type | Role | Number

Project Ref. No.: 551505

Revision: P01

FILE LOCATION: pw:\\CSPWint.grontmij.net:PW_UK Production\Documents\Projects\Transportation\HE551506 - A417 Missing Link at Air Balloon\Environment\General\Drgs & Models - 2D drawing\



Notes

Key to Symbols

- Option 30
- Noise Important Area
- AQMA
- Footpath
- Bridleway
- National Trail - Cotswold Way
- Cycle Paths
- Site of Special Scientific Interest
- Country Park
- Authorised Landfill
- Historic Landfill
- Flood Zone 2
- Flood Zone 3
- Listed Building
- Buried Archaeology
- Scheduled Monument
- Potential Ancient Woodland
- Ancient Woodland
- Conservation Area
- Local Development Area
- Registered Common Land
- Woodland Trust Tree Boundaries
- Special Area of Conservation
- Local Nature Reserve
- National Nature Reserve
- Open Access Land
- Strategic Nature Area (SNA)
- Registered Park & Garden
- Tree Preservation Orders
- Waterbodies
- Area of Outstanding Natural Beauty

Notes

The environmental constraints datasets were dowloaded January 2017. Updates to these datasets may be available and at an appropriate stage the constraints map will be amended.

Rev	Date	Amendment Details	Drw'n	Chk'd	App'd
P01	NOVEMBER 2018	1ST REVISION	SB	AM	BM

Mott MacDonald Sweco

Client: highways england

Drawing Status: FIT FOR INFORMATION

Suitability: S3

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: ENVIRONMENTAL CONSTRAINTS PLAN - OPTION 30

Scale	Designed	Drawn	Checked	Approved
1:15,000	E.RYDER	S.BUCKWELL	A.MASON	B.MULLEY
Original Size	**Date**	**Date**	**Date**	**Date**
A1	SEPTEMBER 2018	SEPTEMBER 2018	SEPTEMBER 2018	SEPTEMBER 2018

Drawing Number: HE PIN 551505 - Originator MMSJV - Volume EGN - Location 000 - Type DR - Role LX - Number 00006

Project Ref. No.: 551505

Revision: P01

FILE LOCATION: pw:\\CSPWint.grontmij.net:PW_UK Production\Documents\Projects\Transportation\HE551506 - A417 Missing Link at Air Balloon\Environment\General\Drgs & Models - 2D drawing\

Appendix B – International, European and National Environmental Legislation

Relevant international, European and national land use planning and environmental legislation for specific environmental topics, applicable to the scheme, are identified below.

Air quality

European legislation

The EC Ambient Air Quality Directive (2008/50/EC)

Sets legally binding limit values and target values for concentrations of major outdoor air pollutants that impact public health such as particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2). The scheme options have the potential to reduce air quality. The scheme would need to ensure that air quality limit values are not exceeded.

National legislation

The Air Quality Standards Regulations 2010 and The Air Quality Standards Regulations (Amendment) 2016

Implements the *EU's Directive 2008/50/EC* and transposes the Directive's limit and target values into legally binding Air Quality Standards with attainment dates in line with the Directive. The standards are based on the assessment of the effects of each pollutant on human health, including the effects on sensitive groups, and ecosystems. The scheme would need to ensure that air quality standards are not exceeded and that sensitive receptors are not adversely affected.

Air Quality (England) Regulations 2000 and Air Quality (England) (Amendment) Regulations 2002

Sets out air quality objectives within a given time period for local authorities in carrying out the air quality management duties in accordance with Part IV of the *Environment Act 1995*. This requires local authorities to monitor the air quality in their area and designate Air Quality Management Areas (AQMAs) where air quality objectives are not being achieved or are unlikely to be achieved by the relevant compliance date. Local authorities must then prepare an Air Quality Action Plan which sets out measures to pursue the achievement of the air quality objectives within the AQMA.

Both scheme options have the potential to improve air quality with the greatest reduction in annual mean NO_2 for the schemes predicted to be within Birdlip AQMA. As a result, the scheme options are currently in full compliance with both supranational and national legislation.

The Environmental Protection Act 1990, Section 79(1)(d)

Defines one type of Statutory Nuisance as 'any dust, steam, smell or other effluvia arising on industrial, trade or business premises and being prejudicial to health or a nuisance'. Where a local authority is satisfied that a statutory nuisance exists, or is likely to occur or recur, it must serve an abatement notice. The construction stage of any of the scheme options has the potential to cause nuisance from construction dust.

Cultural heritage

National legislation

The Ancient Monuments and Archaeological Areas Act 1979 (as amended)

This act relates to the investigation, preservation and recording of matters of archaeological and historical interest. The act provides for the protection of scheduled monuments through a designated schedule of monuments and allows the Secretary of State (SoS) to designate areas of archaeological importance. Relevant with regard to the impact upon the setting of the scheduled monuments that have the potential to be affected by the scheme options.

The Planning (Listed Buildings and Conservation Areas) Act 1990 (as amended)

Provides for the protection of Listed Buildings and Conservation Areas. Relevant with regard to the impact upon the setting of the listed buildings that have the potential to be affected by the scheme options.

Landscape

National legislation

Countryside and Rights of Way Act 2000

Places a duty on government bodies to have regard for the conservation of biodiversity and maintain lists of species and habitats for which conservation steps should be taken or promoted. Specifically, the Act places a statutory duty on relevant authorities to have regard to the purpose of conserving and enhancing the natural beauty of the Area of Outstanding Natural Beauty (AONB) when exercising or performing any functions affecting land in the AONB.

Both scheme options are wholly located within the Cotswold AONB.

Biodiversity

International legislation

The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)

The Convention has 3 ‘pillars’ of activity: the designation of wetlands of international importance as Ramsar sites; the promotion of the wise-use of all wetlands in the territory of each country; and international co-operation with other countries to further the wise-use of wetlands and their resources.

No Ramsar Sites have been identified within 2 kilometres of either scheme option.

European legislation

The EC Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (‘Habitats Directive 1982’) (as amended) (92/43/EEC)

Promotes the maintenance of biodiversity by requiring Member States to take measures to maintain or restore natural habitats and wild species listed on the Annexes to the Directive at a favourable conservation status, introducing robust protection for those habitats and species of European importance. Special Areas of Conservation (SAC) are protected sites designated under the EU Habitats Directive to ensure the conservations of these habitats and species.

There are a number of protected habitats and species within the study area of both Option 12 and 30. Cotswold Beechwood SAC is located 430m to the west of Option 12 and 320m to the west of Option 30. Wye Valley and Forest of Dean Bat Sites SAC is located 22 kilometres west of both Option 12 and 30.

The EC Directive on the Conservation of Wild Birds (‘Birds Directive 1979’) (as amended) (79/409/EEC)

The directive provides a framework for the conservation and management of, and human interactions with, wild birds in Europe. The Directive applies to the UK and its overseas territory of Gibraltar. Special Protection Areas (SPA) are protected sites classified for rare and vulnerable birds (listed on Annex I of the Birds Directive), and for regularly occurring migratory species, in accordance with Article 4 of the Birds Directive.

There are no Special Protection Areas within 2 kilometres of Option 12 and 30.

National legislation

Wildlife and Countryside Act 1981 (as amended)

The Wildlife and Countryside Act (WCA) 1981 (as amended) consolidates and amends existing national legislation to implement the EU Habitats Directive and the Birds Directive in the UK. The Act is divided into 17 Schedules which details the protection of wildlife (wild birds, certain wild animals, certain wild plants), the countryside, National Parks, the designation of protected areas (including, but not limited to, Sites of Specific Scientific Interest (SSSI) and Sites of Nature Conservation Importance (SNCI) and Public Rights of Ways (PRoWs) in England and Wales.

There are habitats and species of conservation importance within the study areas of Option 12 and 30.

Conservation of Habitats and Species Regulations 2017

The Conservation of Habitats and Species Regulations 2017 is the transposition of the European Habitats Directive into national law for England and Wales. The regulation provides for the designation and protection of European sites and the adaptation of planning and other controls for their protection.

There are a number of protected habitats and species within the study area of both Option 12 and 30. Cotswold Beechwood SAC is located 430m to the west of Option 12 and 320m to the west of Option 30. Wye Valley and Forest of Dean Bat Sites SAC is located 22 kilometres west of both Option 12 and 30.

Countryside and Rights of Way Act 2000

Places a duty on Government Bodies to have regard for the conservation of biodiversity and maintain lists of species and habitats for which conservation steps should be taken or promoted.

There are habitats and species of conservation importance within the study area of Option 12 and 30.

Natural Environment and Rural Communities Act 2006

The act requires public bodies, including local authorities, *'to have regard to the conservation of biodiversity in England'* when carrying out their normal functions.

There are habitats and species of conservation importance within the study area of Option 12 and 30.

Geology and soils

European legislation

The EC Water Framework Directive (EU Directive 2000/60/EC) and associated national implementation regulations

See the section in this appendix on ‘Road Drainage and the Water Environment’ (page 212) for details of this Directive.

The EC Groundwater Daughter Directive (2006/118/EC)

The Groundwater Daughter Directive (GDD) (2006/118/EC) establishes specific measures in order to prevent and control groundwater pollution, including: criteria for assessing the chemical status of groundwater; criteria for identifying significant and sustained upward trends in groundwater pollution levels and for defining starting points for reversing these trends; and preventing and limiting indirect discharges (after percolation through soil or subsoil) of pollutants into groundwater.

National legislation

The Environmental Protection Act 1990, Part II and Part IIA

Part II of the Environmental Protection Act (EPA) sets out the regime for regulating and licensing the acceptable disposal of controlled waste on land. Part IIA of the act specifically refers to the clean-up which is the minimum that can be done on a cost basis to make and keep the site in a just safe condition for an existing use.

The Contaminated Land (England) Regulations 2006 (as amended)

The Contaminated Land (England) Regulations 2006 set out provisions relating to the identification and remediation of contaminated land under Part IIA of the EPA.

There are five historic landfill sites present within the study area and within 500m of Option 12 and 30.

The Water Resources Act 1991

Section 161 allows the Environment Agency (EA) to recover the costs of cleaning up any poisonous, noxious, or polluting matter, or any solid waste matter, that persons have caused or knowingly permitted to be present in controlled waters. The Water Resources Act (WRA) and WRA 1991 (amendment) (England and Wales) Regulations 2009, Section 93, provides for the establishment of water protection zones.

There are five historic landfill sites present within the study area and within 500m of Option 12 and Option 30 with the potential for contaminated land to be present. The construction of the scheme has the potential to effect controlled waters.

Wildlife and Countryside Act 1981 (as amended)

Geological and geomorphological features considered to be of national importance are designated as SSSI. The importance of nature conservation, including areas with geological features, is emphasised.

Environmental Permitting (England and Wales) Regulations 2016

The prevention of pollution is regulated by several pieces of legislation including the Environmental Permitting Regulations, which regulate pollution control by requiring permits for emissions to, for example, air and water.

The Contaminated Land (England) Regulations 2006 (as amended) and The Contaminated Land (England) (Amendment) Regulations 2012

The regulations set out the provisions relating to the identification and remediation of contaminated land under Part IIA of the *Environmental Protection Act 1990.*

Waste legislation (various)

There are a number of waste-related regulations which serve to protect soils from contamination by waste management, such as the Hazardous Waste (England and Wales) Regulations 2005 (as amended), the Environmental Protection (Duty of care) Regulations 1991, the Waste Management Licensing Regulations 1994 (as amended), the Landfill Directive 1999, the Landfill Tax (Contaminated land) Order 1996, the Landfill (England and Wales) Regulations 2002 (as amended), and the Waste (England and Wales) Regulations 2011 (as amended).

Material assets and waste

European legislation

The EC Waste Framework Directive 2008

The directive requires member states to take appropriate measures to encourage the prevention or reduction of waste production and its harmfulness, and secondly the recovery of waste by means of recycling, re-use or reclamation or any other process with a view to extracting secondary raw materials, or the use of waste as a source of energy.

The directive sets out a 5-step waste hierarchy for waste management as a requirement which applies to anyone who produces or manages waste. The hierarchy ensures that waste is dealt with in the following order of priority:

1. Prevention
2. Preparing for re-use
3. Recycling
4. Other recovery (for example energy recovery)
5. Disposal, only as a last resort

The construction activities associated with Option 12 and 30 would lead to the production of waste.

National legislation

The Waste (England and Wales) Regulations 2011 (as amended)

The Waste (England and Wales) Regulations 2011, implements parts of the revised Waste Framework Directive 2008, particularly the principles of Waste Hierarchy. Organisations are required to confirm that they have applied the waste hierarchy, ensuring that waste is dealt in the priority of prevention, preparation for re-use, recycling, other recovery, and disposal.

Any waste generated during the construction of the scheme is to be dealt with in line with the Waste Hierarchy.

Environmental Protection Act 1990

The Environmental Protection Act defines the fundamental structure and authority for waste management and control of emissions into the environment. Specifically, it outlines the definition of controlled waste, the requirements of the duty of care in respect of waste and transferral of waste, the requirements for permits and authorisations and waste collection and waste disposal authorities and their roles.

The Landfill (England and Wales) Regulations 2002, as amended

The Landfill (England and Wales) Regulations 2002 (as amended)[33] require that landfill sites are classified into 1 of 3 categories: hazardous; non-hazardous; and inert, dependent on the chemical composition of the material. The regulations aim to reduce environmental and health impacts associated with landfilling waste.

The scheme has the potential to produce waste that cannot be used and would therefore need to be sent to landfill.

[33] Statutory Instrument (2002) *The Landfill (England and Wales) Regulations*. *No.1559*.

The Hazardous Waste (England and Wales) Regulations 2016

The Hazardous Waste (England and Wales) Regulations 2016 defines what constitutes as hazardous waste and outlines the measures and controls for handling such wastes. The movement of hazardous waste is to be documented by a system of consignment notes.

Control of Substances Hazardous to Health Regulations 2002 and Construction and Design Management Regulations 2015

These regulations ensure that when known or suspect contaminated soil is found by a developer, provisions must be made to ensure that risks to the public and site works are controlled.

There are five historic landfill sites present within the study area and within 500m of Option 12 and 30 with the potential for contaminated land to be present.

Noise and vibration

European legislation

EC Directive on the assessment and management of environmental noise (2002/49/EC)

The directive outlines a common and holistic approach to avoid, prevent, and reduce the effects on human health of exposure to noise, through an assessment of noise in member states. Such information should be made available to the public.

Both construction and operation phases for both scheme options have the potential to increase noise levels and adversely affect sensitive receptors.

National legislation

The Environmental Noise (England) Regulations 2006

These regulations implement European legislation requiring noise action plans to be developed on a 5-year rolling programme. Action plans have to be developed for the major noise sources and areas for which maps have been produced. Noise action plans provide a framework to manage environmental noise and its associated effects, including noise mitigation if necessary, based on results obtained through mapping exercises.

The Environmental Protection Act 1990, Part III

Under Part III of the act, a number of matters are declared to be Statutory Nuisances, including ‘noise that is prejudicial to health or a nuisance and is emitted from or caused by a vehicle, machinery or equipment…’.

Construction activities associated with the scheme will be temporary and intermittent in nature. As a result, there is potential for Statutory Nuisances to arise if best practice is not applied for the prevention of noisy and dust-creating construction activities.

The Control of Pollution Act 1974

Section 60 of the act enables local authorities to serve a notice which specifies its noise control requirements covering plant and machinery (in use or not in use), hours of working, and levels of noise that can be emitted.

Section 61 relates to prior consent where the contractor must consult the local authority and provide an application prior to construction works commencing to obtain approval for the methods to be used and the steps proposed to minimise noise resulting from the works.

If the local authority considers that the application contains sufficient information and that "best practicable means" (BPM) of noise control are being implemented, and; if the works are being carried out in accordance with the application, it would not serve a notice under Section 60.

"BPM" are defined in Section 72 of the act as "reasonably practicable having regard among other things to local conditions and circumstance, to the current state of technical knowledge and to the financial implications".

The Land Compensation Act 1973 Part 1

The Land Compensation Act 1973 Part 1[34] includes provision for compensation for loss in property value resulting from physical agents, including noise and vibration, resulting from the use of public works, such as new or improved roads.

The Noise Insulation Regulations 1975 (amended 1988)

The Noise Insulation Regulations 1975 (amended 1988)[35] were made under Part 2 of the Land Compensation Act for the obligatory and discretionary provision of noise mitigation measures for dwellings adjacent to new highways.

Road drainage and the water environment

European legislation

The EC Water Framework Directive (2000/60/EC)

The Water Framework Directive (WFD) (EU Directive 2000/60/EC) sets an overarching programme to deliver long-term protection of the water environment and to improve the

[34] HMSO, (1973). "Land Compensation Act."
[35] HMSO, (1975). "Noise Insulation Regulations. Statutory Instruments No. 1763. Building and Buildings."

chemical and ecological health of all waters (groundwater and surface water) and associated wetlands.

The key objectives of the WFD, provided for in the relevant River Basin Management Plan (RBMP), are to:

- To prevent deterioration of the status of surface waters and groundwater
- To achieve objectives and standards for protected areas
- To aim to achieve good status for all water bodies or, for heavily modified water bodies and artificial water bodies, good ecological potential and good surface water chemical status
- To reverse any significant and sustained upward trends in pollutant concentrations in groundwater
- The cessation of discharges, emissions and loses of priority hazardous substances into surface waters
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants

National legislation

The Water Environment (WFD) (England and Wales) Regulations 2017

These regulations implement the WFD into UK legislation to ensure that the objectives of the Water Framework Directive are met.

The Environmental Permitting Regulations 2010

The Environmental Permitting Regulations (EPR) 2010 aim to protect groundwater and surface waters from pollution by controlling the inputs of potentially harmful and polluting substances. The EPR implement the WFD and the Groundwater Daughter Directive 2006. The EPR supersedes elements of the Water Resources Act (WRA) 1991 that relate to the regulation of discharges to controlled waters (including groundwater).

The Flood and Water Management Act 2010

The act makes provisions about water, including the management of risks associated with flooding and coastal erosion.

The scheme options are located within 500m of Flood Zones 2 and 3.

The Highways Act 1980

Under the Highways Act 1980 (Section 100), Highways England has a right to discharge run-off from highways into inland and tidal water, or groundwaters (i.e. controlled waters

as defined under the WRA 1991), subject to the requirement to not pollute controlled waters.

The Water Resources Act

Section 161 allows the EA to recover the costs of cleaning up any poisonous, noxious, or polluting matter, or any solid waste matter, that persons have caused or knowingly permitted to be present in controlled waters. The WRA and WRA 1991 (amendment) (England and Wales) Regulations 2009, Section 93, provides for the establishment of water protection zones and approach for the protection of groundwater.

The Environment Agency's approach to groundwater protection includes the Environment Agency's position statements, which provide information about its approach to managing and protecting groundwater. They detail how the Environment Agency delivers government policy for groundwater and adopts a risk-based approach where legislation allows.

Source Protection Zones (SPZs) are defined for groundwater supplies used for human consumption. The Environment Agency's position statement relating to the use of sustainable drainage systems can be found in The Environment Agency's approach to groundwater protection.

The scheme options skirt 1 Source Protection Zones 3, located 500m from the scheme, for a public water supply abstraction.

Climate

National legislation

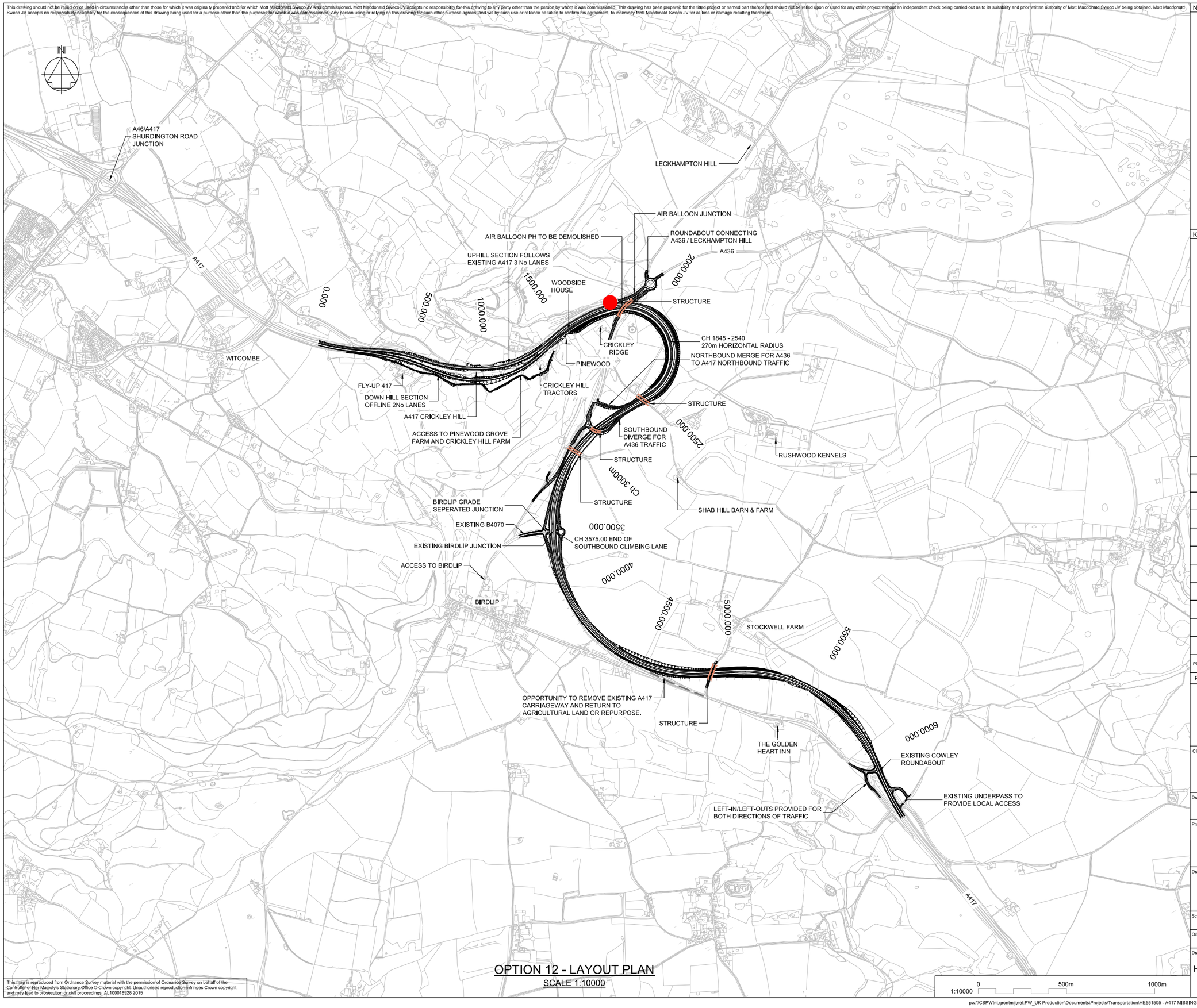
Climate Change Act 2008

The Climate Change Act 2008 forms part of the UK government's plan to reduce Greenhouse Gas (GHG) emissions, committing the government to a reduction of GHGs by at least 80% of 1990 levels by 2050. The Climate Change Act creates a new approach to managing and responding to climate change in the UK, by:

- Setting ambitious, legally binding emission reduction targets
- Taking powers to help meet those targets
- Strengthening the institutional framework
- Enhancing the UK's ability to adapt to the impact of climate change
- Establishing clear and regular accountability to the UK Parliament and to the devolved legislatures[36]

[36] DECC (2012) Climate Change Act 2008

Appendix C – Option 12



OPTION 12 - LAYOUT PLAN

SCALE 1:10000

1:10000 0 500m 1000m

Notes

1. ALL JUNCTION AND SLIP ROAD LAYOUTS SHOWN ARE INDICATIVE ONLY AT THIS STAGE.
2. FOR THE PURPOSES OF EARLY CONSIDERATION THE LEVEL OF BLIGHT ON THE FOLLOWING PROPERTIES MAY REQUIRE DEMOLITION: GROVE LODGE AND PINEWOOD. THE AIR BALLOON PUBLIC HOUSE AND WOODSIDE HOUSE WILL HAVE TO BE DEMOLISHED.
3. THE ACCESS TO RESIDENTIAL / COMMERCIAL PROPERTIES HAS NOT BEEN FULLY DEVELOPED AT THIS STAGE AND ARE SUBJECT TO SEPARATE DESIGN PACKAGES. THESE INCLUDE ACCESS TO COLD SLAD / CRICKLEY HILL TRACTORS AND FLY UP 417 / RUSHWOOD KENNELS AND SHAB HILL FARM. DETAILS TO BE CONFIRMED LATER WITHIN STAGE 2.

Key to symbols

- PROPOSED STRUCTURES
- SECTION OF EXISTING A417 / B4070 CARRIAGEWAY WILL HAVE THE OPPORTUNITY TO BE REMOVED OR RE-PURPOSED. (ARRANGEMENT SUBJECT TO APPROVAL)
- PROPOSED ROUTE / ALIGNMENT
- INDICATIVE LOCATION OF GREEN BRIDGE

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	30/07/18	FOR INFORMATION	RJ	LJ	GS

Mott MacDonald Sweco

Client: highways england

Drawing Status: FOR INFORMATION

Suitability: S2

Project Title: A417 MISSING LINK
PCF STAGE 2

Drawing Title: OPTION 12
GENERAL ARRANGEMENT

Scale	Designed	Drawn	Checked	Approved
1:10000	Jorgensen, Lars	Jones, Richard	Jorgensen, Lars	Smith, Graeme
Original Size	**Date**	**Date**	**Date**	**Date**
A1	30/07/18	30/07/18	30/07/18	30/07/18

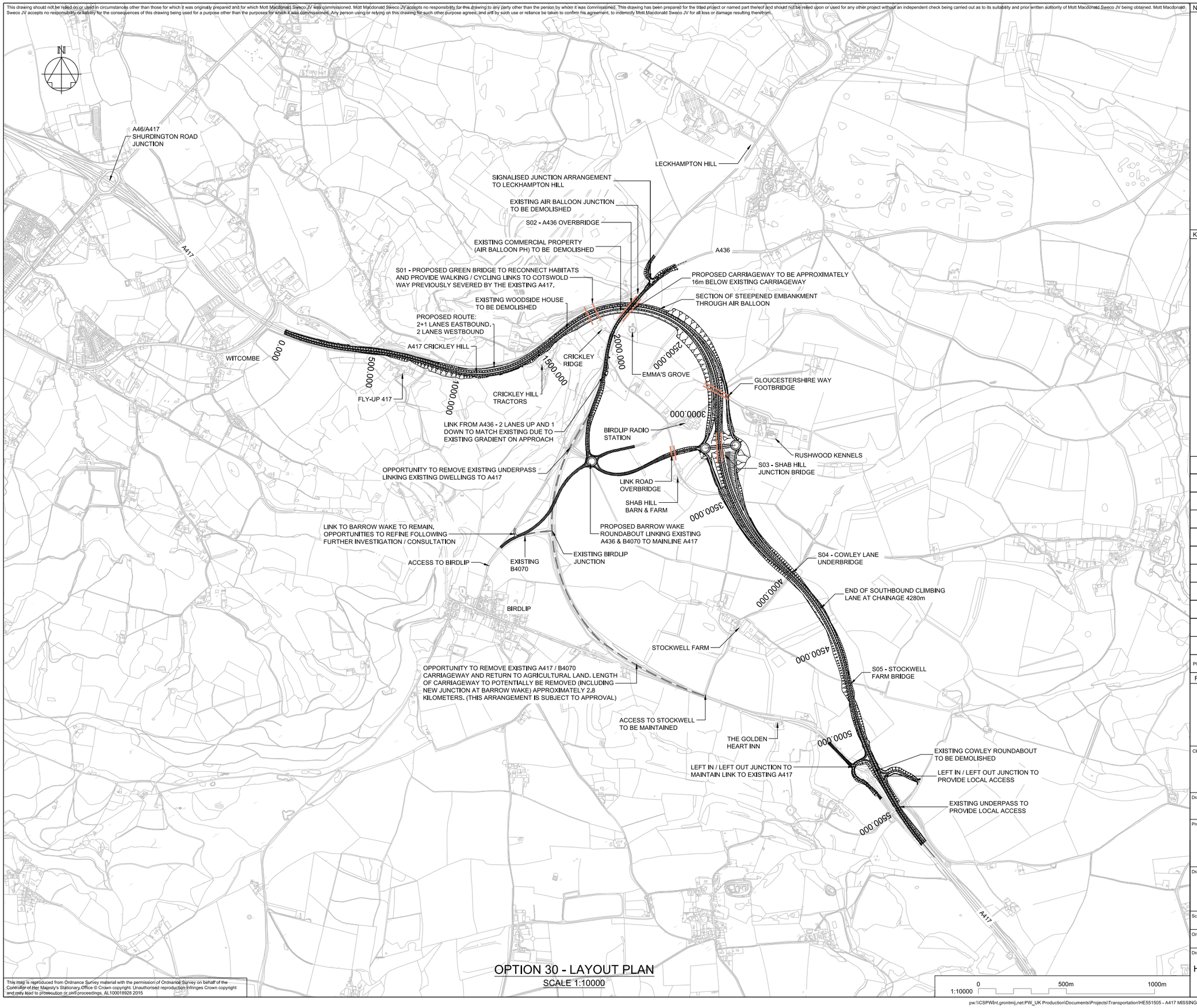
Drawing Number: HE551505 - MMSJV - HGN - 000 - DR - CH - 00109
(HE PIN | Originator | Volume | Location | Type | Role | Number)

Project Ref. No.: HE551505

Revision: P01

pw:\\CSPWInt.grontmij.net:PW_UK Production\Documents\Projects\Transportation\HE551505 - A417 MISSING LINK - PCF STAGE 2\Highways\General\Drgs & Models - 2D drawing\HE551505-MMSJV-HGN-000-DR-CH-00109

Appendix D – Option 30



OPTION 30 - LAYOUT PLAN

SCALE 1:10000

Notes

1. ALL JUNCTION AND SLIP ROAD LAYOUTS SHOWN ARE INDICATIVE ONLY AT THIS STAGE.
2. FOR THE PURPOSES OF EARLY CONSIDERATION THE LEVEL OF BLIGHT ON THE FOLLOWING PROPERTIES MAY REQUIRE DEMOLITION: GROVE LODGE AND PINEWOOD. THE AIR BALLOON PUBLIC HOUSE AND WOODSIDE HOUSE WILL HAVE TO BE DEMOLISHED.
3. THE A417 MISSING LINK SCHEME IS IN PCF STAGE 2, OPTION SELECTION. THIS LAYOUT REPRESENTS OPTION 30 WITH ALTERNATIVE DESIGN ARRANGEMENTS FOLLOWING NON-STATUTORY PUBLIC CONSULTATION. THE CHANGES SINCE THE OPTION ASSESSED FOR PUBLIC CONSULTATION ARE AS FOLLOWS:
   (i) MAINLINE SHIFTED EAST (APPROXIMATELY 230m) BETWEEN CHAINAGE 3250 - 5500 TO FIT MORE CLOSELY WITH THE EXISTING LANDSCAPE.
   (ii) RE-LOCATED JUNCTION AT BARROW WAKE AND RE-ALIGNED LINK ROAD BACK TO SHAB HILL GRADE SEPARATED JUNCTION.
   (iii) AMENDED VERTICAL PROFILE PROVIDING MAXIMUM MAINLINE GRADIENT OF 7% (PREVIOUS OPTION 7.5%).
   (iv) INCLUSION OF LEFT IN/LEFT OUT JUNCTION AT COWLEY (NOT SHOWN).
4. THE ACCESS TO RESIDENTIAL / COMMERCIAL PROPERTIES HAS NOT BEEN FULLY DEVELOPED AT THIS STAGE AND ARE SUBJECT TO SEPARATE DESIGN PACKAGES. THESE INCLUDE ACCESS TO COLD SLAD / CRICKLEY HILL TRACTORS AND FLY UP 417 / RUSHWOOD KENNELS AND SHAB HILL FARM. DETAILS TO BE CONFIRMED LATER WITHIN STAGE 2.

Key to symbols

- PROPOSED STRUCTURES
- SECTION OF EXISTING A417 / B4070 CARRIAGEWAY WILL HAVE THE OPPORTUNITY TO BE REMOVED OR RE-PURPOSED. (ARRANGEMENT SUBJECT TO APPROVAL)
- PROPOSED ROUTE / ALIGNMENT

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	30/07/18	FOR INFORMATION	RJ	LJ	GS

Mott MacDonald Sweco

Client: highways england

Drawing Status: FOR INFORMATION

Suitability: S2

Project Title: A417 MISSING LINK
PCF STAGE 2

Drawing Title: OPTION 30
GENERAL ARRANGEMENT

Scale	Designed	Drawn	Checked	Approved
1:10000	Jorgensen, Lars	Jones, Richard	Jorgensen, Lars	Smith, Graeme
Original Size	**Date**	**Date**	**Date**	**Date**
A1	30/07/18	30/07/18	30/07/18	30/07/18

Drawing Number: HE PIN | Originator | Volume
HE551505 - MMSJV - HGN -
000 - DR - CH - 00110
Location | Type | Role | Number

Project Ref. No.: HE551505

Revision: P01

pw:\\CSPWInt.grontmij.net:PW_UK Production\Documents\Projects\Transportation\HE551505 - A417 MISSING LINK - PCF STAGE 2\Highways\General\Drgs & Models - 2D drawing\HE551505-MMSJV-HGN-000-DR-CH-00110

Appendix E – Forecast traffic flow plots

Figure A.1: Option 12 – Forecast AADT flows in local area

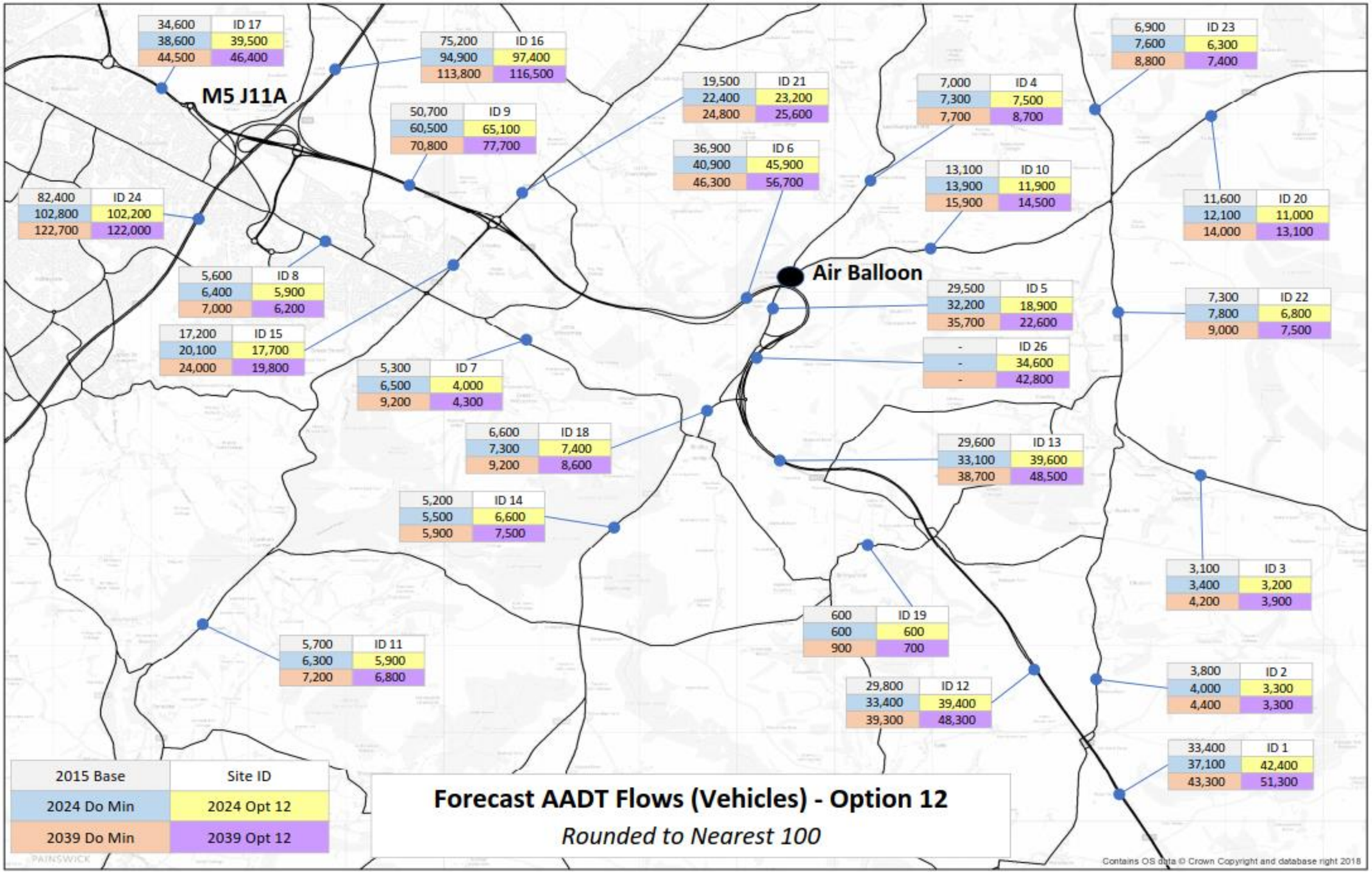


Figure A.2: Option 12 – Forecast AADT flows in wider area

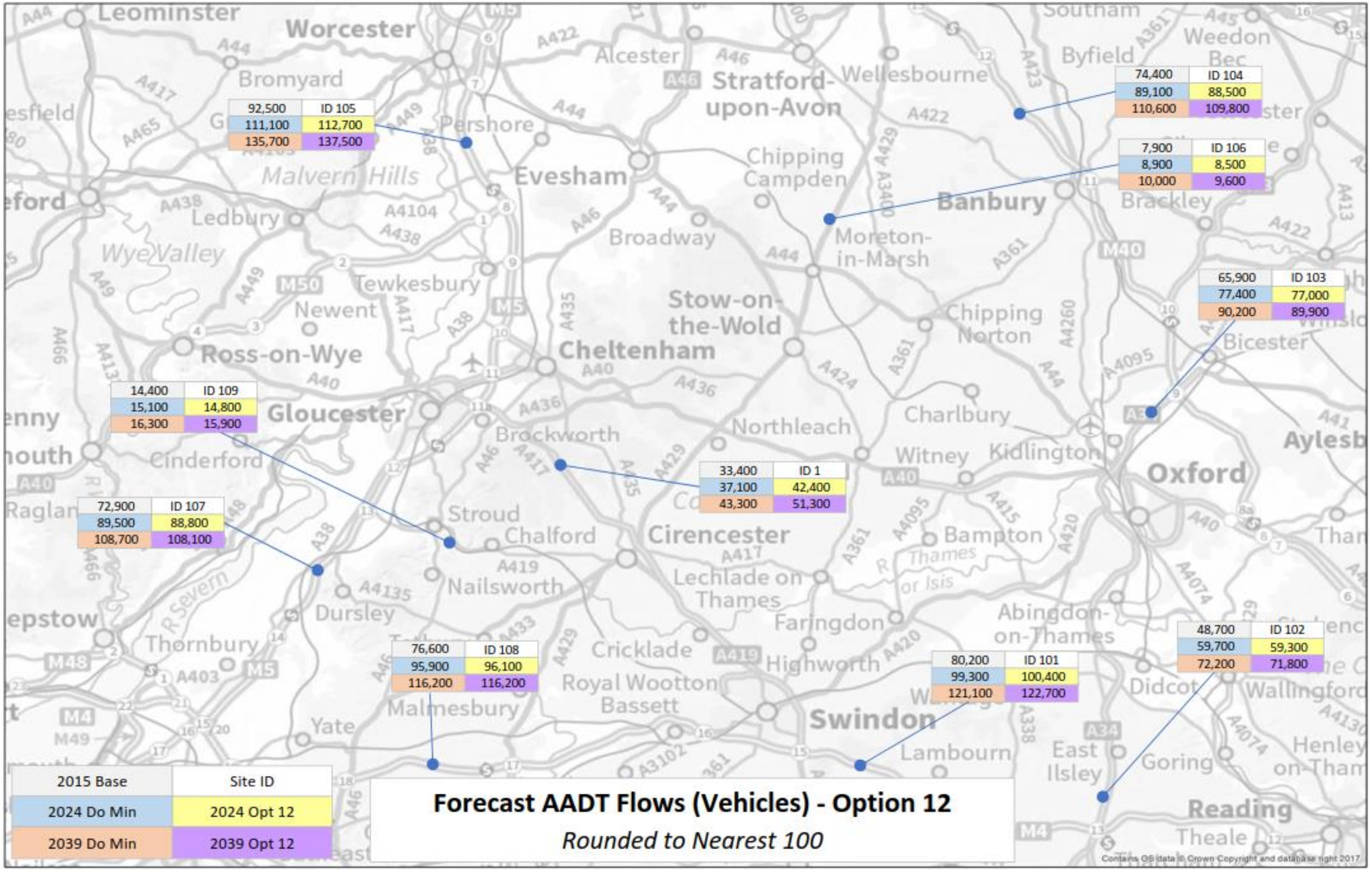


Figure A.3: Option 30 – Forecast AADT flows in local area

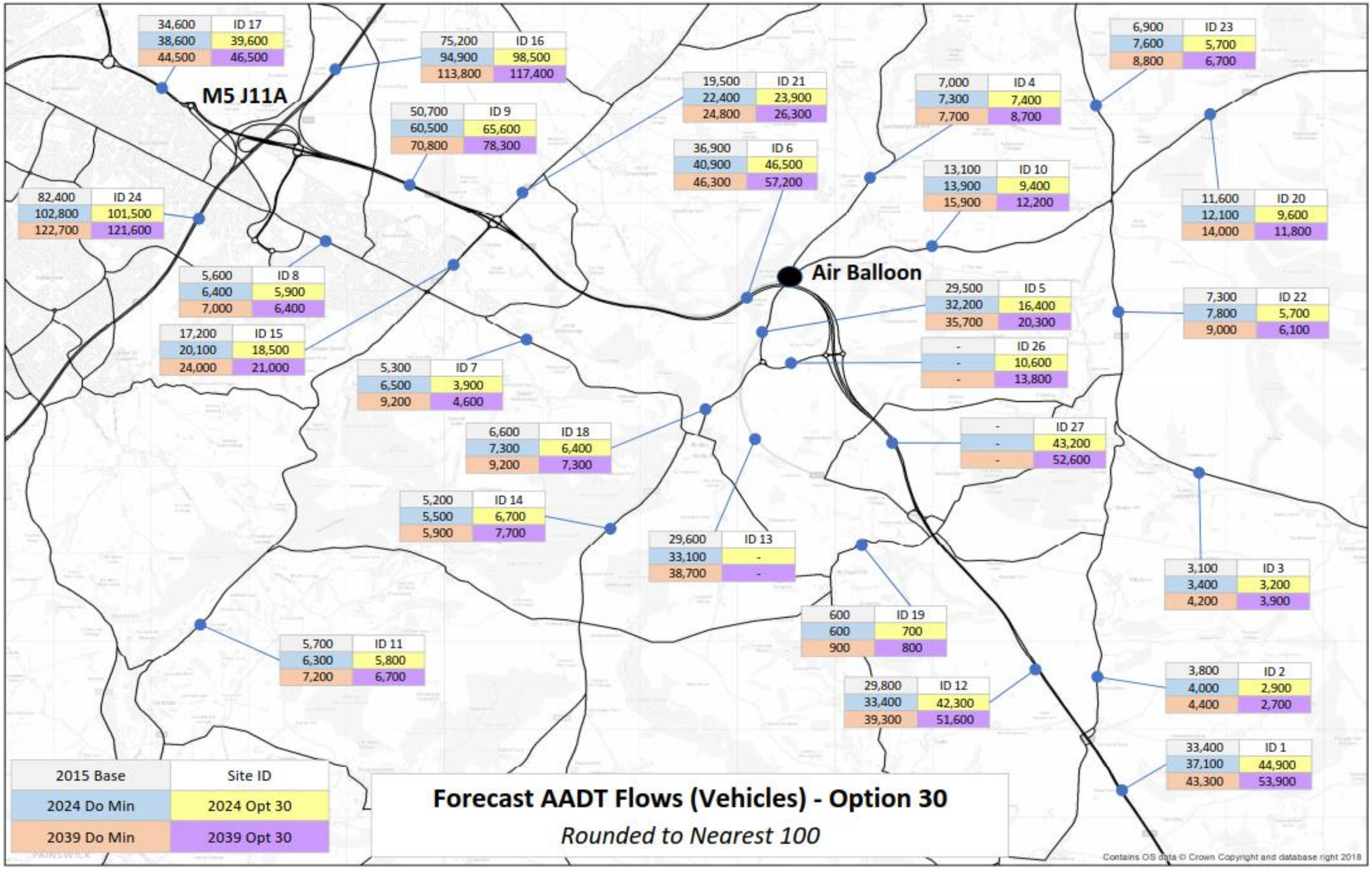
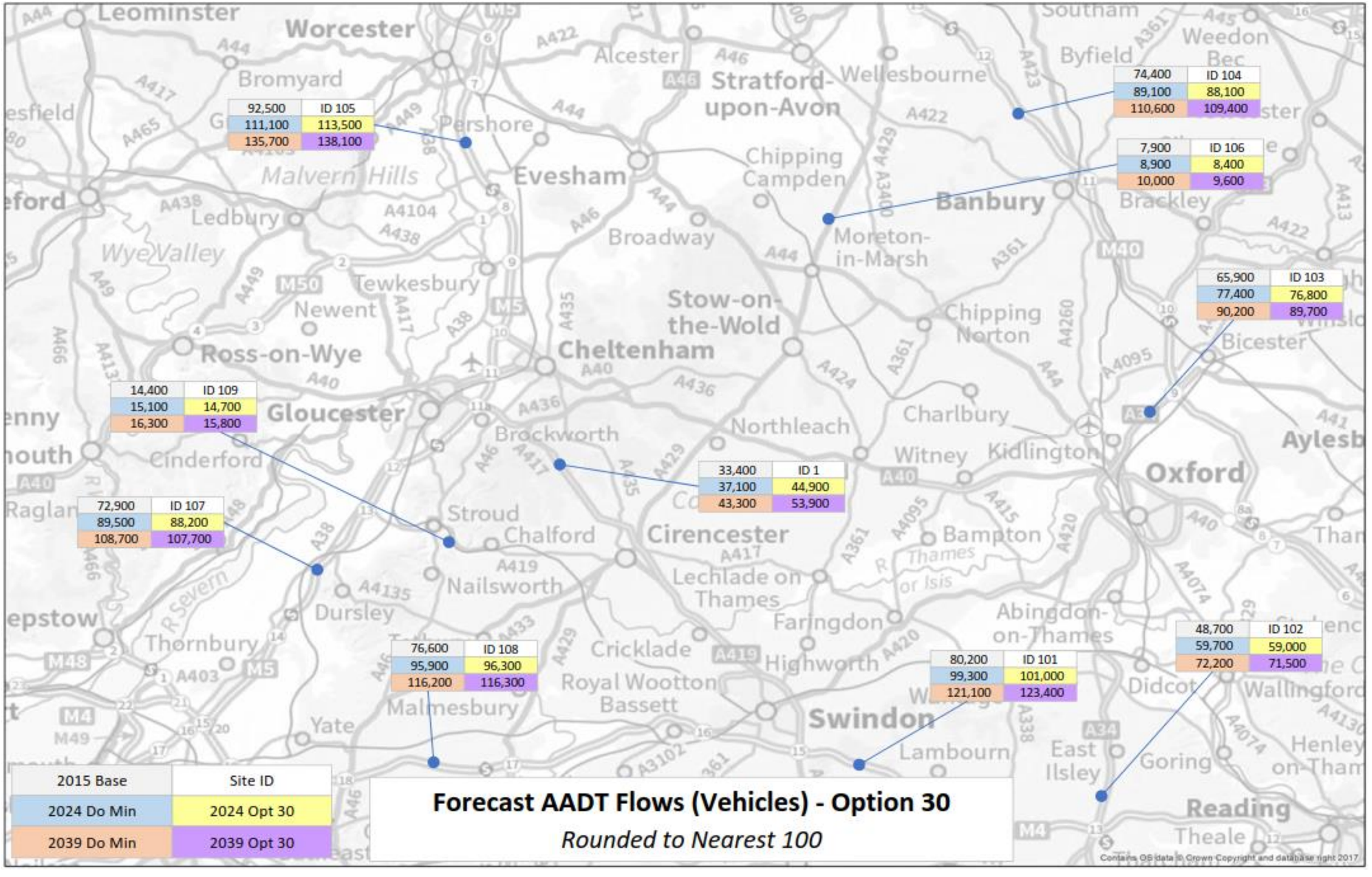


Figure A.4: Option 30 – Forecast AADT flows in wider area



Appendix F – National Policy Statement for National Networks

The National Policy Statement for National Networks (NPSNN) sets out the need for development of Nationally Significant Infrastructure Projects (NSIPs) on the road and rail networks in England and Government's policies to deliver them. It provides planning guidance for applicants of these schemes and is the basis for the examination by the Planning Inspectorate (PINS) and decisions by the Secretary of State for Transport.

This appendix sets out how each environmental topic conforms to the policy requirements of the NPSNN.

The need for the scheme

It may be considered that the scheme can demonstrate that it is in the public interest and that its potential impacts are outweighed by the scheme's benefits to safety and the economy.

The A417/A419 route between Gloucester and Swindon experiences high traffic flow, and at the A417 Missing Link section, the traffic volume considerably exceeds the design capacity which results in frequent congestion and poor journey time reliability. Assessments to date indicate, without improvements, that congestion would increase. Journey times would rise and journey time reliability would be impacted as a result. The increase in traffic flows would also increase the risks of fatal or serious injuries taking place. Constraints on economic performance across Gloucestershire and Swindon would occur as a result of insufficient capacity and the route would struggle to support the wider economic aspirations of the region.

Environmental topics

Air Quality

NPSNN paragraphs of relevance to air quality include:

- 5.3 - 5.15 (Air quality)

Defra's Pollution Climate Mapping (PCM) model is used to assess compliance with the Air Quality Directive. The air quality assessment undertaken at PCF Stage 2 shows that there is one PCM link which overlaps the scheme's affected road network. The assessment concludes that there is a low risk of exceeding EU Limit Values. Considering the predicted changes in air quality from both Options 12 and 30, there are no locations where predicted annual mean NO_2 concentrations are likely to be above the air quality objective of

40µg/m^3. At this stage neither option is considered to perform better than the other in terms of compliance with the requirements of the NPSNN. Further air quality assessments would be undertaken at PCF Stage 3 upon selection of a preferred scheme option.

Cultural Heritage

NPSNN paragraphs of relevance to cultural heritage include:

- 5.120 - 5.142 (The historic environment)

At this stage, based on the current available information, Option 30 has the potential to cause a larger number of adverse effects than Option 12. The most significant effects are considered to be those on Grade II listed building Shab Hill Barn, during the construction and operation of Option 30.

Should a significant impact remain following further assessment and design work in PCF Stage 3, relevant policy requirements as set out within the NPSNN would need to be met. In this instance, the NPSNN states that where a scheme would result in the substantial harm or loss of significance of a heritage asset, the need for the scheme would need to be justified and it would need to be demonstrated that the public benefit delivered by the scheme would outweigh that harm or loss. The need for the scheme, including public benefit, is outlined in Section 0.

Further assessments at PCF Stage 3 would determine both potential enhancement opportunities and mitigation measures for cultural heritage and other aspects of the environment across the scheme.

Landscape and Visual

NPSNN paragraphs relevant to landscape and visual effects include:

- 5.143 – 5.161 (Landscape and visual effects)

Both Options 12 and 30 have the potential to cause significant adverse effects upon both landscape character and visual amenity and therefore at this stage it is not possible to distinguish between the relative merits of either option in terms of their compliance against the relevant NPSNN policy tests.

Should a significant impact remain following further assessment and design work in PCF Stage 3, relevant policy requirements as set out within the NPSNN would need to be met. In reference to paragraph 5.153 of the NPSNN:

"Where consent is given in these areas, the Secretary of State should be satisfied that the applicant has ensured that the project will be carried out to high environmental standards and where possible includes measures to enhance other aspects of the environment."

A key aspect to the scheme design would be the conservation and enhancement of the special character of the Cotswold AONB, reflecting the character of the local landscape and ensuring high environmental standards. With regards to the enhancement of other aspects of the environment, current environmental assessments have concluded that both scheme options would result in air quality benefits. Further assessments at PCF Stage 3 (alongside review of the design principles which will help to guide design development to ensure conservation and enhancement of the AONB) would determine mitigation measures and potential enhancement opportunities for landscape and other aspects of the environment across the scheme.

Biodiversity

NPSNN paragraphs of relevance to biodiversity include:

- 5.27-5.5.29 (International sites and SSSIs)
- 5.32 (Ancient woodland and veteran trees)
- 5.34-5.35 (Protection of other habitats and species)

The impact of Option 30 on Barrow Wake SSSI, and the potential for significant impacts on Bushey Muzzard SSSI and supporting aquifers, would be slightly less than that of Option 12. Further detailed assessments are required to determine the exact impacts of the scheme on groundwater flows. Option 30 would have a lesser impact on ancient woodland due to reduced land take at Emma's Grove in comparison to Option 12. The alignment of Option 12 would result in a roundabout being located close to Ullen Wood, causing potentially greater air quality impacts on this ancient woodland. At this stage, Option 30 would have a less of a direct impact on other protected habitats and species than Option 12, due a reduced impact at Barrow Wake.

Where the scheme would lead to substantial harm to, or loss of, biodiversity assets, the NPSNN states that the need for the scheme would need to be justified and it would need to be demonstrated that the public benefit delivered by the scheme would outweigh that harm or loss. The need for the scheme, including its public benefit, is outlined in Section 0.

Should a significant impact remain in PCF Stage 3 following further environmental assessment and design work and, a compensation strategy would be sought to offset habitat loss. Compensation and enhancement measures would potentially include the purchase of land parcels within close proximity to the scheme to create new habitat areas, compensation planting to form new habitat corridors, and the enhancement of existing Ancient Woodland to compensate the potential loss of any other Ancient Woodland.

Geology and Soils

NPSNN paragraphs relevant to geology and soils include:

- 5.22 (Biodiversity and ecological conservation)
- 5.25 (Biodiversity and ecological conservation)
- 5.168 (Land use including open space, green infrastructure and Green Belt)

The scheme has been designed, as far as possible, to minimise effects on geology and soils. A significant effect is anticipated for both options, however, due to the alignment of each option, the significance of effect for Option 12 would be less than that of Option 30.

Should a significant impact remain at PCF Stage 3 following further environmental assessment and design work, a compensation strategy would be sought to counteract any impacts that could not be avoided or mitigated. Compensation measures may include opportunities for the provision of improvements to geological SSSIs in close proximity to the scheme options, including measures such as erosion protection, new exposures or improved access. Further assessments at PCF Stage 3 would determine potential enhancement opportunities and mitigation measures for geology and soils and other aspects of the environment across the scheme.

Material Assets and Waste

NPSNN paragraphs relevant to material assets and waste include:

- 5.39 – 5.45 (Waste management)

At this stage quantities of waste have not been identified, however cut and fill calculations for both scheme options have identified that there would be a surplus of cut materials. It is estimated that Option 12 would produce a surplus of 1,425,987m^3 and Option 30 would produce a surplus of 760,900m^3.

Should a significant impact remain in PCF Stage 3, the relevant requirements set out within the NPSNN would need to be met. This would include a need to ensure effective management of hazardous and non-hazardous waste arising from the construction and operation of the scheme. Further assessments at PCF Stage 3 would determine potential enhancement opportunities and mitigation measures for material assets and waste and other aspects of the environment across the scheme.

Noise and Vibration

NPSNN paragraphs relevant to noise and vibration include:

- 5.186 – 5.200 (Noise and vibration)

Assessments undertaken to date indicate that Option 12 results in two fewer potential significant adverse effects prior to mitigation. It is considered at this stage that neither option indicates greater compliance with the policy tests set out within the NPSNN for

noise and that further assessments are required to fully determine the impacts of the scheme.

Detailed mitigation has not yet been considered at this stage. The specification of mitigation, including acoustic barriers and bunds, would be considered at PCF Stage 3 to ensure the requirements set out in paragraph 5.195 and 5.196 of the NPSNN are met.

Population and Health

NPSNN paragraphs relevant to population and health include:

- 5.162; 5.166; 5.173 – 5.175; 5.180; 5.184 and 5.185 (Land use including open space, green infrastructure and Green Belt)

An on-balance adverse and significant effect relating to population and health has been predicted for both Option 12 and 30. Option 30 presents a greater risk of conflict with NPSNN policy due to the potential land take at Ullenwood Bharat Cricket Club.

Where the scheme would lead to substantial harm to or loss of community land and facilities, the need for the scheme would need to be justified and it would need to be demonstrated that the public benefit delivered by the scheme would outweigh that harm or loss. The need for the scheme, including its public benefit, is outlined in Section 0. Further assessments at PCF Stage 3 would determine potential enhancement opportunities and mitigation measures for population and health and other aspects of the environment across the scheme.

Further assessment at PCF Stage 3 would be required for impacts on land use, including community land and facilities. Should a significant impact remain at Stage 3 following further environmental assessment and design work, compensation measures in the form of improved or compensatory land or facilities would need to be considered.

Road Drainage and the Water Environment

NPSNN paragraphs relevant to road drainage and the water environment include:

- 5.90 – 5.115 (Flood risk)
- 5.219 – 5.231 (The water environment)

It is considered at this stage, with the current assessments available, that neither option indicates greater compliance with the NPSNN or performs better than the other in terms of environmental outcomes. Further consultation with the Environment Agency and the Lead Local Flood Authority is required at PCF Stage 3 in order to confirm the requirements for further assessment, such as a Flood Risk Assessment and a Water Framework Directive assessment, as well as to develop and agree a robust mitigation plan.

Should a significant impact remain at PCF Stage 3 following further assessment and design work, and the Environment Agency is satisfied that appropriate mitigation has been included in the design, then the scheme would continue to mitigate the risk of impact through careful design and use of best practice.

Climate

NPSNN paragraphs relevant to climate include:

- 4.36 – 4.47 (Climate change adaptation)
- 5.16 – 5.19 (Carbon emission)

It is considered at this stage, with the current assessments available, that Option 12 would result in emissions of approximately 15,241tCO_2e for construction lifecycle stages, and it would perform better than Option 30 in terms of environmental outcomes, which would result in emissions of approximately 26,852tCO_2e. It is considered that the emissions for both options would not impact upon the government's ability to achieve its carbon reduction targets, and therefore it is anticipated that the effect on climate would not be significant.

At PCF Stage 3, the policy tests would be met through the inclusion of mitigation measures (as outlined in Chapter 11) therefore it is not anticipated that either scheme would compromise the Government's ability to meet its targets. Requirements would include evidenced mitigation measures, incorporating engineering plans on route configuration and layout, and use of materials, which would need to be sought in both design and construction.

Appendix G – Appraisal summary tables

Appraisal Summary Table	Version Control - P03	Date produced:	November 2018	Contact:	
Name of scheme:	A417 Missing Link (PCF Stage 2) - Option 12			Name	Michael Goddard
Description of scheme:	The scheme comprises an approximately 6.4 kilometre dual carriageway surface route (historically known as the Modified Brown Route), with a mixture of on-line widening and off-line construction. It follows the existing A417 alignment on Crickley Hill and near Birdlip, with off-line sections to the northeast of Barrow Wake and to the north of Nettleton, before re-joining the existing A417 carriageway south of the location of the existing Cowley Roundabout. There would be a new grade separated junction located at the B4070 (Birdlip) and north-facing slip roads, which would connect the mainline dual carriageway to the existing route at Barrow Wake. A minor junction would also be provided on the A417 near the location of the existing Cowley Roundabout to provide local access.			Organisation	Highways England
				Role	Promoter/Official

	Impacts	Summary of key impacts	Assessment: Quantitative	Qualitative	Monetary £(NPV)	Distributional 7-pt scale/ vulnerable grp
Economy	Business users & transport providers	Journey time benefits arise from the conversion of the existing single carriageway section of the A417 to a modern dual carriageway, with associated junction improvements. Net journey time changes are the net of positive and negatives in a given time band. The majority of journey time benefits are accrued from time savings of between 2 and 5 minutes. Monetary (NPV) includes benefits from journey time savings, vehicle operating cost impacts and changes in user charges.	**Value of journey time changes(£m)** 146.4 **Net journey time changes (£m)** 0 to 2min: -1.0; 2 to 5min: 128.8; > 5min: 18.6	Not applicable	£111.4 million	Not applicable
	Reliability impact on Business users	Reliability impacts have been estimated based on existing journey time variability along single and dual-carriageway sections of the A417. This scheme will provide significant reliability benefits due to the removal of the single-carriageway section of the A417 which experiences high levels of travel time variability.	£35.2 million	Beneficial	£35.2 million	
	Regeneration	The scheme is not in close proximity to a regeneration area.	Not applicable	Not applicable	N/A	
	Wider Impacts	The wider impacts of the scheme have been assessed using the DfT's Wider Impacts in Transport Appraisal (WITA version 1.2.1.2 beta) software. N.B. The WITA analysis of agglomeration and labour supply impacts has been limited to the detailed model area where confidence in the model results is highest. The scheme removes a significant bottleneck from the A417 corridor, leading to reductions in travel costs for journeys that make use of the route. The WITA analysis shows benefits primarily resulting from agglomeration impacts and to a lesser extent from benefits associated with output changes in imperfectly competitive markets. Wider benefits also arise from labour supply impacts.	Agglomeration benefits £38.9 million Labour supply benefits £0.7 million Output change in imperfectly competitive markets £11.1 million	Not applicable	£50.7 million	
Environmental	Noise	Results indicate an overall benefit due to a reduction of traffic using the bypassed section of A417 and some minor roads. Attenuation from alignment changes at some receptors and the relatively unpopulated area adjacent to the scheme would result in an overall benefit. Results do not include the effects of mitigation in the form of noise barriers or bunds which has not been specified at this stage. In the opening year, there are 2 receptors that are assessed to experience significant adverse effects due to noise.	Households experiencing increased daytime noise in forecast year: 17 Households experiencing reduced daytime noise in forecast year: 142 Households experiencing increased night time noise in forecast year: 11 Households experiencing reduced night time noise in forecast year: 101	Not applicable	£1.0 million	Distributional impacts across income groups would be unevenly spread with a Neutral effect on people in quintiles 1 (most deprived) and 3, a Slight Beneficial effect in quintile 5 (least deprived), Moderate Beneficial effect on people in quintile 2 and a Large Beneficial effect in quintile 4.
	Air Quality	Overall there is a net worsening in local and regional air quality as a result of the scheme. This is because of the rerouting of vehicles on to the A417 and M5 away from the M40 and A34 which results in a longer route with a greater number of properties along it. There would be no new exceedances as a result. The scheme is predicted to improve air quality at properties within the Birdlip AQMA near the affected road network. Overall, the total change in NPV is negative, indicating a net deterioration in air quality when considering both local and regional effects. For the purpose of this assessment, it was assumed that one property would be demolished for the scheme ("Woodside House" on Crickley Hill).	Local Air Quality Assessment Score in Year of Opening: 2024: NO2: +225.4 PM10: +80.4 Regional Emissions (Over 60 year appraisal period) NOx: +830 tonnes	Not applicable	PM10 NPV: -£0.2 million NOX NPV: -£0.4 million Total value of change in air quality: -£0.6 million	NO2 and PM10: Distributional impacts across income groups would be unevenly spread with a Neutral effect on people in quintile 1 (most deprived), Slight Adverse effect on people in quintile 4, Moderate Adverse effect on people in quintiles 2 and 5 (least deprived) and Large Adverse effect on people in quintile 3.
	Greenhouse gases	The scheme would result in an increase in both non-traded carbon and traded carbon over the 60 year appraisal period.	Change in non-traded carbon over 60y (CO2e): 822,194 Change in traded carbon over 60y (CO2e): 10,109	Not applicable	-£36.5 million	
	Landscape	The scheme lies within the Cotswolds AONB, designated for its high landscape value. The area around the existing A417 is typical of National Character Area 107 Cotswolds, within which it lies. A dramatic limestone scarp, lined by ancient beech hangers on the upper slopes, rises above rural lowlands to the west. The high wold lies on the dip slope to the east, and is dominated by arable farming on thin soils, with blocks of woodland and plantation. Pasture and woodland occur in the valleys. There is limited settlement in the landscape, which contains accessible land, Public Rights of Way (PRoW), ecological assets and historical features. The scheme runs entirely at surface. The western half of the scheme runs on-line and adjacent with the existing A417, deepening the Crickley Hill cutting and affecting existing vegetation and Horsbere Brook. Elevated views from the top of the escarpment, including at Barrow Wake, look west over falling ground into the neighbouring vale and would likely be affected by this part of the scheme. East and south of Air Balloon, the scheme runs in part off-line, and in part on-line and adjacent with the existing A417, through an undulating rural landscape. The scheme would affect woodland at Emma's Grove and open farmland, with 2 new grade-separated junctions created at Barrow Wake and Birdlip. The new road and associated junctions and infrastructure would give rise to additional fragmentation of the local landscape pattern, an increased level of disturbance of the area and impacts on views from isolated settlement and PRoW.	Not applicable	Large Adverse	Not applicable	
	Townscape	Given the highly rural nature of the route, the scheme would not pass through any developed settlements greater than individual farmsteads. No village settlements would be directly affected by the route. A townscape appraisal is not considered necessary due to the lack of urban features. Instead, the landscape appraisal should be referenced with regard to this route.	Not applicable	Not applicable	Not applicable	
	Historic Environment	The scheme would result in moderate and large adverse impacts to the settings of two highly significant heritage assets, as well as to the rural setting of a heritage asset of medium significance. The scheme would also have a large adverse impact on an asset of low, local significance. Additionally, there would be large adverse impacts to archaeological remains across the entire road corridor during the construction phase of the scheme. In light of the surrounding heritage assets, buried archaeological remains have the potential to be of high, national significance. The detrunking of the existing A417 would, however, improve the setting of some assets of medium significance. Overall, it is considered that the beneficial effects do not balance out the large number of adverse effects that the construction and operation of the scheme would have on the historic environment, particularly buried archaeological remains.	Not applicable	Large Adverse	Not applicable	

	Biodiversity	There is a potential for Large adverse effects on bats. To date, the rare Annex II species greater horseshoe, lesser horseshoe and barbastelle have been recorded foraging and commuting within the footprint of the scheme and lesser horseshoe have been recorded roosting within the zone of influence of the scheme. Ongoing surveys will provide more details on the importance of populations affected. The proposals could potentially directly impact on populations of these species, reduce available habitat, result in habitat fragmentation and the mortality of bats in relation to traffic. Large Adverse effects are identified for Bushley Muzzard SSSI due to potential groundwater impacts as the option may intersect the aquifer that is supplying the SSSI. There is a potential for Moderate Adverse effects on Ancient Woodland due to potential loss and fragmentation of habitats at Emma's Grove. Standard mitigation has been included in the assessment of likely impacts. There are considerable opportunities for additional ecological enhancement measures along the scheme corridor, including the provision of a green bridge in the vicinity of Crickley Hill and Barrow Wake. These benefits have not been included in the assessment of impacts due to their current uncertainty. On balance, the overall assessment is Large Adverse as there are no compensatory effects which could balance out the large adverse effects.	Not applicable	Large Adverse	Not applicable	
	Water Environment	Potentially adverse effects on direct groundwater receptors (groundwater bodies) and indirect groundwater receptors (springs, streams, wetland and abstractions) during construction and operation. A mainline cutting and embankment foundations / piles would intersect the Great Oolite aquifer upgradient of Bushley Muzzard SSSI, potentially leading to a reduction of water supply to this spring-fed wetland and associated habitat loss. Mainline cutting close to Air Balloon would potentially divert groundwater from one catchment to another. Therefore, adopting the precautionary principle, in the absence of ground investigation baseline data, and detailed design and mitigation measures, the assessment score for potential impacts on groundwater receptors would be Very Large Adverse. The potential impacts on surface water receptors would be mainly insignificant due to standard mitigation measures implemented through the CEMP and design. There is a potentially low significant adverse effect during construction on Horsbere Brook, as an indirect receptor, from change in groundwater heads and groundwater flow regime.	Not applicable	Very Large Adverse	Not applicable	
Social	Commuting and Other users	Journey time benefits arise from the conversion of the existing single carriageway section of the A417 to a modern dual carriageway, with associated junction improvements. Net journey time changes are the net of positive and negatives in a given time band. The majority of journey time benefits are accrued from time savings of between 2 and 5 minutes. Monetary (NPV) includes benefits from journey time savings, vehicle operating cost impacts and changes in user charges. User benefits are distributed evenly between income quintiles leading to a moderate beneficial impact.	**Value of journey time changes(£m)** 120.0 **Net journey time changes (£m)** 0 to 2min: 4.0 / 2 to 5min: 103.7 / > 5min: 12.4	Not applicable	£48.6 million	Moderate beneficial
	Reliability impact on Commuting and Other users	Reliability impacts have been estimated based on existing journey time variability along single and dual-carriageway sections of the A417. This scheme will provide significant reliability benefits due to the removal of the single-carriageway section of the A417 which experiences high levels of travel time variability.	£28.9 million	Beneficial	£28.9 million	
	Physical activity	The scheme would result in the severance of some walkers, cyclists and horse-riders (WCH) routes, however the provision of diversions for affected routes and new crossings would reduce changes to journey times and lengths for WCHs. New crossings could potentially improve amenity and would be safer for WCHs. The installation of new and improved facilities for WCHs has the potential to encourage people to make more journeys using non-motorised forms of transport rather than motorised transport modes. Without specific details for where mitigation would be provided at this stage, it is assumed that there would be some journey length increases for WCHs. Although this could affect the usage of routes, there may also be some health benefits as a result of WCH travelling further to reach their destinations and on amenity with new safer crossings.	Not applicable	Neutral	Not applicable	
	Journey quality	Journey quality is anticipated to improve for travellers utilising the road between Cowley Roundabout and Crickley Hill once the scheme is in operation. A slight beneficial impact has been predicted to traveller care through the anticipated provision of new signage, reduced congestion and improved road surface. The impacts upon traveller views are anticipated to be neutral once the scheme is operational. Traveller stress is generally anticipated to reduce once the scheme is operational due to improvements in driver frustration, route uncertainty and fear of potential accidents, although the route would be slightly longer for those wishing to travel along the A436 which may increase frustration for them. The reduced congestion is likely to result in reduced frustration whilst the installation of new signage would result in a slight improvement to route uncertainty. The new safety provisions, particularly the new suitable vehicle restraint system along the central reserve, would lead to a slight reduction in the fear of potential accidents.	Not applicable	Slight Beneficial	Not applicable	
	Accidents	A reduction in the number of fatal and serious casualties results from the conversion of the existing single carriageway section of the A417 to a modern dual carriageway, with associated junction improvements. 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. A distributional impact assessment of accident benefits has shown that the impact of the scheme on vulnerable groups is neutral.	Reduction in PIAs: -23.6 Reduction in casualties Fatal: 77.9 Serious: 101.5 Slight: -33.9	Not applicable	£67.9 million	Neutral
	Security	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. There is potential for WCH routes to be affected, and consideration of measures such as footbridges and underpasses has been given to retain connectivity 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 result in some changes to lighting at the Air Balloon junction, although no lighting is likely to be required at Cowley roundabout, with this feature removed with the scheme in place. 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.	Not applicable	Neutral	Not applicable	Not applicable
	Access to services	The scheme is not anticipated to affect access to services within the vicinity of the scheme and effects on public transport accessibility would be Neutral.	Not applicable	Neutral	Not applicable	Not applicable
	Affordability	There is a forecast to be an overall increase in vehicle operating costs as a result of the scheme, leading to a moderate adverse affordability assessment. The increase in vehicle operating costs however, is driven to an extent by the redistributional impacts of the highway improvement (i.e. people choose to travel further, and incur greater vehicle operating costs, due to the reductions in travel time that the scheme brings). For the majority of existing trips the scheme will reduce vehicle operating costs as the new alignment is more direct and less congested than the current route. Some local movements, particularly traffic travelling between the A417 and A436, will experience increases in journey distance, and therefore costs, as a result of the scheme. A distributional impact assessment has shown that the affordability impacts of the scheme are evenly distributed between income quintiles.	N/A	Moderate Adverse	N/A	Moderate adverse
	Severance	The scheme is predicted to result in a slight increase in severance for walkers, cyclists and horse riders (WCH) wishing to access the 3 community facilities within the study area. A total of 1472 WCHs, of which 814 would be classed as pedestrians, were counted at 31 different locations within the vicinity of the scheme in September 2017 during the summer holidays. Counts were undertaken for a 14-hour period (6am to 8pm) on Saturday 2 September, with an additional survey undertaken at 3 of the sites on Saturday 10 September due to access difficulties for the previous survey. A slight negative impact on severance has been predicted for pedestrians travelling to: 417 Bike Park from Little Witcombe or Brockworth; Ullenwood Bharat Cricket Club from Birdlip, Barrow Wake car park, Little Witcombe or Brockworth, Coberley, Cowley and Ullenwood; Walking milestone from Barrow Wake car park. This is because the scheme is likely to sever WCH routes used to access the community facilities from the nearby communities outlined above. A slight negative impact is predicted on severance for cyclists and horse-riders wishing to access the community facilities within the study area, with some hindrance to movements likely. The scheme is predicted to result in a slight relief in severance for local communities such as Birdlip, Cowley, Coberley, Little Witcombe and Brockworth 15 years after opening, with traffic rerouted onto the scheme alignment. With consideration of mitigation measures which are likely to be applied, including the development of an WCH strategy; which would ensure that permanent diversions and structures comprising footbridges and underpasses are provided at appropriate locations, potential increases in journey lengths for WCHs and also the positive impacts on some local communities with a relief in severance, a Neutral effect is predicted for the scheme on severance.	Not applicable	Neutral	Not applicable	To be assessed at a later stage

	Option and non-use values	The scheme does not include measures that will substantially change the availability of transport services in the study area.	Not applicable	Neutral	Not applicable	
Public Accounts	Cost to Broad Transport Budget	The scheme will be funded through Central Government Funds	Central Govt funding: £311.8 million	Not applicable	£311.8 million	
	Indirect Tax Revenues	There would be some increase in the tax being paid to the Exchequer	Central Govt funding: Wider Public Finances = -£72.8 million	Not applicable	-£72.8 million	

Appraisal Summary Table	Version Control - P03	Date produced:	November 2018	Contact:	
Name of scheme:	A417 Missing Link (PCF Stage 2) - Option 30			Name	Michael Goddard
Description of scheme:	The scheme comprises approximately 5.6 kilometre of dual carriageway surface route, with the majority constructed off-line and to the east of the existing A417 alignment. At its northern end, it follows the alignment of the existing A417 on Crickley Hill before entering the proposed off-line section near the location of the existing Air Balloon roundabout. It continues in a broadly southbound direction before re-joining the existing A417 carriageway south of the location of the existing Cowley Roundabout. A grade separated junction would be provided near Shab Hill, with a single carriageway link road proposed to connect the new dual carriageway to the existing A417 near the B4070 at Birdlip. A minor junction would also be provided on the A417 near the location of the existing Cowley Roundabout to provide local access.			Organisation	Highways England
				Role	Promoter/Official

	Impacts	Summary of key impacts	Assessment			
			Quantitative	Qualitative	Monetary £(NPV)	Distributional 7-pt scale/ vulnerable grp
Economy	Business users & transport providers	Journey time benefits arise from the conversion of the existing single carriageway section of the A417 to a modern dual carriageway, with associated junction improvements. Net journey time changes are the net of positive and negatives in a given time band. The majority of journey time benefits are accrued from time savings of between 2 and 5 minutes. Monetary (NPV) includes benefits from journey time savings, vehicle operating cost impacts and changes in user charges.	**Value of journey time changes(£m)** 170.4 **Net journey time changes (£m)** 0 to 2min: -7.2 / 2 to 5min: 138.3 / > 5min: 39.2	Not applicable	£158.7 million	Not applicable
	Reliability impact on Business users	Reliability impacts have been estimated based on existing journey time variability along single and dual-carriageway sections of the A417. This scheme will provide significant reliability benefits due to the removal of the single-carriageway section of the A417 which experiences high levels of travel time variability.	£38.9 million	Beneficial	£38.9 million	
	Regeneration	The scheme is not in close proximity to a regeneration area.	Not applicable	Not applicable	N/A	
	Wider Impacts	The wider impacts of the scheme have been assessed using the DfT's Wider Impacts in Transport Appraisal (WITA version 1.2.1.2 beta) software. N.B. The WITA analysis of agglomeration and labour supply impacts has been limited to the detailed model area where confidence in the model results is highest. The scheme removes a significant bottleneck from the A417 corridor, leading to reductions in travel costs for journeys that make use of the route. The WITA analysis shows benefits primarily resulting from agglomeration impacts and to a lesser extent from benefits associated with output changes in imperfectly competitive markets. Wider benefits also arise from labour supply impacts.	Agglomeration benefits £46.9 million Labour supply benefits £0.8 million Output change in imperfectly competitive markets £15.9 million	Not applicable	£63.6 million	
Environmental	Noise	Results indicate an overall benefit due to reduction of traffic using bypassed section of A417 and on some minor roads. Attenuation from alignment changes at some receptors and the relatively unpopulated area adjacent to the scheme results in an overall benefit. Results do not include effects of mitigation in the form of noise barriers or bunds which has not been specified at this stage. In the opening year, there are 4 receptors that are assessed to experience significant adverse effects due to noise.	Households experiencing increased daytime noise in forecast year: 23 Households experiencing reduced daytime noise in forecast year: 185 Households experiencing increased night time noise in forecast year: 18 Households experiencing reduced night time noise in forecast year: 121	Not applicable	£1.2 million	Distributional impacts would be unevenly spread across income groups with a Neutral effect on people in quintiles 1 (most deprived), 2 and 3, a Slight Beneficial effect on people in quintile 4 and Large Beneficial effect on people in quintile 5 (least deprived).
	Air Quality	Overall there is a net worsening in local and regional air quality as a result of the scheme. This is because of the rerouting of vehicles on to the A417 and M5 away from the M40 and A34 which results in a longer route with a greater number of properties along it. There would be no new exceedances as a result. The scheme is predicted to improve air quality at properties within the Birdlip AQMA and Oxford AQMA near the affected road network. Overall the net change in NPV is negative, indicating a net deterioration in air quality when considering both local and regional effects. For the purpose of this assessment, it was assumed that one property would be demolished for the scheme ("Woodside House" on Crickley Hill).	Local Air Quality Assessment Score in Year of Opening: 2024: NO2: +591.0 PM10: +218.5 Regional Emissions (Over 60 year appraisal period) NOx: +898 tonnes	Not applicable	PM10 NPV: -£0.5 million NOX NPV: -£0.4 million Total value of change in air quality: -£1.0 million	NO2: Distributional impacts across income groups would be unevenly spread with a Slight Adverse effect on people in quintiles 4 and 5 (least deprived), Moderate Adverse effect on people in quintiles 1 and 2, and Large Adverse effect on people in quintile 3. PM10: Distributional impacts would be relatively evenly spread across income groups with a Neutral effect on people in quintile 1 (most deprived) and a Moderate Adverse effect on people in quintiles 2,3 4 and 5 (least deprived).
	Greenhouse gases	The scheme would result in an increase in both non-traded carbon and traded carbon over the 60 year appraisal period.	Change in non-traded carbon over 60y (CO2e): 835,792 Change in traded carbon over 60y (CO2e): 11,316	Not applicable	-£37.1 million	
	Landscape	The scheme lies within the Cotswolds AONB, designated for its high landscape value. The area around the existing A417 is typical of National Character Area 107 Cotswolds, within which it lies. A dramatic limestone scarp, lined by ancient beech hangers on the upper slopes, rises above rural lowlands to the west. The high wold lies on the dip slope to the east, and is dominated by arable farming on thin soils, with blocks of woodland and plantation. Pasture and woodland occur in the valleys. There is limited settlement in the landscape, which contains accessible land, Public Rights of Way (PRoW), ecological assets and historical features. The scheme runs entirely at surface. The western section runs on-line and adjacent with the existing A417, deepening the Crickley Hill cutting and affecting existing vegetation and Horsbere Brook. Elevated views from the top of the escarpment, including at Barrow Wake, look west over falling ground into the neighbouring vale and would likely be affected by this part of the scheme. East and southeast of Air Balloon, the scheme runs off-line through an undulating rural landscape, affecting open farmland, woodland at Emma's Grove and a wooded valley at Shab Hill where a substantial new grade separated junction is proposed. The new road and associated junctions and infrastructure would give rise to fragmentation of the local landscape pattern, an increased level of disturbance of the area and impacts on views from isolated settlement and PRoW.	Not applicable	Large Adverse	Not applicable	
	Townscape	Given the highly rural nature of the route, the scheme would not pass through any developed settlements greater than individual farmsteads. No village settlements would be directly affected by the route. A townscape appraisal is not considered necessary due to the lack of urban features. Instead, the landscape appraisal should be referenced with regard to this route.	Not applicable	Not applicable	Not applicable	
	Historic Environment	The scheme would result in a moderate adverse impact to the settings of two highly significant heritage assets, as well as to the rural setting of heritage assets of medium significance. The scheme would also have a large adverse impact on an asset of low, local significance. Additionally, there would be large adverse impacts to archaeological remains across the entire road corridor during the construction phase of the scheme. In light of the surrounding heritage assets, buried archaeological remains have the potential to be of high, national significance. The detrunking of the existing A417 would, however, improve the setting of some assets of medium significance. Overall, it is considered that the beneficial effects do not balance out the large number of adverse effects that the construction and operation of the scheme would have on the historic environment, particularly buried archaeological remains.	Not applicable	Large Adverse	Not applicable	

	Biodiversity	There is a potential for Large adverse effects on bats. To date, the rare Annex II species greater horseshoe, lesser horseshoe and barbastelle have been recorded foraging and commuting within the footprint of the scheme and lesser horseshoe have been recorded roosting within the zone of influence of the scheme. Ongoing surveys will provide more details on the importance of populations affected. The proposals could potentially directly impact on populations of these species, reduce available habitat, result in habitat fragmentation and the mortality of bats in relation to traffic. There is a potential for Moderate Adverse effects on Ancient Woodland due to potential loss and fragmentation of habitats at Emma's Grove. Standard mitigation has been included in the assessment of likely impacts. There are considerable opportunities for ecological enhancement measures along the scheme corridor, including the provision of a green bridge in the vicinity of Crickley Hill and Barrow Wake. These benefits have not been included in the assessment of impacts due to the uncertainty of these measures. On balance, the overall assessment is Large Adverse as there are no compensatory effects which could balance out the large adverse effects.	Not applicable	Large Adverse	Not applicable	
	Water Environment	Potentially adverse effects on direct groundwater receptors (groundwater bodies) and indirect groundwater receptors (springs, streams, wetland and abstractions) during construction and operation. A mainline cutting and embankment foundations / piles would intersect the Great Oolite aquifer upgradient of Bushley Muzzard SSSI, potentially leading to a reduction of water supply to this spring-fed wetland and associated habitat loss. Mainline cutting close to Air Balloon would potentially divert groundwater from one catchment to another. Therefore, adopting the precautionary principle in the absence of ground investigation baseline data, and detailed design and mitigation measures, the assessment score for potential impacts on groundwater receptors would be Very Large Adverse. The potential impacts on surface water receptors would be insignificant due to standard mitigation measures implemented through the CEMP and design.	Not applicable	Very Large Adverse	Not applicable	
Social	Commuting and Other users	Journey time benefits arise from the conversion of the existing single carriageway section of the A417 to a modern dual carriageway, with associated junction improvements. Net journey time changes are the net of positive and negatives in a given time band. The majority of journey time benefits are accrued from time savings of between 2 and 5 minutes. Monetary (NPV) includes benefits from journey time savings, vehicle operating cost impacts and changes in user charges. User benefits are distributed evenly between income quintiles leading to a moderate beneficial impact.	**Value of journey time changes(£m)** 130.8 **Net journey time changes (£m)** 0 to 2min: -13.6 / 2 to 5min: 114.6 / > 5min: 29.8	Not applicable	£56.2 million	Moderate beneficial
	Reliability impact on Commuting and Other users	Reliability impacts have been estimated based on existing journey time variability along single and dual-carriageway sections of the A417. This scheme will provide significant reliability benefits due to the removal of the single-carriageway section of the A417 which experiences high levels of travel time variability.	£29.8 million	Beneficial	£29.8 million	
	Physical activity	The scheme would result in the severance of some walkers, cyclists and horse-riders (WCH) routes, however the provision of diversions for affected routes and new crossings would reduce changes to journey times and lengths for WCHs. New crossings could potentially improve amenity and would be safer for WCHs. The installation of new and improved facilities for WCHs has the potential to encourage people to make more journeys using non-motorised forms of transport rather than motorised transport modes. Without specific details for where mitigation would be provided at this stage, it is assumed that there would be some journey length increases for WCHs. Although this could affect the usage of routes, there may also be some health benefits as a result of WCH travelling further to reach their destinations and on amenity with new safer crossings.	Not applicable	Neutral	Not applicable	
	Journey quality	Journey quality is anticipated to improve for travellers utilising the road between Cowley Roundabout and Crickley Hill once the scheme is in operation. A slight beneficial impact has been predicted to traveller care through the anticipated provision of new signage, reduced congestion and improved road surface. The impacts upon traveller views are anticipated to be neutral once the scheme is operational. Traveller stress is generally anticipated to reduce once the scheme is operational due to improvements in driver frustration, route uncertainty and fear of potential accidents, although the route would be slightly longer for those wishing to travel along the A436 which may increase frustration for them. The reduced congestion is likely to result in reduced frustration whilst the installation of new signage would result in a slight improvement to route uncertainty. The new safety provisions, particularly the new suitable vehicle restraint system along the central reserve, would lead to a slight reduction in the fear of potential accidents.	Not applicable	Slight Beneficial	Not applicable	
	Accidents	A reduction in the number of fatal and serious casualties results from the conversion of the existing single carriageway section of the A417 to a modern dual carriageway, with associated junction improvements. 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. A distributional impact assessment of accident benefits has shown that the impact of the scheme on vulnerable groups is neutral.	Reduction in PIAs: -101.8 Reduction in casualties Fatal: 77.8 Serious: 95.6 Slight: -129.2	Not applicable	£65.3 million	Neutral
	Security	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 will be installed provided to a level which is consistent with the wider A417 / A419 corridor which would be beneficial. There is potential for WCH routes to be affected, and consideration of measures such as footbridges and underpasses has been given to retain connectivity 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 result in some changes to lighting at the Air Balloon junction, although no lighting is likely to be required at Cowley roundabout, with this feature removed with the scheme in place. 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.	Not applicable	Neutral	Not applicable	Not applicable
	Access to services	The scheme is not anticipated to affect access to services within the vicinity of the scheme and effects on public transport accessibility would be Neutral.	Not applicable	Neutral	Not applicable	Not applicable
	Affordability	There is a forecast to be an overall increase in vehicle operating costs as a result of the scheme, leading to a moderate adverse affordability assessment. The increase in vehicle operating costs however, is driven to an extent by the redistributional impacts of the highway improvement (i.e. people choose to travel further, and incur greater vehicle operating costs, due to the reductions in travel time that the scheme brings). For the majority of existing trips the scheme will reduce vehicle operating costs as the new alignment is more direct and less congested than the current route. Some local movements, particularly traffic travelling between the A417 and A436, will experience increases in journey distance, and therefore costs, as a result of the scheme. A distributional impact assessment has shown that the affordability impacts of the scheme are evenly distributed between income quintiles.	N/A	Moderate Adverse	N/A	Moderate adverse
	Severance	The scheme is predicted to result in a slight increase in severance for walkers, cyclists and horse riders (WCH) wishing to access 2 of the 3 community facilities within the study area. A total of 1472 WCHs, of which 814 would be classed as pedestrians, were counted at 31 different locations within the vicinity of the scheme in September 2017 during the summer holidays. Counts were undertaken for a 14-hour period (6am to 8pm) on Saturday 2 September, with an additional survey undertaken at 3 of the sites on Saturday 10 September due to access difficulties for the previous survey. A slight negative impact on severance has been predicted for pedestrians travelling to: 417 Bike Park from Little Witcombe or Brockworth; Ullenwood Bharat Club from Birdlip, Barrow Wake car park, Little Witcombe or Brockworth, Coberley, Cowley and Ullenwood. No severance impacts are predicted for pedestrians travelling to St John Chrysostom Greek Orthodox Church. The scheme is likely to sever WCH routes used to access the 417 Bike Park and Ullenwood Bharat Cricket Club community facilities from the nearby communities outlined above. A slight negative impact is predicted on severance for cyclists and horse-riders wishing to access the community facilities within the study area, with some hindrance to movements likely. The scheme is predicted to result in a slight relief in severance for local communities such as Birdlip, Cowley, Coberley, Little Witcombe and Brockworth in the opening year and 15 years after opening, with traffic rerouted onto the scheme alignment. With consideration of mitigation measures which are likely to be applied, including the development of an WCH strategy; which would ensure that permanent diversions and structures comprising footbridges and underpasses are provided at appropriate locations, potential increases in journey lengths for WCHs and also the positive impacts on some local communities with a relief in severance, a Neutral effect is predicted for the scheme on severance.	Not applicable	Neutral	Not applicable	To be assessed at a later stage
	Option and non-use values	The scheme does not include measures that will substantially change the availability of transport services in the study area.	Not applicable	Neutral	Not applicable	
Public Accounts	Cost to Broad Transport Budget	The scheme will be funded through Central Government Funds	Central Govt funding: £302.7 million	Not applicable	£302.7 million	
	Indirect Tax Revenues	There would be some increase in the tax being paid to the Exchequer	Central Govt funding: Wider Public Finances = -£73.8 million	Not applicable	-£73.8 million	

Appendix H – Abbreviations list

Abbreviation	Definition
AADT	Annual Average Daily Traffic
ALC	Agricultural Land Classification
AMCB	Analysis of Monetised Costs and Benefits
AONB	Area of Outstanding Natural Beauty
AQMA	Air Quality Management Area
ARN	Affected Road Network
AST	Appraisal Summary Table
ATC	Automatic Traffic Count
BCR	Benefit Cost Ratio
BGS	British Geological Survey
BMV	Best and Most Versatile
BPM	Best practicable means
CDM	Construction (Design and Management)
CO2e	Carbon dioxide equivalent
COBALT	Cost and Benefits of Accidents – Light Touch
ComMA	Combined Modelling and Appraisal
COSHH	Control of Substances Hazardous to Health Regulations 2002
CRF	Congestion Reference Flow
CRoW	Countryside and Rights of Way Act 2000
CSR	Client Scheme Requirements
D2AP	Dual 2 Lane All Purpose Carriageway
DBFO	Design, Build, Finance and Operate
DCO	Development Consent Order
DEFRA	Department for Environment Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Road and Bridges
EAST Plus	Early Assessment and Sifting Tool Plus
EC	European Commission
ECP	Emergency Crossing Points
EEC	European Economic Community

Abbreviation	Definition
EIA	Environmental Impact Assessment
EPA	Environment Protection Act
EPR	Environmental Permitting Regulations
EU	European Union
GDD	Groundwater Daughter Directive
GHG	Green House Gases
GI	Ground Investigation
GIS	Geographical Information System
HDV	Heavy duty vehicle
HER	Historic Environment Record
HGV	Heavy goods vehicle
IP	Inter-peak
KPI	Key Performance Indicators
LEP	Local Enterprise Partnership
LGV	Light goods vehicles
LOAEL	Lowest Observed Adverse Effect Level
MAFF	Ministry of Agriculture, Fisheries and Food
MT	Motorised travellers
NERC	Natural Environment and Rural Communities
N/A	Not/Applicable
NIA	Noise Important Areas
NMU	Non-motorised user(s)
NO_2	Nitrogen dioxide
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NPS	National Policy Statement
NPSNN	National Policy Statement for National Networks
NPV	Net Present Value
NSIP	Nationally Significant Infrastructure Project
NTEM	National trip End Model
OD	Operations Directorate
OE	Option Estimate

Abbreviation	Definition
OME	Order of Magnitude Estimates
OP	Off-peak
PCF	Project Control Framework
PIA	Personal Injury Accidents
PINS	Planning Inspectorate
PM10	Particulate Matter
PRoW	Public Rights of Way
PRA	Preferred Route Announcement
QUADRO	Queues and Delays at Roadworks
RBMP	River Basin Management Plan
RoF	Region of Focus
RIP	Road Investment Programme
RIS	Road Investment Strategy
RIU	Regional Intelligence Units
RTF	Road Traffic Forecasts
RTM	Regional Transport Models
S2	Single lane Carriageway
SAC	Special Area of Conservation
SAR	Scheme Assessment Report
SATURN	Simulation and Assignment of Traffic to Urban Road Networks
SDM	Sustainable Decision Model
SNCI	Site of Nature Conservation Importance
SOAEL	Significant Observed Adverse Effect Level
SPZ	Source Protection Zone
SRN	Strategy Road Network
SSD	Stopping Sight Distance
SSSI	Site of Special Scientific Interest
SWRTM	South West Regional Traffic Model
TAG	Transport Analysis Guidance
TAR	Technical Appraisal Report
TUBA	Transport Users Benefit Appraisal software
VOC	Vehicle operating costs

Abbreviation	Definition
VOR	Value of Reliability
VfM	Value for Money
VMS	Variable Message Signs
WCA	Wildlife and Countryside Act
WCH	Walkers, cyclists and horse riders
WebTAG	Transport Analysis Guidance
WFD	Water Framework Directive
WITA	Wider Impact in Transport Appraisal
WRA	Water Resources Act
WS2	Wide single lane carriageway

Appendix I – Glossary

Affected Road Network	The parts of the road network that would be affected by a change in traffic levels as the result of a transport scheme.
Agricultural Land Classification	A system used for the grading of agricultural land in England and Wales. Land is classified into grades, from grade 1 (best quality) to grade 5 (poorest quality. Criteria used for assessment include climate, site conditions, and soil characteristics.
Air Quality Management Area	An area identified where the National Air Quality Objectives are not likely to be achieved. The Local Authority is required to produce a Local Air Quality Action Plan to plan how air quality in the area is to be improved.
Annual Average Daily Traffic	The number of vehicles travelling on a particular stretch of road on an average day.
Appraisal Summary Table	A table that appraises the performance of each option against economic, environmental, social and distributional sub-impacts and is used to directly inform the Value for Money assessment for the Economic Case.
Area of Outstanding Natural Beauty	An area outside a National Park designated for conservation due to its natural beauty.
At-grade	On the same level, for example, an at-grade junction is two or more roads meeting or crossing on the same level.
Benefit (to) Cost Ratio	The ratio of Present Value of Benefits (PVB) to Present Value of Costs (PVC).
Best and Most Versatile	Defined as Grades 1, 2 and 3a of the Agricultural Land Classification as land which is most flexible, productive and efficient in response to inputs and which can best deliver future crops for food and non-food uses such as biomass, fibres and pharmaceuticals.
CDM Regulations 2015	The main set of regulations for managing the health, safety and welfare of construction projects.

Chainage	Used to measure the horizontal distance along an imaginary line made up of straights and curves. For the A417, the chainage used to describe the distance along the proposed road, measured from the scheme extents.
Client Scheme Requirements	The objectives of the A417 Missing Link scheme.
Congestion Reference Flow	The maximum achievable hourly throughput of traffic on a particular stretch of road, expressed in terms of AADT.
Conservation Area	An area of special environmental or historic interest or importance, of which the character or appearance is protected by law against undesirable changes (Section 69 of the Planning (Listed Buildings and Conservation Areas) Act 1990).
Control of Substances Hazardous to Health Regulations 2002	The law that requires employers to control substances that are hazardous to health.
Corridor	Refers to the wider A417 / A419 link between the M4 and M5.
Cotswolds Conservation Board	An independent statutory body that works to conserve and enhance the natural beauty of the Cotswolds AONB.
Countryside and Rights of Way Act 2000	Gives a public right of access to land mapped as 'open country' or registered common land.
Defra	Defra is the Government department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom of Great Britain and Northern Ireland. Defra is a ministerial department, supported by 33 agencies and public bodies.
Department for Transport	Government department responsible for the transport network in England, and for aspects of the transport network in the devolved administrations.
Design Manual for Roads and Bridges	A series of 15 volumes prepared by the Department for Transport and Highways England that provide standards, advice notes and other published documents relating to the design, assessment and operation of trunk roads, including motorways, in the

	United Kingdom. Full listings are available here: http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm.
Distributional Impact Assessment	Describes the assessment of the scheme's (route options) impacts on different social groups across a range of indicators, namely: user benefits, noise, air quality, accidents, security, severance, accessibility and personal affordability.
Do Minimum Scenario	The situation without implementation of the scheme.
Do Something Scenario	The future year situation with implementation of the scheme.
Development Consent Order	The means of applying for consent to undertake a Nationally Significant Infrastructure Project (NSIP). NSIPs include, for example, major energy and transport projects.
Early Assessment and Sifting Tool	Provides a framework for summarising options which is consistent with the "Transport Business Case Five Case Model".
Economic Assessment Report	Summarises the transport modelling process, details the data and justifies the assumptions used in the economic assessment. It combines the monetised costs and benefits for each assessed option in standard economic appraisal tables to produce economic performance indicators.
English Heritage	Charity that cares for the National Heritage Collection of state-owned historic sites and monuments across England, under licence from Historic England.
Environmental Assessment Report	The non-statutory environmental assessment report that forms part of the Project Control Framework's (PCF) Stage 1: Options Identification (Options Phase). The report follows on from, and is underpinned by, the PCF Stage 1: Environmental Scoping Report (ESR).
Environmental Permitting Regulations	These require regulators to control activities which could harm the environment or human health, therefore taking into account potential impacts on conservation sites.
Environmental Protection Act	Defines the improved control of pollution by the regulation of emissions and waste management,

	placing a duty of care on any person or business to safely deal with waste, whether it be production, storage, transport or disposal.
Expressway / Expressway Standard	A road with high quality performance and safety standards, as described in the July 2013 Action for Roads report.
Gloucestershire Local Nature Partnership	A partnership of organisations from public, private and third sector organisations around Gloucestershire which works to recognise the importance of embedding nature's value in local decisions.
Gloucestershire Wildlife Trust	An organisation working to protect habitats and species across Gloucestershire, operating 60 nature reserves in the county.
Grade-separated junction	A junction where intersecting roads are placed at different heights, so that traffic flows do not intersect and interrupt one another.
Groundwater Daughter Directive	A directive that establishes specific measures in order to prevent and control groundwater pollution.
Heavy duty vehicles	Heavy goods vehicles (HGVs) and buses.
Heavy goods vehicle	Any vehicle with a gross combination mass (GCM) of over 3,500 kilograms.
Historic England	Publicly funded body that champions and protects England's historic places. Also known as the Historic Buildings and Monuments Commission for England.
Historic Environment Record	Provides information on the archaeology and historic built environment of a geographic area.
The Infrastructure Planning (Environmental Impact Assessment) Regulations 2009	The regulations governing the process of environmental impact assessment for nationally significant infrastructure projects considered under the Planning Act 2008.
Interim Advice Note	Documents issued by Highways England containing specific guidance relating to works on motorways and trunk roads, subject to any specific implementation instructions.

Landscape Character Assessment	A process whereby the character of a landscape is identified and explained through describing the combination of features that make it distinctive.
Local Enterprise Partnership	A voluntary partnership set up between local authorities and businesses to drive local economic growth and job creation activities. There are 39 LEPs across England.
Lower Super Output Area	A geography for the collection and publication of small area statistics (including Census data). They have an average of roughly 1,500 residents and 650 households.
National Planning Policy Framework	The primary national policy document guiding the designation of local plans and consideration of applications for planning permission by local authorities.
National Policy Statement for National Networks (2015)	Sets out the national roads policy framework, as presented to Parliament in December 2014.
National Trip End Model	Forecasts the growth in trip origin-destinations up to 2051 for use in transport modelling.
National Trust	Charity that cares for historic houses, gardens, ancient monuments, countryside and other sites across England, Wales and Northern Ireland, including the Crickley Hill Country Park.
Nationally Significant Infrastructure Project	A project which requires development consent to be granted by the relevant Secretary of State, as defined by the Planning Act 2008.
Natural England	An executive non-departmental public body responsible for the natural environment.
Net Present Value	A measure of profitability calculated by subtracting the present value of cash outflows (costs) from the present value of cash inflows.
Noise Important Area	Areas where the 1% of the population that are affected by the highest noise levels from major roads are located according to the results of Defra's strategic noise maps.
Non-Motorised User	Cyclists, pedestrians (including wheelchair users), and equestrians using the public highway.

Personal Injury Accident	An accident that involves personal injury occurring on the public highway (including footways) in which at least one road vehicle or a vehicle in collision with a pedestrian in involved and which becomes known to the police within 30 days of its occurrence.
Planning Inspectorate	The body responsible for planning appeals, national infrastructure planning applications, examinations of local plans and other planning-related and specialist casework in England and Wales.
Planning Practice Guidance	A suite of documents setting out how specific matters should be considered and assessed in the planning process.
Project Control Framework	A joint Department for Transport and Highways England approach to managing major projects. The Framework comprises a standard project lifecycle; standard project deliverables; project control processes and governance arrangements.
Public Consultation Report	A report summarising the results of the non-statutory consultation and the responses received.
Public right of way	A way over which the public have a right to pass and repass. The route option may be used on foot, on (or leading) a horse, on a pedal cycle or with a motor vehicle, depending on its status. Although the land may be owned by a private individual, the public may still gain access across that land along a specific route option. Public Rights of Way are all highways in law.
Relaxations and Departures from Standards	Relaxations are written into design standards to introduce limited flexibility in certain circumstances allowing designers to design to less stringent requirements than those specified in a standard. These need to be agreed with but not approved by the Project Sponsor. A departure from standard is any other variation or waiving from a requirement contained within the design standards and requires formal approval from the Project Sponsor.
River Basin Management Plan	River basin management plans (RBMPs) set out how organisations, stakeholders and communities will work together to improve the water environment. The Water Environment has been divided nationally into River Basin Districts (RDBs). There are 11 river basin

	districts in England and Wales. The Environment Agency manage the seven RBDs in England.
Road Traffic Forecast 2018	A series of traffic forecasts issued by the Department for Transport using the National Transport Model to generate measures of traffic demand, congestion and emissions in England up to 2050.
Road Investment Strategy	The long-term strategy to improve England's motorways and major A roads. The first RIS (known as RIS1) was published in 2014 and covers the period 2015-2020. A second RIS (RIS2) was published in 2015, and covers the post-2020 period.
Scheduled Monument	A 'nationally important' archaeological site or historic building, given protection against unauthorised change and included in the Schedule of Monuments kept by the Secretary of State for Culture, Media and Sport. The protection given to Scheduled Monuments is given under the Ancient Monuments and Archaeological Areas Act 1979.
The scheme	The A417 Missing Link scheme (where not implicit).
Site of Special Scientific Interest	A conservation designation denoting to a protected area in the United Kingdom. The sites are protected by law to conserve their wildlife or geology.
Source Protection Zone	Areas of land around over 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. The zones show the risk of contamination from any activities that might cause pollution in the area. The closer the activity, the greater the risk. There are three main zones (inner, outer and total catchment) and a fourth zone of special interest, which is occasionally applied to a groundwater source. The zones are used in conjunction with the Groundwater Protection Policy to set up pollution prevention measures in areas which are at a higher risk, and to monitor the activities of potential polluters nearby.
South West Regional Transport Model	A Highways England regional transport model of the South West of England, currently under development. The model simulates traffic movements within the strategic road network of the South West.

Special Area of Conservation	A site designated under the Habitats Directive. These sites, together with Special Protection Areas (or SPAs), are called Natura sites and they are internationally important for threatened habitats and species.
Special Protection Area	Areas of strictly protected sites classified in accordance with Article 4 of the EC Birds Directive (2009/147/EC) on the conservation of wild birds. They are classified for rare and vulnerable birds (as listed on Annex I of the Directive), and for regularly occurring migratory species.
Stopping Sight Distance	The worst case distance at which the average driver needs to have visibility of an object in the road in order to stop in time to prevent a collision.
Strategic Road Network	The network of approximately 4,300 miles (6920 km) of motorways and major 'trunk' A roads across England, managed by Highways England.
Trafficmaster	A system for the presentation of data collected from the Global Positioning Systems of from vehicles to plot the time spent to traverse sections of the road network at different times.
Transport User Benefit Appraisal	A computer programme developed by DfT and widely used to undertake economic appraisal for multi modal transport studies, in line with TAG guidance.
Ultra low emission vehicles	Ultra low emission vehicles are those with emissions of CO2 below 75 g/km, or fully electrically powered.
Variable Message Signing	An electronic traffic sign used to give drivers information about events on the road network, such as upcoming congestion, accidents, roadworks, etc.
Water Framework Directive	An EU directive which aims to achieve good status of all water bodies (surface water, groundwater and the sites that depend on them, estuaries and near-shore coastal waters) and prevent any deterioration. It has introduced a comprehensive river basin management planning system to protect and improve the ecological quality of the water environment. It is underpinned by the use of environmental standards.

WebTAG Transport Appraisal Process	The Department for Transport's transport appraisal guide and toolkit consisting of software tools and guidance on transport modelling and appraisal methods that are applicable for highways and public transport interventions. The appraisal of transport interventions is a three step process including Option Development, Further Appraisal and Implementation, Monitoring and Evaluation.
Wider Impacts Framework	A framework to capture wider impacts (WIs), positive and negative, that include productivity and welfare changes associated with the impact of transport on agglomeration and labour supply.

If you need help accessing this or any other Highways England information, please call **0300 123 5000** and we will help you.