

A417

Missing Link

Technical Appraisal Report
February 2018

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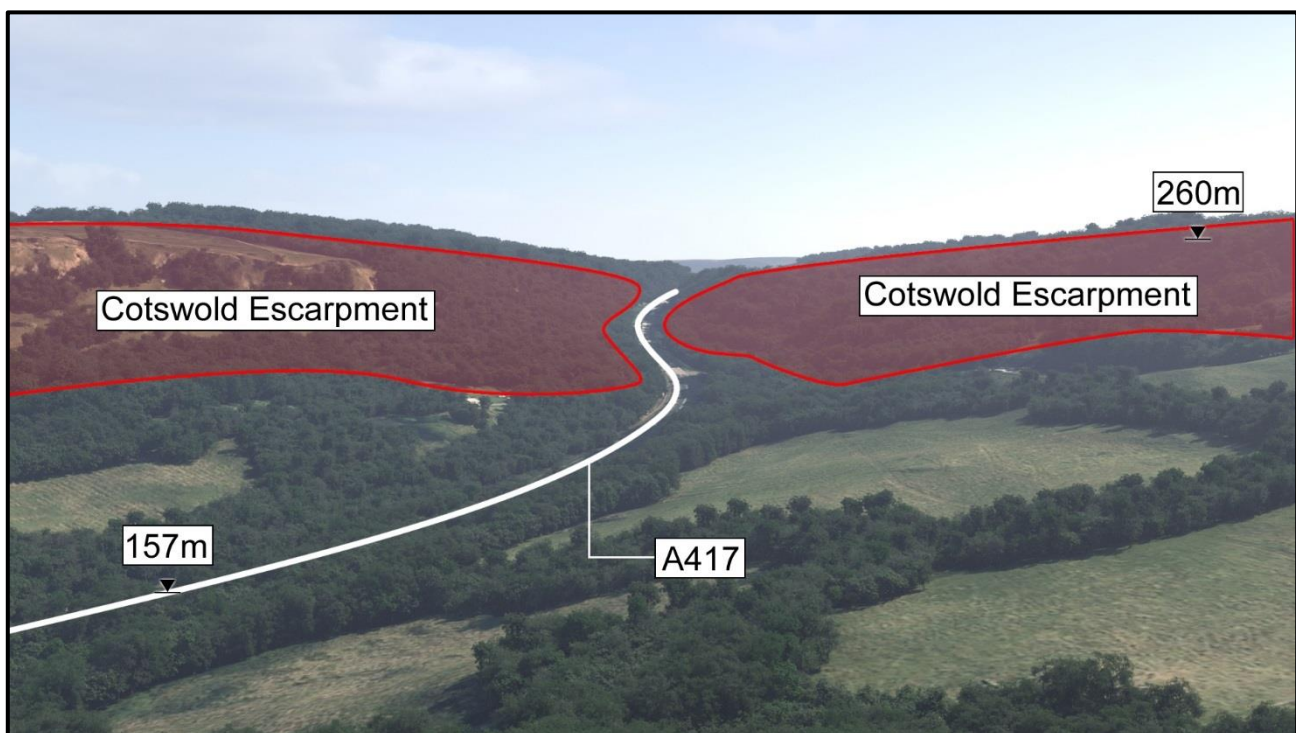
Executive summary

Purpose of this report

This Technical Appraisal Report (TAR), produced as part of the project control framework (PCF) Stage 1 (Options Identification), reports on 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.

The TAR reports on the landscape led solutions for this route across the sensitive Cotswold escarpment (Figure 0.1), detailing their identification, sifting and appraisal to determine which should be taken to public consultation.

Figure 0.1: Visualisation of the Cotswolds escarpment with the existing road



Source: Mott MacDonald Sweco Joint Venture

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 over 90% of the length of the A417 / A419 - M4 / M5 link. This section near Birdlip in Gloucestershire was not improved as part of the scheme. 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 to be taken to 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 Roads Programme. It was classified as being within the ‘longer than 10 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 5 year £15.2 billion investment programme (2015-2020) 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 key challenges and opportunities that the A417 Missing Link scheme will address are:

- **Landscape** – a new route has the opportunity to be a landscape-led scheme. It can be designed to fit the nationally important Cotswolds landscape, whilst successfully meeting the challenge of being a viable route descending the Cotswold escarpment.
- **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.
- **Traffic** - the A417 / A419 is an important route on the strategic road network connecting the M5 near Gloucester to the M4 near Swindon. This section of the A417 is the only single-carriageway section of an otherwise high quality dual-carriageway route. Traffic along the A417 Missing Link often suffers congestion and long delays, causing poor journey times and reliability compared to the rest of the A417 / A419.
- **Safety** - the A417 Missing Link experiences more accidents per kilometre than the A417 / A419 route as a whole.
- **Local and regional economy** – enhancing the route is expected to deliver local and regional economic benefits and provide new opportunities for growth.

Objectives for the A417 Missing Link

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

Table 0.1: Scheme objectives for the A417 Missing Link

A417 scheme objectives			
<p>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.</p>	<p>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.</p>	<p>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.</p>	<p>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.</p>

Option identification and sifting

A 4 step process (Table 0.2) was followed to identify options for a solution to the A417 Missing Link, and then reduce those options down to a number of routes to be fully assessed and to inform the choice of routes to be taken forwards for public consultation.

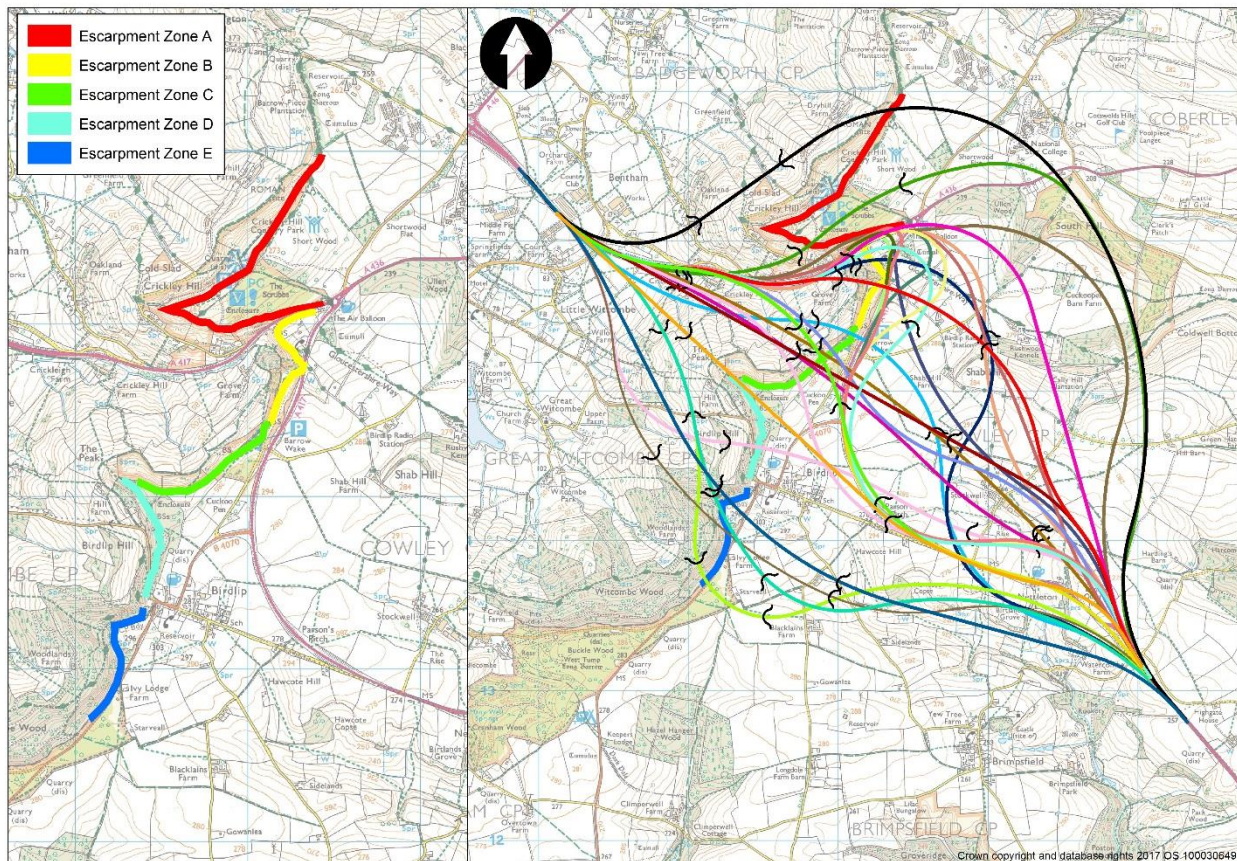
Table 0.2: Sifting methodology

Sifting steps	Assessment Work
Step 1	Identification, development and categorisation of options
Step 2	Engineering assessment of options
Step 3	Assessment of remaining routes using Early Assessment and Sifting Tool (EAST) Plus methodology
Step 4	Assessment of highest scoring routes on value for money and affordability

Step 1 - Initial option identification

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 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 0.2 below.

Figure 0.2: Initial 30 options



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The initial 30 options were categorised into 5 escarpment corridors, A, B, C, D and E, based on where the surface or tunnel options run across and down the escarpment.

Step 2 - Engineering assessment

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.

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

Step 3 - Early Assessment and Sifting Tool Plus

The 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.

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 3 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 5 options taken for full assessment at this step were options 3, 21, 24, 29 and 30.

Step 4 - Value for money and affordability assessment

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.

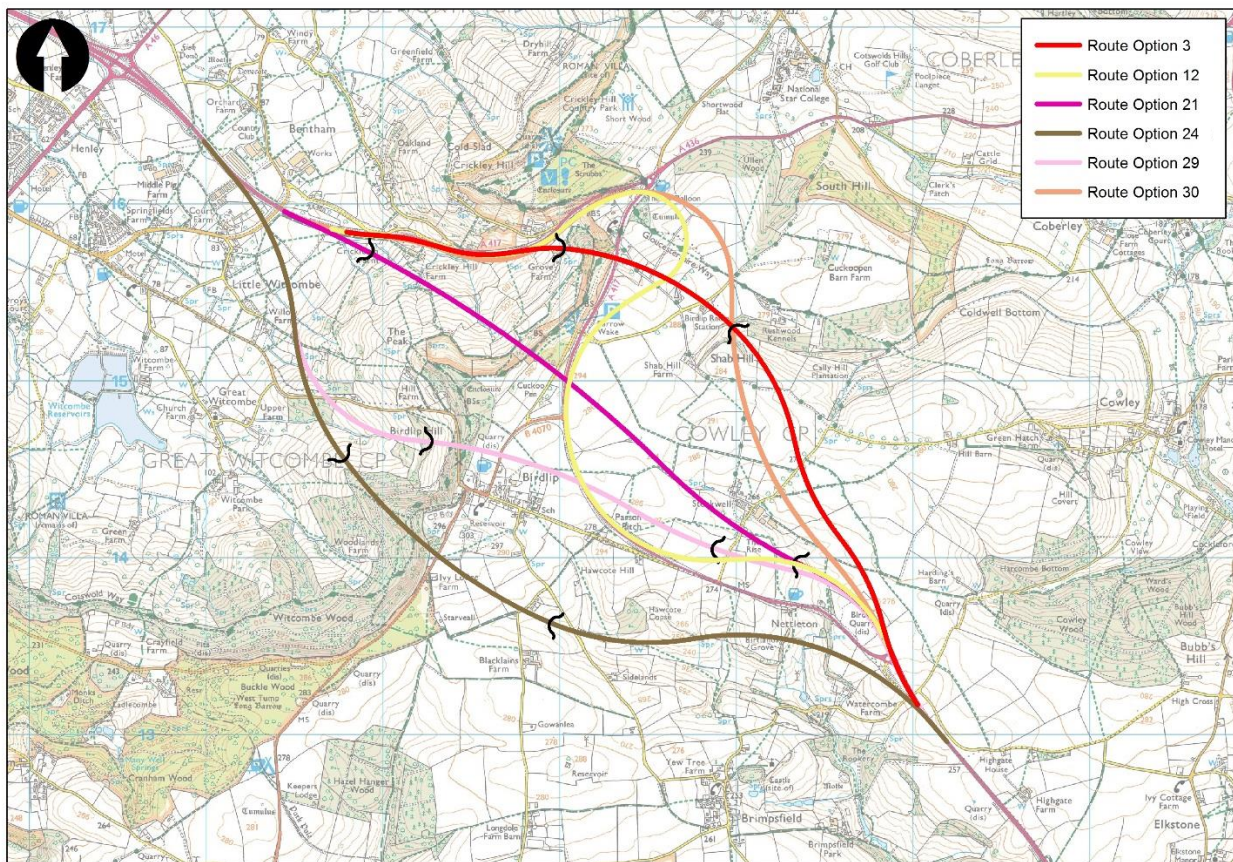
To ensure that a second affordable route was progressed from Stage 1, the next best performing surface route from the first 3 steps of the sifting was taken forward for full assessment and appraisal. This route was Option 12, a route from historic studies which was formerly known as the Modified Brown Route.

As a result of the 4 sifting steps, 6 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.

Full assessment and appraisal

The 6 options taken forward for full assessment and appraisal are shown below.

Figure 0.3: 6 options taken forward for full assessment and appraisal



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Option estimates

Commercial estimates were prepared following development of the options. These order of magnitude estimates are given in Table 0.3 below.

Table 0.3: 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

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.

The traffic model's forecast is that all options will 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 6 options, though still shows a significant reduction in journey times compared to the existing route.

Economic analysis

The economic appraisal of each option has 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 0.4 below.

Table 0.4: Adjusted BCRs for the 6 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

The tunnel options (Options 3, 21, 24 and 29) all have high benefit values, but their high costs cause them to have poor BCRs. Options 12 and 30, the surface routes, have lower benefits but their significantly lower costs give them higher BCRs compared to the more costly tunnel options. Option 30 is the only route to offer positive value for money (greater than 1), meaning the returns are estimated to be greater than the cost.

Safety assessment

A road safety assessment of the 6 routes has been completed based on the engineering development of the routes at this early stage. All 6 options give rise to safety considerations which will need to be addressed as part of the further development of the project. Option 12 presents the biggest challenges in overcoming elements of the

proposed alignment which are below current standards, gradients which are above the desirable maximum and horizontal curves up to 4 steps below the desirable minimum. All the proposed options would be expected to improve road safety, reducing the number of people killed or seriously injured on the route.

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 6 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.

Environmental assessment

The potential environmental impacts of the 6 options have been appraised in accordance with WebTAG guidance to a scoping level, and to a simple level appropriate to the stage. Consultation has taken place with statutory environmental bodies throughout the stage.

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

Across the areas assessed, Option 21 generally outperforms the other options due to the length of the route within a tunnel, and the route avoiding sensitive areas. All options have net benefits in noise reduction compared to the existing route, however in all other areas the options provide disbenefits.

Further work is planned to refine the environmental assessment, to further identify and refine mitigation measures required to ensure the offsetting of impacts and to explore the considerable opportunities for enhancement measures along the scheme corridor and within the wider landscape. 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.

Of the tunnelled solutions, Options, 24 and 29 perform less well across all measures than Options 3 and 21. Between the 2 surface options, there is little difference in the appraisal results. Option 12 outperforms Option 30 in noise reduction but Option 30 has lower air quality disbenefits.

Social assessment

Social impacts of the 6 options have been appraised in accordance with WebTAG guidance. Social assessment and appraisal addresses the impacts of the scheme on commuters and the public, through journey time and reliability, physical activity, accidents and accessibility among other areas.

The routes largely perform at a similar level within the social appraisal area. The key differentiator between the routes in this area is the reduced journey time for commuters. Relative to the current route, the 6 options deliver significant benefits in terms of net

present value. The tunnel options deliver greater benefits than the surface routes, and between the surface routes option 30 delivers significantly greater benefits than Option 12.

Additional environmental assessment

To supplement the appraisal of potential environmental and social impacts of the routes in accordance with the Web TAG guidance, several additional studies have been 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.

The Sustainable Decision Model (SDM) is a tool that provides a qualitative assessment of sustainability performance. The results of the model in Stage 1 showed Option 21 had the highest sustainability performance, with all tunnel options outperforming the surface options. Between the 2 surface options, Option 12 has the lowest performance.

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 AONB.

A landscape monetisation assessment was prepared, alongside the qualitative WebTAG appraisal. This assessment places a value on the landscape types within the scheme extents and quantifies 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.

Following consultations with stakeholders such as the Cotswolds Conservation Board, a landscape study has been undertaken for the scheme to appraise the options for the A417 Missing Link. The overarching purpose of the study is 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 has been to focus on the identification of how well different highway alignment options might generate opportunities for broader scale as well as localised landscape enhancements.

Appraisal summary

Appraisal Summary Tables (ASTs) were produced for each of the 6 options to collate all of the assessments against the criteria of Economy, Environmental, Social and Public Accounts.

Comparison between the appraisal summary tables for each option show that the tunnel options, Options 3, 21, 24 and 29 outperform the surface options in most of the economy, environmental and social measures.

This is balanced against an estimated cost which is substantially higher than either surface route, which takes the tunnel routes above the upper limit of the cost range (£500 million). All tunnel options are also forecast to offer 'poor' value for money. Of the surface routes, Option 12 is also forecast to offer 'poor' value and Option 30 is forecast to offer 'low' value for money.

Programme

At this stage, all options would require design development and further constructability input that may have an impact on the current programme. The start of construction is currently scheduled for mid-2021.

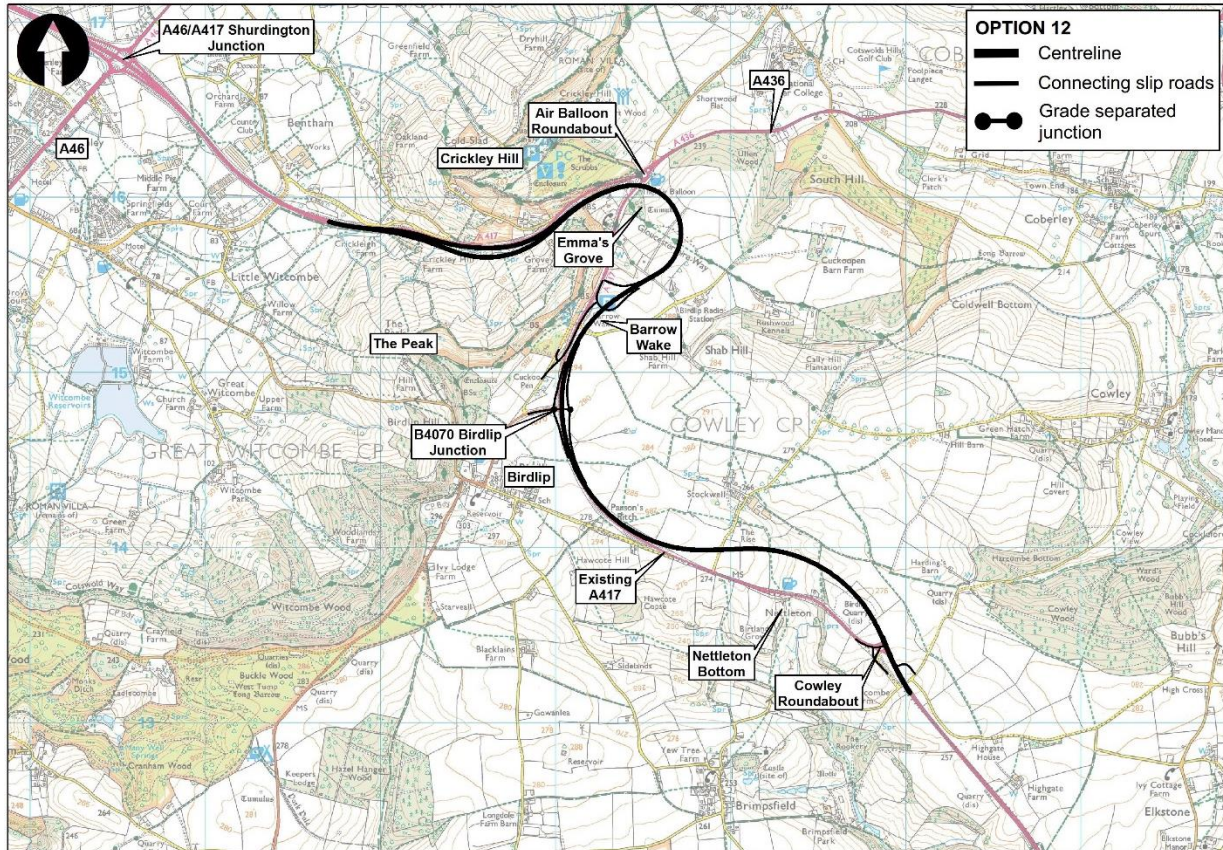
Conclusions

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 cannot be recommended for further development.

The 2 surface routes, Option 12 and Option 30 are 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 0.4 and Figure 0.5, 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.

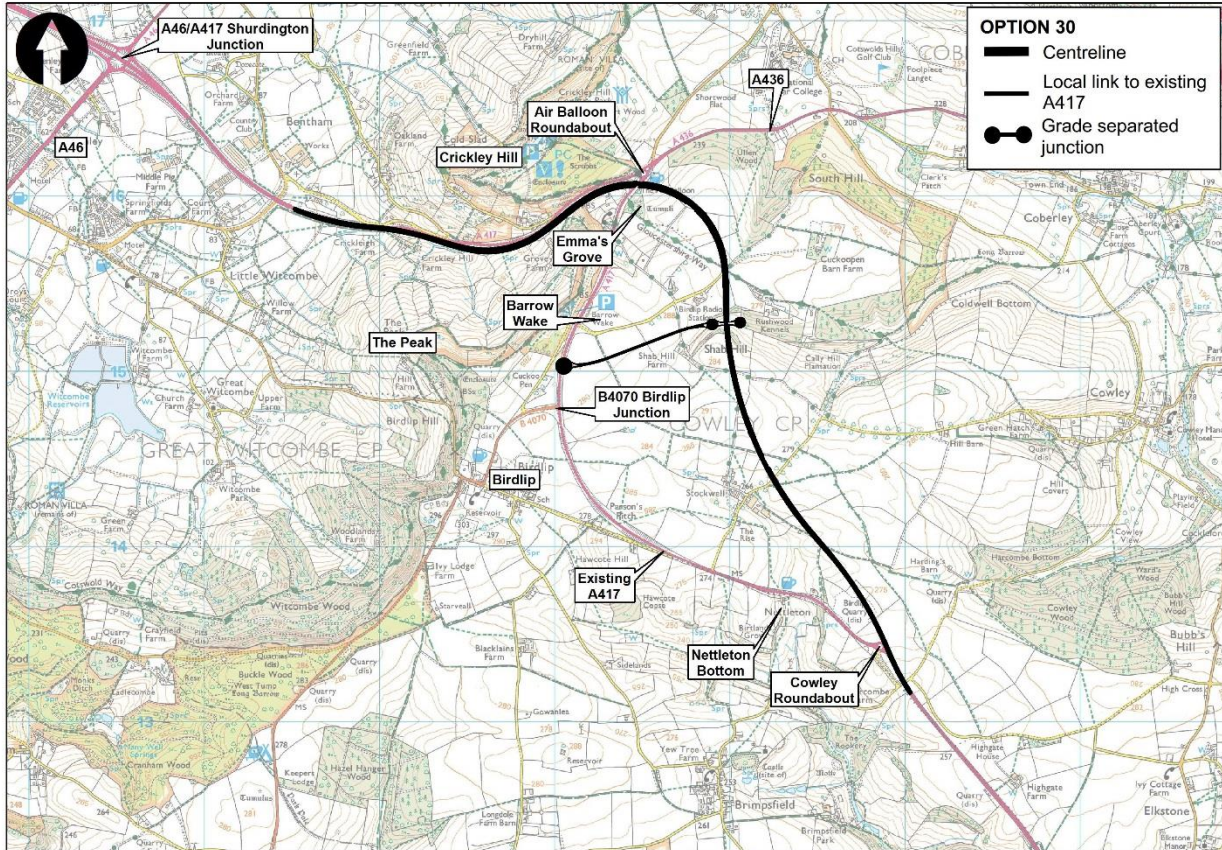
Figure 0.4: Option 12



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- 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 0.5: Option 30



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Between the 2 surface routes, Highways England's preference would be Option 30 because on balance it would:

- have a lower impact on air quality
- be a higher quality road, and be safer for road users
- provide shorter journeys
- deliver greater benefits and the best overall value for money

1. Introduction

1.1 Purpose of this report

- 1.1.1 This Technical Appraisal Report (TAR), produced as part of the project control framework (PCF) Stage 1 (Options Identification), reports on 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.
- 1.1.2 The TAR reports on the landscape led solutions for this route across the sensitive Cotswold escarpment, detailing their identification, sifting and appraisal to determine which should be taken to public consultation

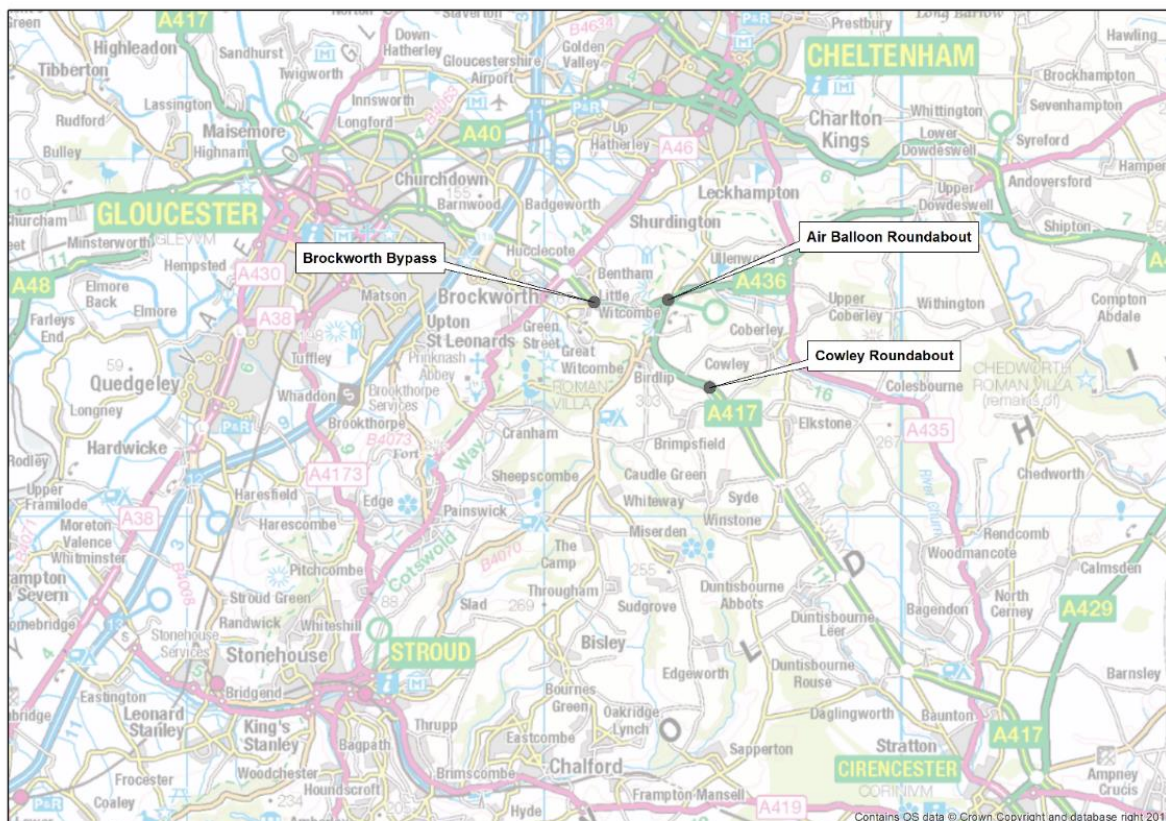
1.2 Scheme context

- 1.2.1 In 2014, the Department for Transport (DfT) announced its 5-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 between the Brockworth bypass and Cowley roundabout 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.
- 1.2.2 Together, the A417 and A419 make up 1 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), 2 of the region's top growth areas, help south-west businesses 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.
- 1.2.3 Most of the route is dual-carriageway, but there is 1 section that is not. Known as the Missing Link, this stretch of around 3 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. Delays of 20 minutes or more are not unusual, and nor is the sight of queuing traffic or the sound and smell of idling engines. This results in some motorists diverting onto local roads to avoid tailbacks, causing difficulties for neighbouring communities. Poor forward looking visibility and challenging gradients also mean that a disproportionately high number of accidents are seen along this stretch of road.
- 1.2.4 Upgrading this section of A417 to dual-carriageway, in a way that is sensitive to the surrounding Cotswold AONB, will help unlock Gloucestershire's potential for

growth, support regional plans for more homes and jobs and improve life in local communities.

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

Figure 1.1: A417 Missing Link scheme location plan



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

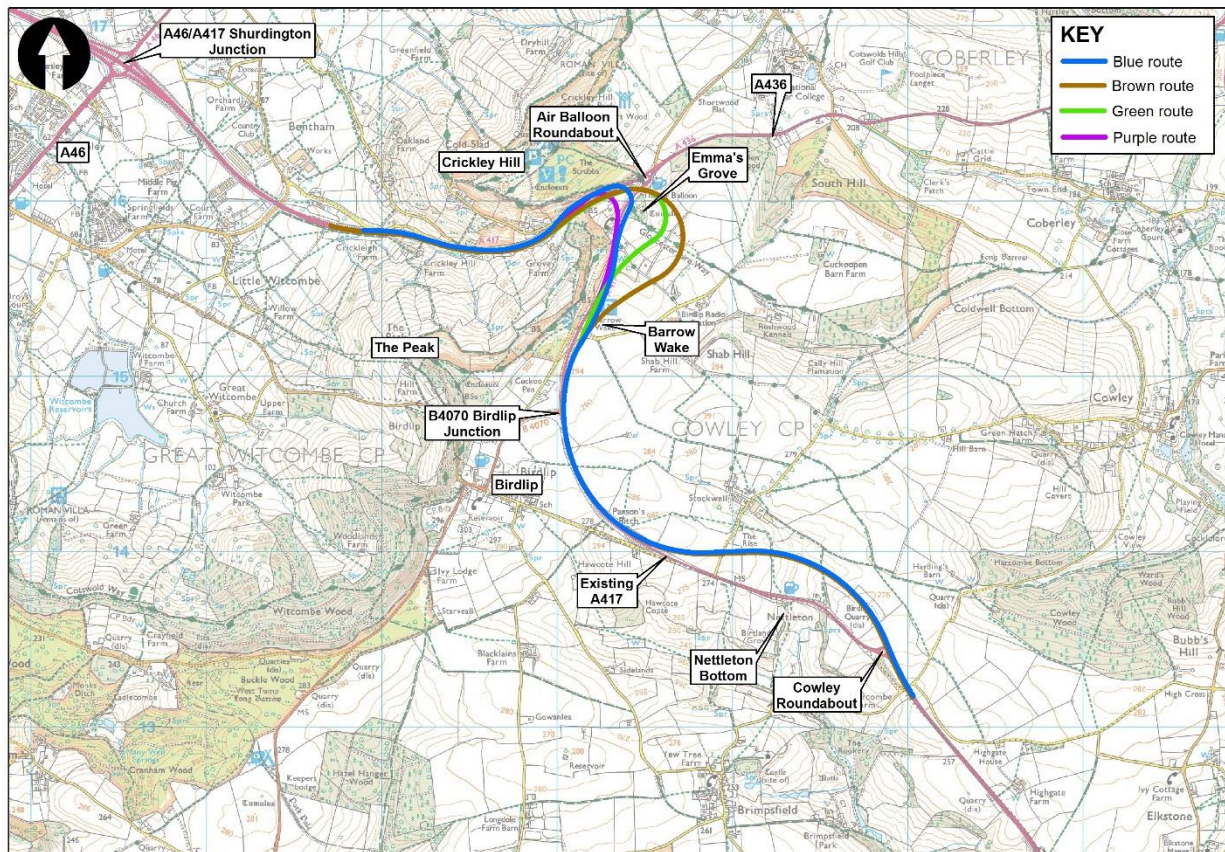
1.3 History of the scheme

- 1.3.1 The A417 Missing Link scheme has been under consideration for more than 20 years. By 1998, dual-carriageway improvements were completed over 90% of the length of the A417 / A419 link. This single-carriageway section near Birdlip in Gloucester was not improved as part of the scheme. However, it is maintained by the Design, Build, Finance and Operate (DBFO) Company and has subsequently been referred to as the A417 Missing Link.
- 1.3.2 In 2001, the Highways Agency appointed consultants to undertake a study to identify the environmental constraints within a study area centred on the existing route, 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 at this stage due to an estimated cost of £1billion and a holding objection in respect of ground water

contamination from the Environment Agency (refer to section 11.9 for details of the potential environmental impacts that caused this objection).

- 1.3.3 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 3 groups of schemes; off-line, tunnel and on-line. From this point, 4 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

- 1.3.4 In October 2003 the Highways Agency held a site meeting with the Countryside Agency, including their AONB officer, (Cotswold Conservation Board was not established until 2004) to consider the impact of the Blue, Purple, Green and Brown options on the area around the Air Balloon roundabout. Of particular concern was the impact of the Green option on Emma's Grove, (Scheduled Ancient Monument) and the minor valley around Four Winds at Shab Hill. The Brown option would minimise the impact on Emma's Grove and allow the Gloucester bound slip roads to be moved away from both the Cotswold escarpment and Barrow Wake Site of Specific Scientific Interest (SSSI), thereby reducing the impact at this most sensitive location. Though it was furthest off-line, the Brown Route was concluded to be the preferred route in environmental terms.

- 1.3.5 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
- 1.3.6 The resulting route became known as the Modified Brown Route.
- 1.3.7 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.
- 1.3.8 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 Modified Brown Route. 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.
- 1.3.9 During 2005 Badgeworth and Cowley parishes sought urgent action due to concerns over safety and severance caused by the existing road. Public consultation was planned for March 2006.
- 1.3.10 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.
- 1.3.11 The Stage 2 Scheme Assessment Report (SAR) was prepared and issued in March 2006 and concluded the Modified Brown Route should be taken forward.
- 1.3.12 This scheme was prepared for public consultation in 2006, promoting the Modified Brown Route. However, the consultation did not take place as the scheme was not included in the Roads Programme. It was within the 'longer than 10 years' plan and therefore consultation and further development was not progressed.
- 1.3.13 The Highways Agency began work on a lower cost scheme review which concluded in 2008 that there were no lower cost solutions which would be capable of providing long-term safety and congestion benefits along the A417 between Cowley and Brockworth. The work confirmed the A417 Modified Brown Route as the only viable solution.
- 1.3.14 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 may be appropriate on lengths of 2+1 lane layout and around Air Balloon roundabout where the capacity of lane 2 might be increased.

1.3.15 Further measures were established that focussed on enhancements to the Air Balloon roundabout:

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

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

1.3.17 In 2014 the Highways Agency conducted a further study of the potential for low cost (less than £50m) improvement options to solve the congestion that exists on the A417 Missing Link, focussing particularly on the Air Balloon roundabout. This study identified 2 options for grade-separation of the Air Balloon junction. Neither of these options were taken forward due to concerns over buildability.

1.3.18 In September 2015, Mott MacDonald Sweco Joint Venture (with sub-consultant WSP | Parsons Brinckerhoff) completed the Project Control Framework (PCF) Stage 0 submission in respect of the A417 Missing Link scheme. In September 2016 Highway England appointed the Mott MacDonald Sweco Joint Venture to progress the PCF Stage 1, Options Identification.

2. Planning brief

2.1 Client scheme requirements

2.1.1 A set of Client Scheme Requirements (CSRs) have been developed by Highways England which are aligned with the objectives and vision of RIS1. The CSRs set requirements and objectives for the scheme as below.

CSR objectives

2.1.2 The specific CSR objectives are to:

- Improve the operation and efficiency of the existing transport networks
- Support economic growth
- Improve connectivity and community cohesion
- 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

2.1.3 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

2.1.4 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 5 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.

2.1.5 The Highways England Licence document sets out key requirements which 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.

Other requirements

2.1.6 Consultation and collaboration with Statutory Environmental Bodies (SEBs) will be required, to confirm that all environmental constraints and possible mitigation measures are appropriately considered.

2.1.7 The scheme development will need to take account of the various legal constraints and mitigation developed to avoid / reduce the impacts of the scheme. Consultation and collaboration will be undertaken with the SEBs and local authorities to confirm that the constraints are appropriately considered and where possible mitigated.

2.1.8 There are a number of small local road accesses and direct property accesses onto the existing A417, which require consideration in order to address community severance and improve accessibility for non-motorised users.

Constraints

- 2.1.9 There are a large number of sensitive environmental locations in the vicinity of the scheme, such as special areas of conservation (SACs), sites of special scientific interest (SSSIs), ancient woodlands and scheduled monuments, in addition to the Cotswolds AONB which the A417 Missing Link passes directly through. The existing junction arrangement and the resulting congestion also cause poor air quality, and an air quality management area (AQMA) having been designated within the study area. Further information on environmental constraints is provided in Section 3.14.

2.2 Key stakeholder objectives

- 2.2.1 The Cotswolds 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.
- 2.2.2 The integrated project team have worked closely with key stakeholders represented on the scheme steering group including Gloucestershire County Council (GCC), Cotswolds Conservation Board (CCB), National Trust, Gloucestershire Local Nature Partnership (GLNP), Gloucestershire Wildlife Trust (GWT) and G-First LEP to develop a scheme specific vision statement, 4 scheme specific objectives and a number of sub-objectives.
- 2.2.3 The scheme specific vision statement, 4 scheme specific objectives and associated sub objectives are identified in Table 2.1 including how they cascade down from the Client Scheme Requirements.

Table 2.1: 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 & protect the quality of the surrounding environment while conforming to the principles of sustainable transport
Scheme vision					
<p><i>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.</i></p>					
Scheme design principles					
<p>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.</p> <p>Any scheme should bring about substantial benefits for the Cotswolds landscape and environment as well as people's enjoyment of the area.</p> <p>Any scheme must have substantially more benefits than negative impacts for the Cotswolds AONB.</p>					
A417 scheme objectives					
<p>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.</p>		<p>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.</p>		<p>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.</p>	<p>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.</p>
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. Existing conditions

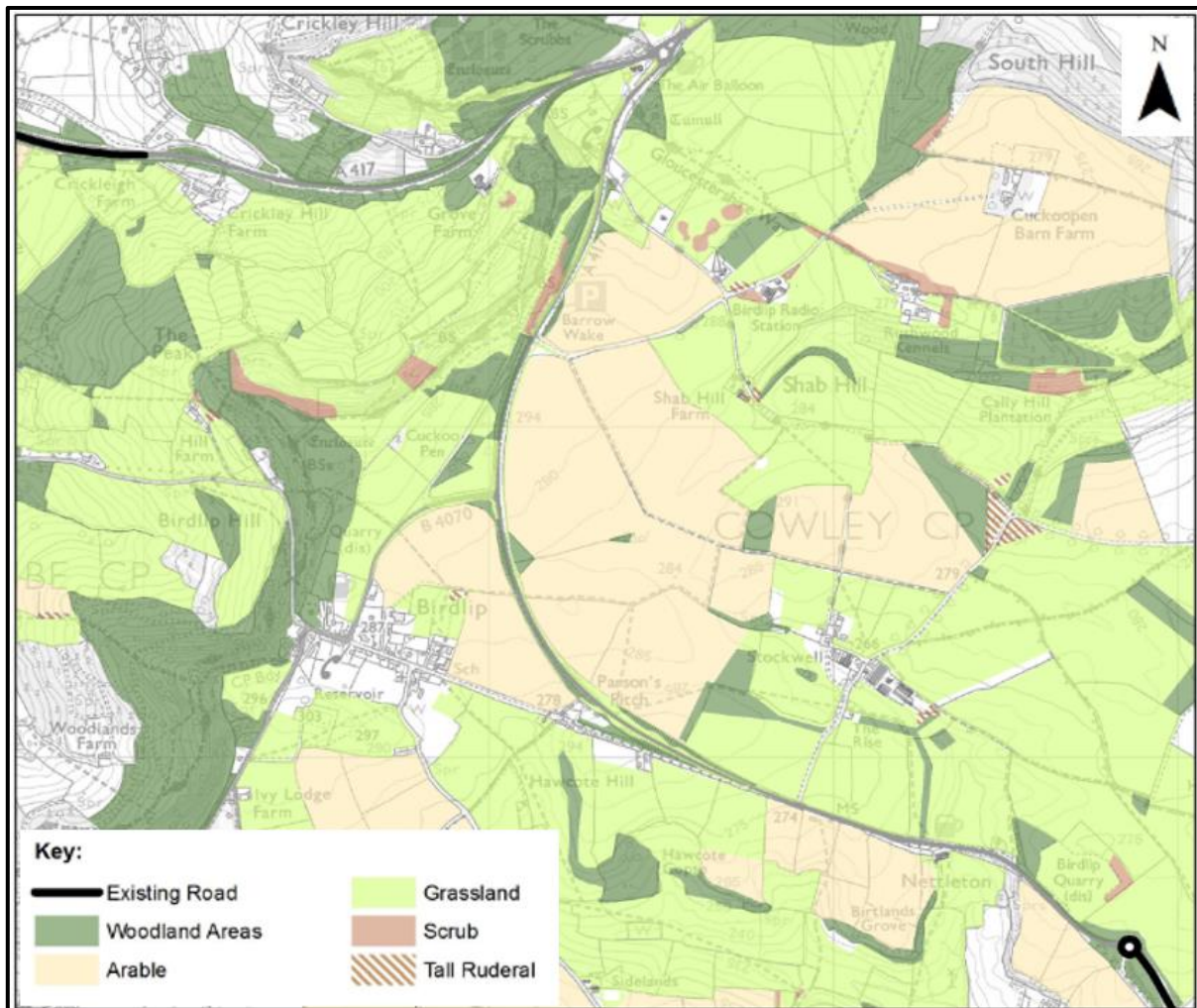
3.1 General

3.1.1 This chapter describes existing conditions and potential development along the current route of the A417 between Cowley roundabout and the Brockworth bypass, as well as within the wider A417 Missing Link study area. All references in this chapter to options relate to the proposed options described in Chapter 7 of this report.

3.2 Description of the locality

3.2.1 The surrounding area of the existing A417 route contains a mix of agricultural land, woodland and common land. The nearest village is Birdlip and is situated approximately midway between Cowley roundabout to the east and Brockworth bypass to the west. Spotted adjacently either side of the existing A417 over its route are farms, private properties, private enterprises and Crickley Hill Country Park which is situated immediately west of the Air Balloon roundabout. The habitat areas showing the character of the locality are shown below on Figure 3.1

Figure 3.1: Habitat areas



Source: Mott MacDonald Sweco Joint Venture – Crown Copyright 2016 100030649

3.3 Existing highway network

Highway network congestion and gradients

- 3.3.1 The A419 / A417 route between junction 15 of the M4 and junction 11a of the M5 is part of the Strategic Road Network.
- 3.3.2 The 5.5km A417 Missing Link between Cowley roundabout and Brockworth bypass is the only remaining single-carriageway section on the 52km length of the A417 / A419 between the M4 and M5.
- 3.3.3 There is a major at-grade junction with the A436 at the Air Balloon roundabout which, along with other junctions and private means of access along the route which are not to the current standards, constrain traffic flow. As a result, this section of trunk road suffers from severe congestion with queues regularly occurring at peak periods.
- 3.3.4 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 (average 7.5% for 1.7km), 7% on Birdlip Hill and up to 10% at Nettleton Bottom. Birdlip Hill forms the steep downhill approach to the A417 / A436 Air Balloon roundabout, which further compounds congestion and queuing.
- 3.3.5 The existing highway alignment, junctions and accesses coupled with the increasing congestion has led to a poor safety record with accident clusters at Nettleton Bottom, Birdlip junction, Air Balloon roundabout and Crickley Hill.
- 3.3.6 As a consequence of the high traffic flows and steep gradients even minor incidents cause considerable disruption and delay. HGV's regularly breakdown on the steep hill and despite the 2 lanes these problems occur at higher frequency than incidents on near flat roads.
- 3.3.7 Recovery of broken down vehicles or accidents is also complicated. The police regularly close the road, at least in one direction for incidents, leading to substantial queues and other problems on the local road network such as rat-running.
- 3.3.8 It also has been indicated by the local residents that the problem is far more concerning than that indicated by police incident records as most of the incidents are not attended by Police.

A417 Road type and speed limit

- 3.3.9 The existing A417 varies in lane provision and speed limit between the extents of the route proposals:
- Both the start and end points of all proposals are on Dual 2 Lane Carriageway (D2AP) sections of the existing road, with 70mph speed limits.

- At the foot of Crickley Hill the dual-carriageway changes to a Wide Single-Carriageway Climbing Lane (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.

3.3.10 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%

A436 and B4070 road types and speed limits.

3.3.11 The A436 is a S2 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.

3.3.12 The B4070 is a S2 road with a speed limit of 60mph and is the approach road to the A417 from Birdlip.

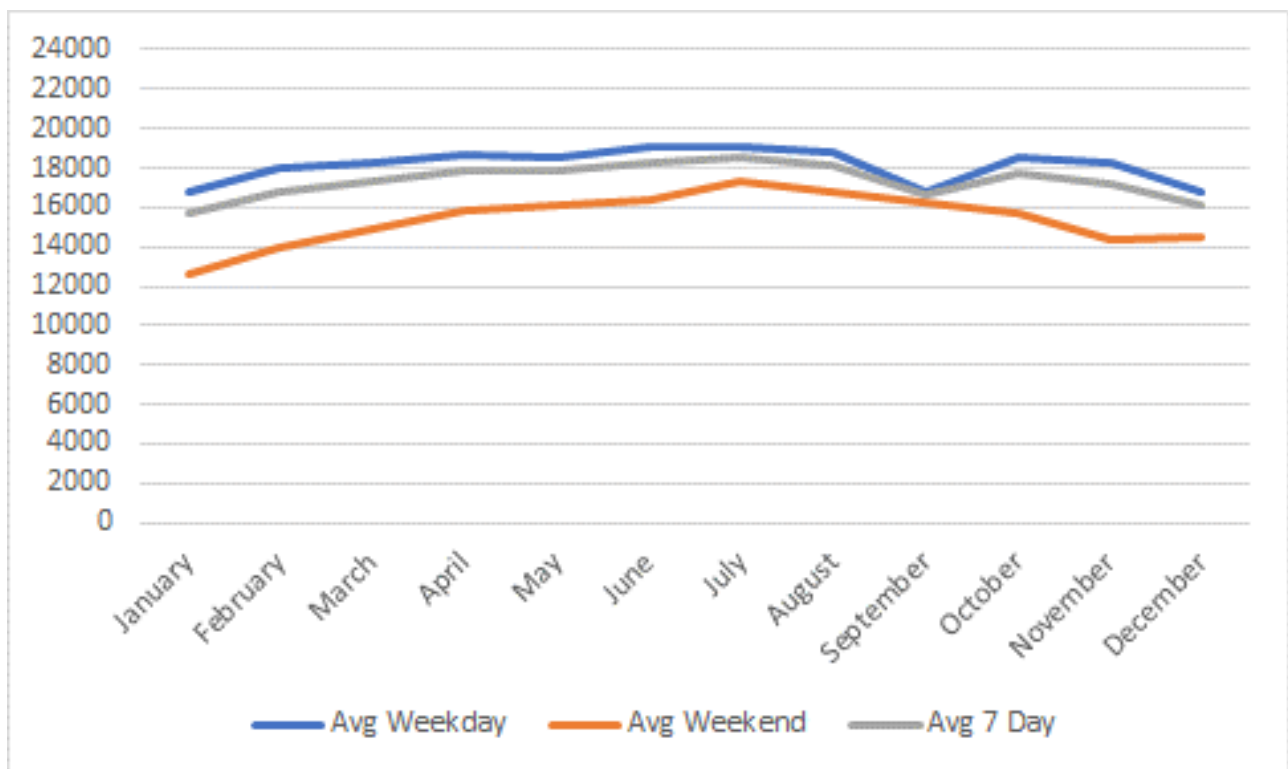
3.4 Traffic

3.4.1 The A417 in this area suffers from high levels of congestion and poor journey time reliability. Performance is hindered by the capacity limitations on the single-carriageway section, with limited forward visibility, steep gradients and 2 at-grade roundabouts restricting traffic flow between Brockworth bypass and Cowley roundabout.

3.4.2 The Air Balloon roundabout is a key junction and a main cause of congestion in the area. The morning peak is characterised by slow moving and queuing traffic on all approaches. The A417 from the south is particularly congested, with capacity on this approach restricted by its single lane approach and, despite widening to around 8.0m on entry to the roundabout, traffic turning left onto the A417 towards the M5 must do so from a single lane only. Northbound traffic on this approach in the morning peak is typically slow moving from as far south as Cowley roundabout, the location at which the A417 becomes single-carriageway and where northbound traffic merges into a single lane. 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.

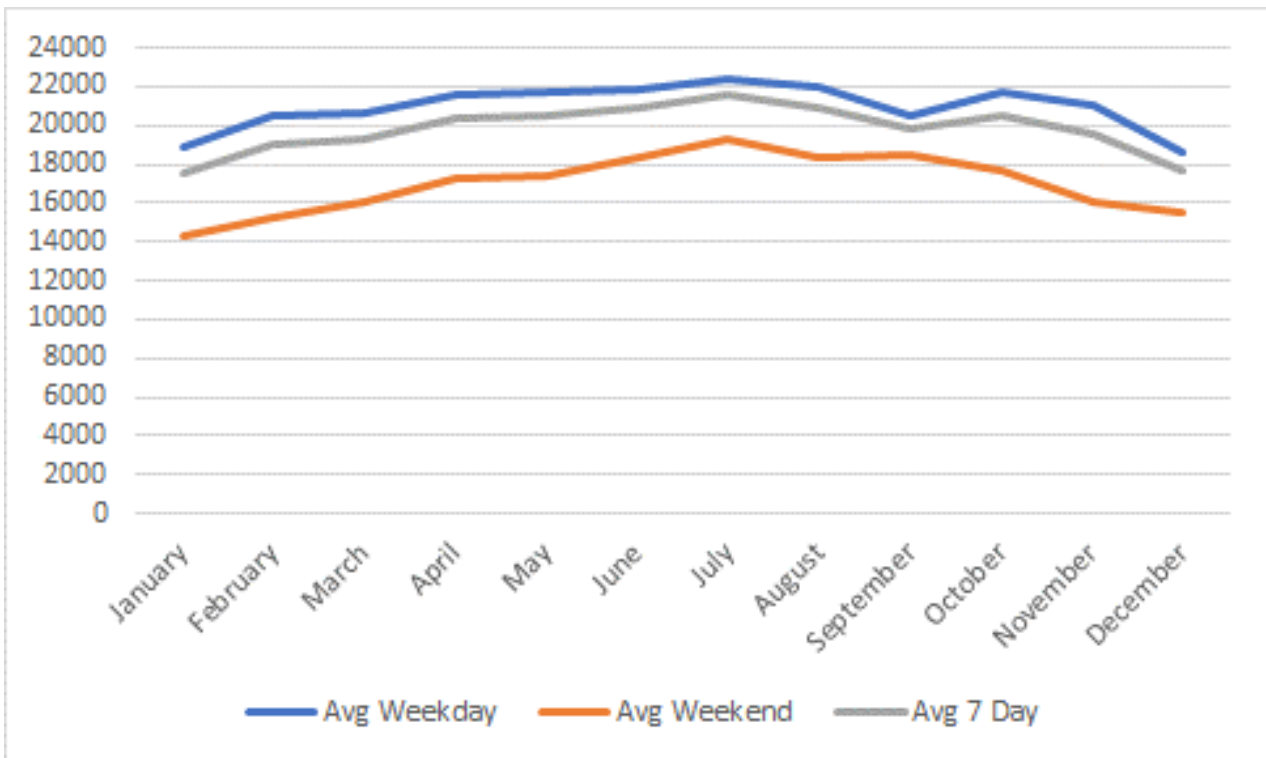
- 3.4.3 The dual-carriageway section of the A417 to the west of the Air Balloon roundabout generally operates with few capacity problems. Slow moving and queuing traffic occurs in the morning peak on the A417 southbound off-slip at the A417 / A46 grade separated junction, but otherwise the junction typically operates within capacity.
- 3.4.4 The highest traffic flows in this area are between the Air Balloon roundabout and the A46, with two-way weekday flows of approximately 39,000 vehicles. Traffic flows south of Air Balloon are approximately 31,000 vehicles per day. Manual Classified Turning Counts undertaken in 2015 show that around 24% of vehicles are vans or goods vehicles.
- 3.4.5 Figure 3.2 and Figure 3.3 show the distribution of daily traffic volumes on the A417 between the A46 and Air Balloon roundabout across the year (between November 2015 and October 2016), using data from Highways England’s DBFO Contractor for the A417 / A419 trunk road. Figure 3.4 and Figure 3.5 provide data for the A417 between the Air Balloon roundabout and the B4070. This data is derived from all days of the year and have not been adjusted to exclude, for example, school or bank holidays.

Figure 3.2: A417 daily traffic northbound between Air Balloon and A46 by month



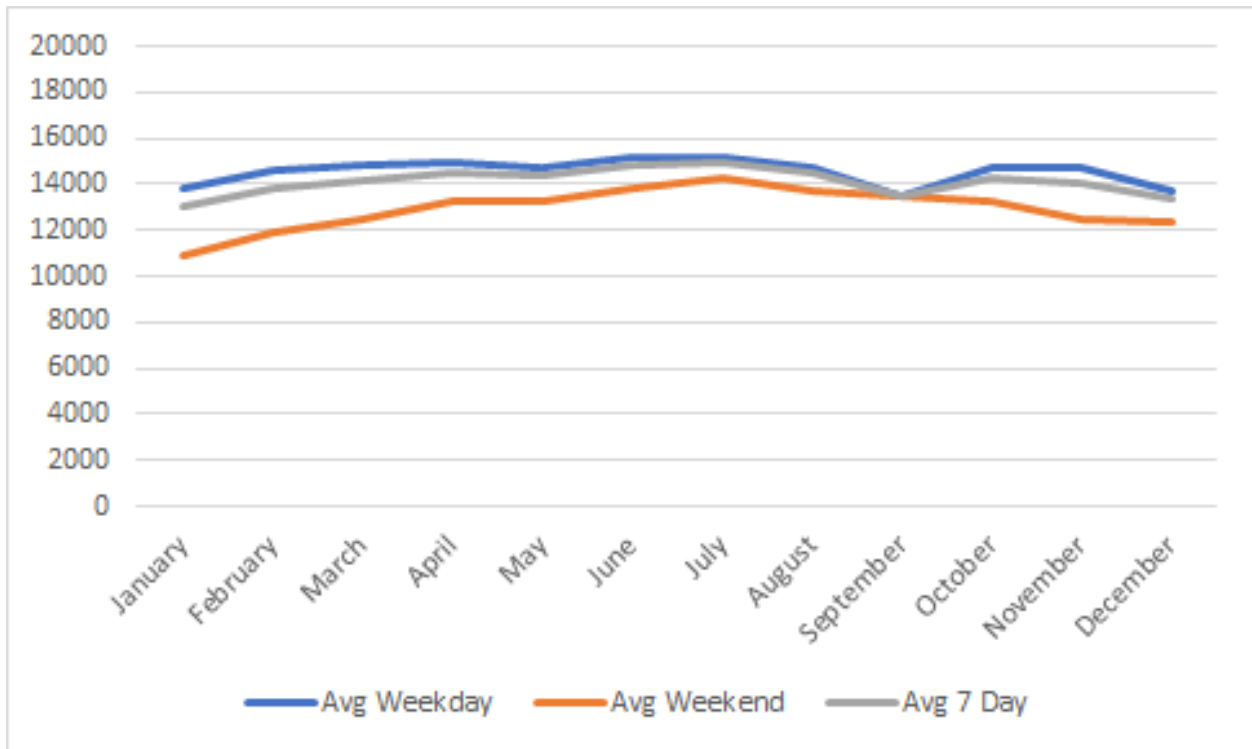
Source: Mott MacDonald Sweco Joint Venture

Figure 3.3: A417 daily traffic southbound between Air Balloon and A46 by month



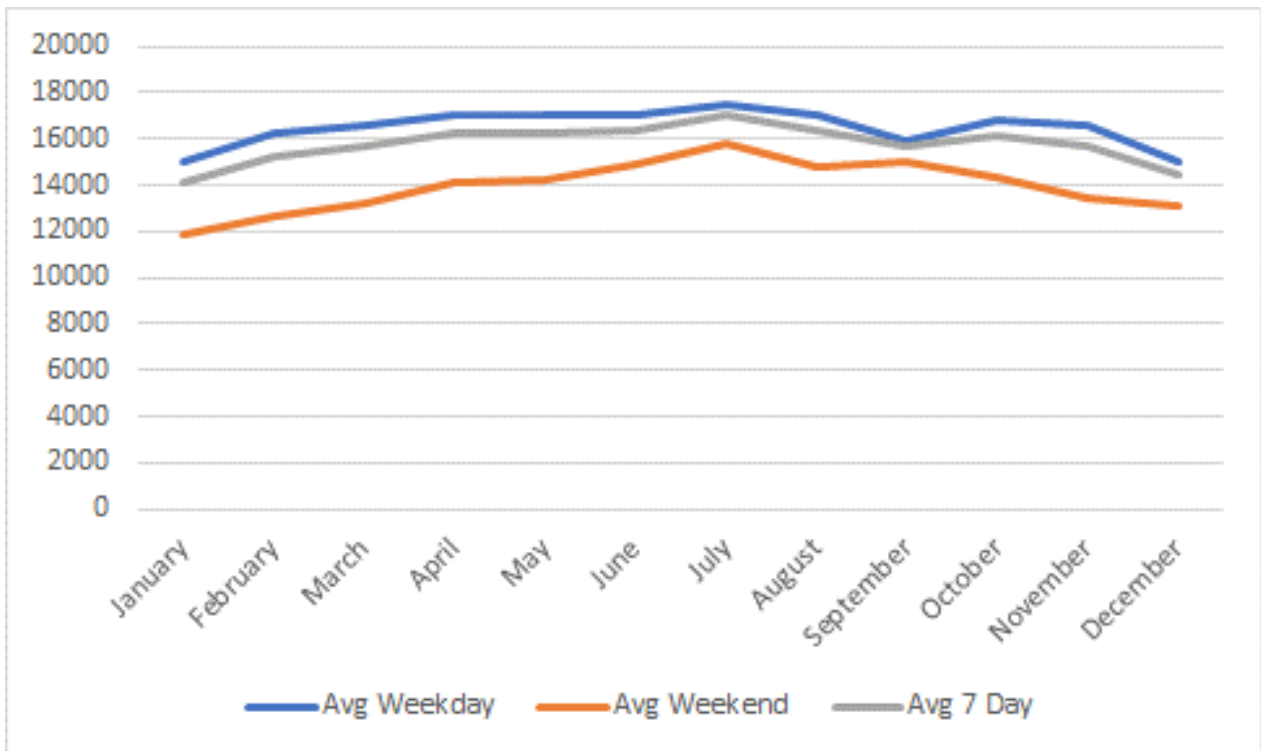
Source: Mott MacDonald Sweco Joint Venture

Figure 3.4: A417 daily traffic northbound between Air Balloon and B4070 by month



Source: Mott MacDonald Sweco Joint Venture

Figure 3.5: A417 daily traffic southbound between Air Balloon and B4070 by month



Source: Mott MacDonald Sweco Joint Venture

- 3.4.6 The above figures show a relatively moderate weekday 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. A notable drop in weekday traffic volumes also occurs in September, is coincident with scheduled weekday night time maintenance works on the A417.
- 3.4.7 The figures also identify notable directional variations in traffic flows on this section of the A417. Between the Air Balloon roundabout and the A46, average annual weekday flows on the A417 are approximately 18,000 northbound and 21,000 southbound. Between the Air Balloon roundabout and B4070, northbound flows are approximately 14,500 compared to 16,500 southbound.
- 3.4.8 The variation in directional flows shown in the above figures is reflective of congestion along this section of the A417. 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. As a result, a number of northbound “rat-runs” are observed which are not reflected to the same degree in the southbound direction. Traffic to Cheltenham is known to divert off the A417 and travel along the local road network through the villages of Elkstone and Cockleford before joining the A435. Traffic destined for Gloucester is known to divert off the A417 at Birdlip and travel along Birdlip Hill and Ermin Way through the village of Little Witcombe.
- 3.4.9 Figure 3.6 shows the hourly weekday traffic flows, by direction, in February 2016 on the A417 between the Air Balloon roundabout and the A46.

Figure 3.6: Hourly traffic flows between Air Balloon and A46 by direction (February 2016)



Source: Mott MacDonald Sweco Joint Venture

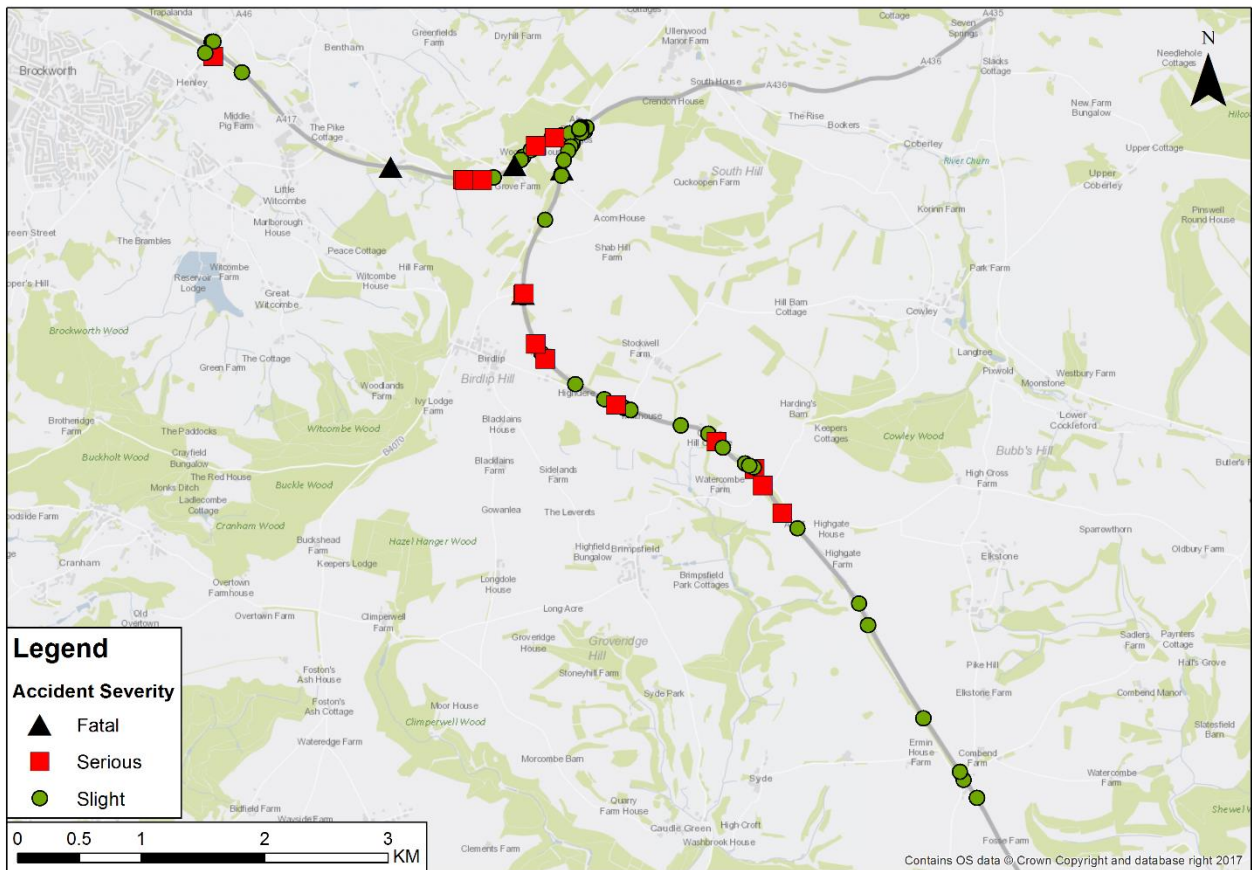
3.4.10 The above figure clearly identifies morning and evening peak periods for southbound traffic, but the peaks for northbound traffic are far less pronounced with relatively little variation in flows in the 12 hours between 07:00 and 19:00. The northbound peak periods are also much lower than the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

3.5 Accident and journey time reliability

Accidents

3.5.1 Personal Injury Collision (PIC) data has been obtained for the latest 5-year period (19/11/2011 to 18/11/2016) for the A417 in the vicinity of the Missing Link. Figure 3.7 identifies the location and severity of these PICs.

Figure 3.7: Locations of personal injury collisions



Source: Mott MacDonald Sweco Joint Venture – Crown Copyright 2016 100030649

3.5.2 Table 3.1 provides a breakdown of PICs on the A417 corridor. This shows that there was a total of 68 collisions on the corridor for the 5-year period, of which 17 (25%) were classified as serious or fatal where casualties were either Killed or Seriously Injured (KSI). There is no evidence to suggest that collision patterns have materially changed over the 5-year period. Although 2013 had a comparatively low number of collisions, this included 2 fatal and 2 serious collisions (50% KSI). Collision numbers in 2011 only include collisions from mid-November onwards.

Table 3.1: Collisions by severity and year

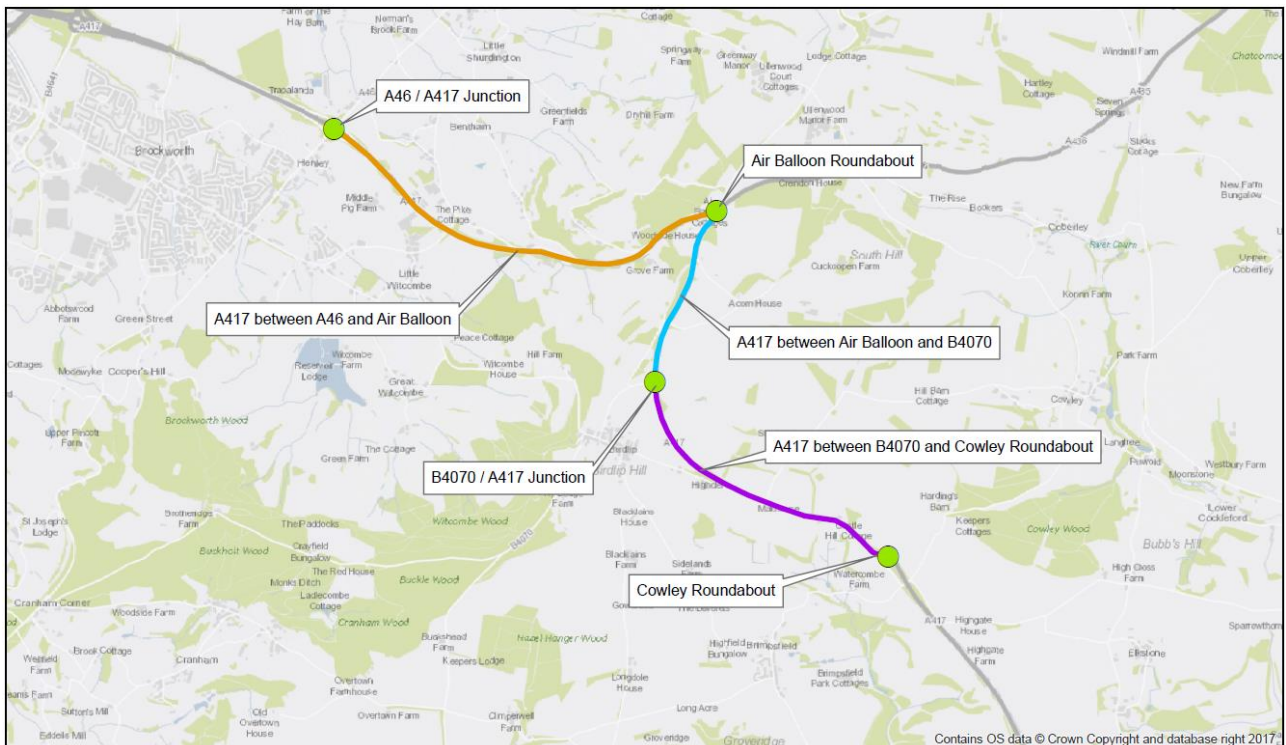
Year	Slight	Serious	Fatal	Total
2011 (from Nov.)	2	0	0	2
2012	17	2	0	19
2013	4	2	2	8
2014	11	1	2	14
2015	7	3	0	10
2016	10	5	0	15
Total	51	13	4	68

3.5.3 The A417 corridor has been further split into the following sections / locations:

- A46 / A417 Junction
- A417 between A46 and Air Balloon
- Air Balloon roundabout
- A417 between Air Balloon and B4070
- B4070 / A417 Junction
- A417 between B4070 and Cowley roundabout
- Cowley roundabout

3.5.4 These sections are illustrated in Figure 3.8.

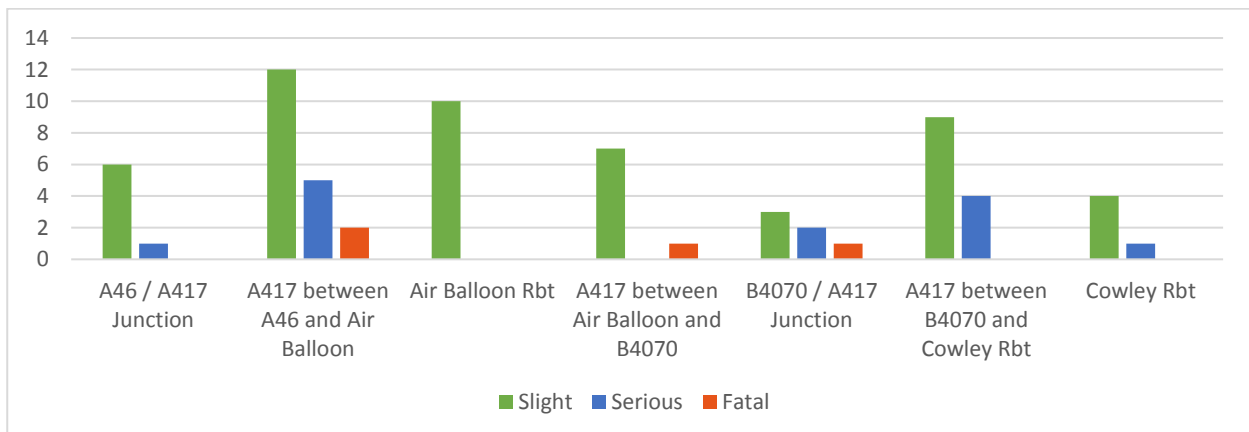
Figure 3.8: A417 accident section locations



Source: Mott MacDonald Sweco Joint Venture - Crown Copyright 2016 100030649

3.5.5 Figure 3.9 summarises the severity of collisions occurring at each of the above sections / locations.

Figure 3.9: A417 Missing Link collisions by severity



Source: Mott MacDonald Sweco Joint Venture

- 3.5.6 Figure 3.9 shows that the 3.2km section of the A417 between the A46 and Air Balloon roundabout accounts for 19 (28%) of the 68 total collisions, and 7 (41%) of the 17 KSI collisions.
- 3.5.7 There were 13 collisions along the 2.4km section of A417 between the B4070 and Cowley roundabout, which equates to 19% of all collisions in the study area. Within these collisions on this section, 4 were KSIs, which accounts for 24% of all KSIs.
- 3.5.8 Ten collisions occurred at the Air Balloon roundabout, all of which were classified as slight. A total of 6 collisions occurred at the B4070 / A417 junction, however half of these were classified as serious or fatal, which accounts for 18% of KSI collisions across the study area.
- 3.5.9 Accident data will be regularly updated as the scheme progresses. The PIC data included within this report does not account for the fatalities which occurred following an incident on the A417 close to Nettleton Bottom in November 2017.

Journey time reliability

- 3.5.10 In accordance with TAG Unit A1.3, reliability in this section refers to journey times that individuals are unable to predict. This could include variation on a day-to-day basis or from non-recurring events or incidents, but does not include predictable variations relating to general, regular congestion that travellers are assumed to be aware of.
- 3.5.11 The stress-based approach set out in TAG A1.3 Appendix C.5 has been used to provide an indicative measure of the reliability on the Crickley Hill section of the A417 (i.e. the section between the Air Balloon roundabout and the A46). This approach involves calculating a level of stress, which is defined as the ratio of annual average daily flow (AADT) to a congestion reference flow (CRF)¹. As roads approach their capacity (i.e. with a stress level approaching 100%), the reliability of journey times declines.
- 3.5.12 Based on existing AADT flows, a stress level of 109% is derived for the A417 section between the Air Balloon roundabout and the A46 (Crickley Hill). This indicates that this section of the A417 is already operating above its CRF and, as such, it is likely that journey times are inherently unreliable. In effect, relatively minor variations in traffic demand that can occur on a day-to-day basis or as a result of non-recurring events or incidents are likely to result in unreliable journey times.
- 3.5.13 Forecast improvements in the reliability of journey times resulting from the proposed Missing Link at Air Balloon options are assessed using the above stress-based approach and are detailed in sections 9.2.14 to 9.2.16.

¹ CRF is defined in DMRB Volume 5, Section 1, Part 3, TA46/97 as being an estimate of the AADT flow at which the carriageway is likely to be 'congested' in the peak periods on an average day.

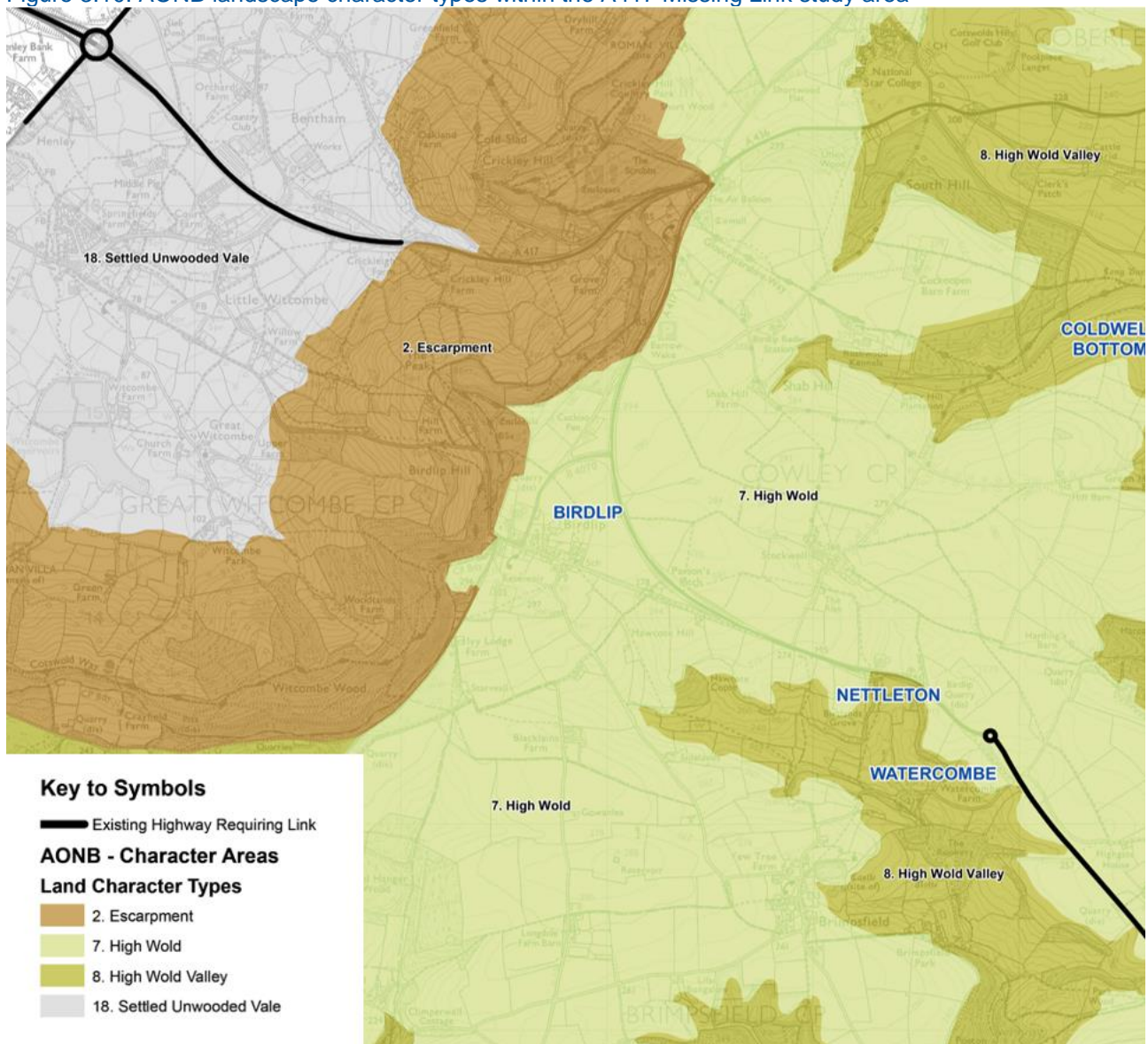
3.6 Topography

3.6.1 The study area falls within the Cotswolds landscape as defined by Natural England. The landscape character assessment of the AONB divides the landscape of the study area within the AONB into the following character areas, shown on Figure 3.10:

- Vale
- Scarp
- High Wold (2 parts to north and south of the existing A417)
- High Wold Valley (2 areas to north and south)

3.6.2 Additional information on landscape can be found in Section 3.14.

Figure 3.10: AONB landscape character types within the A417 Missing Link study area

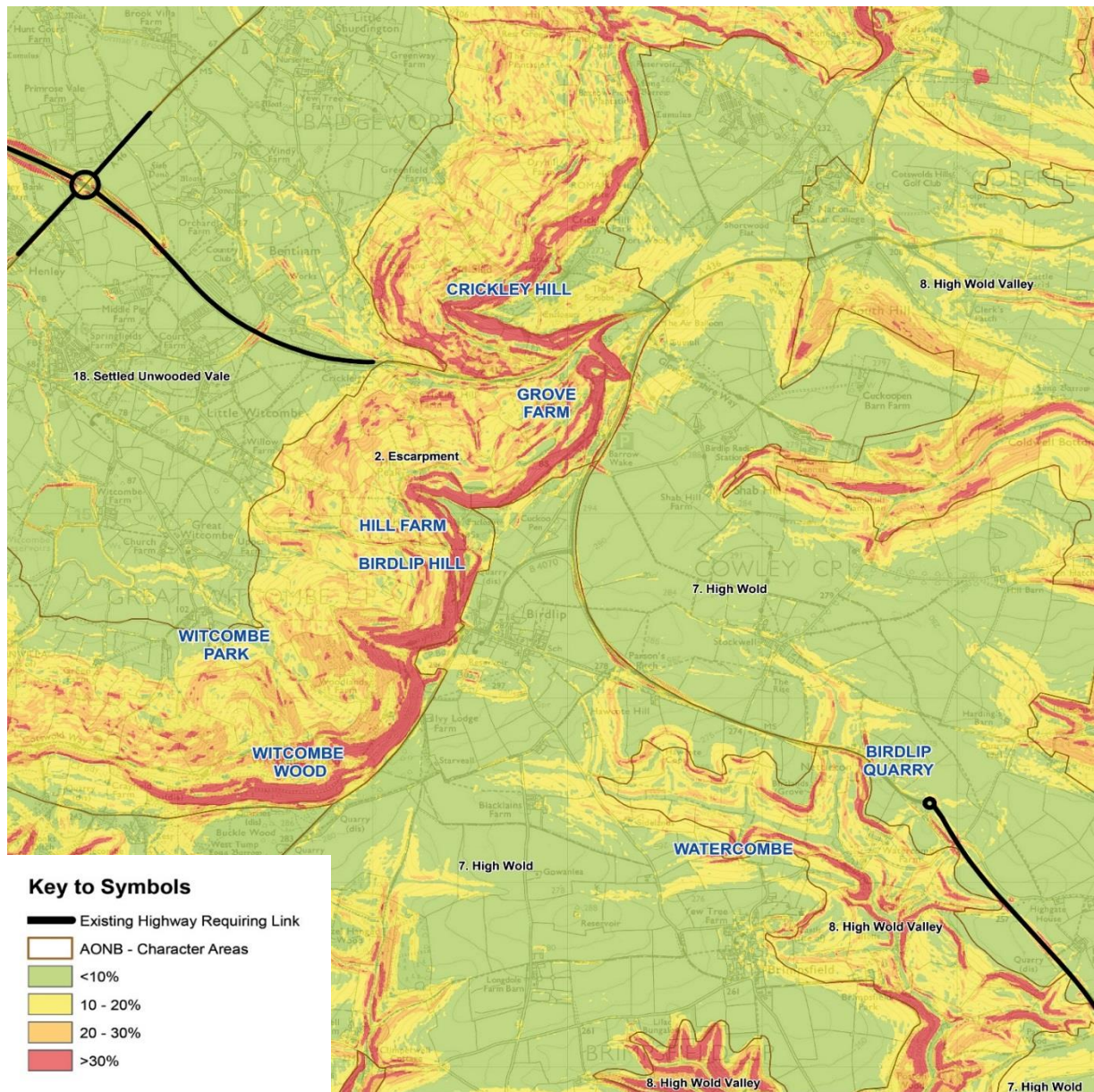


Source – Mott MacDonald Sweco Joint Venture – Crown Copyright 2016 100030649

3.6.3 The topography of the study area is relatively undulating with a particularly tight concentration of contours along the geographical escarpment, the topographic form of the landscape is distinct and dramatic.

- 3.6.4 The escarpment defines both of the following:
- The landscape character types that exist across the landscape from west to east
 - The principle challenge of the required highway scheme – i.e. to accommodate over a relatively short distance an approximate 160m difference in level
- 3.6.5 There are also the following features present within the area of study, shown in Figure 3.11:
- The shallow slope of the Vale to the west
 - The peaks and embayments along the west facing scarp slope
 - A plateau area of Wold top along the alignment of the required link
 - The undulating landscape and valleys of the upland area

Figure 3.11: Slope appraisal



Source: Mott MacDonald Sweco Joint Venture – Crown Copyright 2016 100030649

- 3.6.6 The topographical analysis describes the relative elevation of different parts of the landscape but not the degree to which it slopes. The impact of the required highway scheme will be reduced by taking advantage of areas of gently sloping gradient and the avoidance of steeply sloping ground and rapid changes in gradient where substantial areas of alternating cut and fill might be required to meet necessary highway standards.
- 3.6.7 Dark green areas comprise those which slope by less than 10% indicating areas where required cut and fill would be reduced and the highway scheme could travel largely close to existing grade. In the vicinity of the required connection the green area is seen to extend further south east south of Crickley Hill, at Birdlip Hill and on the northern side of Witcombe Park.
- 3.6.8 Red areas highlight the most steeply sloping ground within the study area. It is notable that the red area along the upper slopes of the scarp face are almost continuous from north to south. There is no location within the study area where the scarp face does not include these very steeply sloping upper slopes. The existing highway connections at the A417 and at Birdlip Hill can be seen to take advantage of some areas of less steeply sloping ground (probably in part due to alteration from original grade).
- 3.6.9 The slope analysis also highlights the shallow gradient that exists along the floor of Watercombe.

Further contour characteristics

- 3.6.10 Some further comments can be made by identifying areas in relation to the existing A417 and surrounding landmarks, whereby the following locations seem to offer similar and generic conditions of the same order. These are given below in Table 3.2.

Table 3.2: Further contour characteristics, by location

Location	Further comments
North of the existing A417 to the Air Balloon roundabout	The terrain generally rises at a moderate slope up from the A417 towards Dog Lane and beyond to Dryhill Farm with a typical slope of 1 in 3. Further along there is a separate steep bank that supports the edge of the wooded area leading up to Crickley Hill car park, here the slope is typically 1 in 1.5.
Between the existing A417 to the Air Balloon roundabout and the escarpment	This triangular area generally rises from A417 toe of batter to the bottom of the escarpment face with typical slopes of about 1 in 5.
East of the existing A417 between the Air Balloon roundabout and the Cowley roundabout	The contours peak on the existing A417 with a level of 295 AOD at about 700m north of Birdlip, either side of this peak, the levels fall away of slopes typically between 1 in 25 to the north and 1 in 30 to the south. At the Golden Heart Inn, there is a local valley that runs approximately north to south at an approximate offset of 275m either side of the existing A417. This valley is approximately 200m wide and drops in level to between 10 and 20m

Location	Further comments
Between existing the A417 (the Air Balloon roundabout to Birdlip) and the escarpment	<p>The ground contours indicate that environment is relatively flat with slopes typically between 1 in 20 and 1 in 10, generally falling from north to south and blending in with escarpment edge profile.</p> <p>For the interests of this scheme, this escarpment runs the full length between the Air Balloon Junction in a southerly direction along its ridge. The level difference along the escarpment ridge generally increases from north to south.</p> <p>The existing A417 traverses around the escarpment outcrop by following an eastward route along Crickley Hill to Air Balloon roundabout before changing to a southerly direction before heading east to Cowley roundabout.</p> <p>The maximum level difference is about 200m and is relative to the High Wold and a location on the existing A417 approximately 700m north of Birdlip at the end of the Brockworth bypass.</p>

3.7 Land use, property and industry

- 3.7.1 The Air Balloon roundabout located at the centre of the study area is a key junction on the A417 / A419. There is a pub at this location called The Air Balloon, which is popular with commuters along this route despite the sharp entrance / exit point on the A417.
- 3.7.2 Much of the land immediately surrounding the roundabout junction is rural farmland as well as public recreational land, such as the Crickley Hill Country Park and the Ullenwood Manor Golf Course.
- 3.7.3 On the edge of the study area is Gloucester Business Park, which is located between Gloucester and Cheltenham and is easily accessible from both the M5 and the A417 dual-carriageway. Gloucester Business Park offers available land for industrial, warehouse and office space from 20,000 sq ft upwards. Although sites have already been taken across the park, there are significant amounts of land available for development. Current occupants of Gloucester Business Park include NHS Gloucestershire, Horizon Nuclear Power, Ageas, GTEM and BAE.
- 3.7.4 North Brockworth also lies on the boundary of the study area and is 1 of the strategic allocations identified in the Joint Core Strategy, allocated as a mixed-use development site to be split between B1/B2/B8 land uses. North Brockworth is bounded by Mill Lane and the urban areas of Brockworth and Hucclecote, to the west by the M5, to the North by the A417 dual-carriageway, and to the East by the A46 Shurdington Road.

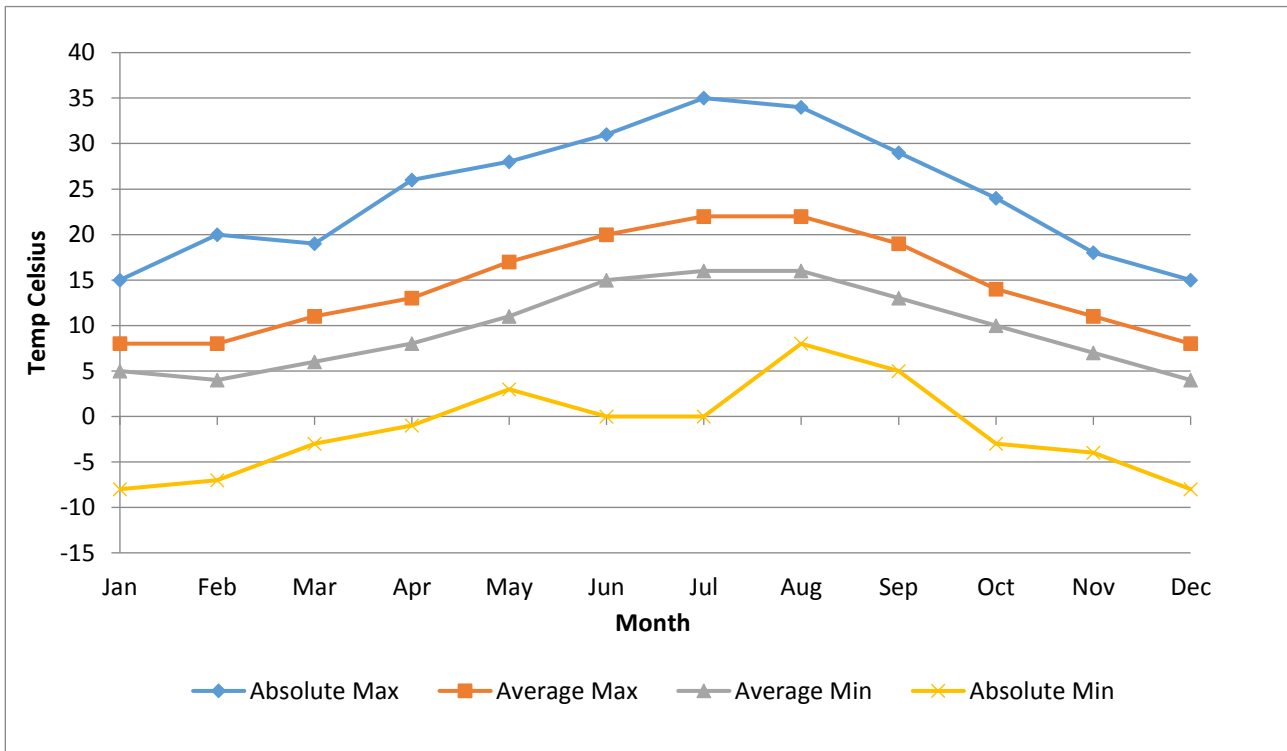
3.8 Climate

- 3.8.1 The Midlands climatic region of England, in which the proposed scheme lies², experiences a temperate maritime climate, which is typified by mild cold, wet winters and dry, sunny summers. The average temperature of all months is between 8° and 10°C, with the summer months of July and August being the warmest characterised by a mean daily maximum of 22°C (Figure 3.12). During

² Met Office (2016) Midlands: climate <http://www.metoffice.gov.uk/climate/uk/regional-climates/mi>

winter, a mean minimum temperature of just below 0°C is common. The distance of the Midlands from the coast compared to the rest of England means that light winds with warm days and cold nights are typical. However, records for Birdlip (adjacent to the existing A417 between Gloucester and Cirencester) show that this inland site has comparatively higher extreme maximum temperatures than the average for the South West and relatively higher average maximum and minimum temperatures than the average for the Midlands.

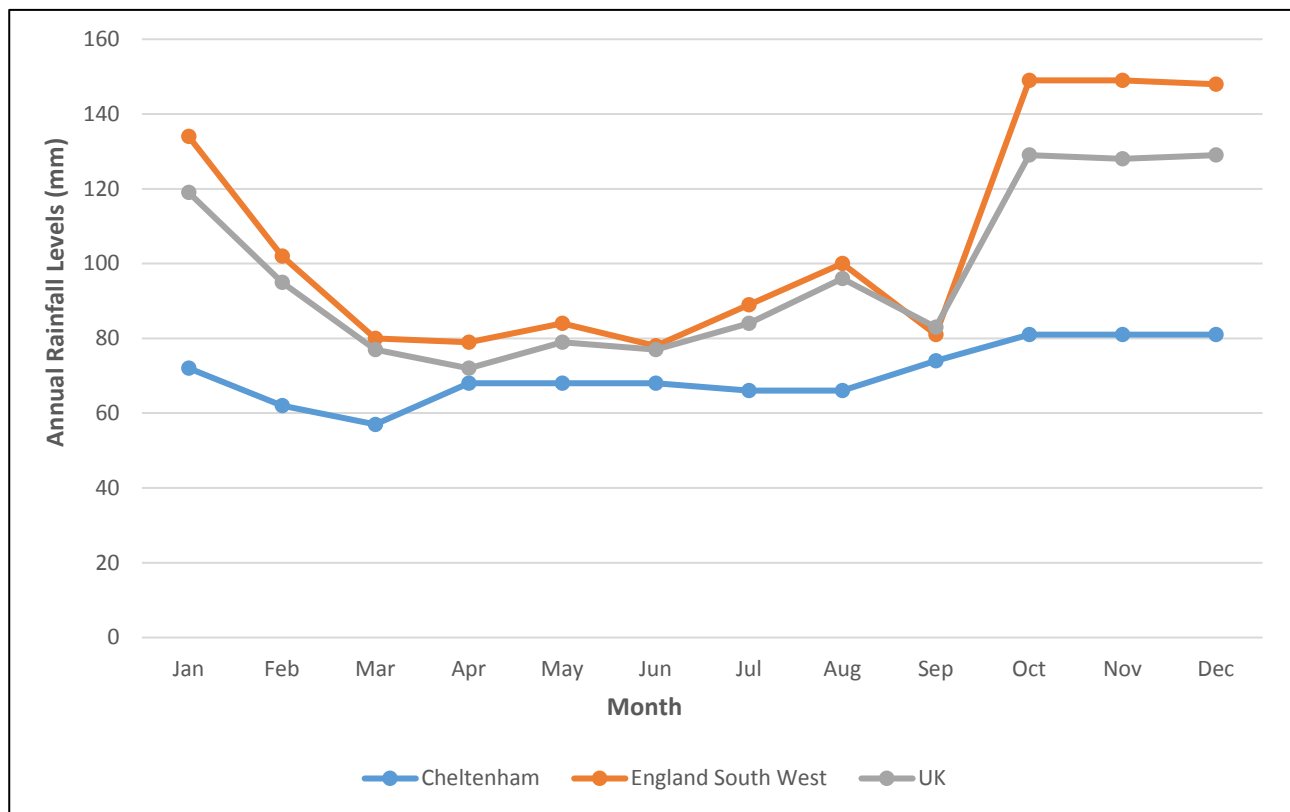
Figure 3.12: Temperature: averages and extremes for the Birdlip area



Source: <http://www.myweather2.com> (consulted in July 2017)

3.8.2 Figure 3.13 compares consolidated data for 2 decades of monthly average rainfall levels between Cheltenham, the south-west of England and the UK. It is important to highlight that this analysis was made based on public information available from the websites www.metoffice.gov.uk. The south-west is representative of the wider UK rainfall patterns, but Figure 3.13 indicates that Cheltenham receives less rainfall than the UK average. This is because Cheltenham and the scheme location is inland, in the lee of higher ground, and therefore less affected by Atlantic depression and convection weather patterns, which influence rainfall for the Midlands.

Figure 3.13: Rainfall levels for Cheltenham, the south-west of England and the UK



Source: <http://www.myweather2.com> (consulted in July 2017)

3.9 Road drainage

- 3.9.1 The available drainage inventory on the Highways Agency Drainage Data Management System (HADDMS) has been reviewed together with the aerial images to identify the existing drainage network along the existing A417 from Little Witcombe to Cowley.
- 3.9.2 The carriageway 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. Based on the HADDMS information, there appears to be pipelines 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.
- 3.9.3 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. Based on the HADDMS information, 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.

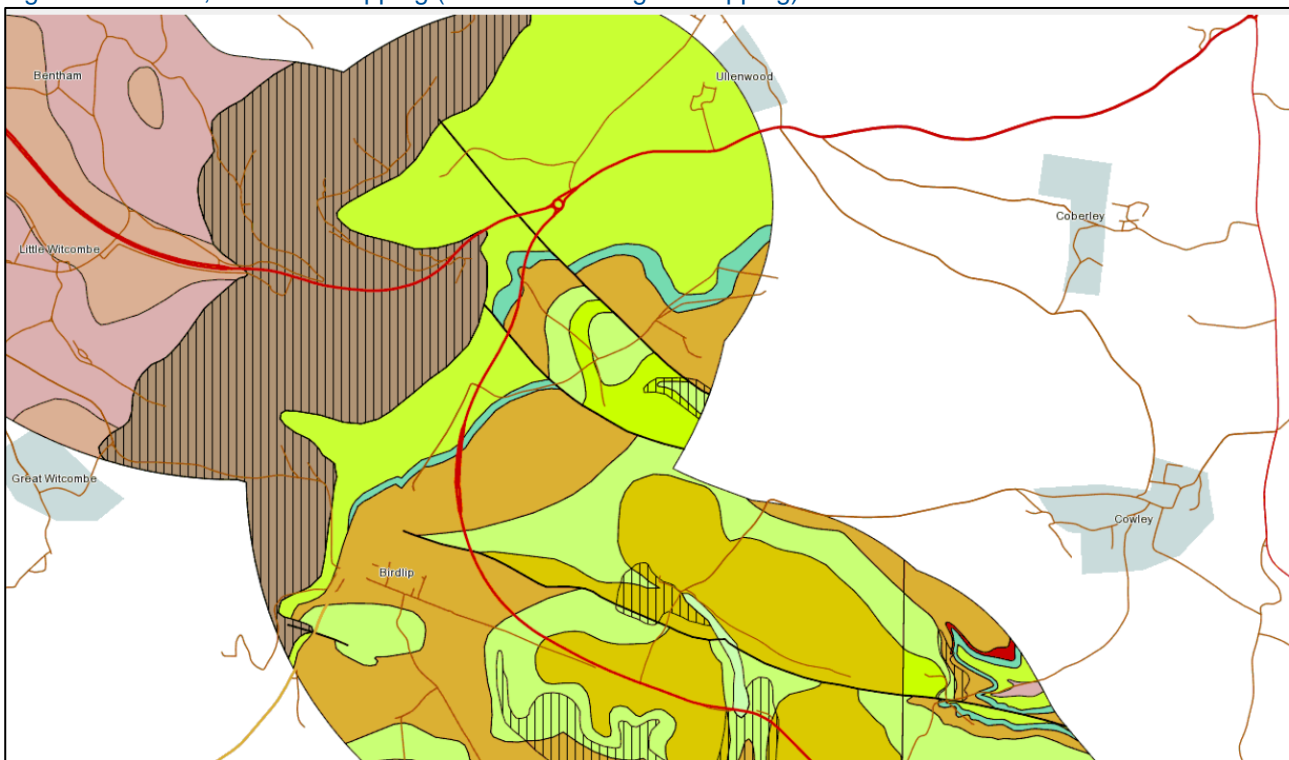
- 3.9.4 A previous drainage strategy report prepared in 2005 for the A417 Cowley to Brockworth bypass Improvement project has also been reviewed. The report identifies that there are 16 main discharge locations along the A417 trunk road between the Cowley roundabout and the Brockworth bypass. Approximately 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.

3.10 Geology

- 3.10.1 This section describes the general geology of the area in the vicinity of the study area. At the time of writing the Preliminary Sources Study Report (PSSR) for the current scheme was in progress and therefore the overview of geological condition has been based on an earlier version of the PSSR (2003) and other available background information. For more detailed information on the geology of the site, refer to the PSSR (2003).

- 3.10.2 The mapped geology of the area is represented in the excerpt of the 1:50,000 scale British Geological Survey (BGS) digital mapping extracted from HA GDMS as shown in Figure 3.14.

Figure 3.14: 1:50,000 BGS mapping (solid and drift digital mapping)



Source: Contains British Geological Survey materials © NERC 2016.

Superficial deposits

3.10.3 The BGS mapping indicates that the majority of the scheme area is not underlain by superficial deposits with the exception of localised areas of Cheltenham Sand and Gravel located in the west of the site at the foot of the Crickley Hill and localised alluvial valleys on the dip slope about Nettleton in the east. In addition, the existing road and potential routes cross significant and extensive mass movement landslide deposits associated with the 200m high Cotswold escarpment. Landslide deposits are also present in localised valley areas of the escarpment dip slope.

Bedrock geology

3.10.4 The underlying 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, which can be generalised as follows:

- Lias Group: a sequence of dominant mudstones, with limestone, marlstone rock and sandstones.
- Inferior Oolite Group: a sequence of limestone rocks, designated as a Principal Aquifer.
- Great Oolite Group: a sequence of limestone, mudstone and clay beds, designated as a Principal Aquifer. The Fullers Earth Formation (grey mudstone with limestone beds) is at the base of the Great Oolite Group, forming a boundary to the underlying Inferior Oolite limestone.

3.10.5 The steep western scarp at Crickley Hill exposes sections through the Great and Inferior Oolite Groups that dip gently to the east and south-east. The Lias Group deposits, which lie conformably below the Oolitic Limestones are not exposed within the escarpment since they have been largely buried by ancient mass movement and slope instability deposits (colluvium). The strata dip very gently (2 to 5 degrees) to the south-east and east but are subject to local variations.

3.10.6 Mapped and named normal faults are located in the vicinity of the options, these are the Stockwell, Shab Hill Barn and Shab Hill faults. The latter 2 faults form a graben structure in which some rotation may have occurred. All 3 faults trend north-west to south-east and are roughly parallel.

3.10.7 Solution features, fissures and gulls may be present in the limestones of the Inferior Oolite and Great Oolite.

3.11 Mining

3.11.1 According to BGS online records³ and the Coal Authority Interactive Viewer⁴, it is unlikely that any coal mine workings, present or past, are in the vicinity of the options. However, due to the nature of the underlying bedrock geology, the site is within an area with a high likelihood of non-coal mining hazards generally

³BGS online records - <http://mapapps2.bgs.ac.uk/geoindex/home.html><http://mapapps2.bgs.ac.uk/geoindex/home.html>

⁴ Coal Authority Interactive Viewer <http://mapapps2.bgs.ac.uk/coalauthority/home.html>

associated with the localised mining of limestone building materials. Figure 3.15 highlights the areas of potential mining instability as indicated in HA GDMS mapping for Mining Instability and the BGS's non-coal mining areas of Great Britain. There is no record of significant thickness of made ground related to the area (Figure 3.15), indicating that any potential historical mining is more likely to be underground mining than quarrying.

Figure 3.15: Non-coal mining instability areas



Source: HA GDMS

3.12 Public utilities

C2 inquiry

- 3.12.1 Enquiries have been conducted in accordance with the requirements of MHCW SA 10/05, New Roads and Street Works Act (NRSWA) 1991 – Diversionary Works and standard practice to determine the location of public utilities apparatus within the scheme area. As part of this exercise, a Statutory Undertakers Estimate report was generated.
- 3.12.2 The results of the C2 enquiry indicated that several statutory undertakers have equipment that may require protection or diversion as a result of the proposed options:
- Openreach BT
 - Gigaclear
 - Severn Trent Water – Potable
 - Virgin Media
 - Wales and West
 - Western Power Distribution

3.13 Environmental status (designated areas)

- 3.13.1 The following section summarises the existing environmental constraints in relation to the proximity of the specific options. The options are described in Chapter 7.
- 3.13.2 Internationally recognised nature conservation sites, designated under Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the EC Habitats Directive), are identified within the proposed scheme extents. They are as follows and are identified in Appendix B:
- Cotswold Beechwoods SAC (designated for its beech forests)
 - Wye Valley and Forest of Dean SAC (designated for bat populations)
- 3.13.3 No additional internationally designated sites of nature conservation or heritage value are within the scheme extents or within 2km of the 6 proposed options. However, nationally and locally designated sites of historical, landscape and nature conservation interest are located within the footprint of the options. They are as follows:
- The Cotswolds Area of Outstanding Natural Beauty (AONB) is located within the scheme extents. This 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.
 - Eight Scheduled Ancient Monuments, which are nationally designated under the Ancient Monuments and Archaeological Areas Act 1979 (as amended) are within 1km of the options. They include: 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, Moated site and fishpond at Urrist Barn and Two bowl barrows, known as Crippet's Wood round barrows.
 - Approximately 55 nationally listed buildings within 1km of the options, including 2 Grade I, 51 Grade II and 2 Grade II*. These are designated under the Planning (Listed Buildings and Conservation Areas) Act 1990.
 - One nationally Registered Park and Garden has been identified within the potential scheme footprint (Cowley Manor (Grade II* Listed)).
 - Four nationally designated SSSI would be located within 1km of the scheme extent of the options (Crickley Hill and Barrow Wake SSSI, Bushley Muzzard SSSI, Knap House Quarry SSSI, Cotswolds Commons and Beechwoods SSSI). SSSIs are designated for their flora, fauna, geological or physiographical features.
 - One Regionally Important Geological Site (RIGS) (Tuffleys Quarry) is located within 1km of options 3 and 30. RIGS are designated to recognise and protect important earth science and landscape features.
 - Crickley Hill Country Park is located within 1km of the options 3, 12, 21 and 30. This is nationally designated under the Countryside Act 1968 for recreation and leisure opportunities.
 - Six key wildlife sites are located within the scheme footprint of all options. These are locally designated for their important wildlife.

- Barrow Wake Gloucestershire Wildlife Trust Reserve is located within 1km of Option 3.

3.13.4 In addition, Birdlip Air Quality Management Area (AQMA), located on the existing A417 at the Air Balloon roundabout, has been declared for exceedances in the national NO₂ annual mean objective.

3.14 Environment

3.14.1 A plan of the environmental constraints is shown in Appendix B of this report.

Noise

3.14.2 Six Noise Important Areas (NIAs) have been identified from the Department for Environment Food and Rural Affairs (Defra) strategic noise mapping data and are located within the footprint of the proposed options as shown in Appendix B. These are located as follows:

- Six within the footprint of options 3, 12 and 30
- Five within the footprint of options 24 and 29
- Four within the footprint of Option 21

3.14.3 There are several sensitive receptors within 500m of the options. These include between 30 and 100 residential properties, 5 and 15 farms, 5 and 10 commercial properties and up to 2 community facilities (St John of Chrysostom church and Birdlip primary school).

3.14.4 There is currently no baseline noise monitoring data within the vicinity of the scheme. Therefore, in support of the scheme and future environmental assessment, baseline noise monitoring would be undertaken at locations representative of sensitive receptors within the study area during later PCF Stages.

Local air quality

3.14.5 Based on 2015 roadside NO₂ concentrations projected by the Defra web-based Pollution Climate Mapping (PCM) Model, as well as information available on the Defra website (Defra, 2016), no links exceeding 40µg/m³ are present within the scheme vicinity. In 2015 the PCM model predicts a roadside concentration of 44µg/m³ on the A40, approximately 6km north of Birdlip and to the west of Cheltenham and is predicted to reduce to 32µg/m³ by 2020.

3.14.6 There is 1 AQMA named Birdlip AQMA, located adjacent to options 12 and 30, within 400m of Option 3 and within 1km of options 24, 29 and 30. Cheltenham Borough AQMA is located approximately 3.5km north east of the scheme alignments and was also declared due to exceedances of the NO₂ annual mean air quality objectives.

3.14.7 A scheme specific air quality monitoring survey was undertaken between December 2015 and May 2016 in support of the scheme on behalf of Highways England.

- 3.14.8 There are several sensitive receptors within 500m of the options. These include between 30 and 100 residential properties, 5 and 15 farms, 5 and 10 commercial properties and up to 2 community facilities (St John of Chrysostom Church and Birdlip Primary School).

Greenhouse gases

- 3.14.9 The greenhouse gas baseline was quantified using the WebTAG data tables to estimate emissions. These calculations were based on the modelled Do-Minimum scenario for each option.

Landscape

- 3.14.10 The scheme area is located entirely within the Cotswolds AONB. This highly valued and sensitive receptor is designated for its unifying character of limestone geology which has a visible presence as natural outcrops. The Cotswold Escarpment forms the backdrop to towns and villages in the Severn and Avon Vales and river valleys form the headwaters of the river Thames. The High Wolds open and elevated landscape and dry-stone walls give the AONB its essential character. The AONB also contains distinctive settlements of high architectural quality and a rich bio-diverse landscape with internationally important flower rich grasslands and ancient broadleaved woodland. In addition, there is a rich assemblage of archaeological and historical sites and remnant historic landscapes. The AONB offers tranquillity, an accessible landscape for quiet recreation and characteristic parks, gardens and designed landscapes. There are no National Parks or Heritage Coasts located within 1km of the scheme.
- 3.14.11 The scheme sits within National Character Area (NCA) 107 Cotswolds, with a very small part of the northern-most edge of study area sitting in NCA 106 Severn Avon and Vales. The Cotswolds NCA is characterised by a dramatic limestone scarp rising above adjacent lowlands with steep combes, and outliers illustrating the slow erosion of escarpments. The landscape character consists of open and expansive scarp and is dominated by arable farming. There are large areas of common land, characteristic of the scarp and high wold around the Stroud valleys. Field patterns are defined by drystone walls and hedgerows and are reflective of the medieval open field system. Ancient beech hangers line stretches of the upper slopes of the scarp with regular blocks of coniferous and mixed plantations. The area contains a rich history from Neolithic barrows to Roman roads and grand country houses. In addition, locally quarried limestone brings a harmony to the built environment of scattered villages and drystone walls, giving the area a strong sense of unity for which the Cotswolds are renowned.
- 3.14.12 There are numerous visual receptors located within the likely Zone of Theoretical Visibility including several village settlements, footpaths, bridleways and 2 long distance footpaths, the Cotswold Way and Gloucestershire Way. Due to the greatly varying topography of the area, there are also several elevated views

which may be affected, including but not limited to viewpoints from Crickley Hill, Barrow Wake, Hawcote Hill and Shab Hill.

Townscape

3.14.13 Several settlements in combination with a varied agricultural land use system lie along of the existing A417 at the villages of Birdlip, Shurdington to the north west, Ullenwood to the north, Seven Springs to the north east, Cowley and Cockleford to the east and Great Witcombe and Little Witcombe to the south west.

Heritage and historic resources

3.14.14 There are 8 Scheduled Ancient Monuments within the scheme vicinity which includes:

- Crickley Hill Camp within 1km of options 3, 12, 21 and 30
- Dryhill Roman villa and 3 bowl barrows known as Emma's Grove round barrows within 1km of options 3, 12 and 30
- Brimpsfield Castle and Brimpsfield Castle mound within 1km of all options.
- Moat and fishpond at Bentham Manor within 1km of options 12, 21, 24, 29 and 30
- Moated site and fishpond at Urrist Barn within 1km of options 24 and 29.
- Two bowl barrows, known as Crippet's Wood round barrows within 1km of Option 30

3.14.15 There are numerous listed buildings within the 1km of all options, comprising Grade I, Grade II and Grade III listed buildings. They are located as follows:

- Option 3: 27 Listed Buildings (1 Grade I, 24 Grade II and 2 Grade II*)
- Option 12: 35 Listed Buildings (1 Grade I, 32 Grade II and 2 Grade II*)
- Option 21: 35 Listed Buildings (1 Grade I, 32 Grade II and 2 Grade II*)
- Option 24: 55 Listed Buildings (2 Grade I, 51 Grade II and 2 Grade II*)
- Option 29: 50 Listed Buildings (2 Grade I, 46 Grade II and 2 Grade II*)
- Option 30: 28 Listed Buildings (1 Grade I, 25 Grade II and 2 Grade II*)

3.14.16 All options are within 1km of Cowley Manor (Grade II* Listed) Registered Park and Garden. In addition, Crickley Hill, known to contain buried archaeology, is within 1km of all options. Registered Common Land within 1km of the options includes Cold Slad, Barrow Wake, Brimpsfield Common, Bucklewood Common, Buckle Wood and Cranham Wood and Cranham Common.

3.14.17 Records of archaeological events, historic monuments and finds within 1km of the options has been obtained from Historic England's National Heritage List and the Gloucestershire Historic Environment Record. These include Peak Camp Neolithic Promontory Fort, Middle Iron Age settlement, remains of medieval routes and villages and areas of quarrying.

Biodiversity

- 3.14.18 Cotswold Beechwoods SAC is located within 1km of options 3, 12, 21 and 30. For options 24 and 29, Cotswold Beechwoods SAC is located within the scheme extents within the tunnel section of options 3, 21, 24 and 30. Wye Valley and Forest of Dean SAC is located 22km west of the options.
- 3.14.19 Crickley Hill and Barrow Wake SSSI is partially located within Option 12 and adjacent to Option 30. The SSSI is also within the tunnel section of options 3 and 21 which pass beneath the land covered by the SSSI designation. Options 24 and 29 are within 1km of the SSSI. Bushley Muzzard SSSI is located partly directly within Option 24 and within 1km of options 3, 12, 21, 29 and 30. Knap House Quarry SSSI is located within the scheme extents within the tunnel section of Option 29 and within 1km of options 3, 12, 21, 24 and 30. Cotswolds Commons and Beechwoods SSSI is located within the scheme extents within the tunnel section of options 24 and 29 and is located within 1km of options 3, 12, 21 and 30.
- 3.14.20 Crickley Hill Country Park is located adjacent to Option 12 and within 1km of options 3, 21 and 30. Barrow Wake Gloucestershire Wildlife Trust (GWT) Reserves is located partially within the footprint of Option 12 and within 1km of options 3, 21, 29 and 30. There are 3 Key Wildlife Sites and 2 Conservation Road Verges (CRV) within the scheme options in addition to 6 Ancient and Semi Natural woodland sites located within 1km of the options.
- 3.14.21 The main habitats recorded within the study area identified during the Extended Phase 1 Habitat Survey, undertaken in May and June 2017, include broadleaved woodland, ancient woodland, plantation broadleaved woodland, hedgerows, calcareous grassland, semi-improved, improved and amenity grassland and arable fields. In addition, this survey work in combination with desktop studies have identified habitats suitable to support bats, breeding birds, barn owls, badgers, dormice, reptiles, great crested newts, otters, water voles and notable invertebrates.

Water environment

- 3.14.22 The Environment Agency's indicative flood mapping shows that the proposed options are within close proximity of Flood Zone 2 and Flood Zone 3. Flood Zone 2 comprises land assessed as having between a 1-in-100 and 1-in-1000 (1%-0.1%) chance of flooding from fluvial sources each year. Flood Zone 3 comprises land assessed as having a 1% or 1-in-100 or greater chance of flooding from fluvial sources (>1%) each year. Horsebere Brook, Norman Brook, the River Frome and the River Churn are classed by the Environment Agency as ordinary watercourses within the options.
- 3.14.23 Three Water Framework Directive surface waterbodies are within the vicinity of the options: in the Severn Vale Management Catchment include Norman's Brook, Horsebere Brook, Frome and the Churn (source to Perrots Brook).

- 3.14.24 There are approximately 5 priority outfalls identified within the vicinity of Shurdington Road junction and Cowley roundabout. Four of these were classed as not determined in terms of action status.
- 3.14.25 The options are underlain by principal aquifers, which are the Great and Inferior Oolite and Secondary (undifferentiated) aquifers within the underlying Lias. The principal aquifers have an Environment Agency vulnerability classification of Major Aquifer High. The options are underlain by a Secondary A aquifer comprising permeable superficial deposits. The Great and Inferior Oolite aquifers are included in the Burford Jurassic Groundwater Body under the Water Framework Directive. The outcrop of the Great and Inferior Oolite is designated as a Nitrate Vulnerable Zone. There is limited understanding of the groundwater in the area / region and how the scheme could affect this and additional investigation will therefore be required.
- 3.14.26 All options intersect or skirt the edge of a groundwater Source Protection Zone (total catchment) of a public water supply source.

Physical activity

- 3.14.27 The study area offers significant opportunities for outdoor activities such as walking and cycling. Car parks at Barrow Wake viewpoint and the Crickley Hill Country Park offer access to the dense network of Public Rights of Way (PRoWs). The PRoW and restricted byways within the vicinity of the options are as follows:
- Option 3: 15 footpaths, 2 bridleways, and the Cotswold Way national trail
 - Option 12: 31 footpaths, 3 bridleways, and the Cotswold Way national trail
 - Option 21: 16 footpaths, 2 bridleways, and the Cotswold Way national trail
 - Option 24: 18 footpaths, 1 bridleway, and the Cotswold Way national trail
 - Option 29: 20 footpaths, 2 bridleways and the Cotswold Way national trail
 - Option 30: 17 footpaths, 2 bridleways and the Cotswold Way national trail

Journey quality

- 3.14.28 The Centurion service areas is located approximately 3.2 miles south of Cowley roundabout. The area provides access from the A417 to roadside services including a filling station and café for both motorised travellers and non-motorised users. In addition, the village of Birdlip is located within the study area to the west of the A417.
- 3.14.29 The view from the road to the north and the south of the existing A417 is largely rural, with varied agricultural land use, as well as view of settlements combined with the undulating and elevated topography of the surrounding landscape.
- 3.14.30 At present the A417 at the Air Balloon junction can experience delays and congestion particularly during peak times, leading to driver stress.

Security

- 3.14.31 The majority of the existing A417 is unlit, with limited lighting at Cowley roundabout and Air Balloon roundabout. There is informal surveillance provided by the constant flow of traffic along the road.

3.15 Accessibility

Severance

- 3.15.1 Numerous Public Rights of Ways (PROWs), undesignated paths and the Cotswold Way national trail are situated within the vicinity of all options, a number of which have been severed by the existing A417 and A436. Crossings suitable for non-motorised users (NMU) are not common features in the area with the crossing of the Air Balloon junction being a particular hindrance; where the footpaths cross the A417 then generally no crossing facilities or grade-separation is provided, causing severance for walkers, cyclists and equestrians. There are various sections of footway in the vicinity of the A417 however they provide a limited network of footway in the vicinity of the Air Balloon roundabout. The study area is also dissected by 2 long distance walks; the Gloucestershire Way passing through the study area in an east / west orientation and the Cotswold Way passing through the study area in a north / south orientation. Both long distance walks cross the A417 at the Air Balloon roundabout where no formal crossings are provided, and walkers are severed by the heavy traffic flows and various turning movements at the roundabout.
- 3.15.2 Away from the Air Balloon roundabout, the A417 has no footway provision. There are 2 dedicated cycle facilities in the scheme vicinity and several bridleways however no dedicated equestrian crossings. In addition, there are a number of community facilities within the scheme vicinity such as public houses, and recreational centres. There is potential for existing traffic flows on the A417 to significantly impede NMU movements, potentially including vulnerable social groups.

Access to the transport system

- 3.15.3 The A417 / A419 link is an important route between Gloucester and Swindon and helps to connect the North and South of England, providing an alternative to the M5/M4 route via Bristol. The A417 / A419 corridor connects directly with the motorway network. There is 1 bus stop along the A417 located south-west of the Air Balloon Public house and close to the Barrow Wake viewpoint. The bus stop serves buses in the northbound direction only. Two bus routes use the stop; the 852 between Gloucester and Cirencester and the 23 between Stroud and Cheltenham. There are also bus stops on the A46, either side of the Shurdington Road junction, served by several bus routes.

3.16 Integration

Land-use policy

3.16.1 This section examines the key policies for the local authority areas around the A417 and the key settlements within them. This local planning framework focuses on Gloucestershire County and the relevant local authorities, namely Tewkesbury Borough, Cheltenham Borough, Gloucester City, and Cotswold District Council. We have also included reference to GFirst Local Enterprise Partnership (LEP) in this section as its policies have an influence on planning matters.

Transport interchange

3.16.2 The A417 Air Balloon junction is over 6km from the closest rail station (Cheltenham Spa). There is only a single bus stop along the A417 between Cowley roundabout and the A46. This locale therefore does not act as a local interchange with other forms of transport.

Housing land allocations - GFirst LEP

3.16.3 In 2014, GFirst LEP published the Strategic Economic Plan (SEP) for Gloucestershire which stated that housing “is critically important in securing economy growth. The construction sector is an important sector in its own right. And the supply, quality and price of housing have implications for the composition of the local workforce, the skills mix and the attractiveness of an area as a place in which to live, work and invest”⁵.

3.16.4 Late in 2016, GFirst LEP published ‘Building on success: Gloucestershire Growth Deal 3 which outlined projects that would complement and enhance the SEP which in total, are expected to create an additional 3,595 homes for Gloucestershire.

3.16.5 Table 3.3 below shows the proposed projects and the amount of new additional housing they are expected to create.

Table 3.3: Growth deal 3 projects – additional housing creation.

Project	Number of dwellings
Forest of Dean	55
Cinderford Regeneration	110
Gloucester Station	1,200
Longford Housing	1,300
Cheltenham Cyber Park	500
Briscombe Housing	160

⁵ ‘Strategic Economic Plan for Gloucestershire’ (2014), page 71.
https://www.lepnetwork.net/modules/downloads/download.php?file_name=15

Project	Number of dwellings
Littlecombe Housing	270

Source: Building on success: Gloucestershire Growth Deal 3

Housing land allocations- Joint Core Strategy

3.16.6 In the Joint Core Strategy (JCS), Gloucester City was one of the 3 areas that would contribute towards the overall additional housing target of 30,500 by 2031. However, after the main modifications to the JCS were made in 2017, the latest additional housing allocation requirement was set at 14,359 dwellings⁶. Of these 14,359 additional homes, only 13,047 dwellings are allocated in the modified JCS⁷. There is not enough land available within Gloucester City to accommodate all the new allocated homes, so will be provided within the Gloucester City administrative boundary, as well as the Winnycroft Strategic Allocation, and urban extensions at Innsworth and Twigworth, South Churchdown and North Brockworth within Tewkesbury Borough⁸.

3.16.7 Table 3.4 below outlines the sources of additional housing allocations in the modified JCS.

Table 3.4: Sources of housing supply – Gloucester city

Project	Number of dwellings
Completions	2,526
Commitments	2,237
Windfall allowance	832
Gloucester City Plan (Further potential)	1,937
Strategic allocations (Gloucester City)	620
Urban Extensions (Tewkesbury Borough)	4,895
Total	13,047

Source: Joint Core Strategy Proposed Main Modifications

3.16.8 Table 3.5 below outlines the apportionment of additional dwellings to strategic allocation sites for Gloucester City.

Table 3.5: Apportionment of strategic allocation sites – Gloucester city.

Strategic allocation site	Number of dwellings
Gloucester City urban capacity	7,532
Winnycroft urban extension	620
Innsworth & Twigworth urban extension	2,295

⁶ 'JCS Proposed Main Modification' (2017) <http://consult.gct-jcs.org/consult/ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

⁷ 'JCS Proposed Main Modification' (2017) <http://consult.gct-jcs.org/consult/ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

⁸ 'JCS Proposed Main Modification' (2017) <http://consult.gct-jcs.org/consult/ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

Strategic allocation site	Number of dwellings
South Churchdown urban extension	1,100
North Brockworth urban extension	620

Source: Joint Core Strategy Main Modifications

3.16.9 Of the total housing target of 30,500 in the JCS by 2031, Cheltenham Borough is expected to provide 9,100 new homes within its boundaries⁹. However, after the main modifications to the JCS were made in 2017 the latest additional housing allocation was set at 10,996 dwellings¹⁰. As with Gloucester City, there is not enough land available within Cheltenham Borough to accommodate all the new allocated homes, therefore they will be provided within the Cheltenham Borough administrative boundary and cross-boundary urban extensions at North West Cheltenham and West Cheltenham (both of which are partly within Tewkesbury Borough).

3.16.10 Table 3.6 below outlines the sources of additional housing allocations in the modified JCS.

Table 3.6: Sources of housing supply – Cheltenham borough.

Sources of housing	Number of dwellings
Completions	1,426
Commitments	2,353
Existing Local Plan allocations	10
Windfall allowance	865
Cheltenham Borough Plan (Further potential)	957
Urban extensions (Cheltenham Borough)	2,775
Urban extensions (Tewkesbury Borough)	2,610
Total	10,996

Source: Joint Core Strategy Main Modifications

3.16.11 Table 3.7 below outlines the apportionment of additional dwellings to strategic allocation sites for Cheltenham Borough.

Table 3.7: Apportionment of strategic allocation sites – Cheltenham borough.

Strategic allocation site	Number of dwellings
Cheltenham District capacity	5,611
North West Cheltenham urban extension	4,285
West of Cheltenham urban extension	1,100

Source: Joint Core Strategy Main Modifications

⁹ 'Joint Core Strategy: Gloucester, Cheltenham, Tewkesbury' (2014), page 27. <http://www.gct-jcs.org/Documents/Publications/Submission/JCS-Submission-Version-November-2014a-corrected.pdf>

¹⁰ 'JCS Proposed Main Modification' (2017) <http://consult.gct-jcs.org/consult.ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

- 3.16.12 Of the total housing target of 30,500 in the JCS by 2031, Tewkesbury Borough is expected to provide 10,100 new homes within its boundaries¹¹. After the main modifications to the JCS were made in 2017, to meet the needs of Tewkesbury Borough, outside of the urban extensions to Gloucester and Cheltenham, the JCS will make provisions for at least 9,899 new homes. Of these 9,899 additional homes, only 7,057 dwellings are allocated in the modified JCS¹². These will be provided through existing commitments, development at Tewkesbury Town in line with its role as a market town, smaller-scale development meeting local needs at Rural Service Centre and Service Villages¹³.
- 3.16.13 Unlike Gloucester City and Cheltenham Borough there is enough available land in Tewkesbury Borough to meet the demand for additional housing and as such, Tewkesbury Borough has been allocated additional housing that could not be met by Gloucester City and Cheltenham Borough in the JCS.
- 3.16.14 Table 3.8 below outlines the sources of additional housing allocations in the modified JCS.

Table 3.8: Sources of housing supply – Tewkesbury borough.

Sources of housing	Number of dwellings
Completions	2,496
Deliverable commitments	3,148
Existing Local Plan allocations	0
Windfall allowance	598
Tewkesbury Borough Plan (Further potential)	315
Mitton (Wychavon District)	500
Total	7,057

Source: Joint Core Strategy Main Modifications

Housing land allocations - Cotswold District

- 3.16.15 In the Cotswold District Local Plan 2011-2031¹⁴ it was stated that there was a need for 8,400 additional dwellings to fulfil the current and future demands of the local population within the time frame of this Local Plan¹⁵. The land allocated to deliver these 8,400 additional dwellings over the plan period will be in 17 principal settlements¹⁶.

¹¹ 'Joint Core Strategy: Gloucester, Cheltenham, Tewkesbury' (2014), page 27. <http://www.gct-jcs.org/Documents/Publications/Submission/JCS-Submission-Version-November-2014a-corrected.pdf>

¹² 'JCS Proposed Main Modification' (2017) <http://consult.gct-jcs.org/consult/ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

¹³ 'JCS Proposed Main Modification' (2017) <http://consult.gct-jcs.org/consult/ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

¹⁴ 'Cotswold District Local Plan 2011-2031' (2016) http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031/addendum/focussed_changes?pointId=4338317

¹⁵ Cirencester; Andoversford; Blockley; Bourton-on-the-Water; Chipping Campden; Down Ampney; Fairford; Kemble; Lechlade; Mickleton; Moreton-in-Marsh; Northleach; South Cerney; Stow-on-the-Wold; Tetbury; Upper Rissington; and Willersey.

¹⁶ 'Cotswold District Local Plan 2011-2031' (2016) [http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-](http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031)

3.16.16 The principal settlements were identified as the most sustainable locations to deliver future growth on the basis of their social and economic sustainability, including accessibility to services and facilities. Although there are a significant number of settlements identified for housing allocations, Cirencester will be the main centre of land allocation for the Cotswolds District¹⁷. To meet the housing requirements for Cotswolds District a strategic mixed-use site at Chesterton, south of Cirencester, has also been proposed as a location for additional housing¹⁸.

3.16.17 The main source of housing supply in Cotswold District is summarised in Table 3.9 below.

Table 3.9: Housing requirements and sources of land supply.

Overall housing requirement and sources of land supply	Number of dwellings
Housing land requirement	8,400
Housing land supply	
Completions 1 April 2011 – 31 March 2016	2,385
Extant planning permissions at 1 April 2016	3,387
Chesterton strategic site	2,350
Other new land allocations in local plan	760
Windfalls estimate 2019 to 2031 @ 80 p.a.	960
Total supply	9,842

Source: Cotswold District Local Plan 2011-2031

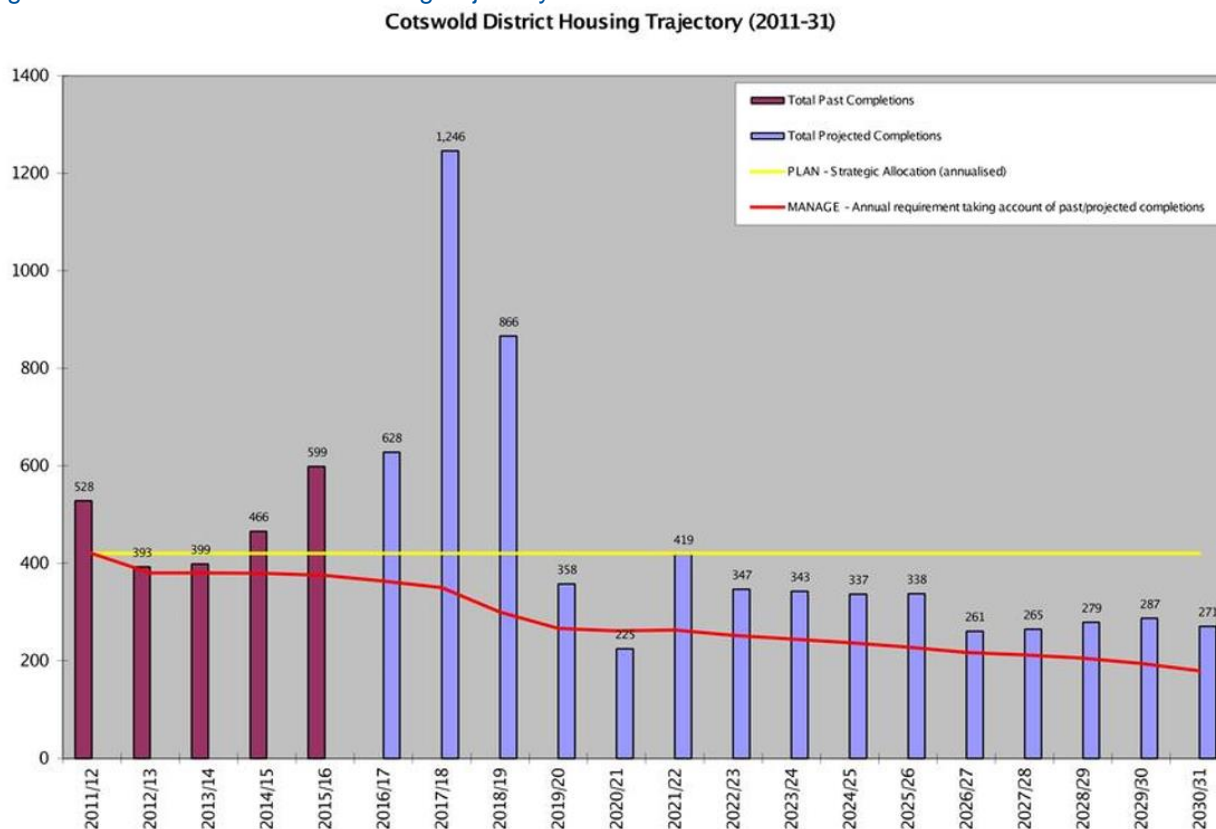
3.16.18 Figure 3.16 below offers a further breakdown of future housing allocations by demonstrating the housing trajectory for Cotswold District during the plan period until 2031.

[2031/addendum/focussed_changes?pointId=4338317](http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031/addendum/focussed_changes?pointId=4338317)

¹⁷ 'Cotswold District Local Plan 2011-2031' (2016) http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031/addendum/focussed_changes?pointId=4338317

¹⁸ 'Cotswold District Local Plan 2011-2031' (2016) http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031/addendum/focussed_changes?pointId=4338317

Figure 3.16: Cotswold District housing trajectory 2011-2031



Source: Cotswold District Local Plan 2011-2031

Employment land allocations - GFirst LEP

3.16.19 In the GFirst LEP’s report, Building on Success: Gloucestershire Growth Deal 3, many of the proposed projects involve the unlocking of employment land. In total, the proposed projects are expected to create an additional 111.5ha of employment land for the Gloucestershire County. Table 3.10 below shows the proposed projects and the amount of employment land each is expected to unlock.

Table 3.10: Identified employment land allocations in GFirst LEP.

Area	Employment land allocation (ha)
Cheltenham Cyber Park	45
Eco Park and Sports Stadium	18.9 (64,000m ² of commercial floor space) (31 B1/B2/B8 class commercial buildings)
Cirencester Enterprise Park	14.5
Airport expansion	9.5 (24,000m ² of commercial floor space)
Longford Housing	8.3
Littlecombe Housing	1.2 (3,600m ² of commercial floor space)
Briscombe Housing	4

Area	Employment land allocation (ha)
	(1,800m ² of retail/commercial floor space)
Gloucester Railway Station	5.3
Cinderford Regeneration	4.8 (9,800m ² of commercial floor space)
Gloucestershire College Forest of Dean Campus	0 (6,000m ² of skill capital floor space)
Centre of Excellence for Food and Drink	0 (660m ² of skill capital floor space)

Source: Building on success: Gloucestershire Growth Deal 3

Employment land allocations - Joint Core Strategy

3.16.20 In the modified JCS, it was proposed that within the JCS area a minimum of 192ha of employment land should be allocated to support the creation of 39,500 jobs for the period 2011 to 2031¹⁹.

3.16.21 In the Gloucester City Plan 2016-2031 published in 2017, Gloucester City Council identified a series of potential sites that could be used for employment land. The sites are shown in Table 3.11 below.

Table 3.11: Identified employment land allocations in JCS.

Site name	Gross area (ha)	Proposed use
Gloucester Mail Centre, Eastern Avenue	2.25	Employment land
Wessex House, off Great Western Road	0.25	Potentially employment use
Great Western Road Sidings	4.34	Potentially employment use
Land East of Waterwells Business Park	1.8	Employment land
King's Quarter	2.2	Includes 5,000 – 10,000 sq. m gross retail
Northgate Street	0.06	Includes 50 sq. m for commercial uses
Land adjacent to Eastgate Shopping Centre	0.32	Up to 5,000 sq. m gross retail
Secunda Way Industrial Estate	0.7	Employment land
Southgate Moorings off Commercial Street	0.5	Mixed-use
104, Northgate Street	0.06	Includes 50 sq. m for commercial uses
Total	12.48	

Source: Gloucester City Plan 2016-2031

3.16.22 In the JCS it was set out that Cheltenham would establish its district capacity with the publication of its Cheltenham Plan, but this has not yet been published

¹⁹ 'JCS Proposed Main Modification' (2017) <http://consult.gct-ics.org/consult.ti/mainmods/viewCompoundDoc?docid=8026484&partid=8197684&sessionid=&voteid=&clientuid>

as of the time of writing. Cheltenham has an outstanding need for 23.4ha of employment land which is to be met within urban extensions to Gloucester and Cheltenham²⁰.

3.16.23 In the JCS it was established that Tewkesbury would establish its district capacity with the publication of its Tewkesbury Borough Plan but this has also not yet been published as of the writing of this report²¹. There is currently a total supply of 34.3ha of employment land in the Tewkesbury Borough²².

Employment land allocations - Cotswold District

3.16.24 In the Cotswold District Local Plan 2011-2031, the council outlined plans to release at least 27ha of land to accommodate B-Class employment uses over the plan period²³. This minimum amount of 27ha of B-Class employment land will be released across the area but focused in 7 principal settlements²⁴.

3.16.25 In total, the Cotswold District Local Plan 2011-2031 allocated employment land to 17 different sub-areas across the Cotswolds.

3.16.26 Table 3.12 below outlines the allocations.

Table 3.12: Identified employment land allocations for sub-areas in the Cotswold District Local Plan.

Settlement	Employment allocation (ha)	Retail need (floor space m2)
Cirencester		
Chesterton	9.1	5,600 sq. m across whole of Cirencester during the plan period
Waterloo car park	0.67	
Sheep Street Island	0.96	
Forum cap park	0.54	
South Cotswold		
Down Ampney	0	0
Fairford	0	0
Kemble	0	0
Lechlade	1.25	0
South Cerney	0	0

²⁰ 'Joint Core Strategy: Gloucester, Cheltenham, Tewkesbury' (2014), page 36. <http://www.gct-ics.org/Documents/Publications/Submission/JCS-Submission-Version-November-2014a-corrected.pdf>

²¹ 'Joint Core Strategy: Gloucester, Cheltenham, Tewkesbury' (2014), page 36. <http://www.gct-ics.org/Documents/Publications/Submission/JCS-Submission-Version-November-2014a-corrected.pdf>

²² 'Joint Core Strategy: Gloucester, Cheltenham, Tewkesbury' (2014), page 36. <http://www.gct-ics.org/Documents/Publications/Submission/JCS-Submission-Version-November-2014a-corrected.pdf>

²³ 'Cotswold District Local Plan 2011-2031' (2016), page 27. http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031/reg_19/reg_19?pointId=3961210

²⁴ Cirencester; Bourton-on-the-Water; Chipping Campden; Lechlade; Moreton-in-Marsh; Tetbury; Willersey.

'Cotswold District Local Plan 2011-2031' (2016), page 27. http://consult.cotswold.gov.uk/portal/fp/local_plan_2011-2031/reg_19/reg_19?pointId=3961210

Settlement	Employment allocation (ha)	Retail need (floor space m2)
Tetbury	2.08	240
Mid Cotswold		
Andoversford	0	0
Bourton-on-the-Water	3.38	310
Northleach	0	0
Stow-on-the-Wold	0	0
Upper Rissington	0	0
North Cotswold		
Blockley	0	0
Chipping Campden	0.67	0
Mickleton	0	0
Moreton in Marsh	9.16	750
Willersey	1.97	0
Total	29.8	6,900

Source: Cotswold District Local Plan 2011-2031

Conclusion

3.16.27 It is evident from examination of the local authority key policies in the vicinity of the A417 Missing Link that there are ambitions across Gloucestershire to foster and benefit from future economic and social development through inclusive growth. This future growth relates to increases in residential housing requirements (see summary Table 3.13 below) as well as 111.5ha employment land across Gloucestershire that would provide a boost to both productivity and employment levels in the local economy once developed.

Table 3.13: Housing Requirements and allocations in study area.

Location	Number of dwellings	
	Housing requirements	Housing allocations
Gloucester City	14,359	13,047
Cheltenham Borough	10,996	10,996
Tewkesbury Borough	9,899	7,057
Cotswold District	8,400	9,842

Source: Various, as indicated in preceding sections

Other government policies

- 3.16.28 The National Planning Policy Framework (Department for Communities and Local Government, March 2012) and National Policy Statement for National Networks (Department for Transport, December 2014) both require applicants to promote sustainable transport, improve accessibility and integrate transport modes.
- 3.16.29 The government requires local authorities to work with transport providers and neighbouring authorities to develop strategies for the provision of large scale roadside facilities to support growth of ports, airports or other major generators of travel demand in their areas and maximise sustainable transport modes. A Transport Statement or Transport Assessment is required for all developments that generate significant movements of traffic.
- 3.16.30 Decisions will consider whether opportunities for sustainable transport modes have been taken up and if safe and suitable access to sites can be achieved for all people. Decisions will only be prevented or refused on transport grounds where residual cumulative impacts of development are severe. Furthermore, the protection and enhancement of public rights of way and access is encouraged, for instance where the national road network severs communities and community facilities and acts as a barrier for walking and cycling, developers are expected to correct historic problems and provide easier and safer access for non-motorised users.
- 3.16.31 The government's strategy for improving accessibility for disabled people is set out in Transport for Everyone (Department for Transport, December 2012), which is an action plan to improve accessibility for all. Compliance with the Equalities Act (2010) is also expected. Further information on guidance at a national level can be found in section 4.2 of this report.

Maintenance and repair statement

- 3.16.32 The A417 is managed by Road Management Services (RMS) Cirencester, the DBFO company. Discussions with RMS are ongoing and further liaison will be required to determine the full details of the existing infrastructure, particularly for sections of online widening where there is an opportunity to integrate the existing carriageway.
- 3.16.33 It has been confirmed that as part of this DBFO contract, during Autumn 2016, a substantial amount of work has been undertaken by the DBFO contractor to renew key parts of the infrastructure on the A417. This included resurfacing of the Air Balloon roundabout, sections of Birdlip and Crickley Hill. There was also laying of high friction surfacing on the approaches to Air Balloon roundabout, and renewal of kerbing, road studs, road markings and road signs.
- 3.16.34 The design of all options will be undertaken with consideration of eliminating the need for future maintenance activities that would impose risks upon those that work on the highway.

- 3.16.35 Where the asset is deemed to be required and in accordance with IAN 69/15, civil engineering design principles will be considered where practicable to:
- Reduce the effort when maintaining i.e. avoid using hard to reach locations such as the underside of bridges for mounting point for maintainable assets such as lighting.
 - Reduce the proximity of maintainers to hazards i.e. drainage to be designed to avoid locating manholes on running lanes or hardshoulders,
 - Improve access i.e. walkways and ladders provided at structures.
 - Improve management systems i.e. improve asset management standards to reduce site visits where possible by storing records of bolt types, fittings, lengths, etc.
 - Provide safe and convenient diversion options as that currently used by the DBFO utilising the A40 and the A429.
 - Provide identifiers i.e. reduce time exposure to risk during maintenance by improved labelling of maintainable assets for rapid identification.
 - Anti-theft / vandalism i.e. reduce triggers for maintenance by considering anti-graffiti coatings.
 - Tunnel maintenance would be subject to the provisions in RTSR 2007 (excludes options 12 and 30).
 - Tunnel closure for maintenance would take place on a cyclical basis only during night-time, quiet periods and excluding periods when more traffic than normal is expected (excludes options 12 and 30).
 - The route diversion would operate along current sections of the A417 along with other roads of the highway network. Traffic management needs during tunnel maintenance is subject to further assessment relative to each option under consideration (excludes options 12 and 30).
- 3.16.36 The design of all options will be developed adhering to the Construction (Design and Management) Regulations (CDM 2015). Further information regarding CDM is discussed in section 10.3.

4. Planning factors

4.1 Legislation and guidance - International, European and national

4.1.1 Relevant international, European and national land use planning and environmental legislation applicable to the scheme constraints has been listed according to the topic in Table 4.1 below²⁵.

Table 4.1: International Legislation

Topic	Key International, European and National Environmental Legislation
Air Quality	<p>International and European</p> <p>The Ambient Air Quality Directive (2008/50/EC) – Sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health such as particulate matter (PM₁₀ and PM_{2.5}) and nitrogen dioxide (NO₂).</p> <p>The proposed options have the potential to affect air quality. The scheme would need to ensure that pollutant limits are not exceeded.</p> <hr/> <p>National</p> <p>The Air Quality Standards Regulations 2010 – Implements the EU’s Directive 2008/50/EC and transposes the Directive into UK law. This covers both human health and ecologically designated sites.</p> <p>The scheme would need to ensure that pollutant limits are not exceeded and that sensitive receptors are not adversely affected.</p> <p>Air Quality (England) Regulations 2000 and Air Quality (England) (Amendment) Regulations 2002 – Set air quality objectives specifically for use by local authorities in carrying out their air quality management duties under Part IV of the Environment Act 1995, which requires the Secretary of State to produce a national Air Quality Strategy and for local authorities to monitor air quality in their area. Any parts of an authority’s area where the objectives are not being achieved, or are not likely to be achieved within the relevant period must be identified and declared as an Air Quality Management Area (AQMA).</p> <p>There is 1 AQMA within the study area of the proposed scheme - Birdlip AQMA at the Air Balloon roundabout.</p> <p>The Environmental Protection Act 1990, Section 79(1)(d) – Defines one type of ‘statutory nuisance’ as ‘<i>any dust, steam, smell or other effluvia arising on industrial, trade or business premises and being prejudicial to health or a nuisance</i>’. Where a local authority is satisfied that a statutory nuisance exists, or is likely to occur or recur, it must serve an abatement notice.</p> <p>The construction stage of any of the proposed options has the potential to cause nuisance.</p>
Cultural Heritage	<p>International and European</p> <p>No legislation applicable</p>

²⁵ The legislation included in Table 4.1 contains key relevant legislation and is not exhaustive.

Topic	Key International, European and National Environmental Legislation
	<p>National</p> <p>The Ancient Monuments and Archaeological Areas Act 1979 – Provides for the protection of Scheduled Monuments through a designated schedule of monuments and also allows the Secretary of State to designate areas of archaeological importance.</p> <p>Relevant with regard to the impact upon the setting of the Scheduled Monuments that have the potential to be affected by the proposed scheme.</p> <p>The Planning (Listed Buildings and Conservation Areas) Act 2009 – Provides for the protection of Listed Buildings and Conservation Areas.</p> <p>Relevant with regard to the impact upon the setting of the Listed Buildings that have the potential to be affected by the proposed scheme.</p>
Landscape	<p>International and European</p> <p>No legislation applicable</p> <hr/> <p>National</p> <p>Countryside and Rights of Way (CRoW) Act 2000 – Places a duty on Government Departments 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 AONB when exercising or performing any functions affecting land in the AONB.</p> <p>There are habitats and species of conservation importance within the footprint of all of the proposed options. The scheme lies within the Cotswolds AONB.</p>
Nature Conservation and Biodiversity	<p>International and European</p> <p>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.</p> <p>There are protected habitats and species within the footprint of all of the proposed options.</p> <p>The EC Directive on the Conservation of Wild Birds ('Birds Directive 1979') (as amended) (79/409/EEC) – Provides a framework for the conservation and management of, and human interactions with, wild birds in Europe.</p> <p>There is the potential for habitats suitable for wild birds, including nesting and breeding birds, within the footprint of all of the proposed options.</p>

Topic	Key International, European and National Environmental Legislation
	<p>National</p> <p>Wildlife and Countryside Act 1981 (as amended) – Protects all wild birds, certain wild animals and certain wild plants.</p> <p>There are habitats and species of conservation importance within the footprint of all of the proposed options.</p> <p>Conservation of Habitats and Species Regulations 2017 – Provide for the designation and protection of ‘European sites’, the protection of ‘European protected sites’, and the adaptation of planning and other controls for the protection of European sites.</p> <p>There are two Special Areas of Conservation; Cotswolds Beechwoods SAC and Wye Valley and Forest of Dean Bat Sites SAC designated for their bat populations within 30km of the existing A417.</p> <p>Countryside and Rights of Way (CRoW) Act 2000 – Places a duty on Government Departments to have regard for the conservation of biodiversity and maintain lists of species and habitats for which conservation steps should be taken or promoted.</p> <p>There are habitats and species of conservation importance within the footprint of all of the proposed options.</p> <p>Natural Environment and Rural Communities (NERC) Act 2006 – Requires public bodies, including local authorities, ‘to have regard to the conservation of biodiversity in England’ when carrying out their normal functions.</p> <p>There are habitats and species of conservation importance within the footprint of all of the proposed options.</p>
Noise and Vibration	<p>International and European</p> <p>EC Directive on the assessment and management of environmental noise (2002/49/EC) – Sets out a common 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.</p> <p>Both construction and operation phases for all of the proposed options have the potential to increase noise levels and adversely affect sensitive receptors.</p>
	<p>National</p> <p>The Environmental Protection Act 1990, Part III – Under Part III of the Act, certain 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...’</p> <p>Construction activities associated with the proposed options could lead to a statutory nuisance if best practice measures are not undertaken to prevent noisy and dust-creating works.</p>
Road Drainage and	<p>International and European</p> <p>The EC Water Framework (WFD) Directive (2000/60/EC) – Sets an overarching programme to deliver long-term protection of the water</p>

Topic	Key International, European and National Environmental Legislation
the Water Environment	<p>environment and to improve the chemical and ecological health of all waters (groundwater and surface water) and associated wetlands.</p> <p>There are 4 WFD waterbodies within the scheme area.</p> <p>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.</p> <p>There are rivers, streams and areas of standing water with the potential to support biodiversity that require protection.</p> <p>The EC Directive on the Conservation of Wild Birds ('Birds Directive 1979') as amended (79/409/EEC) - Provides a framework for the conservation and management of, and human interactions with, wild birds in Europe.</p> <p>There are a large number of waterbodies with the potential to support wild birds that require protection.</p> <hr/> <p>National</p> <p>The Water Environment (WFD) (England and Wales) Regulations 2017 – Implements the WFD Directive into UK Legislation. The purpose of the Directive is to establish a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater.</p> <p>There are 7 WFD waterbodies within close proximity to the proposed options. Replaces the 2003 regulations, consolidating amendments made since then, and primarily affect the management of water quality by the Environment Agency.</p> <p>The Environmental Permitting Regulations 2010 – Aims to protect groundwater and surface waters from pollution by controlling the inputs of potentially harmful and polluting substances.</p>
People and Communities	<p>International and European</p> <p>Not applicable</p> <hr/> <p>National</p> <p>Not applicable</p>
Geology, Soils and Materials	<p>International and European</p> <p>The EC Water Framework Directive (WFD) (2000/60/EC) – Sets an overarching programme to deliver long-term protection of the water environment and to improve the chemical and ecological health of all waters (groundwater and surface water) and associated wetlands.</p> <p>There are 7 WFD waterbodies within close proximity to the proposed options.</p> <p>The EC Framework Directive on Waste (2008/98/EC) – Requires member states to take appropriate measures to encourage the</p>

Topic

Key International, European and National Environmental Legislation

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 construction activities associated with all of the proposed options will lead to the production of some waste.

EU Groundwater Daughter Directive (2006/118/EC) – Aims for the protection of groundwater against pollution and deterioration

National

The Environmental Protection Act (EPA) 1990, Part II – This section sets out a regime for regulating and licencing the acceptable disposal of controlled waste on land. Controlled waste is any household, industrial and commercial waste. Part II stipulates that controlled waste must be treated, stored and disposed of in a manner that is not likely to cause pollution of the environment or harm to human health.

The construction of the scheme will require the disposal of some controlled waste.

The Environmental Protection Act (EPA) 1990, Part IIA – Part IIA principally deals with sites where individual historic contamination linkages present a “Significant Possibility of Significant Harm” (SPOSH) or a “Significant Possibility of Significant Pollution to Controlled Waters” (SPOSPCOW) representing an unacceptable level of contamination risk for each linkage.

There are a number of historic landfills and 1 authorised landfill in close proximity to all of the proposed options with the potential for contaminated land to be present.

The Contaminated Land (England) Regulations 2006 (as amended) – Set out provisions relating to the identification and remediation of contaminated land under Part 2A of the Environmental Protection Act 1990.

There are a number of historic landfills and 1 authorised landfill in close proximity to all of the proposed options with the potential for contaminated land to be present.

Waste (England and Wales) Regulations 2011 (as amended) – Require organisations 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 proposed scheme is to be dealt with in line with the Waste Hierarchy.

The Hazardous Waste (England and Wales) Regulations 2009 – Define what constitutes hazardous waste and set out the controls on handling such wastes. The movement of hazardous waste is to be documented by a system of consignment notes.

The construction of the scheme may lead to the production of some hazardous waste.

Topic	Key International, European and National Environmental Legislation
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Environmental Protection (Duty of care) Regulations 1991 – Sets out the documentary requirements as part of waste management. Transfers of waste must be accompanied by a transfer note containing a description of the waste, details concerning the ‘transferor’ and the ‘transferee’, and the place and time of the transfer.

The construction of the scheme will require the disposal of some controlled waste.

Clean Neighbourhoods and Environment Act 2005 – Sets out new provisions for local environmental and social issues such as litter, fly-tipping and anti-social behaviour.

Will be of particular relevance during the construction of the proposed scheme.

Landfill (England and Wales) Regulations 2002 (as amended) – Aims to reduce the negative environmental and health impacts associated with landfilling waste.

The scheme has the potential to produce waste that cannot be used and will therefore need to be landfilled.

Control of Substances Hazardous to Health Regulations 2002 (COSHH) and the Construction (Design and Management) Regulations 2015 (CDM 2015) – Under these sets of regulations,

where a developer knows or suspects the presence of contaminated soil, provision must be made to ensure that risks to the public and site works are controlled. The CDM aims to improve health and safety in the construction industry.

There are a number of historic landfills and 1 authorised landfill in close proximity to all of the proposed options with the potential for contaminated land to be present.

Climate	International and European Not applicable
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National

The Climate Change Act 2008 – forms part of the UK government’s plan to reduce greenhouse gas emissions, committing the Government to a reduction of greenhouse gases by at least 80% of 1990 levels by 2050.

The scheme may contribute to climate change through producing greenhouse gas emissions.

Environmental Planning	International and European The Environmental Impact Assessment (EIA) Directive (2011/92/EU) (as amended) – Before development consent is given, Member States must take all measures necessary to make sure that projects likely to have significant effects on the environment by virtue of their nature, size or location are subject to an Environmental Impact Assessment (EIA).
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Topic

Key International, European and National Environmental Legislation

The scheme will be subject to an EIA as this type of development falls within Annex 1 of the EIA Directive.

National

The Planning Act 2008 – Establishes a system to deal with Nationally Significant Infrastructure Projects (NSIPs) and also to introduce a community infrastructure levy that can be charged on developers by local authorities.

The area of development for the proposed options is, on average, 80 hectares, which exceeds the relevant threshold of 12.5 hectares in section 22 (4) (b) of the Planning Act 2008 for the construction or alteration of highways, other than motorways, where the speed limit for any class of vehicle is expected to be 50 miles per hour or greater. The scheme is therefore considered an NSIP for the purposes of sections 14 (1) (h) and 22 of the 2008 Act.

The Highway and Railway (Nationally Significant Infrastructure Project) Order 2013 – Made amendments to the Planning Act 2008 to ensure that only genuinely nationally significant infrastructure projects fall within the Development Consent Order (DCO) regime; highway related development is only considered an NSIP where it exceeds specific thresholds.

As described above, the scheme is considered to be an NSIP.

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended) – These regulations are in accordance with the Planning Act 2008 and impose various procedural requirements, in particular the carrying out of an EIA in relation to applications for development consent and subsequent consent.

The scheme will be subject to an EIA as this type of development falls within Annex 1 of the EIA Directive.

4.2 Legislation and guidance - national

- 4.2.1 Policy at the national level for each environmental topic is set out in the National Networks National Policy Statement (NNNPS), the National Planning Policy Framework (NPPF), and National Planning Practice Guidance (NPPG). A summary of each is given below, and Table 4.2 provides a summary of the guidance relevant to each environmental topic contained within the documents.

National Networks National Policy Statement

- 4.2.2 The NNNPS sets out the need for, and Government's policies to deliver development of, NSIPs on the national road network in England and sets out the primary basis for making decisions of development consent for NSIPs in England. There are no specific policies for NSIPs in the NPPF. The Secretary of State determines these in accordance with the Planning Act 2008 and relevant national policy statements (NPSs) for major infrastructure, as well as any other matters that are considered both important and relevant.

4.2.3 Relevant policies from the NNNPS for each environmental topic are listed below in Table 4.2.

National Planning Policy Framework

4.2.4 The NPPF sets out the Government’s planning policies for England and the requirements for the planning system. It provides a framework within which local authorities and residents can produce local and neighbourhood plans reflecting the needs and priorities of communities. The NPPF was published in March 2012 and sets out the Government’s planning policies for England and how these are expected to be applied. The framework acts as guidance for local planning authorities and decision-makers, both in drawing up plans and making decisions about planning applications.

Table 4.2: National Policy

Topic	Relevant National Policies
Air Quality	<p>NNNPS</p> <p>Where (after considering mitigation) a project would lead to a significant air quality impact in relation to EIA and/or lead to deterioration in air quality in a zone / agglomeration, substantial air quality considerations should be given. The Secretary of State should refuse consent where, after taking into account mitigation, the air quality impacts of the scheme will either result in a zone / agglomeration which is currently reported as being compliant with the Air Quality Directive becoming non-compliant, or affect the ability of a non-compliant area to achieve compliance.</p>
Cultural Heritage	<p>NNNPS</p> <p>The Secretary of State should identify and assess the particular significance of any heritage asset that may be affected by a development, whilst the significance of the heritage asset and value they hold now and in the future should also be considered. Substantial harm to or loss of designated assets of the highest significance should be wholly exceptional. Where a proposed development would lead to the substantial harm or total loss of significance of a heritage asset, the Secretary of State should refuse consent unless it can be demonstrated that substantial public benefits outweigh the loss or harm.</p>
Landscape	<p>NNNPS</p> <p>The scheme assessment should consider any relevant national and local development policy, significant effects during construction and operation, and visibility and conspicuousness. Compliance with the respective duties in section 11A of the National Parks and Access to Countryside Act 1949 and section 85 of the Countryside and Rights of Way Act 2000 is required. Local designations should be given consideration in decision making by the Secretary of State, and the Secretary of State will judge whether visual effects on sensitive receptors outweigh the benefits of the development.</p>

Topic	Relevant National Policies
Nature Conservation and Biodiversity	<p>NNNPS</p> <p>The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity conservation interests including appropriate mitigation measures. Prior to granting Development Consent, the Secretary of State must, under the Habitats Regulations, consider whether the project would be likely to have a significant effect on the objectives of a European site, or on any site to which the same protection.</p>
Noise and Vibration	<p>NNNPS</p> <p>Developments to be undertaken in accordance with the statutory requirements for noise. Applicants should identify measures to avoid, reduce or compensate for adverse health impacts as a result of noise, and contributes to improvements to health and quality of life through effective management and control of noise. For most national network projects, the relevant Noise Insulation Regulations will apply.</p>
Road Drainage and the Water Environment	<p>NNNPS</p> <p>Applications for schemes in Flood Zones 2 and 3 should be accompanied by a FRA. In addition, applications for schemes that are located within Flood Zone 1 and are 1 hectare in area or greater, or subject to other sources of flooding (local watercourses, surface water, groundwater or reservoirs), or where the Environment Agency has notified the local planning authority that there are critical drainage problems, should also be accompanied by an FRA. For projects which may be affected by, or may add to flood risk, sufficiently early pre-application discussions should be sought between the applicant and the Environment Agency, and, where relevant, other flood risk management bodies. Surface water flood issues also need to be understood and then taken account of.</p>
People and Communities	<p>NNNPS</p> <p>For the development of the national road networks to be sustainable they should be designed to reduce social and environmental impacts to improve quality of life. Evidence should be provided by applicants, demonstrating that reasonable opportunities have been considered to deliver environmental and social benefits as part of schemes. Existing open space should not be developed unless the land is surplus to requirements or the loss would be replaced by equivalent or better provision in terms of quantity and quality in a suitable location. PRowS, National Trails, and other rights of access to land (e.g. open access land) are important recreational facilities for walkers, cyclists and equestrians. Applicants should consider appropriate mitigation measures to address adverse effects on coastal access, National Trails, other PRowS and open access land and, where appropriate, to consider what opportunities there may be to improve access.</p>
Geology, Soils and Materials	<p>NNNPS</p> <p>Where necessary, land stability should be considered in respect of new development, as set out in the NPPF and supporting planning</p>

Topic	Relevant National Policies
	guidance. Specifically, proposals should be appropriate for the location, including preventing unacceptable risks from land instability. The decision-maker should take into account the economic and other benefits of the best and most versatile agricultural land.
Climate Change	<p>NNNPS</p> <p>Applications should set out how the effects of climate change should be taken into account when developing and consenting infrastructure. The latest UK Climate Projections should be used to take into account the potential impacts of climate change and influence adaptation measures, covering the estimated lifetime of the new infrastructure.</p>

Road Investment Strategy and Highways England Strategic Business Plan

- 4.2.5 In addition to the above national guidance documents, the *Road Investment Strategy: for the 2015/16-2019/20 Period* (Department for Transport, December 2014, updated March 2015), outlines a long-term programme to improve England’s motorways and major roads (the Strategic Road Network (SRN)). The *Road Investment Strategy* comprises:
- A long-term vision for England’s motorways and major roads, outlining how the Department for Transport will create smooth, smart and sustainable roads.
 - A multi-year investment plan that will be used to improve the network and create better roads for users.
 - High-level objectives for the first roads period 2015 to 2020.
- 4.2.6 There is substantial provision within the RIS to enable the programme of investment to deliver better environmental outcomes. The Strategic Business Plan (Highways England, 2014) sets out how Highways England will deliver the investment plan and performance requirements set out within the government’s RIS over the coming 5-years. One of the key objectives of the Strategic Business Plan is for an improved environment, where the impact of the activities are further reduced ensuring a long-term and sustainable benefit to the environment. With this in mind, Highways England has created a series of ring-fenced funds (‘Designated Funds’), to address a range of specific issues over and above the traditional focus of road investment. These funds allow for actions beyond business as usual and will help the company invest in retrofitting measures to improve the existing road network as well as maximising the opportunities offered by new road schemes to deliver additional improvements at the same time.
- 4.2.7 A £300 million Environment Fund is available and relevant to the A417 Missing Link scheme. This fund is to deliver specific enhancements to the network, which will enable the Company to deliver the improved environmental outcomes. The fund will be used to mitigate the worst impacts of noise on those living close to the network, support the transition to low-carbon road transport, improve local

water quality and resilience to flooding, maintain an attractive landscape, and work to halt the loss of biodiversity.

- 4.2.8 Highways England strives to do even more to deliver improved outcomes for those living and working near the network, for example through the provision of new crossings and also the intention to produce our first National Cycling Strategy by the end of 2015.
- 4.2.9 Highways England has also ring-fenced £250 million in a Cycling, Safety and Integration Fund to help deliver improvements in these areas through both bespoke interventions, as well as enhancements to new and existing schemes. This includes investing £100 million to improve cycling provision on at least 200 sections of the network, as well as ensuring all new schemes are cycle-proofed. Another £105 million will be spent on additional measures to boost safety that extend beyond the high safety standards already in place.
- 4.2.10 Highways England have also stated that the SRN must be easier to get over, under or around to ensure that roads serve communities instead of severing them. Around £45 million of the Cycling, Safety and Innovation fund is therefore dedicated to improving all elements of integration.

DEFRA Environment Plan “A Green Future: Our 25 Year Plan to Improve the Environment”

- 4.2.11 On the 11th of January 2018 Defra published an environmental plan “A Green Future: Our 25 Year Plan to Improve the Environment” which sets out the Government’s ambition to be the first generation to leave the environment in a better state than it was found. It aims to deliver cleaner air and water in cities and rural landscapes, protect threatened species and provide richer wildlife habitats. It calls for an approach to agriculture, forestry, land use and fishing that puts the environment first. It is intended to be read as a statement of intent, setting the direction of travel for future government policy.
- 4.2.12 The plan has identified a number of goals and 6 areas where future policy will be focused, including embedding an ‘environmental net gain’ principle for development, including infrastructure. The 25 Year Plan and any subsequent new legislation or policies that arise from this plan will be taken into consideration during subsequent stages of the assessment, where appropriate.

Highways England Environment Strategy

- 4.2.13 The Highways England Environment Strategy²⁶ sets out Highways England’s vision that will guide their environmental actions and activities over the next 5 years. The strategy outlines Highways England’s commitment to improve their environmental outcomes. In doing this, it seeks to help protect, manage and enhance the quality of the surrounding environment, with a focus on people and

²⁶Highways England (2017) Environment Strategy: Our Approach [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/605063/Environment_Strategy_21_.pdf (last accessed July 2017).

the built, natural and historic environment. The strategy will be delivered through all aspects of Highways England's business, and in particular the operation, maintenance and improvement of Highways England's network.

Highways England Sustainable Development Strategy

4.2.14 Highways England's Sustainable Development Strategy²⁷ intends to communicate the approach and priorities for sustainable development to Highways England's key stakeholders. Sustainable development is defined in Highways England's licence to operate as "encouraging economic growth whilst protecting the environment and improving safety and quality of life for current and future generations".

4.3 Legislation and guidance - local

4.3.1 Local planning and land-use policy of relevance to the A417 Missing Link scheme is outlined below for information only.

Cotswold Emerging Local Plan (2011 – 2031)

4.3.2 The Cotswold Emerging Local Plan was published in June 2016 and defines the spatial implications of economic, social and environmental change. The Local Plan includes a collection of policies which set out the long-term vision and strategic context for managing and accommodating economic and social growth within Cirencester whilst protecting and enhancing the local environment. Policies based around environmental protection include the following:

- **Policy EN1 Natural and historic environment:** New development will, where appropriate, promote the protection, conservation and enhancement of the historic and natural environment by:
 - ensuring the protection and enhancement of existing environmental assets.
 - contributing to the provision and enhancement of green infrastructure.
 - addressing climate change, habitat loss and fragmentation.
 - seeking to improve air, soil and water quality where feasible.
 - ensuring design standards that complement the character of the area.
- **Policy EN2 The wider natural and historic landscape:** Development will be permitted where it does not have a significant detrimental impact on the natural and historic landscape (including the tranquillity of the countryside) of Cotswold District or neighbouring areas; and, proposals will take account of landscape and historic landscape character, visual quality and local distinctiveness.

²⁷ Highways England (2017) Sustainable Development Strategy: Our Approach [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/605079/Sustainable_Development_Strategy_6.pdf (last accessed July 2017).

- **Policy EN3 Cotswolds area of outstanding natural beauty:** great weight will be given in determining development proposals within the AONB and major development will not be permitted within the AONB unless it satisfies the exceptions set out in national Policy and Guidance.
- **Policy EN4: Special landscape areas:** Development within Special Landscape Areas that demonstrably meets the economic and social needs of communities will be permitted provided it does not have a detrimental impact upon:
 - the quality of the natural or historic environment.
 - the landscape character, appearance or tranquillity of the area.
- **Policy EN5 Trees, hedgerows and woodlands:** Where such natural assets are likely to be affected, development will not be permitted that fails to conserve and enhance:
 - trees of high landscape, amenity, ecological or historical value;
 - veteran trees.
 - hedgerows of high landscape, amenity, ecological or historical value.
 - woodland of high landscape, amenity, ecological or historical value.
- **Policy EN6 Biodiversity and geodiversity:** Features, Habitats and Species: Development will be permitted that conserves and enhances biodiversity and geodiversity, providing net gains where possible. Proposals that would result in significant habitat fragmentation and loss of ecological connectivity will not be permitted.
- **Policy EN7 Biodiversity and geodiversity:** Designated Sites: Internationally designated wildlife sites will be safeguarded from development that could adversely affect them. Development that is likely to have an adverse effect upon a nationally designated nature conservation site will not be permitted unless the benefits of development at the site clearly outweigh the impact development is likely to have. Proposals that are likely to cause significant harm to locally identified wildlife sites and Local Nature Reserves will not be permitted unless it can be demonstrated that the benefits of the proposal clearly outweigh the impacts.
- **Policy EN8 Designated heritage assets:** Conservation areas: Proposals that would affect Conservation Areas and their settings will be permitted provided they meet the particular policy requirements.
- **Policy EN10 Non-Designated heritage assets:** Development affecting a non-designated heritage asset will be permitted provided the proposal satisfactorily demonstrates how the asset will be retained, and how any special features that contribute to the asset's significance will be retained or enhanced as appropriate.

- **Policy EN11 Pollution and contaminated land:** Development will be permitted that does not result in unacceptable:
 - risk to public health or safety, the natural environment or existing land uses.
 - levels of pollution of the air, land, surface water, or ground water sources.
 - noise or light levels (pollution), or other disturbance such as spillage, flicker, vibration, dust or smell.
- **Policy INF7 Green infrastructure:** All development proposals must contribute, depending on their scale, use and location, to the protection and enhancement of existing Green Infrastructure and/or the delivery of new Green Infrastructure.
- **Policy INF8 Managing flood risk and the water environment:** Minimise the risk of flooding and providing resilience to flooding, taking account of climate change.

DRAFT Joint Core Strategy Gloucester Cheltenham Tewkesbury

4.3.3 The Gloucester, Cheltenham and Tewkesbury Joint Core Strategy will form a key part of the development plan for the area. The Strategy is still to be adopted by each of the boroughs. Relevant policies are likely to include:

- Policy SD7: Landscape
- Policy SD8: The Cotswolds AONB
- Policy SD9: Historic Environment
- Policy SD10: Biodiversity and Geodiversity
- Policy SD15: Health and Environmental Quality
- Policy INF3: Flood Risk Management
- Policy INF4: Green Infrastructure
- Policy INF5: Social and Community Infrastructure

DRAFT Tewkesbury Borough Plan 2011 – 2031

4.3.4 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 JCS. Relevant draft policies include:

- Policy IRC1: Community Infrastructure
- Policy TRAC1: Cycle Network & Infrastructure
- Policy TRAC2: Pedestrian Accessibility
- Policy RCN1: Outdoor Playing Space
- Policy RCN3: Horse Riding Facilities
- Policy HER4: Buildings and Features of Local Historic, Industrial Archaeological or Architectural Interest
- Policy HER6: Historic Parks and Gardens
- Policy ENV1: Special Landscape Areas
- Policy ENV2: Landscape Protection Zones

- Policy ENV3: Locally Important Open Spaces
- Policy ENV4: Key Wildlife Sites, Strategic Nature Areas and Regionally Important Geological / Geomorphological Sites
- Policy ENV5: Ponds

4.4 Environmental Impact Assessment Determination – Screening

4.4.1 All options currently under consideration would be classed as a NSIP under the Planning Act 2008 Section 2 as amended by The Highway and Railway (Nationally Significant Infrastructure Project) Order 2013 by virtue of the fact that they would meet the following criteria:

- The scheme would involve the construction of a highway that is wholly within England for which the Secretary of State is the highway authority.
- The scheme would involve 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, and the land take required is in excess of 12.5 hectares.

5. Options development

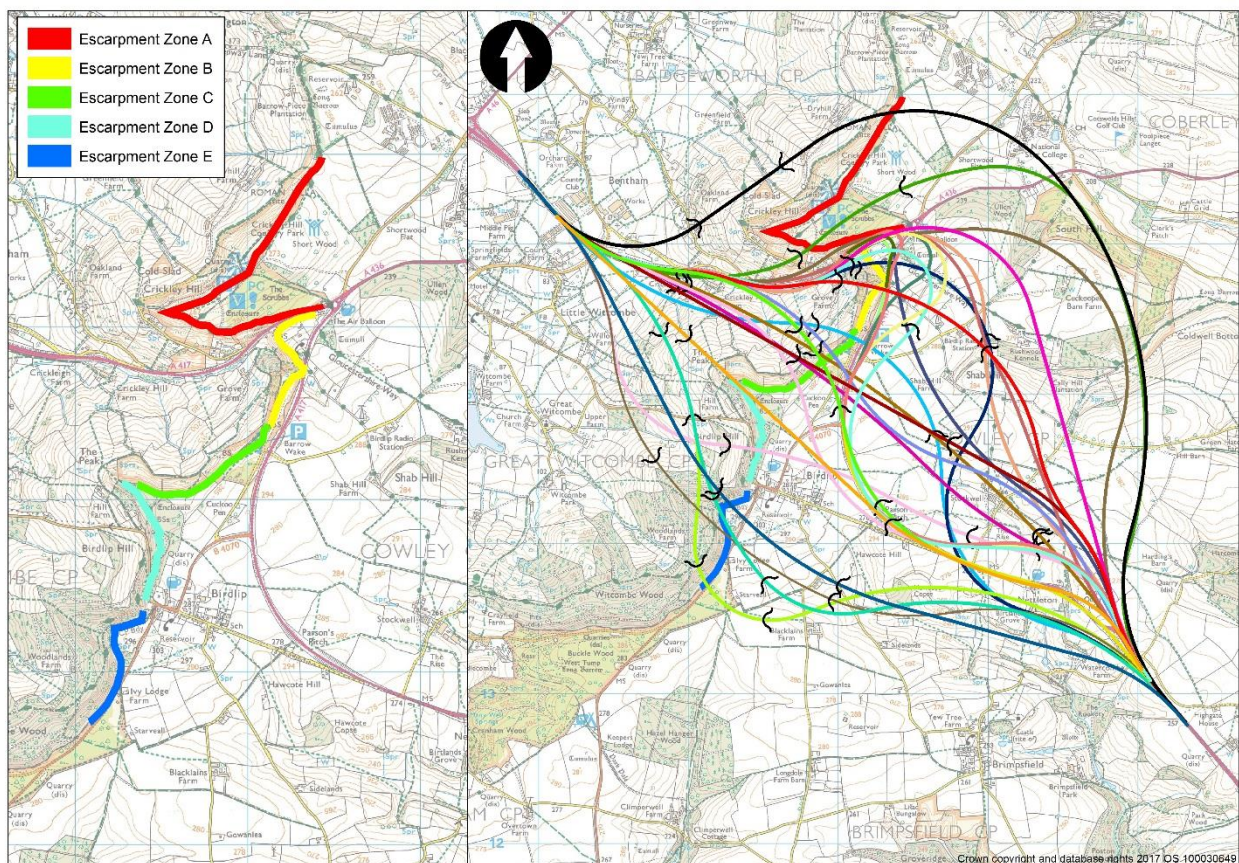
5.1 Initial option generation

5.1.1 The process of identifying the initial set of 30 possible options was completed by utilising multiple sources for the route corridors:

- Historic work completed by WSP, Gloucestershire County Council and Highways Agency
- Option outputs from Project Control Framework (PCF) Stage 0
- Option outputs from PCF Stage 1 initial value management workshop
- Refinement and resolution of alternative route solutions by the immediate project team

5.1.2 The topography of the study area enables different solutions to be considered, so to allow ease of reference the various options have been categorised relative to where they cross the escarpment. This will allow the review and comparison of smaller groups of routes. Figure 5.1 below provides a plan of the 30 options and their escarpment corridor. Refer to sections 5.2 to 5.7 for plans of the individual escarpment corridors.

Figure 5.1: Options and escarpment corridors



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5.1.3 The identified options have been developed as centreline alignments to allow the assessment of both horizontal and vertical alignment, a critical element of highway design. These alignments also provide a suitable route to assess likely

impacts in relation to surface (structures, hydrology, ecology and landscape) and sub-surface features (geotechnical, geology, drainage, archaeology and hydrogeology).

5.1.4 The outline vertical alignments were produced from the existing ground profile to gain an indication regarding how each option might integrate into the landscape. Each alignment was compliant with geometric standards. In Stage 1, the alignment work is subject to further development and limitations such as:

- Environmental mitigation - although environmental constraints were avoided where possible, this was not always achievable. For example, mitigation of the visual impact resulting from any proposed route being near or above existing ground level was not fully considered at this early stage. Though on occasion, although the centreline of a route may have avoided environmental constraints and property, the earthworks footprint may not have done.
- Earthworks balance - most of the options comprised an earthworks surplus which would need to be balanced in future route development.
- Tunnel length - tunnel lengths were shown indicatively during the initial work with future opportunity to refine the lengths as the design process developed.

5.1.5 A reference length has been measured for each option based on travel distance between 2 points on the A417 at each end of the scheme (Brockworth bypass to the west and Cowley roundabout to the east). Whilst these are not necessarily construction lengths, they were used for comparison purposes during assessment. The length for the existing road was measured to be 6784m.

5.1.6 Reference lengths and gradients of individual options are stated in Table 5.1 below

Table 5.1: Option lengths and gradients

Option	Reference length (m)	Maximum Gradient (%)
1	5,034	8
2	5,266	8
3	4,722	8.6
4	6,300	8
5	6,100	8
6	5,665	8
7	7,985	8
8	638	11.5
9	5,357	8
10	5,196	18
11	5,800	8.4
12	6,430	8.4
13	4,600	8
14	5,072	8
15	5,900	8.5
16	6,269	8.4

Option	Reference length (m)	Maximum Gradient (%)
17	3,658	9
18	3,574	-
19	5,867	10
20	4,582	4.5
21	4,630	5
22	4,528	5.2
23	6,208	8
24	6,103	6
25	6,616	7.5
26	7,736	8
27	6,902	8
28	6,030	8
29	5,667	6
30	5,540	7.5

5.1.7 Indications of possible junction strategies and treatments of local roads were considered for each option. However, these would require further consideration for those options progressed to future stages.

5.2 Escarpment corridors

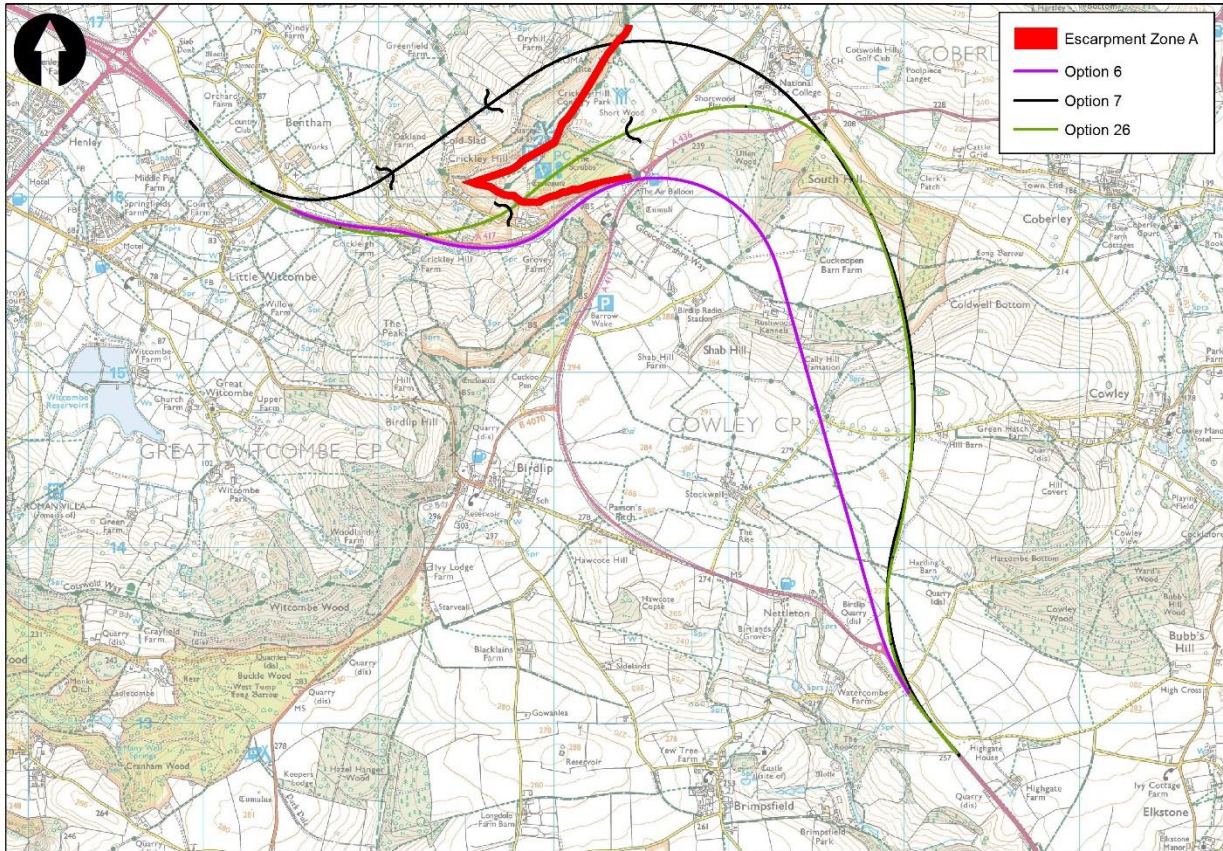
5.2.1 The 30 options can broadly be classified into 5 escarpment corridors as described in Table 5.2.

Table 5.2: Escarpment corridor description

Escarpment corridor	Colour	Description
A	Red	Escarpment corridor A includes options which cross the escarpment north of the existing Air Balloon roundabout and routes which re-use the existing Crickley Hill highways corridor. Options within this corridor include 6, 7 and 26.
B	Yellow	Escarpment corridor B includes options which cross the escarpment south of the existing Air Balloon roundabout and Barrow Wake viewpoint. Options within this corridor include 3, 4, 8, 11, 12, 15, 16, 17, 18, 19, 27 and 30
C	Green	Escarpment corridor C includes routes options which cross the escarpment between Barrow Wake viewpoint and the promontory (The Peak). Options included in this corridor include 2, 9, 10, 13, 14, 20, 21, 22 and 28
D	Cyan	Escarpment corridor D includes options which cross the escarpment north of Birdlip between the promontory (The Peak) and the junction of the B4070 and Roman Road to Witcombe. Options within this corridor include 1 and 29.
E	Blue	Escarpment corridor E includes options which cross the escarpment south of Birdlip between Witcombe Wood and the junction of the B4070 and Roman Road to Witcombe. Options within this corridor include 5, 23, 24 and 25.

5.3 Escarpment corridor A

Figure 5.2: Escarpment corridor A options



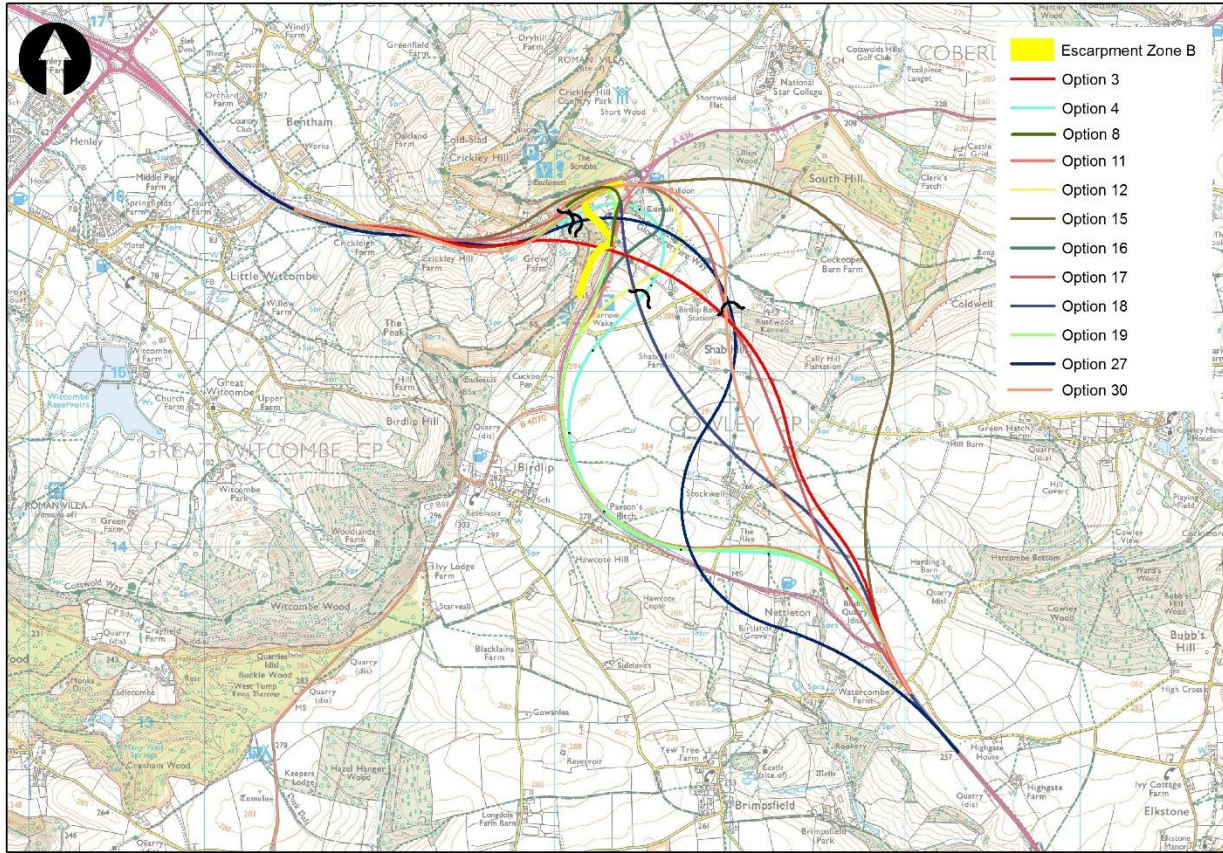
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Table 5.3: Escarpment corridor A options

Option	Description
6	Route from Air Balloon junction to Cowley roundabout aligned to east of existing carriageway and Shab Hill.
7	Route from A417 / A46 Shurdington Road junction to Cowley roundabout aligned to east of existing carriageway and avoiding Crickley Hill Country Park, with a 0.8km tunnel and 0.9km viaduct.
26	Off-line route from Crickley Hill east of the existing carriageway with a 0.8km section of tunnel below Crickley Hill Country Park.

5.4 Escarpment corridor B

Figure 5.3: Escarpment corridor B options



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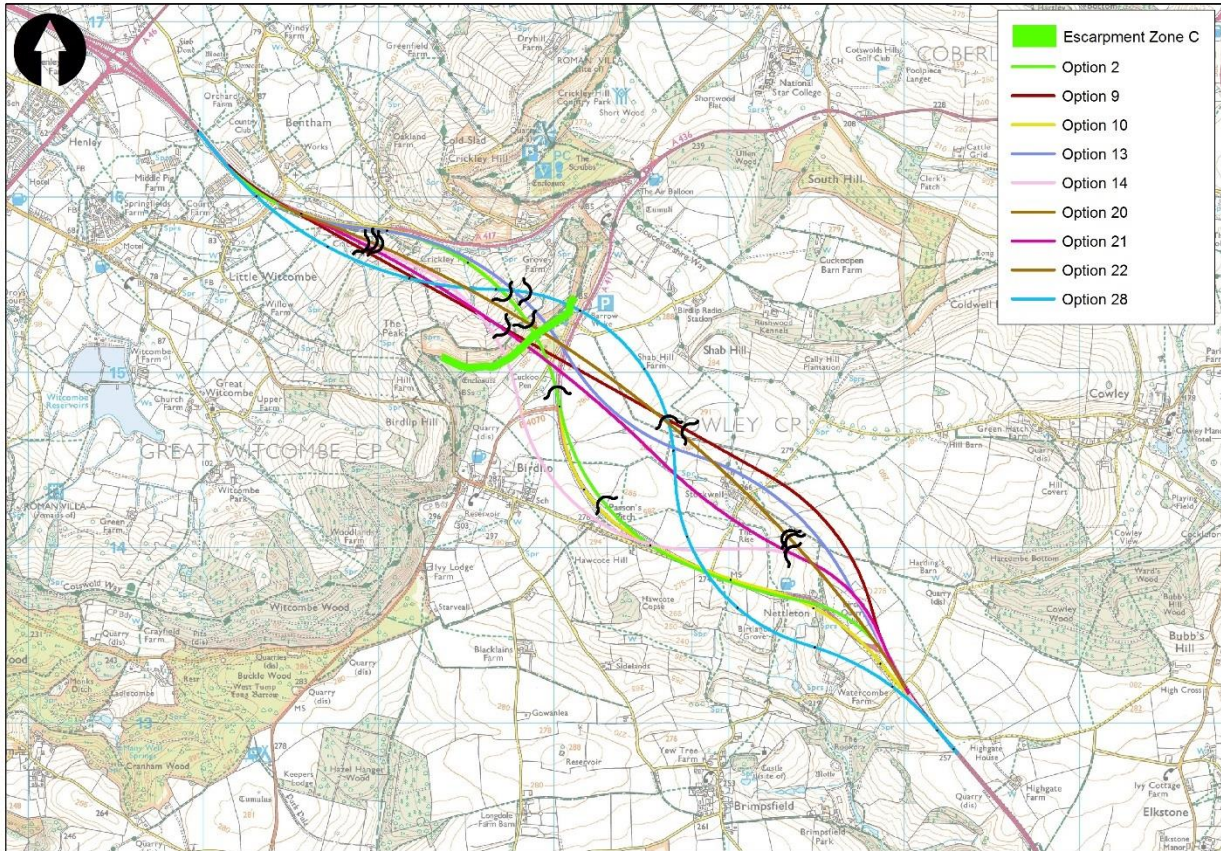
Table 5.4: Escarpment corridor B options

Option	Description
3	Online upgrade of existing carriageway from A417 / A46 Shurdington Road junction to Crickley Hill, before entering a 1km tunnel south of the Air Balloon junction and exiting onto a new off-line dual carriageway which re-joins the existing road a Cowley Roundabout.
4	1km tunnel loop avoiding Air Balloon junction and re-joining the existing carriageway at Birdlip junction followed by a new alignment east of Nettleton Bottom to Cowley roundabout.
8	New link road between A417 that avoids Air Balloon roundabout.
11	Online upgrade of existing A417 to dual-carriageway with new link road avoiding Air Balloon roundabout and off-line section east of Nettleton Bottom.
12	Online upgrade of existing A417 to dual-carriageway with new loop section avoiding Air Balloon junction to re-join existing carriageway north of Birdlip junction. New section off-line east of Nettleton Bottom to Cowley roundabout. Link to Air Balloon junction is maintained.
15	Online upgrade of existing carriageway from A417 / A46 Shurdington Road junction to Air Balloon junction with east carriageway to Cowley roundabout.
16	Online upgrade of existing carriageway from A417 / A46 Shurdington Road junction to Cowley roundabout with new off-line sections to avoid Air Balloon junction and east of Nettleton Bottom.

Option	Description
17	Online upgrade of existing carriageway from A417 / A46 Shurdington Road junction to Air Balloon junction with east carriageway to Cowley roundabout.
18	Direct route from Air Balloon junction to Cowley roundabout north of Stockwell Farm.
19	Online upgrade of existing A417 to dual-carriageway with new loop section avoiding Air Balloon junction. New section off-line east of Nettleton Bottom to Cowley roundabout. Link to Air Balloon junction is maintained.
27	Online upgrade from A417 / A46 Shurdington Road junction to new alignment east of Crickley Hill to Cowley roundabout. 1km tunnel section and carriageway west of Nettleton Bottom.
30	Online upgrade of existing carriageway from A417 / A46 Shurdington Road junction to Air Balloon junction with east carriageway to Cowley roundabout.

5.5 Escarpment corridor C

Figure 5.4: Escarpment corridor C options



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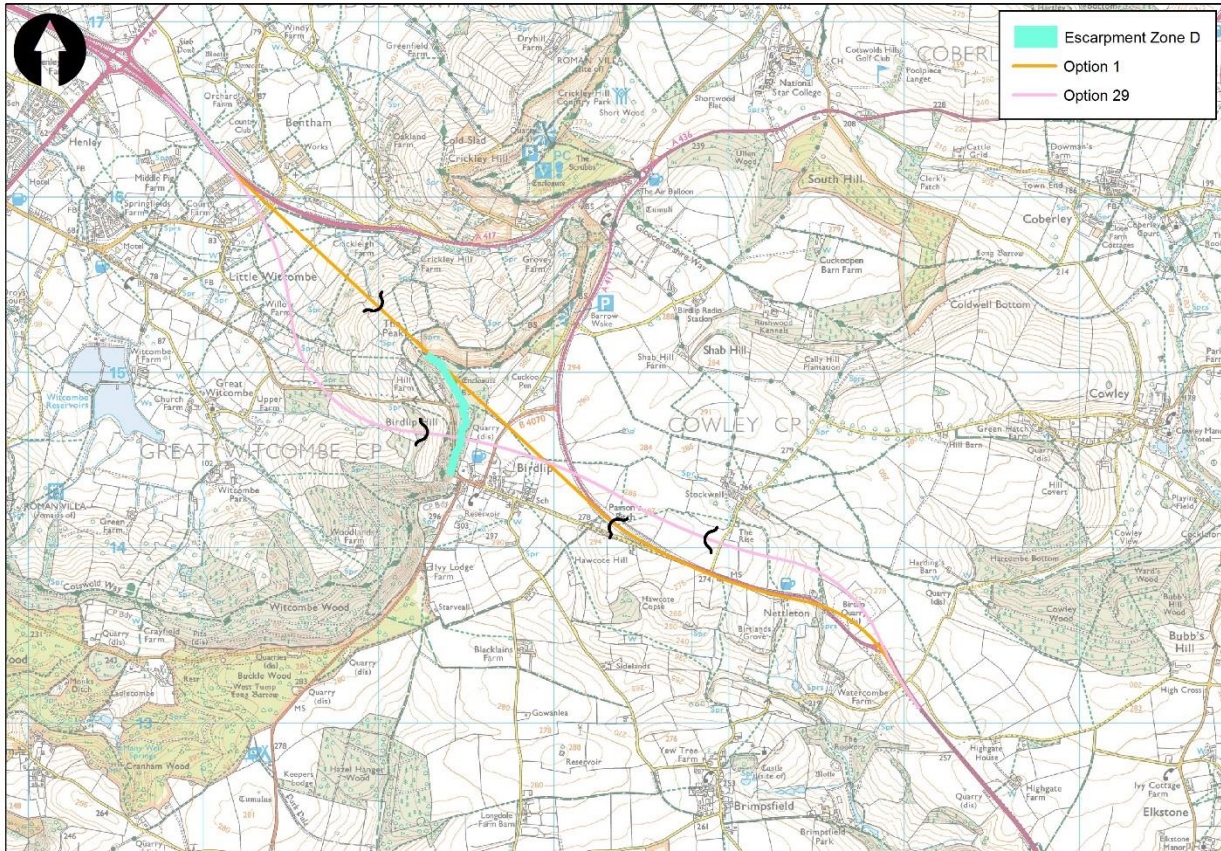
Table 5.5: Escarpment corridor C options

Option	Description
2	1.3km tunnel section between Crickley Hill and Birdlip junction utilising existing carriageway and a new grade separated junction at Nettleton Bottom.
9	Direct route between A417 / A46 Shurdington Road junction and Cowley roundabout avoiding Stockwell Farm and with 1.2km section of tunnel north of Birdlip junction.
10	Route from Crickley Hill south of Air Balloon roundabout and north of Birdlip village to re-join the existing carriageway south of Birdlip junction. 0.35km tunnel section in vicinity of Birdlip and embankment structure at Nettleton Bottom.
13	Direct route from A417 / A46 Shurdington Road junction to Cowley roundabout with new carriageway north of Birdlip junction and Stockwell Farm.
14	Direct route from A417 / A46 Shurdington Road junction to Cowley roundabout with new carriageway east of Birdlip junction and north of Nettleton Bottom.
20	Direct off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with a 2.8km section of tunnel.
21	Direct off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with a 3km section of tunnel.

Option	Description
22	Direct off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with a 2.8km section of tunnel.
28	Off-line route from A417 / A46 Shurdington Road junction with a 1.1km section of tunnel north of Birdlip junction and new carriageway west of Nettleton Bottom.

5.6 Escarpment corridor D

Figure 5.5: Escarpment corridor D options



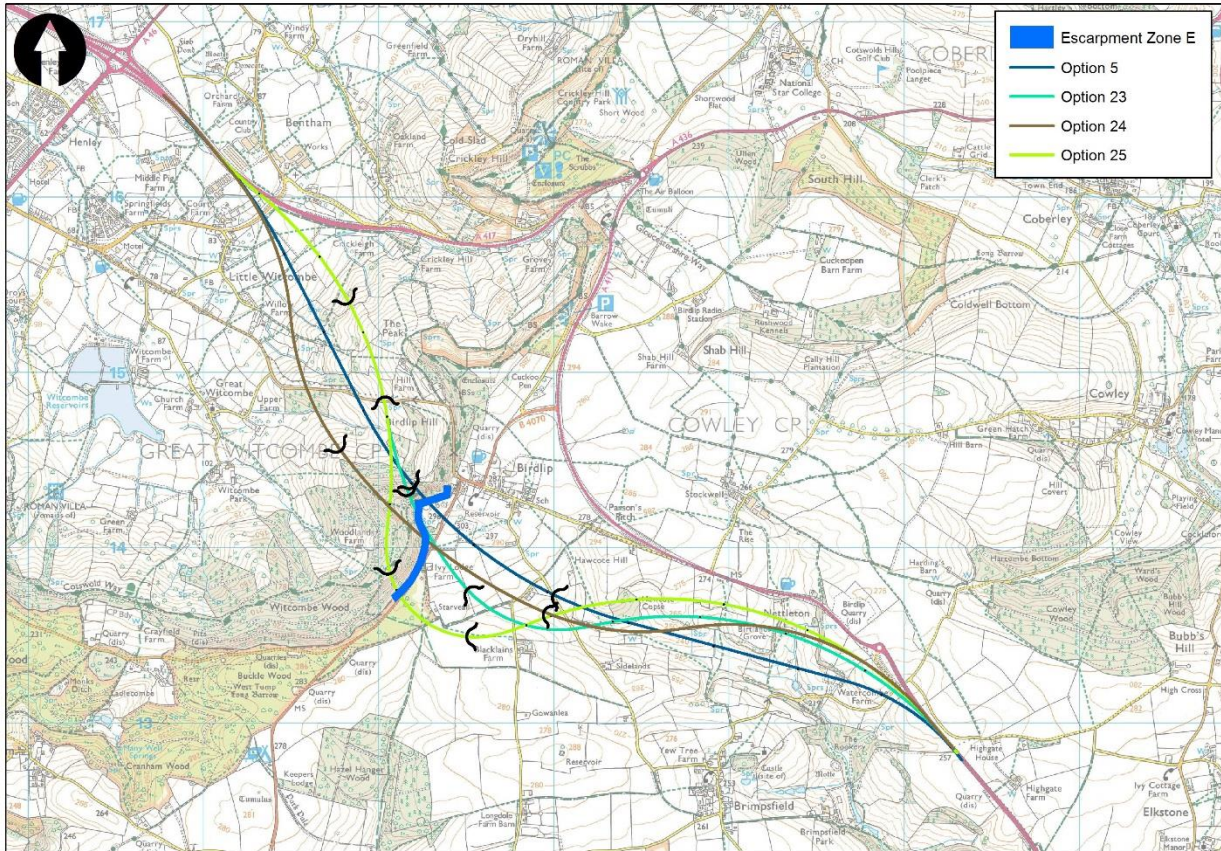
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Table 5.6: Escarpment corridor D options

Options	Description
1	Route from A417 / A46 Shurdington Road junction to Cowley roundabout aligned to south west of existing route with a 1.8km tunnel and utilising part of A417 south of Birdlip junction and grade separated junction at Nettleton Bottom.
29	Off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with a 1.7km section of tunnel north of Birdlip village and new carriageway west of Nettleton Bottom.

5.7 Escarpment corridor E

Figure 5.6: Escarpment corridor E options



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Table 5.7: Escarpment corridor E options

Options	Description
5	Route from A417 / A46 Shurdington Road junction to Cowley roundabout aligned to south west of Birdlip village and Nettleton, including a 0.7km embankment structure and 1.2km tunnel section
23	Off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with a 0.65km section of tunnel west of Birdlip village and Nettleton Bottom
24	Off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with a 1.6km section of tunnel west of Birdlip village and Nettleton Bottom
25	Off-line route from A417 / A46 Shurdington Road junction to Cowley roundabout with 2 0.6km tunnel sections west of Birdlip village and Nettleton Bottom

6. Options sifting

6.1 Sifting methodology

6.1.1 The sifting methodology was developed through Stage 1 to reduce the number of options and identify the most suitable routes to be assessed, and to inform the decision on which routes should be taken through to the non-statutory public consultation in PCF Stage 2. This chapter explains the methodology and how its application enabled the 30 options identified in Chapter 5, to be reduced to 6 options. The 6 options were then fully assessed as described in the following Chapters.

6.1.2 The methodology has 4 distinct sifting steps, and these are given below in Table 6.1.

Table 6.1: Sifting methodology steps

Sifting steps	Assessment Work
Step 1	Development and categorisation of options as described in Chapter 5.
Step 2	Engineering assessment of viability of options, see section 6.2.
Step 3	Assessment of remaining routes using Early Assessment and Sifting Tool (EAST) Plus methodology, see section 6.3.
Step 4	Assessment of highest scoring routes on value for money and affordability, see section 6.4.

6.1.3 The results of the sifting methodology are provided below.

6.2 Step 2 – Engineering assessment

6.2.1 The 30 options were reviewed to confirm compliance with the Design Manual for Roads and Bridges (DMRB). The route geometry was reviewed from a highways perspective in accordance with TD9/93 Table 3, based on a Design Speed of 120kph, against the following criteria:

- Horizontal Curvature – only proposed alignments with a mainline horizontal curvature of greater than 255m were taken forward to the next step. This was to enable a wide range of solutions to be considered in the context of delivering a landscape led scheme in constrained topography.
- Vertical Gradient – alignments with a proposed gradient steeper than the existing gradient of 8.4% identified on the existing alignment were discounted.

6.2.2 In accordance with BD78/99, Design of Road Tunnels, based on a Design Speed of 120kph, options with a proposed tunnel solution were assessed against:

- Chapter 4. The geometric review considered the alignment through the indicative tunnel sections, most critically concerning gradient and horizontal radii.
- Table 4.4 identifies the horizontal curvature in tunnels to provide sufficient Stopping Sight Distance (SSD) in a tunnel. From the table, any radius

within the proposed tunnel below 840m for a 120km/h design speed was discounted to meet the two step relaxation in SSD within the tunnel.

- Paragraph 4.22 states “Trunk road tunnels with gradients exceeding 6% are unlikely to be practical.” Therefore any option with a gradient within the tunnel greater than 6% was discounted.

Results

6.2.3 Due to the historic nature of a number of the options the information available for them was incomplete. They were discounted as they could not be assessed in the same context as those alignments developed over the full required length.

6.2.4 Table 6.2 below identifies the 30 options and, where applicable, their reason for removal from the sifting methodology based on the initial engineering assessment.

Table 6.2: Removed options following sifting Step 2, the engineering assessment

Option	Escarpment corridor	Historic route reference	Tunnel or surface route	Engineering assessment outcome (✓/✗)	Reason for discounting
1	D		Tunnel	✓	
2	C		Tunnel	✓	
3	A		Tunnel	✓	
4	B		Tunnel	✗	The proposed horizontal radius (255m) and vertical gradient (8%) through the tunnel section were not deemed acceptable.
5	E		Tunnel	✓	
6	A	Orange route	Surface	✓	
7	A		Tunnel	✓	
8	B		Surface	✗	The proposal included a 640m length of carriageway at Air Balloon only and was not assessed as the horizontal radius (80m) was not deemed acceptable.
9	C		Tunnel	✓	
10	C		Tunnel	✗	The proposed vertical gradient (18%) through both tunnel and open carriageway sections was not deemed acceptable.
11	B	Blue Route	Surface	✗	The proposed horizontal radius (<90m) and vertical gradient (10%) were not deemed acceptable.

Option	Escarpment corridor	Historic route reference	Tunnel or surface route	Engineering assessment outcome (✓/✗)	Reason for discounting
12	B	Brown Route	Surface	✓	
13	C	Direct Route	Surface	✓	
14	C	Escarpment	Surface	✓	
15	B	Far East (orange route)	Surface	✓	
16	B	Green Route	Surface	✗	The proposed horizontal radius (160m) was not deemed acceptable.
17	B	Middle East B	Surface	✗	The proposed vertical gradient (9%) was not deemed acceptable.
18	B	Middle East	Surface	✗	An incomplete alignment prevented further appraisal.
19	B	Purple Route	Surface	✗	The proposed horizontal radius (100m) and vertical gradient (10%) through the tunnel section were not deemed acceptable.
20	C	Tunnel 4.5%	Tunnel	✓	Similar to Option 21 but still to be considered.
21	C	Tunnel 5%	Tunnel	✓	
22	C	Tunnel 5.2%	Tunnel	✓	Similar to Option 21 but still to be considered.
23	E		Tunnel	✓	Similar to Option 24 but still to be considered.
24	E		Tunnel	✓	
25	E		Tunnel	✗	The proposed horizontal radius (510m) through the tunnel section was not deemed acceptable.
26	A		Tunnel	✓	
27	B		Tunnel	✗	The proposed horizontal radius (720m) through the tunnel section was not deemed acceptable.
28	C		Tunnel	✓	
29	D		Tunnel	✓	
30	B		Surface	✓	

6.2.5 From the engineering assessment 10 options were removed leaving 20 options to be taken through to Step 3 of sifting methodology as shown in Table 6.3 below.

Table 6.3: Remaining 20 options taken through to Step 3

Option	Escarpment Corridor
1	D
2	C
3	B
5	E
6	A
7	A
9	C
12	B
13	C
14	C
15	B
20	C
21	C
22	C
23	E
24	E
26	A
28	C
29	B
30	B

6.3 Step 3 – Early Assessment and Sifting Tool Plus assessment

Sifting Methodology

6.3.1 Initial option sifting was undertaken in accordance with the Transport Analysis Guidance – The Transport Appraisal Process or WebTAG. The sift used the Early Assessment and Sifting Tool (EAST), which forms part of Step 6 of WebTAG – Initial Sifting.

6.3.2 EAST is split into 5 areas of consideration which looks at different aspects of the emerging options, these are:

- Strategic
- Economic
- Managerial
- Financial
- Commercial

6.3.3 Each area of consideration contains a number of criteria for which each option is individually assessed against. These criteria range from questions such as “What impact will this option have on crime?” to accordance with a statement such as “Practical feasibility”.

- 6.3.4 EAST does not provide a numeric scoring system so the assessment team created a scoring mechanism to rank the options based on the result of the initial sift. The scoring system was based on accordance or impact depending on the criteria. The creation of a scoring system allowed each option to be directly compared against the others. A full explanation of the scoring system and how it was applied to each assessed option is given in Appendix D.
- 6.3.5 A key criterion for an option to be taken forwards was that it meets the objectives of the Roads Investment Strategy, the CSRs and the scheme objectives which were developed in collaboration with stakeholders. These objectives are set out in Chapter 2 of this report. The EAST tool does not allow for these to be assessed against, so to allow a consistent approach an EAST Plus methodology was developed. The EAST Plus methodology allowed the scheme objectives to be included as additional criteria to the Strategic area of consideration for assessing the options. They are then scored on how strongly they meet the objectives.
- 6.3.6 All 20 options were assessed against each individual EAST Plus criteria at the same time, to provide a direct comparison and allow for moderation of the scores. This was completed for each EAST Plus criteria to ensure a robust score was developed. The overall ranking for each option was then created by adding together all the individual scores that the initial options received when measured against all of the criteria.

Results of Step 3 – EAST Plus assessment

- 6.3.7 In early 2017 the budget range for the scheme was reviewed, and it was decided not to restrict the range of options being taken forward to the next step on grounds of affordability. On this basis, an indicative cost was recorded within the EAST Plus tool but excluded from any of the results and rankings.
- 6.3.8 The best performing options from each escarpment corridor were taken (except for Corridor A, as explained in 6.3.11) into the next step of evaluation as set out below. This approach would ensure a wide spread of options were progressed rather than variations of the same route through a particular section of the escarpment.
- 6.3.9 The output from the EAST Plus Assessment has been provided in Table 6.4 filtered in order of option number and Table 6.5 filtered in order of overall score (excluding cost). Table 6.6 groups the options into escarpment corridors, and orders by overall EAST Plus score with some commentary.

Table 6.4: Output of scores from A417 East Plus v20

Option	Escarpment Corridor	Scheme Objectives - CSR	Overall (without cost)	Capital cost / BCR	Environmental Objectives	Landscape Objectives	Strategic Objectives	Economic Objectives
1	D	5	6	14	6	6	5	4
2	C	11	8	8	12	15	12	5
3	B	8	7	14	7	8	8	7
5	E	11	12	10	10	8	10	13
6	A	14	16	5	17	13	14	16
7	A	16	19	10	15	17	17	19
9	C	6	5	8	7	10	6	5
12	B	14	17	1	13	10	14	18
13	C	16	13	3	19	19	16	9
14	C	19	13	3	20	20	17	9
15	B	20	17	1	18	16	20	16
20	C	1	2	18	2	1	1	2
21	C	1	1	19	1	1	1	1
22	C	1	2	19	2	1	1	2
23	E	9	11	7	9	6	9	13
24	E	6	9	14	5	5	6	11
26	A	16	19	10	15	17	17	19
28	C	9	10	10	10	13	10	12
29	D	4	4	14	4	4	4	7
30	B	13	15	5	13	12	13	15

Table 6.5: EAST Plus v20 scores for A417 Missing Link options, ranked from highest to lowest for overall score

Option	Surface / Tunnel	Escarpment corridor	Scheme objectives - CSR	Overall (without cost)	Capital cost / BCR	Environmental objectives	Landscape objectives	Strategic objectives	Economic objectives
21	Tunnel	C	1	1	19	1	1	1	1
20	Tunnel	C	1	2	18	2	1	1	2
22	Tunnel	C	1	2	19	2	1	1	2
29	Tunnel	D	4	4	14	4	4	4	7
9	Tunnel	C	6	5	8	7	10	6	5
1	Tunnel	D	5	6	14	6	6	5	4
3	Tunnel	B	8	7	14	7	8	8	7
2	Tunnel	C	11	8	8	12	15	12	5
24	Tunnel	E	6	9	14	5	5	6	11
28	Tunnel	C	9	10	10	10	13	10	12
23	Tunnel	E	9	11	7	9	6	9	13
5	Tunnel	E	11	12	10	10	8	10	13
13	Surface	C	16	13	3	19	19	16	9
14	Surface	C	19	13	3	20	20	17	9
30	Surface	B	13	15	5	13	12	13	15
6	Surface	A	14	16	5	17	13	14	16
12	Surface	B	14	17	1	13	10	14	18
15	Surface	B	20	17	1	18	16	20	16
7	Tunnel	A	16	19	10	15	17	17	19
26	Tunnel	A	16	19	10	15	17	17	19

Table 6.6: EAST Plus v20 scores for A417 Missing Link options, ranked from highest to lowest for overall score for each corridor

Option	Escarpment corridor	Surface / Tunnel route	Overall (without cost)	Comments
6	A	Surface	16	No options taken forward from this corridor, due to the highest ranked option (Option 6) being sixteenth. This route would have a significant impact on Rushwood Kennels and severe impact on a section of semi-natural woodland to the east of Air Balloon junction. To progress with a route from corridor A would result in better performing options from other corridors not being progressed.
7	A	Tunnel	19	
26	A	Tunnel	19	
3	B	Tunnel	7	Shortest tunnel solution to be taken forward
30	B	Surface	15	Taken forwards as the highest scoring feasible surface option.
15	B	Surface	17	Similar to Option 6 with greater adverse impacts on areas of Ancient Woodland.
12	B	Surface	17	
21	C	Tunnel	1	
20	C	Tunnel	2	Options 20 and 22 are similar in alignment to option 21. Option 21 avoids tunnelling below Stockwell Farm.
22	C	Tunnel	2	
9	C	Tunnel	5	Western tunnel portal positioned below escarpment at Barrow Wake. This tunnel portal would result in significant visual intrusion with a major structure crossing the lower plateau.
2	C	Tunnel	8	Buildability issue with tunnel portal located on-line of existing A417.
28	C	Tunnel	10	Tunnel portal exits through escarpment below Barrow Wake with significant visual intrusion.
13	C	Surface	13	Options 13 and 14 are open cut versions of options 20-22. Routes discounted due to severe visual and environmental impact through escarpment requiring a cut of up to 80m.
14	C	Surface	13	
29	D	Tunnel	4	
1	D	Tunnel	6	Buildability issue with tunnel portal located on-line on existing A417.
24	E	Tunnel	9	
23	E	Tunnel	11	Similar to Option 24, though a tunnel portal encroaches into a Special Area of Conservation.
5	E	Tunnel	12	

- 6.3.10 The ranking of options based on overall scores in Table 6.5 show routes from escarpment corridors B, C, D and E all within the top 10. The highest-ranking routes from each corridor were selected for further appraisal (highlighted green).
- 6.3.11 In comparison, the highest-ranking route from Escarpment Corridor A is ranked sixteenth out of the 20 options (Option 6, highlighted orange). Due to its poor performance, Option 6 from Corridor A was not progressed for further assessment and all options from within Corridor A were discounted. If Option 6 was taken forward for further assessment it would preclude better performing options from other corridors not progressing and reduce the validity of the sifting methodology.
- 6.3.12 Seventy percent of the options that were assessed using EAST Plus were tunnelled solutions, scoring well against landscape, environmental and strategic objectives. It was also considered important that the most suitable surface solution would need to be taken forward for further assessment, ensuring a viable alternative would be available should a tunnel solution become undeliverable.
- 6.3.13 To determine which was the most suitable surface route, the routes were considered in order of EAST Plus score. The 2 highest ranking surface routes, options 13 and 14 are similar alignments to tunnel Option 21 with the difference being that they are open carriageways and require an 81.5m deep cutting through the escarpment between Birdlip junction and Barrow Wake. The visual impact of these options would be severe and permanent, making the routes incompatible with the scheme objectives as reflected in their EAST Plus scores. These routes score well through their economic criteria due to their relatively straight alignment from Cowley roundabout to Brockworth bypass.
- 6.3.14 The next highest ranked surface solution was Option 30 (highlighted green) which was selected to be taken forward for further appraisal as the only surface option of the 5 options taken forward from Step 3.
- 6.3.15 As a result, 4 tunnel options (options 3, 21, 24 and 29), and 1 surface option (Option 30) were taken forward for further Traffic, Economic, Safety, Environmental and Social impact assessment. This assessment work is detailed in Chapters 8 to 12 in this report.

6.4 Step 4 – Value for money and affordability assessment

- 6.4.1 In autumn 2017 the cost range for the scheme was confirmed to be between £250 million and £500 million.
- 6.4.2 This confirmation coincided with the completion of the economic appraisal work to options 3, 21, 24, 29 and 30. A result of this work was the assessment of the Benefit Cost Ratios (BCRs) for the 5 routes. These ratios are an assessment of value for money, and given bandings as identified below Table 6.7

Table 6.7: Value for money categories as identified in Department for Transport WebTAG guidance

Value for Money category	BCR Range
Poor	Less than 1.0
Low	Between 1.0 and 1.5
Medium	Between 1.5 and 2.0
High	Between 2.0 and 4.0
Very high	Greater than 4.0

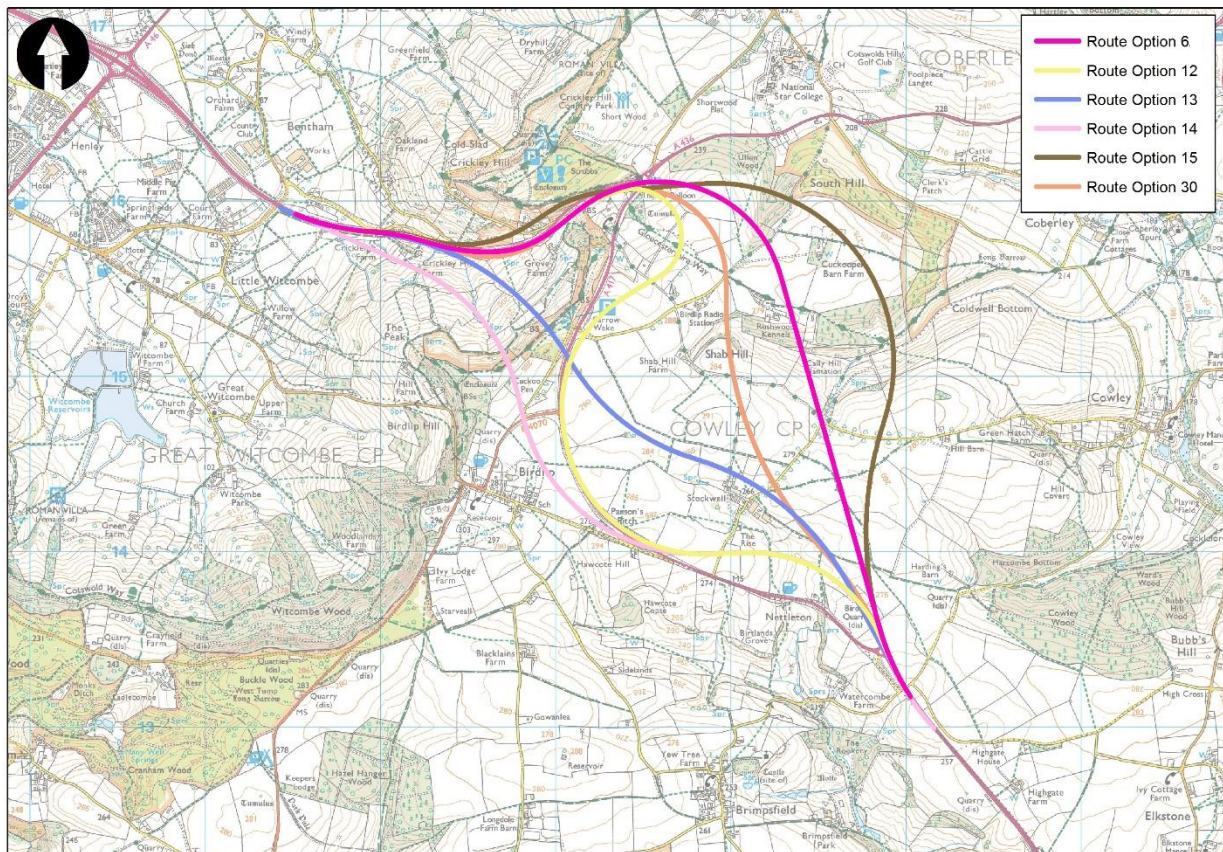
- 6.4.3 All tunnel options (options 3, 21, 24 and 29) produced BCRs below 1, which is categorised as poor value for money. The most significant factor causing the low BCRs was the high estimated costs of the tunnel options, all of which were estimated to cost significantly more than the upper limit of the cost range of £500 million. From this assessment tunnel options were shown to be both unaffordable and poor value for money.
- 6.4.4 It is part of Highways England’s Licence to operate as the Strategic Highway Authority that it must ensure value for money. At this point of the options assessment, the only option which was within the budget range (towards the upper limit) and with a BCR of greater than 1.0 was the only surface route assessed to that date, Option 30.
- 6.4.5 To deliver more than 1 affordable route from Stage 1, it was decided to review the previously identified surface solutions to see if there were further options that would meet the objectives, provide value for money and be affordable. The 6 surface options assessed in Step 3 of the sifting methodology are listed below in Table 6.8 and shown in Figure 6.1.

Table 6.8: Surface options assessed in Step 3

Option	Overall (without cost)	Landscape objectives	Comment
13	13	20	Visual and environmental impact incompatible with a landscape-led scheme
14	13	21	
30	15	13	Already being assessed following completion of step 3
6	16	14	Option 30 was a further development of Option 6, so further assessment of Option 6 would not provide value.
12	17	11	Taken forward for further assessment
15	17	17	Severe impacts on ancient woodland

Note: options highlighted in green were progressed for further assessment and appraisal; options highlighted in grey were not progressed.

Figure 6.1: Surface options assessed in Step 3



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

6.4.6 Option 12 was selected from the 6 surface options assessed in Step 3 for further appraisal, and for comparison with options 3, 21, 24, 29 and 30 because:

- It was developed in collaboration with environmental and landscape groups during a prior study.
- Although 0.9km longer than Option 30 it is largely on-line route and therefore likely to be affordable.
- Formerly known as the Modified Brown Route, it was subject to a large amount of assessment work historically and would act as a good comparator to the new routes being assessed.

6.5 Conclusions

6.5.1 Six options have been taken forward for Traffic, Economic, Safety, Environment and Social impact assessment. These options are:

- Option 3 – A tunnel option in Escarpment Corridor B
- Option 12 – A surface option in Escarpment Corridor B
- Option 21 – A tunnel option in Escarpment Corridor C
- Option 24 – A tunnel option in Escarpment Corridor E
- Option 29 – A tunnel option in Escarpment Corridor D
- Option 30 – A surface option in Escarpment Corridor B

6.5.2 These options are described in detail in Chapter 7 below.

7. Description of options

7.1 General

- 7.1.1 The 6 options described in this Chapter are those being assessed against each other to determine which of the proposed options are to be taken forward for public consultation.
- 7.1.2 The 6 options comprise 4 tunnel options and 2 surface options. The 4 tunnel options comprise a twin-bored tunnel within the design for both the northbound and southbound carriageways. The design features that are common to these 4 tunnel options are discussed below in section 7.2. The engineering descriptions of each option are provided in Sections 7.3 to 7.8.

7.2 Tunnel design

Tunnel design for applicable routes

- 7.2.1 The existing site and topographic conditions, archaeological and environmental constraints, current geological and geotechnical understanding and the highway design requirements were used to set the tunnel alignment and geometry and to assess the impacts and potential mitigation.

Tunnel geometry

- 7.2.2 The tunnel would comprise 2 separate bores with uni-directional traffic in each bore. Each bore would contain 2 lanes of traffic of standard highway width, 3.65m per lane. The existing A417 / A419 corridor is not an existing or proposed to be a heavy or high load route.
- 7.2.3 The verge / walkway width would be a sufficient width to enable emergency access on both carriageways leading to an internal tunnel diameter of around 10.5m. There would be no hardshoulder.
- 7.2.4 Space would be available in the tunnel crown above the traffic envelope for ventilation fans, lane control signage, lighting, fire and incident detection equipment and fire suppression system.

Tunnel alignment

- 7.2.5 The tunnel vertical alignment was set with a maximum gradient of 6% in accordance with BD78/99. Both tunnel bores were taken to be at the same elevation to provide step-free connection between the bores.
- 7.2.6 The tunnel horizontal alignment was set to meet the requirements of minimum stopping sight distances (SSD) for a 120kph design speed. The tunnel on Option 3 requires a relaxation of 1 design speed step on the desirable SSD. It was deemed impractical and uneconomic to increase the verge width to improve SSDs on this alignment.

- 7.2.7 The separation of the centre-lines of the 2 tunnel bores is taken to be 3 tunnel diameters in the centre of the tunnel to improve the stability of the pillar between the 2 bores under the highest cover, reducing to 2 tunnel diameters at the tunnel portals.
- 7.2.8 In the absence of site specific ground information, a cover of 10m above the tunnel crown was assumed to enable the safe start of bored tunnelling.
- 7.2.9 The tunnel length varies between 1,000m for Option 3, 3,000m for Option 21, 1,600m for Option 24 and 1,700m for Option 29.

Cross-passages

- 7.2.10 Cross-passages are required for evacuation and access for the emergency services. It is assumed that cross-passages would be located at 100m intervals.
- 7.2.11 The cross-passages would contain electrical distribution panels, ventilation panels and half of the emergency points. The remaining emergency points would be spaced at 100m intervals adjacent to the near-side walkway.

Tunnel portals

- 7.2.12 The potential location of the portals was based upon a combination of the overall highway geometry, the existing topography and mitigation of the environmental impacts.
- 7.2.13 A section of cut-and-cover tunnel would be provided at either portal extending beyond the bored tunnel portal to reduce the depth and width of the permanent cuttings to reduce environmental impacts.
- 7.2.14 The separation of the centreline of the tunnel bores is taken to be 2 tunnel diameters at the tunnel portal yielding a clear spacing of 1 tunnel diameter. This was aimed at reducing the width and excavation volume of the approach cuttings as well as reducing the size of the cut-and-cover structures whilst maintaining a suitable pillar between the bores for ground stability.
- 7.2.15 The tunnel portals would be designed to be aesthetically pleasing whilst meeting operational and safety requirements and the need to prevent recirculation of the exhaust air from the ventilation system.

Tunnel category

- 7.2.16 Given the tunnel length and the predicted traffic volumes, the tunnel is classified as Category AA in accordance with BD78/99.

Tunnel construction

- 7.2.17 To reduce impact on the groundwater regime during construction, it is envisaged that the main bores would be constructed using a full-face pressurised tunnel

boring machine (TBM). Use of this method of excavation would result in a circular tunnel cross-section.

- 7.2.18 A pre-cast concrete segmental lining would be installed immediately behind the TBM. The tunnel lining thickness is assumed to be between 400mm and 500mm.
- 7.2.19 Cross-passages are anticipated to be constructed by sequential excavation methods, probably using a road-header. To reduce drawdown of the water table during construction, intensive ground treatment local to the cross-passage bore would probably be required prior to excavation.

Tunnel drainage

- 7.2.20 All tunnel alignments have a continuous fall from the eastern portal to the western portal, and therefore gravity drainage would naturally occur.
- 7.2.21 The tunnel would be waterproofed to reduce long-term drawdown of the water table and for operational and maintenance reasons with only minor groundwater seepage envisaged through the tunnel lining.
- 7.2.22 Drainage within the tunnel is designed to capture water brought in on vehicles, leakage from services within the tunnel, tunnel maintenance cleaning liquid run-off, firefighting water and liquid spillages. The tunnel drainage system would connect to a storage tank at the western portal which can be isolated from the highway drainage system in the event of a major incident in the tunnel.

Geotechnical issues

- 7.2.23 There are several geotechnical issues which could influence the design, preferred construction methodology, and the construction cost and programme. Some of these risks also apply to the surface routes.
- 7.2.24 The 2 most major risks currently identified are:
- The potential short-term and long-term impact on the hydrogeological regime of construction of the tunnel.
 - The presence of landslide deposits on the slope below the Cotswold escarpment at the western tunnel portals.
- 7.2.25 Specific ground investigation along the tunnel alignments is required to evaluate these risks and to determine design and construction mitigation measures.

Treatment of existing A417

- 7.2.26 The existing A417 carriageway will remain in-situ should a tunnel solution be constructed. There is limited opportunity to remove sections of the existing carriageway due to the existing connections from the A436 to the A417 at the Air Balloon roundabout, the B4070 at Birdlip, unclassified roads such as the access to Stockwell and Cold Slad and a number of private means of accesses onto the A417.

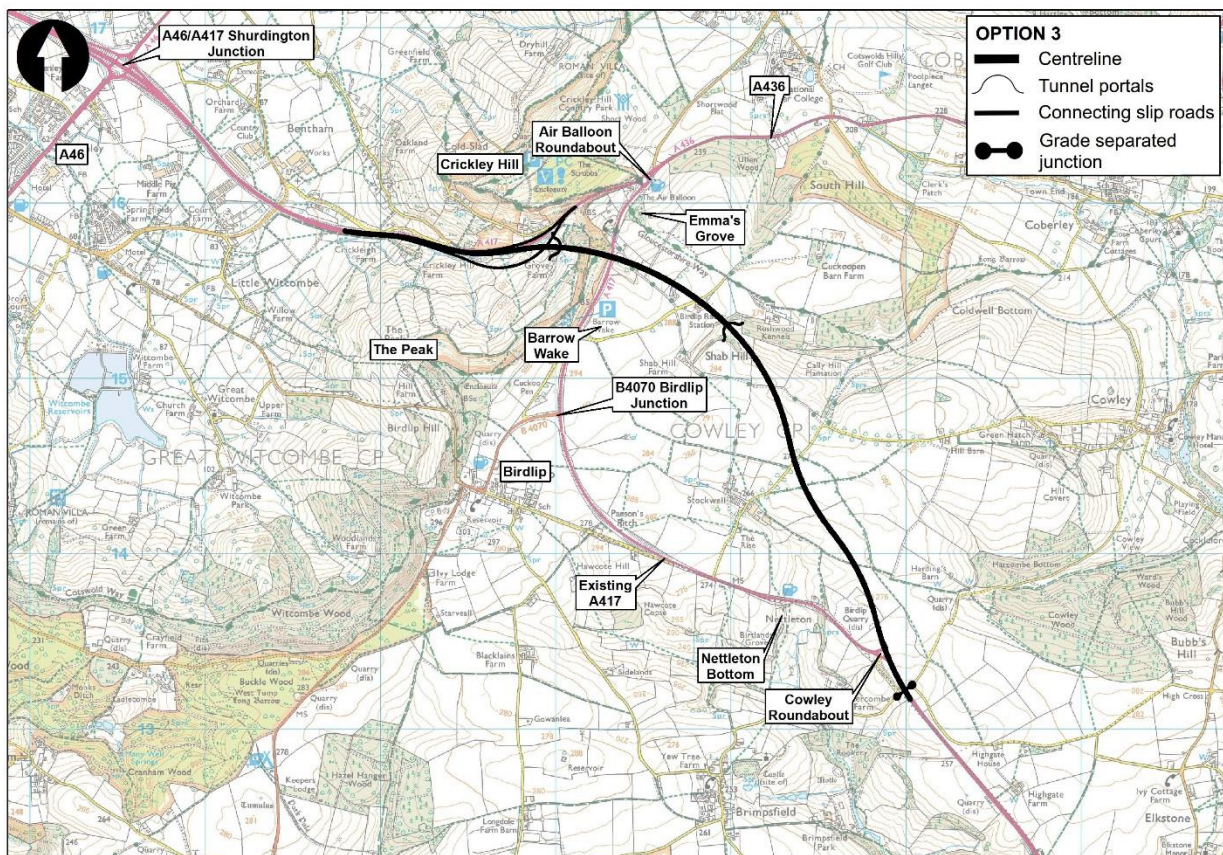
7.2.27 Maintaining the existing A417 would provide an alternative route for traffic during routine maintenance activities or collisions on the network in and around the tunnel. This will reduce the disruption to users of the network and the risk to workers carrying out maintenance and recovery activities. Opportunities to reduce the footprint of the existing A417 carriageway would be investigated during the design development should a tunnel solution be taken forward.

7.3 Option 3

Description of route

7.3.1 This option is approximately 5.2km long, of which the existing A417 is utilised for approximately 1km. The proposed route leaves the existing A417 at Crickley Hill and follows an alignment approximately 1.2km to the north of the existing A417 at Birdlip before returning to the existing A417 approximately 275m north of the Golden Heart Inn before re-joining the existing A417 after the Cowley roundabout. See Figure 7.1 below.

Figure 7.1: Option 3



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

- 7.3.2 Option 3 has a tunnel provision which is 1km long with a west portal approximately 230m east of Crickley Hill and an east portal which is approximately 930m south-east of the Air Balloon junction. The minimum tunnel horizontal radius provision is a right hand 1,510m curve and has a tunnel gradient of 6%.
- 7.3.3 The surface carriageway on the approach to the tunnel has a horizontal right-hand radius of 1,020m along with a gradient of 8%; this is an extension of the Crickley Hill constraint.
- 7.3.4 After the tunnel there are back-to-back 1,440m horizontal radii towards the proposed grade separated junction. The vertical profile is a combination of hog

and sag curves with k values satisfying Table 3's (TD9/93 DMRB) requirements. This combination aims to harmonise the existing contours however, there would still be a significant level of earthworks from either cuttings or embankments.

7.3.5 Option 3's key features are:

- 5.2km in length
- 1.0km tunnel
- Maximum gradient 8%
- Air Balloon direct off-slip / on-slip provision
- Full grade separated junction at Cowley roundabout
- Excavated material approximately 515,000m³. The approximate surplus material volume is 415,000m³
- Outside the tunnel envelope, there would be no adverse impacts to ancient woodland, listed buildings, woodland trust, common land or SSSI
- 1 residential property and 1 commercial property would be demolished

Drainage

7.3.6 Outside the tunnel, the proposed highway drainage could take the form of kerb and gullies, kerb drainage units, grassed channels (swales) or filter drains connecting to carrier pipes. The drainage within the tunnel could be in the form of surface channels located along both sides of the tunnel or in the central reserve taking the minor seepage behind the tunnel linings (assuming the tunnel to be waterproofed), cleaning water and firefighting water.

7.3.7 For the descending arm towards Little Witcombe, the route crosses a tributary of the River Churn before the route enters the east portal of the tunnel. The surface water run-off on the carriageway from the high point to the east portal of the tunnel (approx. 1km) would be intercepted and conveyed to the River Churn tributary if infiltration / soakaway is not feasible. If attenuation is required, a broad estimate shows a volume of 1,120m³ would be required and this could be provided in the form of a storage pond at an appropriate location close to the discharge point or large diameter pipes.

7.3.8 For the tunnel section, the surface water channels within the tunnel would fall towards the west portal and would join into the carriageway drainage outside the tunnel on this side. A tunnel drainage sump would be provided at the western portal to capture water entering the carriageway drainage system. The water from the sump would be discharged into the general highway drainage system. In the event of an incident such as a spillage or fire within the tunnel, a penstock would be closed to stop the water inside the portal sump entering the highway drainage system. This combined drainage system would also drain the new 1.2km of carriageway until it joins with the existing A417 at Little Witcombe. In addition, 2 slip roads would also join with the existing A417 at the west end. At this end, the outfall could be to Horsbere Brook or its tributary (as existing) subject to attenuation using a similar approach as described above. For this section of the route, the estimated attenuation volume for the surface water on the new carriageway and the 2 slip roads is 2,260m³.

- 7.3.9 For the descending arm towards Cowley which comprises the remaining 1.5km of carriageways, the drainage system would fall towards Cowley and could outfall to the River Frome following the existing condition (subject to attenuation). A number of slip roads and 2 roundabouts would also join with the existing A417 at the east end. For this section of the route, the estimated attenuation volume for the surface water on the new carriageway, the slip roads and the roundabouts is 3,170m³.
- 7.3.10 Subject to further investigation and site inspection, more outfalls could be designed if there are other available and appropriate outfall locations identified and if this could make the design more efficient in terms of pipe sizes and storage volume.

Structures

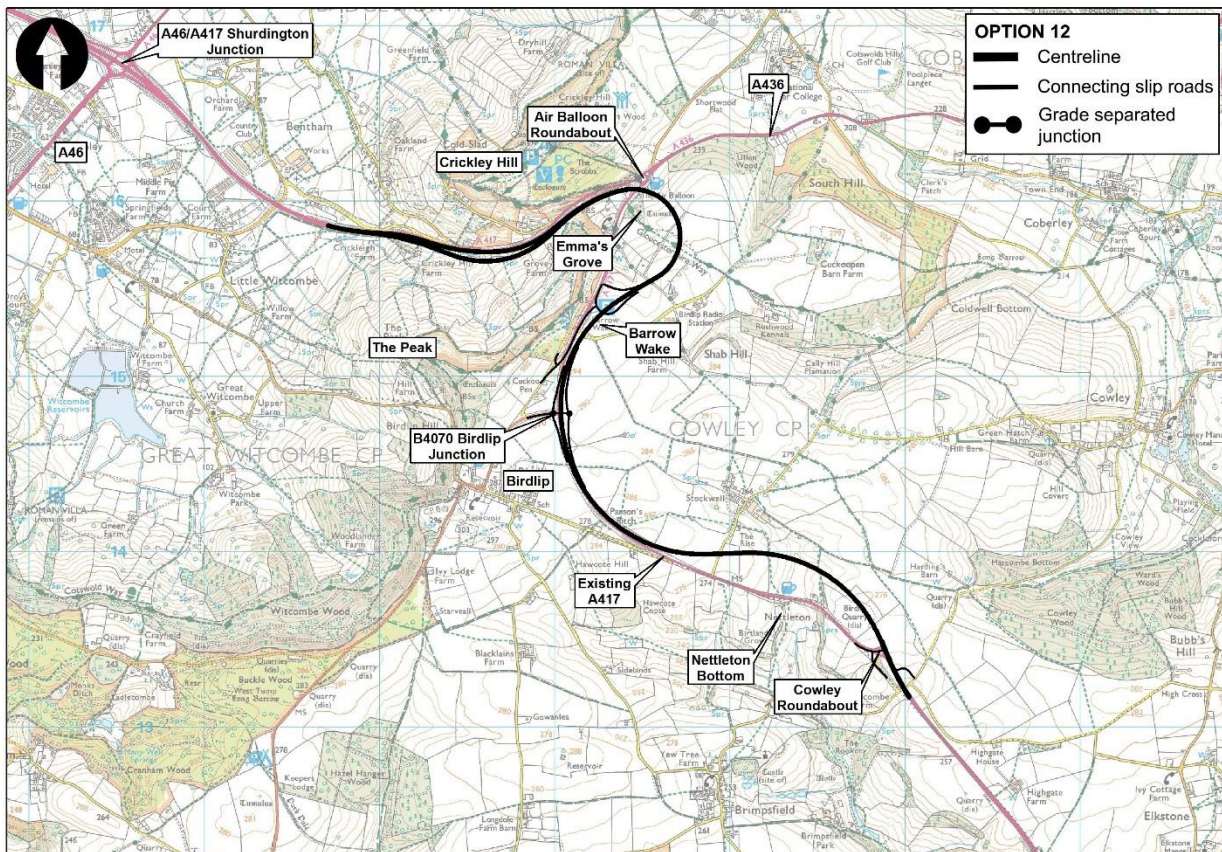
- 7.3.11 Six locations have been identified for major new structures:
- Overbridge carrying the northbound slip road over the A417 at chainage 1100
 - Overbridge for farm track over the A417 at chainage 2700
 - Overbridge for minor road over the A417 at chainage 3200
 - Overbridge for farm track over the A417 at chainage 3800
 - Major retaining walls would be required at the tunnel portals and along the western edge of the southbound slip road south of the Air Balloon roundabout
 - Green bridge over the existing A417 just south of the Air Balloon roundabout 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
- 7.3.12 Existing structures likely to be affected by Option 3 are:
- At the west end of the route there are 2 existing bridges which may need assessment and possibly modification where the merge and diverge tapers cross over / underneath them. The existing Old Coach Road Bridge carries a farm track and NMU route over the A417 carriageway and Witcombe Court Bridge carries the A417 over a minor road
 - Existing Cowley Bridge carrying the A417 over a minor road at chainage 4600 to be retained. Modifications may be required if the carriageway configuration is changed over the bridge

7.4 Option 12

Description of route

7.4.1 This option is approximately 6.4km in length. It utilises the existing A417 corridor for 1.3km 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 1.1km. Approximately 500m west of 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 7.2 below.

Figure 7.2: Option 12



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

7.4.2 Option 12 is a surface dual-carriageway proposal instead of a tunnel through the escarpment. The deepest section of cut along the route is located at chainage 1600, at the vicinity of Air Balloon roundabout, and it is approximately 20m deep. The route has a climbing lane provision for the southbound carriageway which is approximately 3.8km in length, providing 3 lanes in the southbound direction and 2 in the northbound direction for this length.

7.4.3 Option 12's key features are:

- 6.4km in length
- Surface option with reinforced earthworks cut slopes
- Maximum gradient 8.4% with a southbound climbing lane 3.8km in length
- North facing slip roads providing southbound off-slip and northbound on slip approximately 700m south of Air Balloon roundabout
- Grade separated junction approximately 1.5km south of Air Balloon roundabout
- New left-in, left-out junctions provided at Cowley
- Excavated material approximately 1,545,000 m³. Approximate earthworks surplus material volume of 1,425,000m³
- The route intersects with the Crickley Hill SSSI
- 1 residential property and 1 commercial property would be demolished

7.4.4 The development of Option 12 between 2001 and 2006 was centred on the current route therefore maximising the reuse of the existing carriageway into the final solution. The offline 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 0.4km provides an opportunity for the existing carriageway to be removed.

7.4.5 The 270m radius section (or Loop) to the east of Air Balloon is offline, 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.

Drainage

7.4.6 There are 2 high points within the eastern half of the route to Cowley. One high point is located approximately in the middle of the route. The other high point is approximately 500m away from the eastern end of the route forming a sag vertical section in between.

7.4.7 The proposed highway drainage would take the form of kerb and gullies, kerb drainage units, grassed channels (swales) or filter drains connecting to carrier pipes.

7.4.8 For the descending arm towards Little Witcombe, the route would likely cross the tributaries of Horsbere Brook until it joins with the existing A417 at Little Witcombe. A number of slip roads with a roundabout would join with the existing A417 before the route reaches its high point in the middle. The surface water run-off on the carriageway from the high point to the west end of the route (approx. 3.4km) would be intercepted and conveyed to the tributaries of Horsbere Brook if infiltration / soakaway is not feasible. If attenuations are required, to cater for the surface water run-off from all the slip roads and the roundabout, a number of attenuation facilities would be required at different locations. Broad estimates show:

- a volume of 1,850m³ would be required at the west end of the route

- a volume of 3,530m³ would be required at approximate chainage 1500
- a volume of 1,430m³ would be required at approximate chainage 2650

7.4.9 These storage capacities could be provided in the form of a storage pond at appropriate locations close to the discharge points, or large diameter pipes.

7.4.10 For the sag, vertical section of the route between the 2 high points which comprises approximately 2.5km of carriageway as well as a number of slip roads and 2 roundabouts, the drainage system would fall towards the sag point and could outfall to the River Frome following the existing condition (subject to attenuation). For this section of the route the attenuation facilities to cater for the new carriageway, slip roads and roundabouts would be provided at 2 locations:

- a volume of 1,725 m³ at approximate chainage 4250
- a volume of 2,810 m³ at approximate chainage 5400

7.4.11 For the descending arm towards Cowley which comprises the remaining 500m of carriageways, the drainage system would fall towards Cowley and would outfall to the River Frome following the existing condition (subject to attenuation). For this section of the route, the attenuation volume based on a broad estimate is 900m³ at the east end of the route.

7.4.12 Subject to further investigation and site inspection, more outfalls could be designed if there are other available and appropriate outfall locations identified, and if this could make the design more efficient in terms of pipe sizes and storage volumes.

Structures

7.4.13 Eleven major locations have been identified for proposed structures:

- Overbridge to carry the A436 carriageway over the new A417 alignment at chainage 1850
- Overbridge carrying the Gloucestershire Way footpath over the A417 at chainage 2400
- Overbridge for farm track over the A417 at chainage 2600
- Underbridge carrying the A417 dual-carriageway over the slip road at chainage 2930
- Underbridge carrying the A417 dual-carriageway over a minor road at chainage 3100
- Underbridge carrying the A417 dual-carriageway over the new Birdlip junction at chainage 3550
- Underbridge carrying the A417 dual-carriageway over a footpath at chainage 3850
- Overbridge carrying Cowley Lane over the A417 at chainage 4930.
- Overbridge carrying walking, cycling and horse-riding routes over the A417 at chainage 5500
- 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

- Green bridge over both the existing and proposed A417 carriageways at chainage 1600 would link the landscape on either side of the existing road corridor. This would provide a route for wildlife migration and also accommodate a diversion of the Cotswold Way NMU route

7.4.14 Existing structures likely to be affected by the option are:

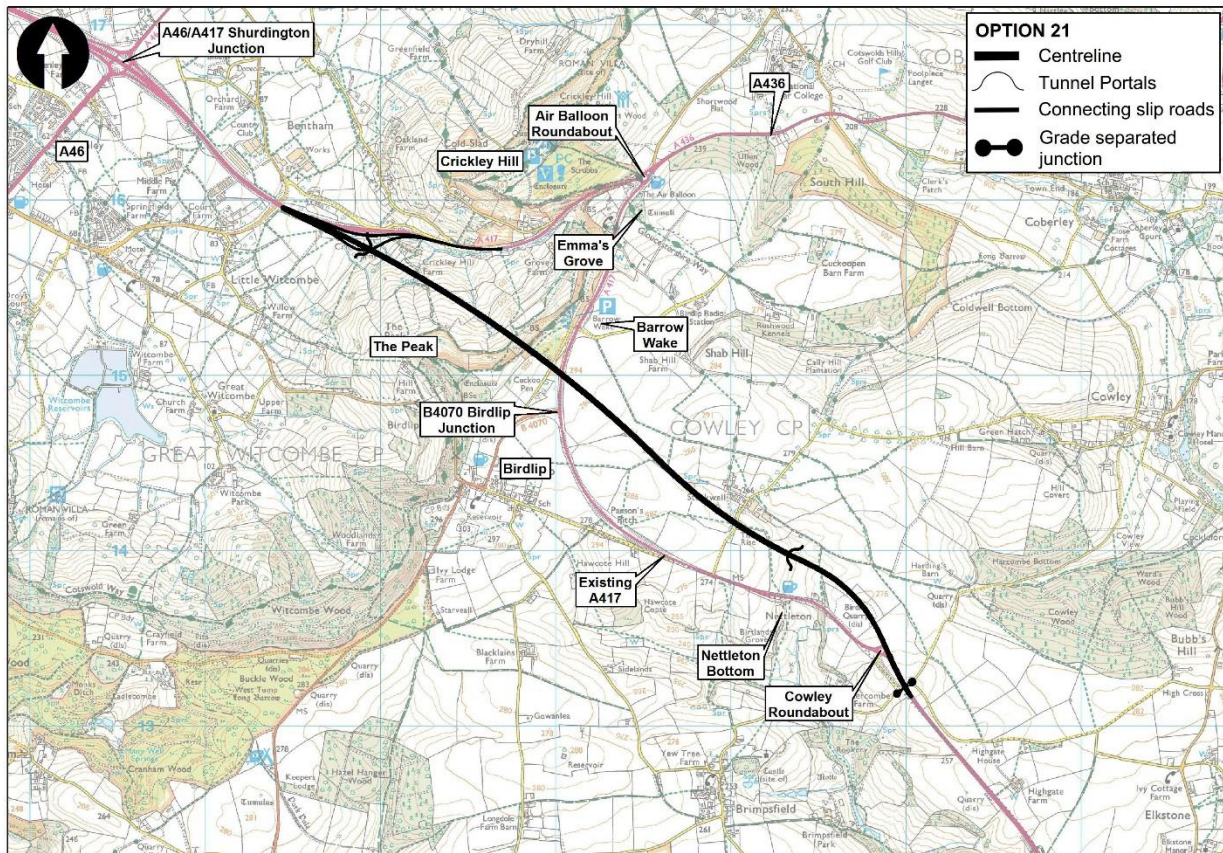
- Barrow Wake Underbridge on the existing A417 may be impacted by the new Birdlip junction arrangements

7.5 Option 21

Description of route

7.5.1 This option is approximately 4.6km long, including utilising the existing A417 corridor for approximately 0.3km. The proposed route disconnects with the existing A417 approximately 100m east of the existing Bentham Lane underpass and follows a direct alignment towards Cowley roundabout passing through a point immediately south of Stockwell Farm and approximately 225m north of the Golden Heart Inn. See Figure 7.3 below.

Figure 7.3: Option 21



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

- 7.5.2 Option 21 has a tunnel provision which is 3km long with a west portal approximately 500m east of the Bentham Lane underpass on the existing A417 and an east portal which is approximately 250m north of the Golden Heart Inn. The minimum tunnel horizontal radius provision is a left hand 2,900m radius curve and the tunnel gradient is 5%.
- 7.5.3 The tunnel approach has a horizontal right-hand radius of 7,000m and has a gradient rising from 1% on the existing A417.
- 7.5.4 After the tunnel there is a 1,020m horizontal right-hand radius towards the proposed grade separated junction to the east of Cowley roundabout. The vertical profile is a combination of hog and sag curves with k values satisfying

Table 3's (TD9/93 DMRB) requirements. This combination aims to harmonise the existing contours, however there would still be a significant level of earthworks cuttings.

7.5.5 Option 21's key features are:

- 4.6km in length
- 3.0km tunnel
- Maximum gradient 5%
- Air Balloon direct off-slip / on-slip provision
- Full grade-separated junction at Cowley roundabout
- Excavated material approximately 945,000 m³. Approximate earthworks surplus material volume of 928,000m³
- Outside the tunnel envelope, there would be no adverse impacts to ancient woodland, listed buildings, woodland trust, common land or SSSIs
- No demolition of properties would be required

Drainage

7.5.6 The high point is close to the end of the route outside the tunnel on its east side. The route falls from this high point to the 2 ends of the route on either side.

7.5.7 Outside the tunnel, the proposed highway drainage could take the form of kerb and gullies, kerb drainage units, grassed channels (swales) or filter drains connecting to carrier pipes. The drainage within the tunnel could be in the form of surface channels located along both sides of the tunnel or in the central reserve taking the minor seepage behind the tunnel linings (assuming the tunnel to be waterproofed), cleaning water and fire-fighting water.

7.5.8 For the descending arm towards Little Witcombe, the route crosses a tributary of the River Frome before the route enters the east portal of the tunnel. The surface water run-off on the carriageway from the high point to the east portal of the tunnel (approx. 600m) would be intercepted and conveyed to the River Frome tributary if infiltration / soakaway is not feasible. If attenuation is required, a broad estimate shows a volume of 850m³ would be required and this could be provided in the form of a storage pond at an appropriate location close to the discharge point or large diameter pipes.

7.5.9 For the tunnel section, the surface water channels within the tunnel would fall towards the west portal and would join into the carriageway drainage outside the tunnel on this side. This combined drainage system would also drain the new 550m of carriageway until it joins with the existing A417 at Little Witcombe. In addition, 2 slip roads would also join with the existing A417 at the west end. At this end, the outfall could be to Horsbere Brook or its tributary (as existing) subject to attenuation using similar approach as described above. For this section of the route, the attenuation volume based on a broad estimate is 1,360m³ for attenuating the surface water on the new carriageway and the 2 slip roads.

- 7.5.10 For the descending arm towards Cowley, which comprises the remaining 500m of carriageways, the drainage system would fall towards Cowley and would outfall to the River Frome following the existing condition (subject to attenuation). A number of slip roads and 2 roundabouts would also join with the existing A417 at the east end. For this section of the route, the attenuation volume based on a broad estimate is 1,100m³ for attenuating the surface water on the new carriageway, the slip roads and the roundabouts.
- 7.5.11 Subject to further investigation and site inspection, more outfalls could be designed if there are other available and appropriate outfall locations identified and if this would make the design more efficient in terms of pipe sizes and storage volume.

Structures

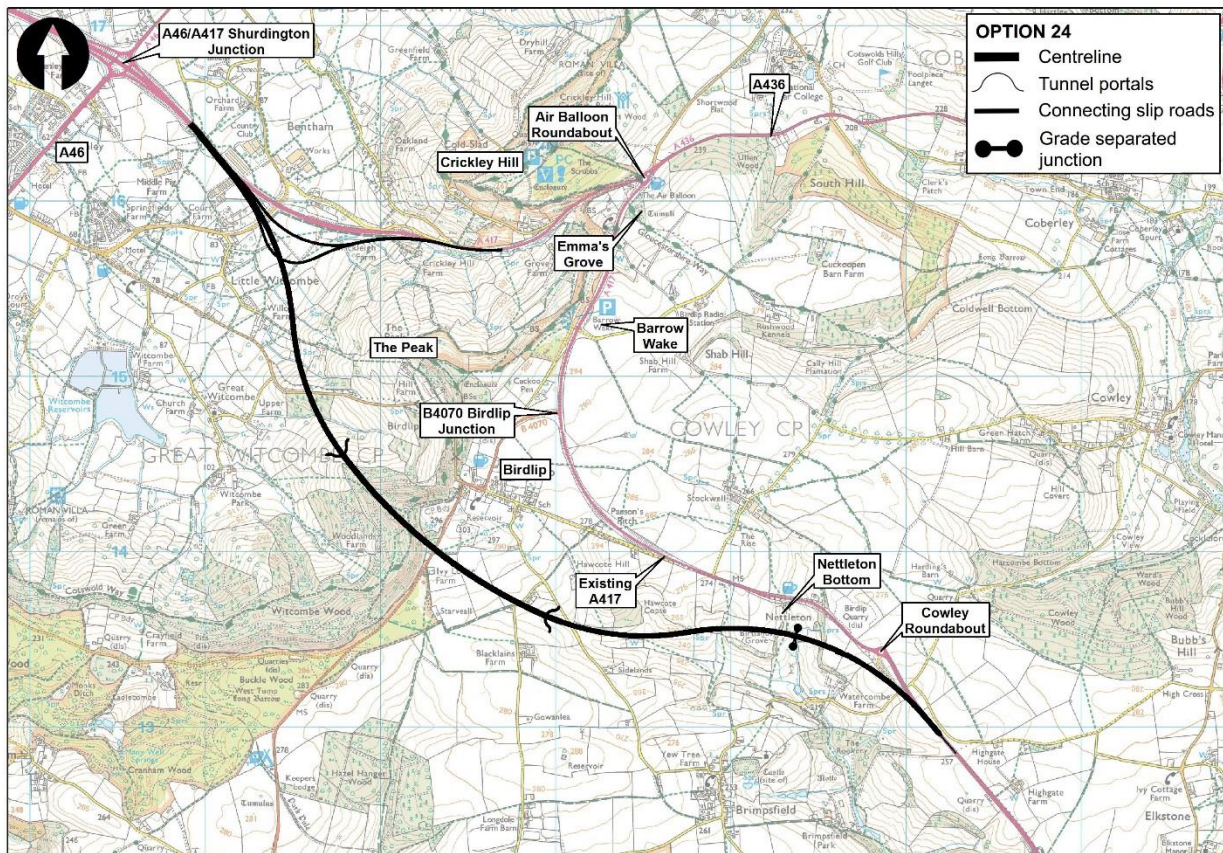
- 7.5.12 Three locations have been identified for major new structures:
- Underbridge carrying the A417 over an existing footpath at chainage 3600
 - Green bridge over the existing A417 just south of the Air Balloon roundabout would link the landscape on either side of the existing road corridor. This would provide a route for wildlife migration and accommodate a diversion of the Cotswold Way walking, cycling and horse-riding route
 - Major retaining walls would be required at the tunnel portals and at one other location on the route
- 7.5.13 Existing structures that would probably be affected by the option are:
- At the west end of the route there are 2 existing bridges which may need assessment and possibly modification where the merge and diverge tapers cross over / underneath them. The existing Old Coach Road Bridge carries a farm track and NMU route over the A417 carriageway and Witcombe Court Bridge carries the A417 over a minor road.
 - Existing Cowley Bridge carrying the A417 over a minor road at chainage 4500 to be retained. Modifications may be required if the carriageway configuration is changed over the bridge.

7.6 Option 24

Description of route

7.6.1 This option is approximately 6.1km long, including utilising the existing A417 corridor for approximately 0.2km. The proposed route leaves with the existing A417 approximately 100m east of the Old Coach Road overbridge and follows a radial alignment towards Cowley roundabout passing through a point approximately 450m south of Birdlip and then a further point approximately 200m south of Nettleton Bottom. See Figure 7.4 below.

Figure 7.4: Option 24



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

7.6.2 Option 24 has a tunnel provision which is 1.6km long with a west portal approximately 700m west of Birdlip and an east portal approximately 650m south-east of Birdlip. The minimum tunnel horizontal radius provision is a left-hand curve with a radius of 2,440m and has a tunnel gradient of 6%.

7.6.3 The tunnel approach has a horizontal left-hand radius of 1,440m and has a gradient rising from the A417 mainline of 0.5%. After the tunnel there are back-to-back 1,440m horizontal radii towards the proposed grade separated junction. The vertical profile is a combination of hog and sag curves with k values satisfying table 3 table 3 (TD9/93 DMRB) requirements. This combination aims to harmonise the existing contours, however there would still be a significant level of earthworks from either cuttings or embankments.

7.6.4 Option 24's key features are:

- 6.1km in length
- 1.6km tunnel
- Maximum gradient 6%
- Air Balloon direct off-slip / on-slip provision
- Full grade separated junction approximately 0.5km west of Cowley roundabout
- Excavated material approximately 1,100,000 m³. Approximate earthworks surplus material volume of 690,000m³
- Outside the tunnel envelope, there would be a marginal impact to Woodland Trust of approximately 4,352 m² and a slight infringement on ancient woodland. As part of the grade separated junction location and the south roundabout, there would be a significant impact to a SSSI
- 1 residential property and 1 commercial property would be demolished

Drainage

7.6.5 There are 2 high points within the eastern third section of the route to Cowley and both high points are on the east side of the tunnel section. One high point is at chainage 4200 and the other is at the east end of the route forming a sag vertical section in between.

7.6.6 Outside the tunnel, the proposed highway drainage would take the form of kerb and gullies, kerb drainage units, grassed channels (swales) or filter drains connecting to carrier pipes. The drainage within the tunnel would be in the form of surface channels located along both sides of the tunnel or in the central reserve taking the minor seepage behind the tunnel linings (assuming the tunnel to be waterproofed), cleaning water and firefighting water.

7.6.7 For the descending arm towards Little Witcombe from the high point at chainage 4200 to the east portal of the tunnel, the route crosses a tributary of the River Frome. The surface water run-off on this section of the carriageway (approx. 600m) would be intercepted and conveyed to the River Frome tributary if infiltration / soakaway is not feasible. If attenuation is required, a broad estimate shows a volume of 760m³ would be required and this could be provided in the form of a storage pond at an appropriate location close to the discharge point or large diameter pipes.

7.6.8 For the tunnel section, the surface water channels within the tunnel would fall towards the west portal and would join into the carriageway drainage outside the tunnel on this side. This combined drainage system would also drain the new 2km of carriageway until it joins with the existing A417 at Little Witcombe. In addition, 2 slip roads would also join with the existing A417 at the west end. At this end, the outfall could be to Horsbere Brook or its tributary (as existing) subject to attenuation using a similar approach as described above. For this section of the route, the attenuation volume based on a broad estimate is 3,350m³ for attenuating the surface water on the new carriageway and the 2 slip roads.

- 7.6.9 For the sag vertical section of the route between the 2 high points at the east end of the route which comprises the remaining 1.75km of carriageways as well as a number of slip roads and 2 roundabouts, the drainage system would fall towards the low point located between the 2 high points and would outfall to the River Frome following the existing condition (subject to attenuation). For this section of the route, the attenuation volume based on a broad estimate is 3510m³ for attenuating the surface water on the new carriageway, the slip roads and the roundabouts.
- 7.6.10 Subject to further investigation and site inspection, more outfalls could be designed if there are other available and appropriate outfall locations identified and if this could make the design more efficient in terms of pipe sizes and storage volumes.

Structures

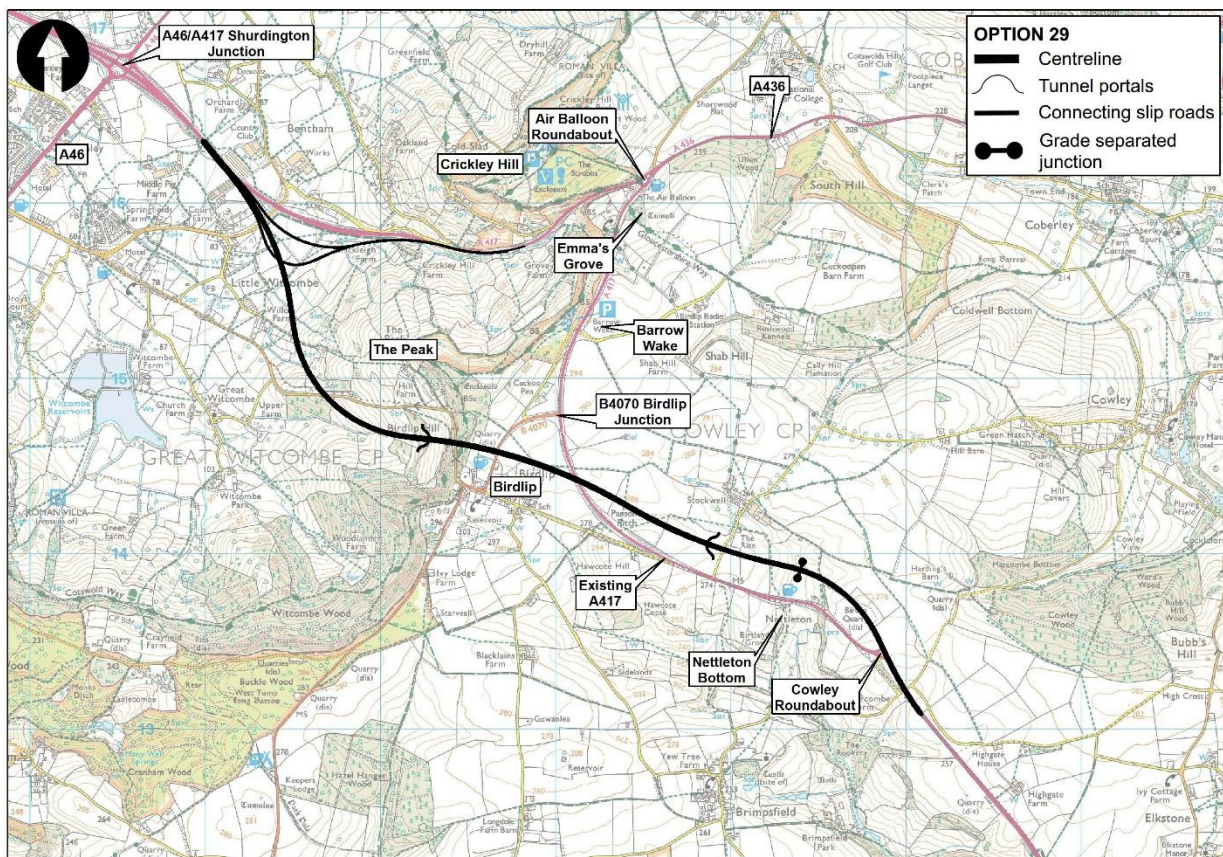
- 7.6.11 Twelve locations have been identified for major new structures:
- New overbridge to replace the existing Old Coach Road Bridge at chainage 100, which would be demolished. The new bridge would carry the farm track and NMU route over the A417 with a widened span
 - Underbridge carrying the A417 over a minor road at chainage 550
 - Underbridge taking the A417 southbound slip road over the minor road at chainage 550, adjacent to the new A417 underbridge
 - Underbridge taking the A417 northbound slip road over the minor road at chainage 550, adjacent to the new A417 underbridge
 - Overbridge carrying the northbound slip road over the A417 at chainage 700
 - Willow Farm Underbridge carrying the A417 over a footpath at chainage 1300
 - Overbridge for a minor road over the A417 at chainage 1600
 - Overbridge carrying a minor road (Brimpsfield Road) over the A417 at chainage 3700 adjacent to the east tunnel portal
 - Multiple span underbridge carrying the A417 over a grade separated junction at chainage 4950. Likely form: 5 span bridge with a bearings, precast concrete beams and discrete column piers, total length 150m.
 - Major retaining walls would be required at the tunnel portals
 - Green bridge over the existing A417 just south of the Air Balloon roundabout would link the landscape on either side of the existing road corridor. This would provide a route for wildlife migration and also accommodate a diversion of the Cotswold Way NMU route
- 7.6.12 Existing structures that would probably be affected by the option are:
- Old Coach Road Bridge at chainage 100 to be demolished and replaced
 - Existing Cowley Bridge carrying the A417 over a minor road at chainage 5600 to be retained. Modifications could be required if the carriageway configuration is changed over the bridge

7.7 Option 29

Description of route

7.7.1 This option is approximately 5.7km long, including utilising the existing A417 corridor for approximately 0.15km. The proposed route leaves the existing A417 approximately 100m east of the Old Coach Road overbridge and follows a relatively direct alignment towards Cowley roundabout immediately to the north of Birdlip. The route passes through a point approximately 270m south of Stockwell Farm and has a grade separated junction approximately 200m north of Nettleton Bottom. See Figure 7.5 below.

Figure 7.5: Option 29



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

- 7.7.2 Option 29 has a tunnel provision which is 1.7km long, with a west portal approximately 460m north west of Birdlip and an east portal approximately 960m east of Birdlip. The minimum tunnel horizontal radius provision is a right-hand curve with a radius of 2,880m and a tunnel gradient of 6%.
- 7.7.3 The tunnel approach has a horizontal left-hand radius of 720m and has a gradient rising from the A417 mainline of 0.5%.
- 7.7.4 After the tunnel, there is a horizontal left-hand radius of 2,880m followed by a right-hand radius of 720m which the proposed grade separated junction is sited upon. The vertical profile is a combination of hog and sag curves with k values

satisfying table 3 table 3 (TD9/93 DMRB) requirements. This combination aims to harmonise the existing contours however there is still a significant level of earthworks from either cuttings or embankments.

7.7.5 Option 29's key features are:

- 5.7km in length
- 1.7km tunnel
- Maximum gradient of 6%
- Air Balloon direct off-slip / on-slip provision
- Full grade separated junction approximately 0.7km north west of Cowley roundabout
- Excavated material approximately 1,200,000 m³. Approximate earthworks surplus material volume of 710,000m³
- Outside the tunnel envelope, there is a moderate impact to Woodland Trust
- 1 residential property and 1 commercial property would be demolished

Drainage

7.7.6 There are 2 high points within the eastern third section of the route to Cowley and both high points are on the east side of the tunnel section. One high point is very close to the east portal of the tunnel at approximate chainage 4225 and the other is closer to the east end of the route forming a sag vertical section in between. The route falls from the 2 high points to the 2 ends of the route respectively on either side.

7.7.7 Outside the tunnel, the proposed highway drainage would take the form of kerb and gullies, kerb drainage units, grassed channels (swales) or filter drains connecting to carrier pipes. The drainage within the tunnel would be in the form of surface channels located along both sides of the tunnel or in the central reserve taking the minor seepage behind the tunnel linings (assuming the tunnel to be waterproofed), cleaning water and firefighting water.

7.7.8 For the sag vertical section between the 2 high points, the route crosses a tributary of the River Frome. The surface water run-off on the carriageway of this section (approx. 740m) as well as a number of slip roads and 2 roundabouts would be intercepted and conveyed to the River Frome tributary if infiltration / soakaway is not feasible. If attenuation is required, a broad estimate shows a volume of 2040m³ would be required and this would be provided in the form of a storage pond at an appropriate location close to the discharge point or large diameter pipes.

7.7.9 For the descending arm towards Little Witcombe between the high point at approximate chainage 4225 and the tunnel east portal (approx. 225m), the surface water run-off on the carriageway would be intercepted and conveyed to the River Frome tributary if infiltration / soakaway is not feasible. If attenuation is required, a broad estimate shows a volume of 240m³ would be required and this would be provided using a similar approach as described above.

- 7.7.10 For the tunnel section, the surface water channels within the tunnel would fall towards the west portal and would join into the carriageway drainage outside the tunnel on this side. This combined drainage system would also drain the new 2.3km of carriageway until it joins with the existing A417 at Little Witcombe. In addition, 2 slip roads would also join with the existing A417 at the west end. At this end, the outfall could be to Horsbere Brook or its tributary (as existing) subject to attenuation using a similar approach as described above. For this section of the route, the attenuation volume based on a broad estimate is 3,850m³ for attenuating the surface water on the new carriageway and the 2 slip roads.
- 7.7.11 For the descending arm from the high point further away from the east portal of the tunnel to the east end of the route which comprises the remaining 700m of carriageways, the drainage system would fall towards Cowley and would outfall to the River Frome following the existing condition (subject to attenuation). For this section of the route, the attenuation volume based on a broad estimate is 1,050m³.
- 7.7.12 Subject to further investigation and site inspection, more outfalls would be designed if there are other available and appropriate outfall locations identified and if this would make the design more efficient in terms of pipe sizes and storage volumes.

Structures

- 7.7.13 Eleven major locations have been identified for proposed structures:
- New overbridge to replace the existing Old Coach Road Bridge at chainage 100, which would be demolished. The new bridge would carry the farm track and NMU route over the A417 with a widened span
 - Underbridge carrying the A417 over a minor road at chainage 550
 - Underbridge taking the A417 southbound slip road over the minor road at chainage 550, adjacent to the new A417 underbridge
 - Underbridge taking the A417 northbound slip road over the minor road at chainage 550, adjacent to the new A417 underbridge
 - Overbridge carrying the northbound slip road over the A417 at chainage 700
 - Willow Farm Underbridge carrying the A417 over a footpath at chainage 1300
 - Overbridge for a minor road over the A417 at chainage 1600
 - Overbridge carrying Cowley Lane over the A417 at chainage 4100 adjacent to the east tunnel portal
 - Multiple span underbridge carrying the A417 over a grade separated junction at chainage 4600
 - Major retaining walls would be required at the tunnel portals
 - Green bridge over the existing A417 just south of the Air Balloon roundabout 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

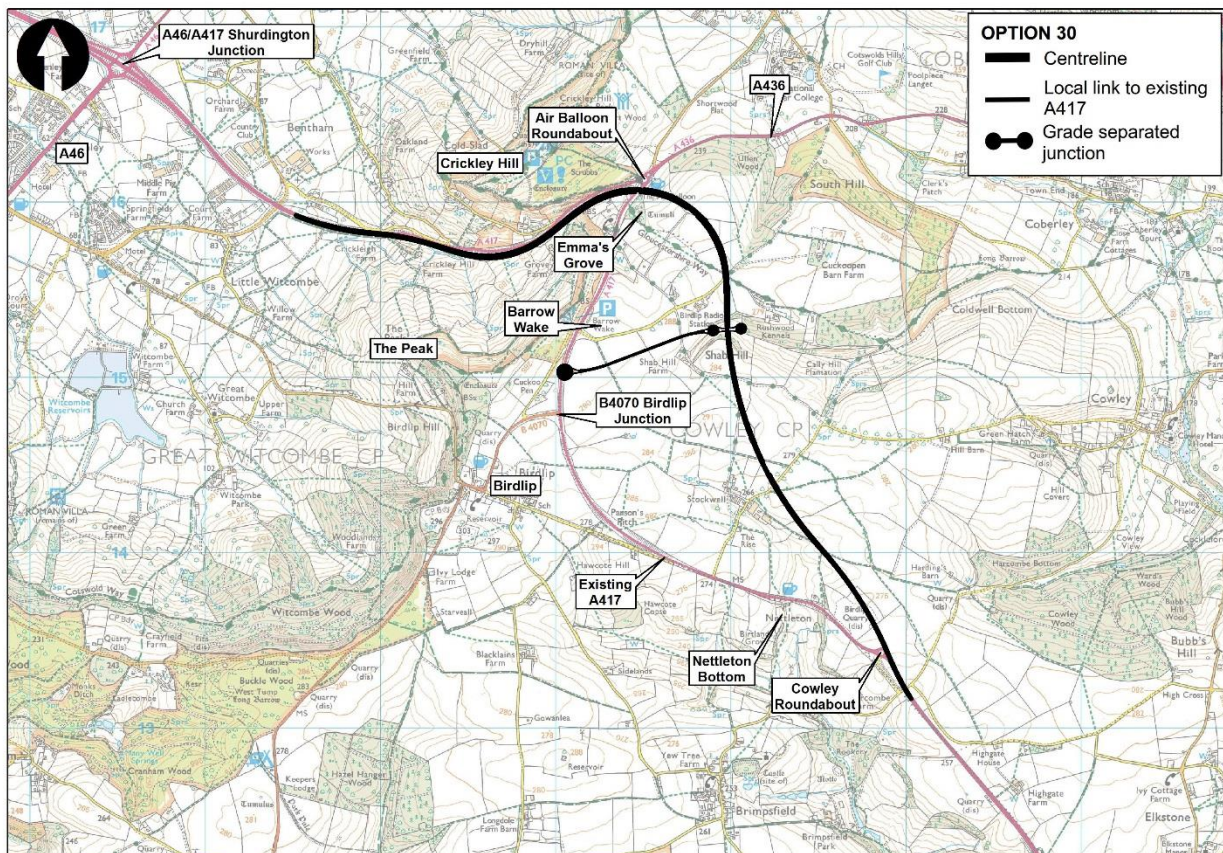
- 7.7.14 Existing structures that would probably be affected by the option are as follows:
- Old Coach Road Bridge at chainage 100 to be demolished and replaced
 - Existing Cowley Bridge carrying the A417 over a minor road at chainage 5600 to be retained. Modifications would be required if the carriageway configuration is changed over the bridge

7.8 Option 30

Description of route

- 7.8.1 During the work to identify solutions early in Stage 1, Option 30 was developed to reduce the impact of Option 6 by tightening the radii to the east of Air Balloon from a 720m radius to a 510m radius avoiding Rushwood Kennels and Ullen Wood ancient woodland. This resulted in Option 30 being 0.9km shorter than Option 6.
- 7.8.2 This option is approximately 5.6km long, including utilising the existing A417 corridor for approximately 0.5km. The proposed route attempts to maintain the existing A417 corridor for a further 1km before leaving the corridor prior to the Air Balloon junction. The route transitions to a right-hand radius of 510m (2 steps below the desirable minimum standard), before passing through a point approximately 160m east of Birdlip Kennels and continues on a long left-hand arc of radius of 2,040m until Stockwell Farm; the alignment then proceeds on a right-hand radius of 2,040m to the point of tie-in with the existing A417. See Figure 7.6 below.

Figure 7.6: Option 30



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

- 7.8.3 Option 30 is a surface dual-carriageway proposal instead of a tunnel through the escarpment. The deepest section of cut along the route is located at chainage

1800, at the vicinity of Air Balloon roundabout, and it is approximately 25m deep. The route has a climbing lane provision for the southbound carriageway approximately 3.7km in length, providing 3 lanes in the southbound direction and 2 in the northbound direction for this length..

- 7.8.4 This option has a grade separated junction approximately 1km to the south-east of Air Balloon junction which further requires an approximate 860m length of link road with the existing A417 which is also utilised for the connection for the Air Balloon traffic.
- 7.8.5 Option 30's key features are:
- 5.6km in length
 - Surface option with reinforced earthworks cut slopes
 - Maximum gradient 7.5% with a southbound climbing lane 3.7km in length
 - Grade separated junction approximately 1km to south east of Air Balloon roundabout
 - Excavated material approximately 1,578,000 m³. Approximate earthworks surplus material volume of 1,255,000m³
 - There are no adverse impacts to ancient woodland, listed buildings, Woodland Trust, common land or SSSI
 - 1 residential property and 1 commercial property would be demolished
- 7.8.6 There is an opportunity for further development of Option 30 to allow for the removal of a length of existing carriageway. The current proposal for Option 30 allows for a single junction at Shab Hill to serve the local road network, with the Air Balloon and Cowley roundabouts removed. If a junction (such as a left-in / left out arrangement) were added at Cowley, a length of approximately 1.3km of the existing A417 between the Stockwell and Birdlip junctions could be removed. This will be reviewed further in future stages.

Drainage

- 7.8.7 There is a high point located approximately at the two-third point of the route to Cowley. The route falls from this high point to the 2 ends of the route on either side.
- 7.8.8 The proposed highway drainage could take the form of kerb and gullies, kerb drainage units, grassed channels (swales) or filter drains connecting to carrier pipes.
- 7.8.9 For the descending arm towards Little Witcombe, the route would likely cross the tributaries of the River Churn as well as Horsbere Brook until it joins with the existing A417 at Little Witcombe. A number of slip roads with 2 roundabouts would join with the existing A417 around the high point location. The surface water run-off on the carriageway from the high point to the west end of the route (approx. 3.7km) would be intercepted and conveyed to the tributaries of Horsbere Brook and the River Churn if infiltration / soakaway is not feasible. If attenuations are required, a broad estimate shows a volume of 1,990m³ would

be required at the west end of the route and a volume of 2,620m³ would be required at approximate chainage 1600. To cater for the surface water run-off from the slip roads and roundabouts, another attenuation would likely be required with a volume of 2,180m³ at approximate chainage 3050. These storages could be provided in the form of a storage pond at appropriate locations close to the discharge points or large diameter pipes.

- 7.8.10 For the descending arm towards Cowley which comprises the remaining 1.8km of carriageways, the drainage system would fall towards Cowley and could outfall to the River Frome following the existing condition (subject to attenuation). For this section of the route, the attenuation volume based on a broad estimate is 2,550m³.
- 7.8.11 Subject to further investigation and site inspection, more outfalls could be designed if there are other available and appropriate outfall locations identified, and if this could make the design more efficient in terms of pipe sizes and storage volumes.

Structures

- 7.8.12 Nine major locations have been identified for proposed structures:
- Overbridge to carry the A436 carriageway over the new A417 alignment at chainage 2100
 - Overbridge for NMU route / farm track over the A417 at chainage 2900
 - Multiple span underbridge carrying the A417 over a grade separated junction at chainage 3200
 - Underbridge carrying A417 over Cowley Lane at chainage 4100
 - Underbridge carrying the A417 over a farm track at chainage 4500
 - 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 30m
 - Overbridge for farm track over the link road connection the new grade separated junction and the existing A417 single-carriageway
 - Underbridge carrying the link road over a farm track
 - Green bridge over both the existing and proposed A417 carriageways at chainage 1800 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
- 7.8.13 An existing structure that would probably be affected by the option is:
- Barrow Wake Underbridge on the existing A417 could be impacted by the new roundabout connecting the link road from the grade separated junction on the proposed route

7.9 Options' statutory undertakers' estimates

7.9.1 Letters with drawings showing existing Statutory Undertakers' (SU) (utility) services and scheme layout were sent to the affected Statutory Undertakers requesting a cost estimate for each of options.

7.9.2 The scheme affects the following Statutory Undertakers:

- Openreach BT
- Gigaclear
- Severn Trent
- Wales and West
- Western Power Distribution

7.9.3 A Budget Estimate was returned from each utility with apparatus affected by the options proposed. Table 7.1 shows a comparison of options and total utility cost.

Table 7.1: Option, utility cost and total cost

Option	Total Statutory Undertaker's Utility Cost
Option 3 (Tunnel)	£104,000
Option 12 (Surface)	£135,000
Option 21 (Tunnel)	£820,000
Option 24 (Tunnel)	£130,000
Option 29 (Tunnel)	£106,000
Option 30 (Surface)	£126,000

7.10 Option estimates

7.10.1 Following the initial engineering development of the options, the 6 options were assessed by Highways England’s Commercial Division to produce the most likely (P50) Order of Magnitude (OME) estimates given below in Table 7.2. These estimates are based on 2016 Q1 prices.

Table 7.2: Most likely order of magnitude option estimates, 2016 Q1 price base

Option	Most likely OME
Option 3 (Tunnel)	£875,000,000
Option 12 (Surface)	£465,000,000
Option 21 (Tunnel)	£1,625,000,000
Option 24 (Tunnel)	£1,210,000,000
Option 29 (Tunnel)	£1,240,000,000
Option 30 (Surface)	£485,000,000

7.11 Conclusions

7.11.1 A summary of the descriptions of the 6 options taken forwards for appraisal and assessment is given below in Table 7.3.

Table 7.3 Summary of option descriptions

Option	Type	Total length (km)	Maximum gradient (%)	Tunnel length (km)	Total attenuation volume (m ³)	Number of structures	Total utility diversion cost	Most likely OME estimate
Option 3	Tunnel	5.2	8.0 ¹	1.0	6,550	5	£104,000	£875,000,000
Option 12	Surface	6.4	8.4	N/A	12,245	10	£135,000	£465,000,000
Option 21	Tunnel	4.6	5.0	3.0	3,310	2	£820,000	£1,625,000,000
Option 24	Tunnel	6.1	6.0	1.6	7,620	10	£130,000	£1,210,000,000
Option 29	Tunnel	5.7	6.0	1.7	7,180	10	£106,000	£1,240,000,000
Option 30	Surface	5.6	7.5	N/A	9,340	8	£126,000	£485,000,000

Notes: 1. Maximum gradient of 8% on Option 3 occurs outside of the tunnel section.

8. Traffic analysis

8.1 Traffic data

- 8.1.1 Highways England has developed 5 'regional' transport models (RTMs) to provide the basis for the development and appraisal of the Road Investment Strategy (RIS) and Road Investment Programme (RIP) schemes. The South West Regional Transport Model (SWRTM) is one of the RTMs and was developed by Arup and Mott MacDonald Sweco Joint Venture (Mott MacDonald Sweco Joint Venture) on behalf of Highways England. The SWRTM, which has a base year of 2015, has been used as the initial basis in the development of a local A417 Missing Link traffic model.
- 8.1.2 The development of a local A417 model has involved enhancing the SWRTM, by including new and existing local traffic surveys within the study area to better represent local traffic movements.
- 8.1.3 Traffic counts were undertaken in accordance with DfT Transport Analysis Guidance WebTAG Unit M1.2, in relation to the specific requirement to undertake a minimum of a 2-week Automatic Traffic Count (ATC).
- 8.1.4 ATC surveys were undertaken in October / November 2016 by Gloucestershire County Council's in-house data collection team and by Streetwise Services Ltd, who were appointed directly by Gloucestershire County Council (GCC).
- 8.1.5 In accordance with DfT WebTAG Unit M1.2 guidance, surveys were programmed to be carried out during neutral months, outside of school holidays and other local abnormal traffic periods.
- 8.1.6 Existing count data has also been obtained from other sources. This includes the following:
- GCC – ATC and Manual Classified Turning Counts (MCTC)
 - Road Management Services (Gloucester) Limited – ATC Counts
 - SWRTM – ATC Counts
 - Highways England WebTRIS – ATC Counts
 - TrafficMaster – Journey Time Data
 - Mott MacDonald Sweco Joint Venture – Road Side Interview (RSI) data

8.2 Traffic analysis

- 8.2.1 As stated above, a traffic model has been developed for the purposes of appraising the A417 Missing Link options in PCF Stage 1, Option Identification. The following sections describe how the base traffic model was built and used to produce future year forecasts for the options.

Base year model

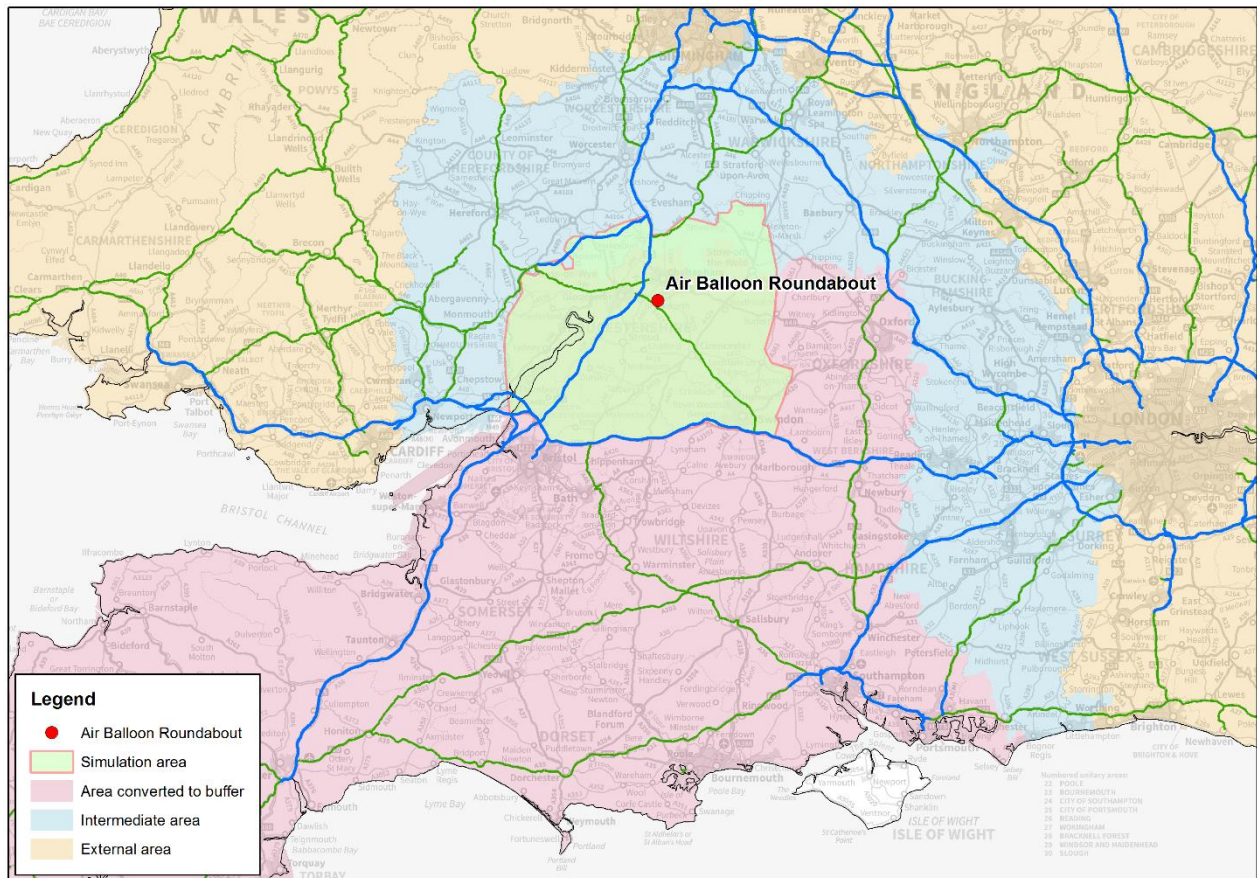
- 8.2.2 The traffic model has been developed in SATURN software to represent 3 weekday time periods that are consistent with the SWRTM model time periods.

These are an average AM peak period hour (07:00-10:00), an average hour in the inter-peak (10:00 – 16:00) and an average PM peak period hour (16:00 – 19:00) for an average Monday to Friday weekday in March 2015 (excluding school holidays and bank holidays). An off-peak (OP) model has also been developed to cover the 12-hour evening/night-time period, although this OP model is not subject to calibration and validation, as it is simply an alternative method to factoring from modelled periods to daily levels.

- 8.2.3 The development of the highway model has relied on the data used in the SWRTM and some additional surveys carried out in autumn 2016. For more information, see the A417 Missing Link Stage 1 Traffic Data Collection Report, February 2017.
- 8.2.4 The SATURN model comprises of 1914 zones, a sub-regional road network and is comprised of the following modelled areas:
- **Simulation area** – this is the area over which proposed intervention has its main strategic and local impact. The network within this area consists of fully simulated links and nodes, in addition to some fixed speed links within some urban areas.
 - **Area converted to buffer** – this comprises of the network within the SWRTM ‘Region of Focus’ (RoF) but outside of the A417 model simulation area. This area of the network has detailed coverage as it still contains all the links, nodes and zones included in the SWRTM but these have been converted to buffer network with fixed speeds.
 - **Intermediate area** – this is the same as the intermediate area defined in the SWRTM and consists of buffer network with fixed speeds but with more detailed network coverage than that of the external area.
 - **External area** – this is the same as the external area defined in the SWRTM.

8.2.5 The model areas described above are shown in Figure 8.1.

Figure 8.1: A417 model areas



Source: Mott MacDonald Sweco Joint Venture

- 8.2.6 The SWRTM SATURN network has been enhanced in the vicinity of 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. Network detail was also added to allow more accurate loading of zone traffic in the local area.
- 8.2.7 The SWRTM trip matrices have been adapted with additional local zones added to better represent the distribution of trips local to the proposed scheme.
- 8.2.8 The SATURN model meets the DfT's WebTAG convergence criteria in all time periods, which demonstrates a good level of stability and reliability in the model.
- 8.2.9 Around 95% of calibration link flows meet the GEH²⁸ or flow criteria in all time periods, which exceeds the WebTAG target of at least 85% of links meeting the criteria. This shows that the model achieves a close match to observations for individual link counts. At the total screenline level, out of a total of 20 calibration screenlines, 15 meet the target of being within 5% of observed flows in both the AM and PM periods and 18 meet this target in the inter-peak. When comparing screenlines against legacy GEH criteria set out in DMRB, 19 out of 20

²⁸ GEH is a form of Chi-squared statistic that incorporates both relative and absolute errors and issued to compare modelled traffic data against observed data.

screenlines meet the target in the AM and interpeak with 17 out of 20 meeting the target in the PM. overall, it was considered that there is a reasonable match on the calibration screenlines between the model and observed flows.

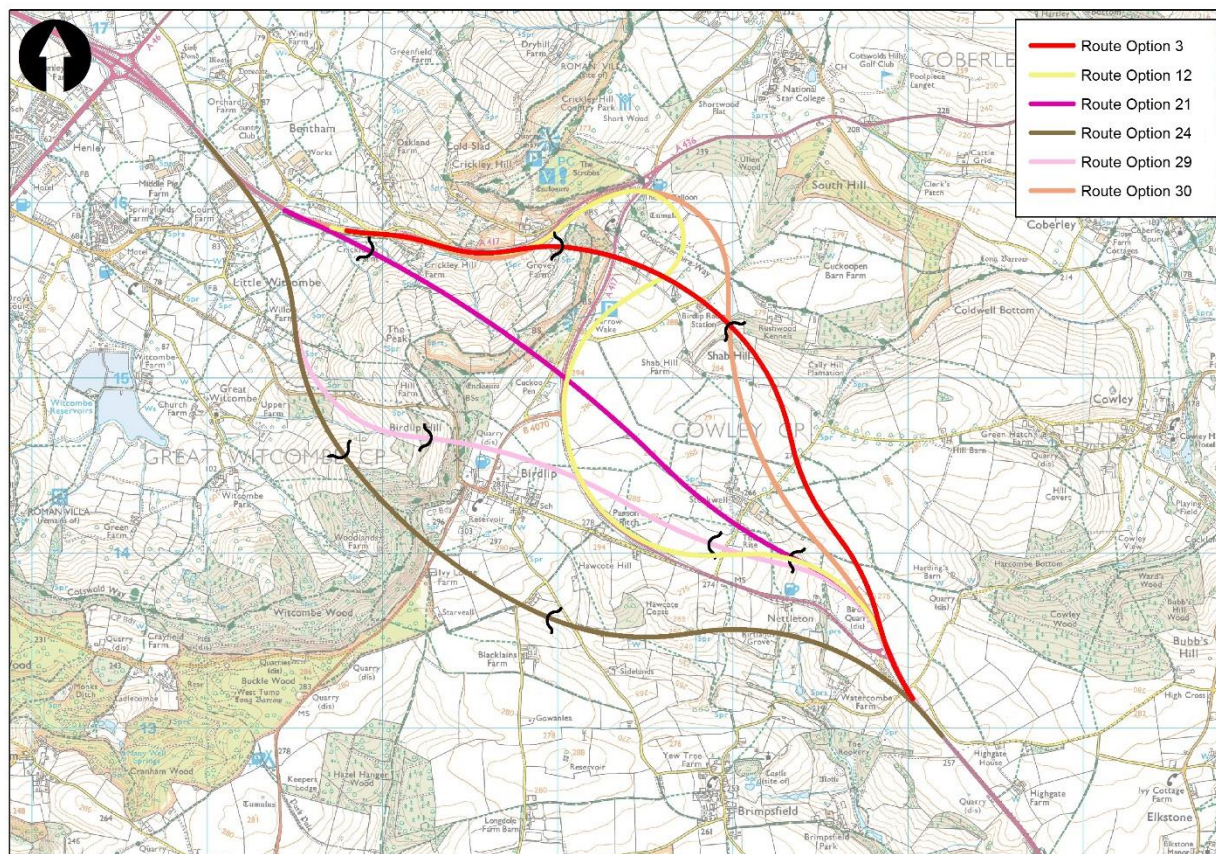
- 8.2.10 Flow validation has been undertaken against independent data not used in calibration or for the matrix building exercise. An assessment of the validation process shows that the model meets the link flow WebTAG validation criteria in all cases. At the total screenline level, out of a total of 6 validation screenlines, 3 meet the WebTAG criteria of being within 5% of observed flows in the AM peak, 5 meet the target in the interpeak and 2 meet it in the PM peak. Achieving a better match to observed flows at the screenline level has been hampered to a degree by the prevalence in the model of rural links with low flows. Where validation screenlines fall short of the targets this is only by a small degree. Using GEH criteria to measure the quality of the screenline validation shows that only 1 screenline falls short in the AM period, 4 out of 6 meet the target in the PM, and all screenlines meet the target in the inter-peak.
- 8.2.11 The journey time route validation meets WebTAG criteria in all cases and the journey time profiles indicate a good match between the model and observations in all time periods. The journey time validation is therefore considered to be good in all time periods with the model recreating journey times that are representative on key routes in the modelled area.
- 8.2.12 Realism testing has been undertaken on the validated model in line with WebTAG guidance. The outturn elasticities calculated from these tests are reasonably well aligned with the values given in TAG Unit M2. They are also very close to the elasticities calculated for the SWRTM and are considered to be acceptable for scheme appraisal purposes.
- 8.2.13 In conclusion, it is considered that the 2015 base year highway assignment model developed for the A417 Missing Link Stage 1 calibrates and validates to within acceptable margins of the WebTAG criteria and therefore demonstrates a good representation of traffic behaviour in the study area and forms a robust basis from which future year forecasts and option testing can be developed.

Traffic forecasting

- 8.2.14 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. The forecasts have used the Department for Transport's National Trip End Model (NTEM / TEMPRO v7.2) and Road Traffic Forecasts (RTF) 2015 forecasting data as well as accounting for local developments which have been assessed in an uncertainty log in accordance with WebTAG unit M4.
- 8.2.15 The traffic forecasts have been undertaken using a variable demand modelling approach that is consistent with that applied in the development of SWRTM.

8.2.16 Traffic forecasts have been prepared for the 6 options (Do Something scenarios) as well as a scenario without the scheme (Do Minimum scenario). The Do Something SATURN networks are shown in Figure 8.2.

Figure 8.2: A417 option alignments



Source: Mott MacDonald Sweco Joint Venture

8.2.17 The 6 options are all forecast to reduce journey times along the A417. Measured from Cirencester to the M5, northbound journey time savings compared to the Do Minimum scenarios are forecast to reach about 6 minutes (30% reduction) in the morning and evening peaks. Southbound journey time reductions are not as great but still equate to around 3 to 4 minutes, or 20-25%, compared to the Do Minimum.

8.2.18 As a result of these improved journey times, all 6 options are forecast to increase traffic flows on the A417 compared to the Do Minimum scenarios. The largest increases in traffic occur on the existing A417 section immediately to the south of the A417 / A46 junction, where flows with the scheme are forecast to increase by up to 42% in 2024 and by nearly 50% in 2039 when compared to the equivalent Do Minimum scenario.

8.2.19 Traffic forecasts show that the increases in flows on the A417 in the vicinity of the scheme are a result of traffic reassigning from various alternative routes, both local and long distance, coupled with some redistributed trips that are taking advantage of the improvements to the route. At the local level, traffic is forecast to reassign away from existing known rat runs including via Elkstone towards

Cheltenham and via Birdlip Hill towards Gloucester. The schemes are also shown to result in reassignment away from alternative longer distance routes, including the A34, M40 and A429, and onto the A417 / M5 route between the South and West Midlands. In the opening year, forecasts indicate that local reassignment typically accounts for around 80% of the increases noted on the A417. Approximately 10% of the increases are attributable to wider reassignment from the M40 / A34, with the remaining 10% of the increases arising from trip redistribution effects and reassignment from other routes.

8.2.20 Since the completion of the forecasting work the government has announced the removal of the toll charges from the Severn Crossing in 2018. This is likely to have a small impact on the forecast traffic in the local area. These changes would occur both with and without the scheme so that the differences for economic and environmental appraisal would be limited. It is proposed that this will be fully assessed in the next stage of scheme development.

8.3 Road layout and standards

8.3.1 The client scheme requirements identify that any proposed scheme will provide a free flowing 'expressway quality journey' between Swindon and Gloucester / Cheltenham.

8.3.2 The RIS sets out a vision for expressways as:

- Roads that can be relied upon to be as well-designed as motorways and which are able to offer the same standard of journey to users, meaning:
 - Largely or entirely dual-carriageway roads that are safe, well-built and resilient to delay.
 - Junctions which are largely or entirely grade separated, so traffic on the main road can pass over or under roundabouts without stopping.
 - Modern safety measures and construction standards.
 - Technology to manage traffic and provide better information to drivers.
- This means an expressway would be able to provide a high-quality journey to its users with mile-a-minute journeys throughout the day, particularly outside of urban areas. Safety levels should match the highest standards of the network and be able to provide a motorway-quality journey.

8.3.3 In developing the highway alignments, a high-quality layout has been developed to understand the range of possible constraints that may be factors in the development of the options.

8.3.4 In line with the scheme objectives, relaxations or departures from highway standards to reduce the environmental impact will be considered as the design progresses, where they do not compromise safety. Alignments will be adapted in conjunction with stakeholders to reduce impact to the landscape.

Road geometry

- 8.3.5 High quality geometry should be achieved by designing the options to desirable minimum standards as defined in Design Manual for Roads and Bridges (DMRB) Standard TD9/93 Highway Link Design (TD9/93). It is recognised that some departures from standard could be incorporated into schemes to address specific issues without compromising safety and such opportunities would be assessed as the design progresses with selection of a preferred option.
- 8.3.6 The design speed for each link has been proposed in accordance with the references in Table 8.1.

Table 8.1: Mainline and link design speeds

Road Type	Design Speed (kph)	Reference
Mainline	120B	DMRB
Tunnels	120B	BD 78/99
Slip roads	70	TD 22/06
Connector roads	Varies 60 - 70	DMRB, TD 22/06
Single carriageways	Varies 50 - 70	Existing conditions or as adopting Authority requirements

- 8.3.7 As the designs develop, conflicts between technical, environmental, economic and community objectives would be assessed, and if appropriate, alignments would be optimised through the application of further relaxations and departures from standard to derive a balanced solution.
- 8.3.8 The cross sections of the proposed route and connections to local roads will be designed in accordance with TD 27/05 'Cross Sections and headroom' (DMRB, Volume 6, Road Geometry, Section 1 Links, Highways England 2005). Headroom clearances are also determined from this standard with no expectation that the road improvement will become a high load route.
- 8.3.9 It may be more appropriate to provide reduced cross sections for some minor local roads to be consistent with the character of the road and this approach will be applied in consultation with the local highway authority.
- 8.3.10 The 6 options have been assessed against TD9/93 and require departures from standard to be implemented. Table 8.3 identifies the numbers of departures for each option identified at Stage 1. Option 12 was developed between 2001 and 2006 in conjunction with a number of environmental bodies and due to the site topography, budget and original scope required 22 departures from standard. The departures for Option 12 were approved by the Highways Agency in 2003 but that approval has expired. Further development of Option 12 would require all previously approved departures from standards to be re-submitted including a detailed risk assessment in support of any submission. This will enable

departures to be considered against Highways England’s current standards, departure process and current Key Performance Indicators (KPIs).

Table 8.2: Options and numbers of anticipated mainline departures from standard

Option	Numbers of anticipated Departures from Standard
3 – Tunnel	8
12 – Surface	22
21 – Tunnel	8
24 – Tunnel	8
29 – Tunnel	6
30 - Surface	8

Junction strategy: location and layout

8.3.11 A preliminary assessment has been undertaken to determine requirements for junction locations for each option. This aims to provide a similar level of interconnectivity between the new road and adjacent local road network as is currently the case. This assessment has concluded with junction locations summarised in Table 8.3.

8.3.12 During subsequent stages of option assessment, the junction locations in Table 8.3 will be validated against an assessment of accident, delay, capital and maintenance costs. This will enable the most appropriate junction location and layout to be taken into consideration.

Table 8.3: Junction locations

Route	Junction	Location	Network connection
Option 3 Tunnel	Grade separated	East of Cowley roundabout	A417, dumb-bell link road and 3No. unclassified roads
	Diverge and merge slips	West of Air Balloon roundabout	A417 and A436
Option 12 Surface	Compact grade separated (Left-in, left out)	At Cowley roundabout	A417 and 3No. unclassified roads
	Grade separated (dumb-bell)	Birdlip (B4070 Junction)	A417 and B4070
	North facing slip roads	Barrow Wake	A417 and A436 (via existing A417)
	Roundabout (at grade)	North-east of Air Balloon roundabout	A436, B4070 and existing A417
Option 21 Tunnel	Grade separated	East of Cowley roundabout	A417, dumb-bell link road and 3No. unclassified roads
	Diverge and merge slips	West of Air Balloon roundabout	A417 and A436

Route	Junction	Location	Network connection
Option 24 Tunnel	Grade separated	West of Cowley roundabout	A417, dumb-bell link road and an unclassified road
	Diverge and merge slips	West of Air Balloon roundabout	A417, A46 Shurdington Road junction
Option 29 Tunnel	Grade separated	West of Cowley roundabout	A417, dumb-bell link road and an unclassified road
	Diverge and merge slips	West of Air Balloon roundabout	A417, A46 Shurdington Road junction
Option 30 Surface	Grade separated	South-east of Air Balloon roundabout	A417 via proposed link road
	Diverge slip and junction	South-west of Air Balloon roundabout	A436
	Roundabout at grade	South of Air Balloon roundabout	A417

8.3.13 An early assessment has been made to adopt full grade separation in accordance with TD22/06 with direct tapers for single lane merge and 2-lane diverge slips. This decision has been based on forecasted traffic flows (AADT) of for 3 geographic locations on the existing A417 route and are shown in Table 8.4.

Table 8.4: Forecasted traffic flows

Forecast Year	West of Air Balloon roundabout	South of Air Balloon roundabout	South of Cowley roundabout
2024	39,800	33,100	34,100
2039	46,500	37,000	40,200

8.4 Conclusions

- 8.4.1 The SWRTM has been enhanced in the vicinity of the A417 scheme in order to develop a local A417 traffic model. The local A417 model has been calibrated and validated to be representative of traffic conditions in March 2015.
- 8.4.2 Using the 2015 base year model as a starting point, forecast traffic models have been developed for the purposes of assessing the impacts of each of the A417 options. The forecast models have been used to inform the traffic, environmental and economic appraisal of the options.
- 8.4.3 The forecasts have been prepared for the current estimated opening year of 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 schemes. The forecasts have used the Department for Transport’s National Trip End Model (NTEM / TEMPRO v7.2) and Road Traffic Forecasts (RTF) 2015 forecasting data as well as accounting for local developments.

- 8.4.4 The traffic models forecast that all options will reduce delays and improve journey times along the A417. The greatest journey time savings are forecast to occur in Option 21, which is reflective of the more direct alignment provided by this tunnelled option. The forecasts for the non-tunnelled Option 12, which provides a less direct alignment compared to the other options, and includes a section with a mandatory 50mph speed limit, still show a significant reduction in journey times compared to the Do Minimum but this option provides the slowest journey time along the A417 of all 6 options.
- 8.4.5 The journey time reductions are forecast to result in an increase in traffic in the vicinity of the scheme, as traffic reassigns from various alternative routes, both local and longer distance.

9. Economic assessment

9.1 Introduction

- 9.1.1 The 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 each A417 options has followed the guidance set out in WebTAG.
- 9.1.2 Table 9.1 identifies the approach adopted to appraise the economic impacts of the A417 options.

Table 9.1: Overview of economic assessments

Element	Assessment Method
Transport economic appraisal	TUBA (Transport Users Benefit Appraisal) software (version 1.9.8)
Accidents	COBALT (COst and Benefit to Accidents – Light Touch) software (version 2013.02)
Journey time reliability	‘Stress-based approach’ set out in WebTAG unit A1.3 Appendix C.5
Delays during construction	QUADRO (QUeues And Delays at ROadworks) software (version QUADRO R14)
Air quality	Approach set out in WebTAG Unit A3 Chapter 3
Noise impacts	Approach set out in WebTAG Unit A3 Chapter 2
Greenhouse gas emissions	Approach set out in WebTAG Unit A3 Chapter 4 including outputs from TUBA (version 1.9.8)
Wider economic impacts	Simplified approach set out in WebTAG 2.1 Section 4.1.

- 9.1.3 The application of the above methods in the economic assessment of the scheme is summarised in this section of the report.

9.2 Application of economic assessment methods

Transport economic appraisal

- 9.2.1 The DfT economic appraisal software TUBA program version 1.9.8 has been used to calculate the transport user benefits for each option in accordance with published DfT guidance.
- 9.2.2 Construction of the scheme is expected to start in summer 2021, although due to differences between the schemes being considered (tunnelled versus surface) the duration of the construction periods varies between the options. Assumed completion dates vary between 2024 for Option 12 and Option 30; 2025 for options 3, 24 and 29; and 2026 for Option 21. At this stage, to allow the options to be easily compared on a like-for-like basis, it has been pragmatically assumed that all options will have an opening year of 2024.

- 9.2.3 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. Highways England Option Estimate (OE) scheme costs have been prepared for each of the options and are input into the TUBA assessments to allow the economic impacts of the scheme to be appraised. Forecasts have been produced for 4 years (2024, 2031, 2039 and 2051) and have been used in the economic appraisal. TUBA uses the input trip and cost matrices for each forecast year and, through a process of interpolation and extrapolation, appraises the economic benefits of the 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 to the present value year (2010) in accordance with WebTAG Unit A1.1.
- 9.2.4 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 inter-peak hour (10:00-16:00), an average PM peak hour (16:00-19:00), and an average off-peak hour (19:00-07:00). Annualisation factors have been used to uplift the results produced for the modelled periods to represent all hours during the year.

Accident benefits

- 9.2.5 COBALT has been used to assess the impact of the proposed options on accidents. To inform the COBALT accident assessment, data was extracted from the Do Minimum and each of the Do Something option highway models for the model years of 2024 and 2039. This data included network structure and forecast traffic flows (2-way 24hr annual average daily traffic (AADT)).
- 9.2.6 The COBALT approach adopted for the A417 Missing Link combines accidents on links and junctions together. The scope of this assessment has been limited to the simulated area of the SATURN traffic model as this area is considered to encompass the majority of the effects of the proposed schemes being assessed.
- 9.2.7 In keeping with COBALT guidance, the highway networks from SATURN were simplified in places to condense complex junction coding down to single nodes. In addition, it was also necessary to combine SATURN links (A-B and B-A) such that a single link in COBALT (A-B) represents both directions of travel. COBALT links were subsequently allocated a link type based on road standard, number of carriageways, width, age and presence or absence of a hard strip.
- 9.2.8 Accident data for 2011 through to 2015 inclusive was taken from DfT Road Safety Data. The statistics relate only to personal injury accidents on public roads that are reported to the police, and subsequently recorded, using the STATS19 accident reporting form.
- 9.2.9 Accident data was subsequently mapped onto the 2015 base year COBALT network links in GIS. Accidents were allocated to the nearest link within 20 metres to avoid erroneously mapping any accidents that occurred on non-modelled links onto the modelled network.

- 9.2.10 The allocated accident data in combination with the 2015 base year modelled flows were then processed in COBALT to give observed accident rates on the base year network links.
- 9.2.11 Do Minimum networks were prepared from the base network by modifying the structure as appropriate. 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 options networks were created from the Do Minimum networks in a similar way, with default accident rates being applied to the new scheme links.
- 9.2.12 COBALT compares the predicted number of accidents with and without the scheme(s) and converts them into monetary values by multiplying the numbers of accidents by default monetised costs (by accident severity).
- 9.2.13 Traffic flows for each scenario and year (2024 and 2039) are input into COBALT as 2-way AADT flows.

Journey time reliability

- 9.2.14 For the A417 Missing Link an estimate of journey time reliability has been undertaken in line with the stress-based approach set out in TAG Unit A1.3 Appendix C.5.
- 9.2.15 In summary, this approach involves calculating a level of stress in the year of opening (2024) for the Do Minimum scenario and for each option. The Crickley Hill section of the A417 between the Air Balloon roundabout and the A46 has been used in the assessment. Stress levels are forecast to increase from the 109% calculated for the 2015 base year to 112% in the 2024 Do Minimum. All the options were forecast to result in a reduction in stress, with the tunnelled options (Options 3, 21, 24 and 29) leading to stress levels between 54% and 58%. A stress level of 63% was calculated for both surface options (options 12 and 30).
- 9.2.16 As per the guidance in TAG Unit A1.3, the reduction in stress calculation assumes a minimum Do Something level of 75%, which results in a 37% reduction in stress for all options (i.e. $112\% - 75\% = 37\%$). Once the reduction in stress is calculated, it is multiplied by the forecast AADT to give a reliability indicator. Using this approach, each option is classified as having a Moderate Beneficial impact in terms of journey time reliability. This is subsequently monetised in accordance with DfT value for money (VfM) guidance, which suggests that a moderate beneficial impact is equivalent to a 10% uplift of the travel time benefits.

Construction delays

- 9.2.17 The construction of a scheme on the A417 at Air Balloon will inevitably lead to delays on the existing local road network during the construction period. Roadworks during the construction phase would be expected to cause delays to traffic (both due to physical presence of the works and any delays caused by breakdowns or accidents occurring within the works). This would lead to impacts on travel times, vehicle operating costs, carbon emissions and accident costs.
- 9.2.18 The economic assessment of delays during construction has been undertaken using QUADRO software. An economic assessment of the delays incurred during construction has been performed for each of the proposed options. The assumptions used in the appraisal are based on an assessment of the possible traffic management arrangements which were provided by the contractor.
- 9.2.19 An assessment of the impact of on-going maintenance has not been undertaken at this stage. Consideration should be given to including this important element of the appraisal (particularly for the tunnelled options) at future stages of the development of the A417 Missing Link scheme, when more detailed information becomes available with respect to the proposed programme of maintenance for each option.

Air quality

- 9.2.20 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 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

- 9.2.21 A noise appraisal has been undertaken in accordance with TAG Unit A3 Chapter 2. Net Present Values (NPV) have been calculated for changes in noise, amenity and several specific health issues. 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.
- 9.2.22 The calculation area for noise is defined by Design Manual for Road and Bridges 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

9.2.23 A greenhouse gases (GHG) appraisal has been undertaken to determine the carbon dioxide equivalent (CO₂e) emissions for each option, and derive the NPV of each option in terms of GHGs. The monetary value of greenhouse gases has been assessed over the 60-year appraisal period based on the approach set out in WebTAG Unit A3 Chapter 4 using outputs from TUBA and the DfT Greenhouse Gases Workbook.

Wider economic impacts

9.2.24 Due to the memory limitations of the current version of DfT's Wider Impact in Transport Appraisal (WITA) software, it has not been possible to undertake a WITA assessment at this stage for the A417 scheme. In the absence of a WITA analysis the simplified approach to estimating wider economic benefits set out in the DfT VfM guidance has been adopted. This recommends that an indicative measure of the value of increased output in imperfectly competitive markets can be estimated using a 10% uplift to Business User Benefits.

9.2.25 It is understood that a 64-bit version of the WITA software is in development that should be able to accommodate the scale of the demand and cost matrices generated by the A417 traffic model. Assuming that this software becomes available in time, then a WITA assessment should be possible at Stage 2.

9.3 Conclusions

9.3.1 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 table is shown in Table 9.2 (see next page). As per WebTAG, all costs and benefits are reported in 2010 prices, discounted to 2010.

9.3.2 It should be noted that 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 GDP-deflator series as published in the March 2017 WebTAG Databook.

Table 9.2: Analysis of monetised costs and benefits (£000's)

Item	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Accidents (not assessed by TUBA) ¹	4,114	3,334	4,240	6,792	6,173	4,333
Roadworks (not assessed by TUBA) ²	-12,617	-24,029	-13,449	-13,596	-13,596	-20,552
Greenhouse Gases (not taken directly from TUBA) ³	-24,115	-31,009	-22,153	-33,216	-23,179	-30,603
Noise (not assessed by TUBA) ⁴	865	1,061	1,951	653	559	772
Air Quality (not assessed by TUBA) ⁵	-1,184	-1,201	-766	-1,083	-1,135	-1,140
Economic Efficiency: Consumer Users (Commuting)	56,531	27,033	60,601	50,560	55,495	44,693
Economic Efficiency: Consumer Users (Other)	35,183	6,807	36,181	21,196	33,972	17,709
Economic Efficiency: Business Users and Providers	248,447	108,326	271,003	237,971	248,379	170,948
Wider Public Finances (Indirect Taxation Revenues)	51,904	62,457	48,595	64,936	49,855	62,929
Present Value of Benefits (PVB)	359,127	152,780	386,203	334,214	356,523	249,090
Broad Transport Budget Present Value of Costs (PVC)	533,104	276,590	956,530	726,200	742,712	286,390
OVERALL IMPACTS						
Net Present Value (NPV)	-174,540	-123,810	-570,843	-392,776	-386,730	-37,300
Initial Benefit to Cost Ratio (BCR)	0.67	0.55	0.40	0.46	0.48	0.87
Reliability Benefits	37,597	25,307	38,586	36,346	36,950	32,592
Wider Economic Benefits	24,845	10,833	27,100	23,797	24,838	17,095
Adjusted BCR	0.79	0.68	0.47	0.54	0.56	1.04

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

- 9.3.3 The majority of benefits arising from all options are achieved through transport economic efficiency improvements, and primarily from travel time benefits. In comparison to the economic efficiency benefits, the monetised arising environmental, accidents, delays, reliability and wider economic impacts are relatively minor. In all cases disbenefits are predominantly attributable to the forecast increase in GHG and also due to disruption to traffic during construction. In addition, there are also monetised disbenefits associated with the Air Quality assessment, although these are very minor in comparison.
- 9.3.4 Present Value of Benefits (PVB) over the 60-year appraisal period range from £153m to £386m. The greatest amounts of benefits are achieved by Option 21, which provides the most direct route alignment and the greatest journey time savings. The surface options (options 12 and 30) provide the least amount of benefits, which reflects the layouts of these options with less direct alignments on the A417 and longer connections between the A417 and the A436. Option 12 provides less than half of the benefits of the worst performing tunnelled option (Option 24), while Option 30 provides approximately 25% less benefits than Option 24. The best performing tunnelled option (Option 21) provides more than 2 and a half times the benefits of the surface Option 12 and over 50% more benefits than the surface Option 30.
- 9.3.5 However, despite offering significantly lower benefits than the tunnelled options, Option 30 is shown to provide the best overall value for money, with an initial BCR of 0.87 and an adjusted BCR of 1.04, when reliability benefits and wider economic benefits are included. This reflects the substantially lower cost of this surface option compared to the tunnelled options.
- 9.3.6 Option 12 is the cheapest option that has been considered at this stage but the lower scheme cost is offset by the comparatively poor levels of benefit that are generated, which result in an initial BCR of 0.55 and an adjusted BCR of 0.68.
- 9.3.7 Of the tunnelled options, Option 3 provides the best value for money, with an initial BCR of 0.67 and an adjusted BCR of 0.79. Options 24 and 29 provide similar levels of value for money, while the substantially greater cost of Option 21 results in this option achieving the poorest overall value for money despite providing the greatest amounts of benefits.

10. Safety assessment

10.1 Impact on road user – strategic safety action plan

Introduction

10.1.1 This section assesses the 6 options against the safety impact on the road user with a review of Personal Injury Collision statistics, a road safety review, and a review of the impact of the options during construction, maintenance, operation and demolition in accordance with the Construction (Design and Management) (CDM) Regulations 2015.

Assessment methodology

10.1.2 This safety assessment reviews the proposed 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 6 alignments: Options 3, 12, 21, 24, 29 and 30

10.1.3 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

10.1.4 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.

Delivery plan and national incident and casualty reduction plan

10.1.5 The Highways England Delivery Plan 2015-2020 (and, subsequently, the National Incident and Casualty Reduction Plan) sets out a target of reducing the number of people killed or injured on the network to as close as possible to zero by the year 2040. More specifically, the target is to reduce the number of collisions involving fatal or serious injuries on the Highways England network to 1,393 per year by 2020. This would represent a reduction of 40% on the baseline of the 2005 to 2009 averages.

10.1.6 Over the length of the existing A417 single-carriageway section between Cowley roundabout in the south and the vicinity of Bentham Lane underpass to the north, 57 Personal Injury Collisions were recorded in the latest 5-year period of 19/11/2011 to 18/11/2016. Of the 57 collisions, 4 were fatal, 11 were serious and 42 were slight in severity.

- 10.1.7 The following list highlights the type of collisions occurring on the A417 Missing Link during the 5-year period of 19/11/2011 to 18/11/2016:
- 11 loss of control collisions of which 2 were serious in severity
 - 21 rear end shunts of which 11 were in traffic – all were slight
 - 12 head-on type collisions resulting in 7 serious and 2 fatal collisions
 - 6 collisions involving vehicles turning onto or off the A417 including one fatal and one serious collision
 - 2 U-turn collisions – both slight in severity
 - 1 collision involving a pedestrian (broken down vehicle) walking along the carriageway – serious in severity
 - 2 other collisions (one road rage resulting in slight injury, and one involved a driver trying to push his broken-down vehicle on the hill and it ran over him resulting in fatal injuries)
 - 2 collisions resulting from failure to give way at the Air Balloon roundabout

Implications of the proposals

- 10.1.8 The A417 Missing Link consists of a single-carriageway trunk road with 2 at-grade roundabout junctions. The A417 also passes through the small hamlet of Nettleton. Notable gradients are present on sections of the A417 Missing Link and crawling lanes are currently provided on the up-hill sections. Where notable gradients are not present, the carriageway is undulating both horizontally and vertically and a large T-Junction is present at the top of the highest incline providing access to the village of Birdlip. Agricultural and other slow-moving vehicles are commonly observed on this section of highway; the existing highway geometry typically impedes ease of movement for such vehicles.
- 10.1.9 Existing highway features include:
- At-grade local road 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
- 10.1.10 The proposed options would eliminate most or all of the above mentioned highway features for the A417. In addition, the horizontal and vertical alignments and associated forward visibility would be improved relative to the existing situation. This should result in a decrease in the number of collisions on the trunk road, due to the single-carriageway and at-grade features of the existing alignment having been removed.
- 10.1.11 All 6 options would continue to utilise the existing A417 as part of the local highway network providing access to the A436 and Cheltenham for motorists travelling to or from the south, with the exception of Options 12 and 30 which all A436 and Cheltenham traffic would use. As such, many of the existing A417

highway features would remain. However, fewer incidents are expected with less traffic anticipated on the existing A417. Reduced traffic flows may also mean vehicles travel at higher speeds. Therefore, the treatment of the existing A417 will require careful consideration to provide a safer road taking consideration of all potential risks.

Safety review principles

General highway design features

- 10.1.12 Forward visibility and associated widening on bends would be expected to be provided within standards and therefore there are no specific concerns with regards to this element. In addition, highway features such as signs and structural elements would be expected to lie outside the visibility splays and not create road safety problems.
- 10.1.13 The cross-section is expected to be formed of 2 standard 3.65m wide lanes in each direction with a central reserve and a 1.0m hard strip, which is similar to the existing A417 dual-carriageway sections at the tie-in locations. The hard strip would be expected to accommodate drainage features such as gullies for them to be located away from live traffic. In addition, during heavy rainfall events any areas of standing / running water would be accommodated within the hard strip to avoid any impact upon live traffic lanes.
- 10.1.14 There are 2 laybys of varying design quality present along the existing A417 single-carriageway section providing opportunity for road users to stop. These are both provided in the southbound direction on the downhill sections either side of Air Balloon roundabout. There is a large layby facility located on the existing northbound A417 dual-carriageway approximately 1.5km in advance of Cowley Road (the commencement of the Missing Link) which would remain. The existing single-carriageway laybys present road safety risks to road users given their position on the downhill sections and their short lengths. The overall provision of laybys will be considered as part of the more detailed future development of the scheme following the choice of the preferred route, with safety to the fore.
- 10.1.15 During the development of landscaping proposals, their impact upon road users would be taken into account at an early stage to incorporate any required mitigation into the design and allow sufficient land-take to be identified.
- 10.1.16 Signs (including VMS) and other roadside features would, where possible, be located away from high risk areas where errant vehicles may be more likely to leave the carriageway. The potential for these features to be struck, and therefore the need to include vehicle restraint systems or passively safe features, would be considered as the design is developed.
- 10.1.17 Vehicle restraint systems would also be required on high embankments or at steep cuttings. This would also be applicable for any roadside structures associated with any proposed tunnels. Further consideration of these systems will be given as the design is developed.

- 10.1.18 The standard of highway design would be similar to the existing A417 at tie-in points at each end of the scheme.
- 10.1.19 All the options include gradients that are in excess of the desirable maximum for an all purpose trunk road of 4%. Where this desirable maximum is exceeded, enforced reduced speed limits may be appropriate; this would be particularly appropriate for options that include tunnels.
- 10.1.20 Consideration to slow moving vehicles will also form part of the scheme's future development considering the potential to cause delay due to the steep gradients proposed on the options.

Street lighting

- 10.1.21 Street lighting is not proposed on the mainline route (except through any tunnels) but may be present at the proposed new junctions. This is consistent with the existing sections of dual-carriageway either side of the proposed scheme. The A417 mainline is unlit, whilst the A46 grade separated junction has lighting present on the circulatory carriageway and at the tops of the slip road.
- 10.1.22 Street lighting at the proposed junctions may be expected to reduce the likelihood of night-time or poor weather collisions and would be considered at the grade separated junctions.
- 10.1.23 TA49/07 Appraisal of New and Replacement Lighting on the Strategic Motorway and All Purpose Trunk Road Network indicates that the road safety benefits of lighting provision are unlikely to be as great as might be expected. A safety assessment of the benefits of street lighting at selected junctions would be undertaken as part of the scheme's future development.

Tunnel options

- 10.1.24 Any tunnel would be subject to the particular safety provisions within the Road Tunnel Safety Regulations 2007 (RTSR 2007) and BD 78/99, and the design would follow adopted best practice principles to secure safe use and response in the event of incidents.
- 10.1.25 Where a proposed tunnel runs in a general east-west direction, there would be an increased risk of the rising / setting sun impacting on motorists. This would be assessed and mitigated in the event of a tunnel option being chosen for the scheme.
- 10.1.26 All tunnel options would result in the prohibition of a number of road user groups and vehicle types from the tunnel sections of road. The A417 passes through an agricultural area and such vehicles are currently permitted to use the route in its entirety. Consideration would need to be given to appropriate alternative routes for any road users or vehicle types prohibited should a tunnel be introduced.

Non-motorised users

- 10.1.27 The area through which the proposed scheme options would pass contains several Public Rights of Way (PRoW), including the Cotswold Way and Gloucestershire Way long distance paths which both cross the existing A417 in the vicinity of the Air Balloon roundabout.
- 10.1.28 During the Stage 1 study a Walking, Cycling and Horse-Riding Assessment in accordance with HD42/17 was carried out to provide a review of the existing facilities for all users, conduct initial surveys to identify use of the existing network and identify opportunities for enhancement to the network.
- 10.1.29 As part of the assessment consultation was conducted with Gloucestershire County Council and a number of local user groups seeking their views on the existing situation.
- 10.1.30 During the initial design development and cost estimating exercise conducted in Stage 1, structures such as underpasses or footbridges have been included where the new alignment severs an existing PRoW to mitigate any further severance of the existing provision.
- 10.1.31 For the tunnel options, a green bridge has been included in the cost estimate. Though the location of this potential green bridge has not been confirmed it is anticipated that it would be located in the vicinity of the Air Balloon public house. In this location it would serve as a green bridge and a non-motorised user facility providing a safe route across the existing A417 at Crickley Hill. This would remove the current crossing point at the Air Balloon roundabout.
- 10.1.32 For the surface options, a green bridge has also been included in the cost estimating exercise. However, if this is to be provided in a similar location (on Crickley Hill) to the tunnelled solutions the size of the structure would be larger than for the tunnel options due to the requirement to span the new carriageway rather than the existing Crickley Hill section only.
- 10.1.33 The Walking, Cycling and Horse-Riding Assessment will be used to assist the project team in developing the design of the options taken forward to subsequent stages. The team will work closely with stakeholders to develop a strategy for managing and enhancing non-motorised users' facilities.
- 10.1.34 Surface options increase the severance of the existing PRoW network in comparison to tunnel options. However through careful design and stakeholder engagement the impact can be mitigated and enhancements to the existing situation realised.

Option 3

Overall alignment

- 10.1.35 The overall horizontal alignment of Option 3 includes curves that are greater than desirable minimum (1,020m radius) for a 120kph design speed.
- 10.1.36 The route includes several vertical (crest) curvatures that are below the desirable minimum for distances of up to approximately 500m. The locations of these appear to be away from junctions or other design features and would be considered and addressed as part of the scheme's future development.

Junctions

- 10.1.37 Two new junctions would be provided within this option; a grade separated dumb-bell junction to the south-east in the vicinity of the existing Cowley roundabout and a slip road junction with the A436 to the north-east. There is also an existing grade separated junction between the A417 and the A46 at Brockworth that would be considered.
- 10.1.38 The distance between the 3 junctions would result in safe weaving lengths above the desirable minimum.
- 10.1.39 The A436 between the Air Balloon roundabout and the new A417 would utilise the existing A417 carriageway. There is a 400m section of the A417 in the vicinity of the proposed junction with the A436 that would have a gradient of 8%. This could result in inappropriate vehicle speeds at the merge and diverge points increasing the risk of collisions. Given the gradient on the A417, it is assumed the A436 would have a greater gradient than this. This could result in inappropriate vehicle speeds through the junction, increasing the risk of speed related collisions. The design would seek to address and mitigate these risks.
- 10.1.40 Post-construction, A436 traffic towards / from Gloucester would continue to use the existing A417 to the west of Air Balloon roundabout. Traffic to / from the Cirencester and Swindon direction would utilise the existing A417 through Nettleton via the proposed A417 grade separated dumb-bell junction. Consideration would be given to any accompanying changes that could beneficially be made to the existing Air Balloon roundabout and the junction between Leckhampton Hill and the A436.
- 10.1.41 There is currently significant flow between the A417 arms of the roundabout creating opportunity for vehicles turning right from the A417 northbound to the A436. With the southbound A417 demand removed, gaps in traffic for northbound motorists may be minimal. Increased waiting time at the junction could lead to driver frustration increasing safety risks. This would have to be addressed.
- 10.1.42 The removal of A417 traffic through Air Balloon roundabout would also allow northbound A436 traffic through the junction unopposed as little traffic would turn

right from the existing A417 southbound approach. Changes to traffic flows / queue lengths on the A436 may result in insufficient gaps in traffic for vehicles turning right into / out of Leckhampton Hill. This would also have to be addressed.

- 10.1.43 The type of junction layout at this location would need to take into account traffic flows and turning movement proportions to reduce the risk of collisions. Removal of the roundabout may be appropriate, whilst provision of a single junction rather than the existing roundabout and T-Junction arrangement may also be necessary.

Tie-in points

- 10.1.44 The north-western tie-in has a horizontal alignment that is relatively straight with good forward visibility.
- 10.1.45 The horizontal alignment of the south-eastern tie-in is also relatively straight and the vertical alignment is slightly undulating. Visibility appears to be good and does not raise any road safety concerns.

Option 12

Overall alignment

- 10.1.46 The overall horizontal alignment of Option 12 includes a number of curves that are notably below the desirable minimum (1020m radius) for a 120kph design speed. A number of these curves are located on steep gradients which represents a safety concern. The tightest of the horizontal radii on the alignment is 270m, 4 steps below desirable minimum for a 120kph design speed. If this design were to be taken forwards for further development, specific safety mitigation would need to be investigated and implemented to ensure road users' safety through this section. These mitigation measures may include a mandatory speed limit of 50mph with appropriate enforcement measures. The undulating vertical alignment of the route combined with the high number of below desirable minimum horizontal curves also raises concerns.
- 10.1.47 The use of curves and gradients below desirable minimum will impact achievable desirable minimum stopping site distance (SSD) on the option. This may raise a safety concern.

Junctions

- 10.1.48 Three new junctions would 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 and a set of left on / off slips 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 would also be undertaken to provide a new roundabout junction.

- 10.1.49 The position of the north facing on / off-slips and the proposed grade separated junction at the top of a steep 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 junctions. It also could increase entry speeds for vehicles joining the A417 in the northbound direction increasing the risk of collisions. These risks would have to be addressed by the design or potential relocation of the junction.
- 10.1.50 The position of the north facing on / off-slips and the proposed grade separated junction are located approximately 500m apart. The close proximity of the 2 merge / diverge points for the 2 junctions gives rise to safety concerns that would have to be addressed by more detailed design.
- 10.1.51 Both the grade separated junction and the north facing on / off-slips are positioned on below desirable minimum (1,020m radius) curves for 120kph design speed. The design would have to allow for sufficient forward visibility to and from merging / diverging vehicles to avoid safety concerns arising from the risk of collisions.
- 10.1.52 The radius of the north-facing on / off-slips is particularly tight and may increase the risk of loss-of-control type collisions at this location. Given concerns relating to the close proximity of this junction with the grade separated junction, and the proposed steep gradient, it could be appropriate for these slip roads to be omitted.
- 10.1.53 The arrangement of the north-facing on / off-slip roads combined with the A436 continuing to the south to the grade separated junction could present a confusing junction arrangement, leading to driver hesitancy and an increased risk of collisions. This outcome would need to be avoided.
- 10.1.54 Post-construction, all A436 traffic would continue to use the existing A417 south of the Air Balloon roundabout. The existing Air Balloon roundabout would be removed and the junction between Leckhampton Hill and the A436 would be modified to form a roundabout junction. The dominant movement at the proposed roundabout would be between the 2 A436 arms. This may result in insufficient safe gaps in traffic for vehicles turning out of Leckhampton Hill which would have to be addressed by more detailed design proposals.
- 10.1.55 A new roundabout is to be provided at the junction of Leckhampton Hill and the A436. The geometry and traffic movements at this junction may cause queuing and driver frustration, with associated safety concerns. Furthermore, forward visibility on the northbound A436 approach may be hindered by the vertical alignment on the approach, which would have to be addressed to avoid increasing the risk of rear-end-shunt type or overshoot related collisions.

- 10.1.56 A set of left on / off-slips are to be provided in both directions in the vicinity of the existing Cowley roundabout. Immediately to the north of the southbound on / off-slip, an 800m radius curve is present. The detailed design would have to allow for sufficient forward visibility to avoid increasing the risk of rear-end-shunt type collisions.

Tie-in points

- 10.1.57 The north-western mainline tie-in follows the existing alignment and has a horizontal alignment that is in close proximity to a 1,240m radius curve. There are no obvious safety concerns regarding the alignment.
- 10.1.58 The horizontal alignment of the south-eastern tie-in is relatively straight, with an 800m radius curve just to the north. There would be sufficient safe forward visibility at the immediate tie-in.

Option 21

Overall alignment

- 10.1.59 The overall horizontal alignment of Option 21 includes curves that are greater than desirable minimum for a 120kph design speed with 1 curve equal to the desirable minimum (1,020m radius). This desirable minimum curve is to be provided in combination with a desirable minimum crest curve; however, this combination is within standard and it is not considered that the horizontal alignment presents any road safety concerns.

Junctions

- 10.1.60 Two new junctions would be provided within this option: a grade separated dumb-bell junction to the south-east in the vicinity of the existing Cowley roundabout; and a slip road junction with the A436 to the north-east. There is also an existing grade separated junction between the A417 and the A46 at Brockworth that would be considered to secure the safe operation of the network.
- 10.1.61 The position of all 3 junctions in relation to the tunnel portals is such that some form of signing would be required within the tunnel to inform motorists of the highway arrangements ahead. Such signs would be clearly visible and understandable. This is particularly important for motorists travelling northbound through the tunnel as the position of the northbound A436 on-slip in relation to the A46 junction creates a weaving section.
- 10.1.62 The weaving section in each direction between the A46 and A436 on / off-slips is approximately 780m which is below the desirable minimum figure of 1km. This raises safety concerns which would be addressed by mitigation measures such as additional traffic signs or reduced speed limits.

- 10.1.63 The nosing of the A436 northbound on-slip is approximately 350m from the northern tunnel portal. This is a safe distance, greater than the desirable minimum stopping sight distance of 295m for a 120kph design speed.
- 10.1.64 Post-construction, A436 traffic towards / from Gloucester would continue to use the existing A417 to the west of Air Balloon roundabout. Traffic to / from the Cirencester and Swindon direction would utilise the existing A417 through Nettleton via the proposed A417 grade separated dumb-bell junction. Beneficial changes to the existing Air Balloon roundabout and the junction between Leckhampton Hill and the A436 would be considered as part of the scheme's further development to address the following.
- There is currently significant flow between the A417 arms of the roundabout creating opportunity for vehicles turning right from the A417 northbound to the A436. With the southbound A417 demand removed, gaps in traffic for northbound motorists may be minimal. Increased waiting time at the junction may encourage motorists to join the roundabout at inappropriate times increasing the risk of collisions.
 - The removal of A417 traffic through Air Balloon roundabout would also allow northbound A436 traffic through the junction unopposed as little, traffic would turn right from the existing A417 southbound approach. Changes to traffic flows / queue lengths on the A436 may result in insufficient gaps in traffic for vehicles turning right into / out of Leckhampton Hill. This may result in motorists turning at inappropriate times increasing the risk of collisions
 - The type of junction layout at Leckhampton Hill would take into account traffic flows and turning movement proportions to reduce the risk of collisions. Removal of the roundabout may be appropriate, whilst provision of a single junction rather than the existing roundabout and T-Junction arrangement may also be necessary.

Tie-in points

- 10.1.65 The north-western tie-in has a horizontal alignment that is relatively straight. Though the tie-in is close to the start of a 5% gradient, forward visibility would not be compromised and there are no obvious safety concerns.
- 10.1.66 The horizontal alignment of the south-eastern tie-in is also relatively straight and the vertical alignment would be slightly undulating. With good visibility, there are no safety concerns.

Option 24

Overall alignment

- 10.1.67 The overall horizontal alignment of Option 24 includes curves that are all greater than desirable minimum (1,020m radius) for a 120kph design speed. As such, there are no road safety concerns associated with the horizontal alignment.

10.1.68 Option 24 includes 2 vertical (crest) curvatures both of which are equal to the desirable minimum for a 120kph design speed. These are for distances of approximately 650m and 1,640m. Again, this does not raise any specific concerns for road safety.

Junctions

10.1.69 One new junction would be provided within this option: a grade separated dumb-bell junction to the south-east in the vicinity of The Golden Heart Inn. The A436 slip roads would tie-in with the existing A46 Shurdington Road junction resulting in a modified grade separated junction with segregated lanes. All A436 southbound and northbound traffic would pass through the existing A46 junction.

10.1.70 The position of these 2 junctions in relation to the tunnel portals are a minimum of approximately 1km away. This does not present any road safety related concerns; however, some form of signing may be required within the tunnel to inform motorists of the highway arrangements ahead. Such signs would be clearly visible and understandable.

10.1.71 To avoid inappropriately short weaving sections on the A417, segregated lanes would be provided between the A46 Shurdington Road junction and the A436 slip roads. This would result in all A436 traffic travelling through the A46 junction. Full junction modelling would be undertaken to demonstrate that this junction could fully accommodate the additional traffic, without resulting in lengthy queues that could cause driver frustration and associated safety concerns.

10.1.72 To allow A417 traffic to continue to exit at the A46 Shurdington Road junction in a northbound direction, the segregated A436 lane ends mid-way along the existing A46 junction slip road. At this point, the slip road would consist of 3 lanes. This would give motorists approximately 100m of weaving length in advance of the junction give-way. This would need to be reviewed to avoid potential safety concerns relating to vehicle weaving over short distances combined with speeds of vehicles exiting the A417.

10.1.73 Post-construction, A436 traffic towards / from Gloucester would continue to use the existing A417 to the west of Air Balloon roundabout. Traffic to / from the Cirencester and Swindon direction would utilise the existing A417 through Nettleton via the proposed A417 grade separated dumb-bell junction. Beneficial changes to the existing Air Balloon roundabout and the junction between Leckhampton Hill and the A436 would be considered as part of the scheme's further development to address the following.

- There is currently significant flow between the A417 arms of the roundabout creating opportunity for vehicles turning right from the A417 northbound to the A436. With the southbound A417 demand removed, gaps in traffic for northbound motorists may be minimal. Increased waiting time at the junction may encourage motorists to join the roundabout at inappropriate times increasing the risk of collisions.

- The removal of A417 traffic through Air Balloon roundabout would also allow northbound A436 traffic through the junction unopposed as little, traffic would turn right from the existing A417 southbound approach. Changes to traffic flows / queue lengths on the A436 may result in insufficient gaps in traffic for vehicles turning right into / out of Leckhampton Hill. This may result in motorists turning at inappropriate times increasing the risk of collisions.
- The type of junction layout at Leckhampton Hill would take into account traffic flows and turning movement proportions to reduce the risk of collisions. Removal of the roundabout may be appropriate, whilst provision of a single junction rather than the existing roundabout and T-Junction arrangement may also be necessary.

Tie-in points

- 10.1.74 The north-western mainline tie-in has a horizontal alignment that is on a 1,440m radius curve. Causing no safety concerns in itself. However, the north-western extent of the scheme also includes the tie-in of the A436 slip roads. The short distance between the end of the segregated lane and the roundabout give-way could increase the risk of lane-changing related side-swipe and rear-end-shunt type collisions. The concern is heightened by the close proximity of the A417 diverge point and the likely high vehicle exit speeds. These concerns would need to be addressed as part of the detailed design.
- 10.1.75 The horizontal alignment of the south-eastern tie-in is on a 1,440m radius curve and a desirable minimum vertical (crest) curvature which does not raise any safety concerns.

Option 29

Overall alignment

- 10.1.76 The overall horizontal alignment of Option 29 includes several curves that are greater than the desirable minimum for a 120kph design speed. There are 2 curves that are 1 step below the desirable minimum with super-elevation of 7%. Whilst such curves are permitted within TD9/93 and do not raise any specific road safety concerns, the horizontal alignment of Option 29 is less preferable to other options presented for review.
- 10.1.77 Option 29 includes 2 vertical (crest) curvatures both of which are equal to the desirable minimum for a 120kph design speed. These are for distances of approximately 740m and 1,340m. This does not raise any specific concerns for road safety.

Junctions

- 10.1.78 One new junction would be provided within this option, namely a grade separated dumb-bell junction to the south-east in the vicinity of The Golden Heart Inn. The A436 slip roads would tie-in with the existing A46 Shurdington Road junction resulting in a modified grade separated junction with segregated

lanes. All A436 southbound and northbound traffic would pass through the existing A46 junction.

- 10.1.79 The position of the A436 / A46 junction in relation to the northern tunnel portal is approximately 1.5km. This is likely to require junction signing to be installed close to the exit from the tunnel portal. Positioning of signing for the junction would need to be carefully considered so that it is clearly visible to motorists as they exit the tunnel.
- 10.1.80 The north facing slip roads for the grade separated junction at the south-eastern extent of the scheme are positioned approximately 175m from the southern tunnel portal. Signing may be required within the tunnel to inform motorists of the highway arrangements ahead. Such signs would be clearly visible and understandable.
- 10.1.81 The details of how the proposed grade separated junction would tie-in with the surrounding local road network remain to be determined and would have to be designed in a way that does not give rise to safety concerns.
- 10.1.82 Immediately to the south of the proposed grade separated junction is a 740m long curve with a radius 1 step below the desirable minimum with super-elevation of 7%. This would have to be taken into account to provide a safe layout.
- 10.1.83 To avoid inappropriately short weaving sections on the A417, segregated lanes would be provided between the A46 Shurdington Road junction and the A436 slip roads. This would result in all A436 traffic travelling through the A46 junction. Full junction modelling would be undertaken to demonstrate that this junction could fully accommodate the additional traffic, without resulting in lengthy queues that could cause driver frustration and associated safety concerns.
- 10.1.84 To allow A417 traffic to continue to exit at the A46 Shurdington Road junction in a northbound direction, the segregated A436 lane ends mid-way along the existing A46 junction slip road. At this point, the slip road would consist of 3 lanes. This would give motorists approximately 100m of weaving length in advance of the junction give-way. This would need to be reviewed to avoid potential safety concerns relating to vehicle weaving over short distances combined with speeds of vehicles exiting the A417.
- 10.1.85 Post-construction, A436 traffic towards / from Gloucester would continue to use the existing A417 to the west of Air Balloon roundabout. Traffic to / from the Cirencester and Swindon direction would utilise the existing A417 through Nettleton via the proposed A417 grade separated dumb-bell junction. Beneficial changes to the existing Air Balloon roundabout and the junction between Leckhampton Hill and the A436 would be considered as part of the scheme's further development to address the following:
- There is currently significant flow between the A417 arms of the roundabout creating opportunity for vehicles turning right from the A417

northbound to the A436. With the southbound A417 demand removed, gaps in traffic for northbound motorists may be minimal. Increased waiting time at the junction may encourage motorists to join the roundabout at inappropriate times increasing the risk of collisions.

- The removal of A417 traffic through Air Balloon roundabout would also allow northbound A436 traffic through the junction unopposed as little, traffic would turn right from the existing A417 southbound approach. Changes to traffic flows / queue lengths on the A436 may result in insufficient gaps in traffic for vehicles turning right into / out of Leckhampton Hill. This may result in motorists turning at inappropriate times increasing the risk of collisions.
- The type of junction layout at Leckhampton Hill would take into account traffic flows and turning movement proportions to reduce the risk of collisions. Removal of the roundabout may be appropriate, whilst provision of a single junction rather than the existing roundabout and T-Junction arrangement may also be necessary.

Tie-in points

10.1.86 The north-western mainline tie-in has a horizontal alignment on a 1,440m radius curve, causing no safety concerns regarding the alignment. However, the north-western extent of the scheme also includes the tie-in of the A436 slip roads. The short distance between the end of the segregated lane and the roundabout give-way could increase the risk of lane-changing related side-swipe and rear-end-shunt type collisions. The concern is heightened by the close proximity of the A417 diverge point and the likely high vehicle exit speeds. These concerns would need to be addressed as part of detailed design.

10.1.87 The horizontal alignment of the south-eastern tie-in is on a 1,960m radius curve. Immediately to the north of this is a reverse curve with a radius 1 step below the desirable minimum with super-elevation of 7%. Whilst this is not considered to introduce particular safety concerns, it should be noted that this situation is less desirable than other options presented for review.

Option 30

Overall alignment

10.1.88 The overall horizontal alignment of Option 30 includes several curves that meet the desirable minimum for a 120kph design speed. However, there are a number of curves that are below the desirable minimum with 1 that is 2 steps below with super-elevation of 7%; this particular curve has a length of approximately 850m. Whilst such curves are permitted within TD9/93, there are factors that would be considered and addressed as part of the scheme's future development, as discussed below.

10.1.89 Option 30 includes a vertical (crest) curvature that is 1 step below the desirable minimum for a 120kph design speed. This is for a distance of approximately

645m. On its own, this does not raise any specific concerns for road safety, however combined with below desirable minimum horizontal curves, this raises potential safety concerns that would be addressed in the detailed design.

- 10.1.90 The gradient along the proposed route is 7% which is above the desirable maximum for an all purpose trunk road of 4%. This gradient, combined with the horizontal alignment and the close proximity of the proposed grade separated junction increases the risk of rear-end-shunt type collisions involving slow moving vehicles and vehicles wishing to exit at the junction. This would also have to be addressed.
- 10.1.91 A climbing lane is provided on the A417 southbound up Crickley Hill and through the proposed grade separated junction terminating at chainage 4700. Sufficient distance and forward visibility would have to be provided for the lane merge to allow the merging movements to be accommodated safely.
- 10.1.92 The use of curves and gradients below desirable minimum will impact achievable desirable minimum stopping site distance (SSD) on the option. This may raise a safety concern.

Junctions

- 10.1.93 Two new junctions would be provided within this option; a grade separated dumb-bell junction mid-way along the new A417 alignment and an at-grade roundabout on the existing A417 close to the B4070 junction. Modifications to the existing A436 / Leckhampton Hill junction would also be undertaken.
- 10.1.94 The position of the proposed grade separated junction at the top of a 7% gradient raises concerns outlined in section 10.1.90. It also may increase the risk of entry speeds for vehicles joining the A417 in the northbound direction. These concerns would have to be addressed, including consideration given to potentially relocating this junction.
- 10.1.95 The proposed at-grade roundabout on the existing A417 is located at the top of a steep gradient. The junction arrangements would have to be designed: to avoid vehicle queues for the roundabout on an uphill gradient increasing the risk of rear-end-shunt type collisions; and to secure sufficient forward visibility to the roundabout.
- 10.1.96 The position of the proposed at-grade roundabout on the existing A417 is located in close proximity to the B4070 junction. The interaction between the 2 junctions would be assessed to avoid: queuing vehicles for the roundabout impeding the safe operation of the B4070; and vehicles waiting to turn onto the B4070 impacting on the safe exit from the roundabout in the southbound direction.
- 10.1.97 Post-construction, all A436 traffic would continue to use the existing A417 south of the Air Balloon roundabout. The existing Air Balloon roundabout would be removed and the junction between Leckhampton Hill and the A436 would be modified to form a simplified T-Junction without a central reserve.

- 10.1.98 Currently, during the peak periods, traffic turning out of Leckhampton Hill can do so due to gaps in queuing traffic. With the removal of the Air Balloon roundabout, it is unlikely that A436 traffic would queue through this section. Changes to traffic flows / queue lengths on the A436 may result in insufficient gaps in traffic for vehicles turning right into / out of Leckhampton Hill. Measures such as signalling this junction would be considered to accommodate safe turning movements.
- 10.1.99 All A436 and south / east Cheltenham traffic would be required to pass through the 2 new roundabout junctions. The junction arrangements would have to be designed to avoid the potential for lengthy queues causing driver frustration and associated safety concerns, or drivers seeking alternative routes, thereby increasing the risk of collisions on the local road network.

Tie-in points

- 10.1.100 The north-western mainline tie-in follows the existing alignment and has a horizontal alignment that is in close proximity to a 1,440m radius curve, causing no safety concerns.
- 10.1.101 The horizontal alignment of the south-eastern tie-in is relatively straight with a 2,040m radius curve just to the north, also causing no safety concerns.
- 10.1.102 At the point at which the proposed link road ties-in with the existing A417, an at-grade roundabout is to be provided, leading to the considerations in section 10.1.94.

Summary

- 10.1.103 All 6 options, through the removal of the existing single-carriageway section of the A417, 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 trunk road network.
- 10.1.104 All the options present gradients above the desirable maximum of 4%. Mitigating measures would be applied to address safety concerns relating to these proposed gradients.
- 10.1.105 All 6 options would give rise to safety considerations that would have to be addressed in the further development of the scheme, with Option 12 giving rise to the greatest number of concerns.

10.2 Buildability and maintenance

Introduction

- 10.2.1 Through its Delivery Plan, Highways England seeks a holistic approach to managing health and safety by working with suppliers and stakeholders with the common goal being that no-one should be harmed when travelling or working on the strategic road network. Specifically, by the end of 2020, Highways England

aims to reach a target of a 40% reduction in the number of KSI accidents, with the longer term aim being to get as close to zero by 2040.

- 10.2.2 Four at risk populations have been identified whose Health and Safety needs must be addressed as part of this approach, they are:
- Road user
 - Customer operations staff, largely consisting of the traffic officer service
 - Road workers and other supply chain employees
 - Highways England employees who work in and away from our offices
- 10.2.3 The A417 Missing Link scheme has a contribution to make to the achievement of Highways England's goal for the first 3 of these groups.
- 10.2.4 Potential Health, Safety and Wellbeing factors were considered during the initial sifting process of the reducing the 30 options down to the current 6 being assessed. Ongoing design developments will continue to address Health, Safety and Wellbeing goals through a structured approach in accordance with the Construction (Design and Management) Regulations 2015 and the Interim Advice Note 69/15 Design for Maintenance (Highways England, April 2015).
- 10.2.5 The IAN 69/15 provides guidance on the risk assessment and liaison process regarding the development of designs that are safe to maintain. It also introduces the concept of 'Maintenance Strategy and Repair Statements' in which designers record assumptions and requirements regarding maintenance. The intent is to identify the key features relating to maintenance activities which:
- Must be undertaken in a particular manner
 - Do not have an obvious approach
 - Are hazardous to those undertaking the work or others who may be affected by it
 - Require a disciplined approach
- 10.2.6 During the design process, reference will also be made to feedback regarding lessons learnt from the latest working and operating practises from forums such as the Road Worker Safety Forum (RowSaF), Safe Use of Roadside Verges in Vehicular Emergencies (SURVIVE) as well as circulars such as Highways England Safety Alerts and Monthly Health, Safety and Wellbeing Briefings to influence developing designs take account of the current experience.

Traffic management

- 10.2.7 Highways England has obtained, and will continue to obtain, expert construction advice in order to understand how traffic on the A417 may be managed during the works. Traffic management arrangements can vary in magnitude and time according to the nature of the construction operation. However, it could be broadly considered that the construction period could be proportional to the traffic management requirement and hence a significant factor contributing to scheme safety, cost and delivery.

10.2.8 For each option, the table below highlights a construction programme aspect that is likely to require an element of significant traffic management. The table shows the general variance in intensity of traffic management requirement between options, and the length of time that the traffic management could be in place at periods during the overall construction period for each option.

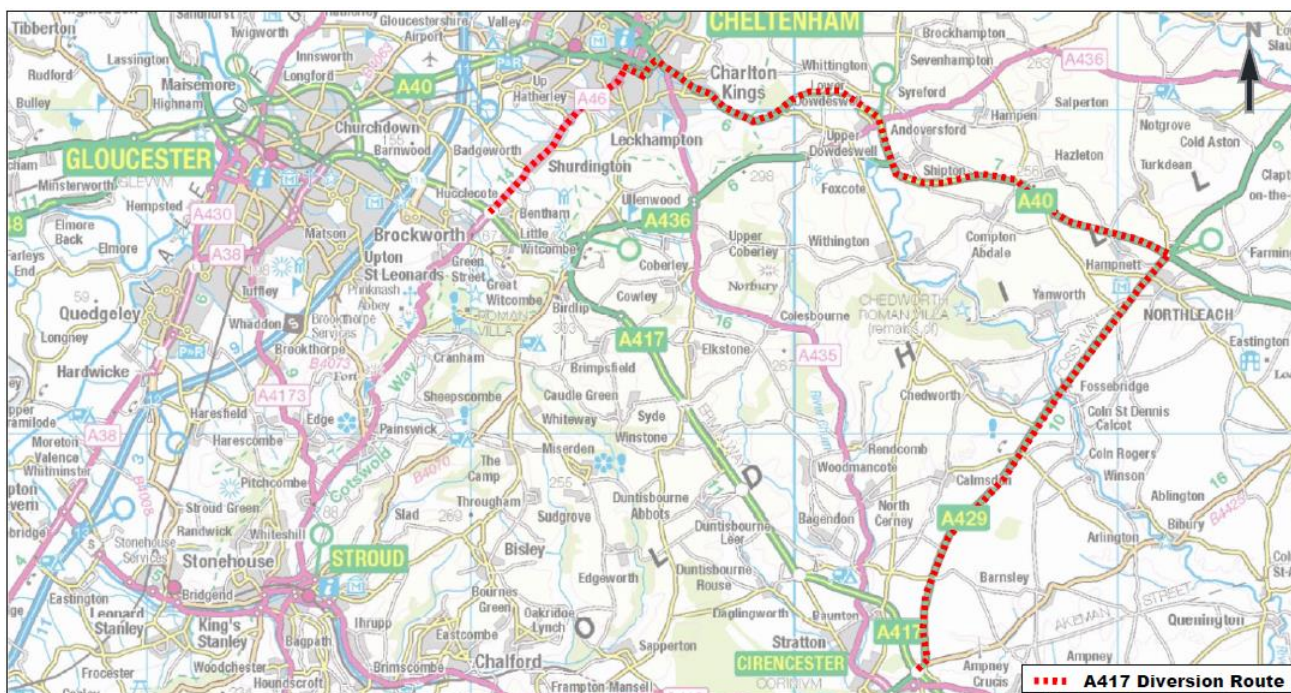
Table 10.1: Estimated construction programme aspect likely to require traffic management with total aspect duration

Option	Estimated construction programme aspect likely to require Traffic Management with total aspect duration			
	Statutory Undertakers	Tunnelling Activities	Highway Works	Comments relating to tunnel portal locations
3 Tunnel	6 (months 4-10)	27 (months 10-37)	8 (months 37-45)	North portal close proximity to A417 (WS2 - Crickley Hill)
12 Surface	Surface option with no tunnelling activities but is likely to have more on-line operations as part of an envisaged longer Highway Works construction programme aspect – full construction period estimated to be 36 months.			
21 Tunnel	6 (months 4-10)	44 (months 10-54)	10 (months 54-64)	North portal close proximity to A417 (D2AP - Crickley Court)
24 Tunnel	6 (months 4-10)	31 (months 10-41)	9 (months 41-50)	Portals remote to A417
29 Tunnel	6 (months 4-10)	32 (months 10-42)	8 (months 42-51)	Portals remote to A417
30 Surface	Surface option with no tunnelling activities but is likely to have more on-line operations as part of an envisaged longer Highway Works construction programme aspect – full construction period estimated to be 36 months.			

10.2.9 Lane width reductions and temporary speed limits would be required at each tie-in and at sections of on-line improvements. Temporary speed limits would be needed along these sections, potentially as low as 40mph to facilitate lanes widths as low as 3.25m.

10.2.10 In the event of carriageway closures, closures would be overnight and diversions would be along 'A' class roads, via the A40 and A429 as shown in Figure 10.1. This route is a safe and convenient diversion that is currently used by the DBFO company managing the A417 / A419 corridor.

Figure 10.1: A417 Closure and diversionary route



Source: Mott MacDonald Sweco Joint Venture - Crown Copyright 2016 100030649

Cost effectiveness

- 10.2.11 The approach to ensuring cost effective construction and maintenance will centre on maximising standardisation of components such as structures, drainage, road restraint systems and enabling the use of familiar and conventional construction and maintenance techniques. This approach should also help maximise the Health and Safety performance of the project during construction and operation.
- 10.2.12 This process is at an early stage but ultimately liaison will be undertaken with Highways England’s construction and maintenance supply chain partners in order to develop opportunities to improve cost.

10.3 Effective construction management – Construction (Design and Management) Regulations 2015

- 10.3.1 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.
- 10.3.2 During PCF Stage 1, Option Identification development of the scheme the duty holders under CDM are:
 - Client – Highways England
 - Principal Designer – Mott MacDonald (on behalf of the Mott MacDonald Sweco JV)

- Principal Contractor – not appointed, (but the existing site is operated by the DBFO company)

10.3.3 During option identification there is considerable scope to design out / 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

10.3.4 The proposed tunnel options are principally off-line for the majority of the alignments, albeit with tie-in lengths to the existing A417 at either end. This allows the majority of 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 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.

10.3.5 Options 12 and 30, in contrast to the tunnel options utilise more of the existing carriageway, both options reuse sections of Crickley Hill. Option 12 utilised approximately 1km 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.

10.3.6 The construction and phasing near the Air Balloon roundabout will be particularly challenging for options 12 and 30. The 3 main challenges to overcome as the design progresses would be:

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

10.3.7 Tunnelling activities come with a set of highly specific and known high-risk activities. It will be essential to understand the geology along the exact route of both tunnel bores if an option involving tunnelling is selected to go forward. Expert advice would be procured to develop a full understanding of the hazards involved and identify the most appropriate tunnelling method to be adopted.

10.3.8 All options currently under consideration involve substantial movements of spoil to create cuttings, tunnels 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.

- 10.3.9 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. Though options 12 and 30 contain elements of on-line works, it should still be possible to phase and manage the construction to avoid interaction with live traffic.
- 10.3.10 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

- 10.3.11 After the construction phase the highway will be turned over to the maintenance organisation. The process for handover and the data sets required is defined in IAN182. To smooth the handover process, the maintainer will be involved in reviewing the content of the Health and Safety File before official handover to ensure it meets their requirements. As per IAN182 it is the responsibility of the issuer to ensure the records are sufficient for the maintainer to use in planning their activities. Maintenance issues to be tackled in the design phase include:
- The A417 is being designed to meet the required standard for a trunk road as currently defined by the DMRB.
 - If a tunnel option is adopted, the daily operations of the tunnel need to be considered. Existing tunnels require a control room to monitor and supply the tunnel safety, lighting and fire suppression systems. Any required facility for a tunnel would need to comply with the relevant standard at the time of design.
 - Tunnel bores would be subject to routine maintenance closures. Existing tunnels have emergency crossovers at either end, but due to the limited width and risks involved in setting up a contraflow in a tunnel bore, an alternative route for traffic needs to be in place to minimise the risk to maintenance personnel.
 - As per Highways England's IAN69/15 guidance, a detailed maintenance strategy would be compiled through the design phase of the scheme.

10.4 Conclusion

- 10.4.1 For the single carriageway section of the A417, the A417 Missing Link, the most recent available 5-year period of accident data is from 19/11/2011 to 18/11/2016. Over this period there were 57 collisions, 4 were fatal, 11 were serious and 42 were slight in severity.
- 10.4.2 Through the removal of the existing single-carriageway section of the A417, all 6 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 trunk road network.
- 10.4.3 All 6 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 concerns relating to these proposed gradients. Of the 6 options, Option 12 gives rise to the greatest number of concerns.
- 10.4.4 From a Construction (Design and Management) Regulations 2015 (CDM 2015) perspective, the tunnel options would require specialised construction and management techniques introduced at an early stage to mitigate risks at the design stage. All 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.

11. Environmental appraisal

11.1 Introduction

- 11.1.1 The section below presents a summary of the assessment of potential environmental impacts during the operational stage of the A417 Missing Link scheme. The environmental appraisal has been completed in accordance with WebTAG Unit A3 Environmental Impact Appraisal (Department for Transport, December 2015).
- 11.1.2 Environmental assessments have also been completed to a Scoping Level and to a proportionate Simple Level in accordance with Volume 11, Section 3, parts 1-2 and parts 4-11 of the *Design Manual for Roads and Bridges*.

11.2 Consultation with Statutory Environmental Bodies

- 11.2.1 Consultation with Statutory Environmental Bodies has been undertaken, including Historic England, Natural England and the Environment Agency. The National Trust, Cotswolds Conservation Board and Gloucestershire Wildlife Trusts have also been engaged through this consultation process. Further information on the consultation that has taken place during the Option Identification stage is presented within section 13 of this document.

11.3 Noise

- 11.3.1 The changes in Noise Net Present Value (NPV) for each of the options are presented below. The values for each option are positive, indicating overall benefits in NPV for all options. This is predominantly due to an anticipated reduction in traffic using the existing road between Brockworth bypass and Cowley roundabout and reductions in traffic on some minor roads. The number of receptors within close vicinity of the proposed options would also affect the overall benefits experienced by each option, as highlighted in Table 11.1 below. For options 3, 21, 24 and 29, the introduction of a tunnel would contribute to the overall benefits in noise which have been predicted.

Table 11.1: Predicted noise benefits – all Do Something options

	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Households experiencing increased day-time noise in forecast year (2038).	139	105	64	243	197	97
Households experiencing reduced day-time noise in forecast year (2038).	181	123	202	243	212	167

	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Households experiencing increased night-time noise in forecast year (2038).	184	41	12	270	226	116
Households experiencing reduced night-time noise in forecast year (2038).	179	176	180	253	21	158
Noise Benefits (NPV).	£0.9 million	£1.1 million	£2.0 million	£0.7 million	£0.6 million	£0.8 million

Notes: All monetary values are rebased to 2010 calendar year profiles for economic calculations

- 11.3.2 Option 3 would include a short 1km long tunnel, which would result in noise benefits, however these benefits would be reduced given that the majority of the route would be above ground. Traffic modelling indicates that this option would be the least effective in diverting traffic onto the new road, it would however pass through a relatively unpopulated area as presented in Table 11.1.
- 11.3.3 A tunnel would not be provided for Option 12, which would reduce the overall noise benefits for this option. However, this option would be effective in diverting traffic onto the new road, and as with Option 3, would pass through a relatively unpopulated area as presented in Table 11.1.
- 11.3.4 Option 21 would provide a 3km long tunnel which would result in the greatest noise benefits of the options. This option would be the most effective at diverting traffic onto the new road and would pass close to the fewest receptors of the options, as presented in Table 11.1. Therefore would result in the greatest overall noise benefits of the 6 options.
- 11.3.5 Option 24 would provide a 1.5km long tunnel which would result in noise benefits, however these benefits would be reduced given that the majority of the route would be above ground. This option would be effective at diverting traffic onto the new road, but would pass through a relatively populated area as shown in Table 11.1.
- 11.3.6 Option 29 would provide a 1.7km long tunnel, which would result in noise benefits, however these benefits would be reduced given that the majority of the route would be above ground. This option would be effective in diverting traffic onto the new road, but would pass through the most populated area of the options, as shown in Table 11.1, which would result in the least overall noise benefits of the 6 options.
- 11.3.7 A tunnel would not be provided for Option 30, which would reduce the overall benefits for this option. However, this option would divert a reasonable amount of

traffic onto the new road and as with options 3 and 12, would pass through a relatively unpopulated area as presented in Table 11.1.

11.4 Air quality

- 11.4.1 The WebTAG quantitative appraisal for local air quality has concluded that there would be an overall worsening of local ambient air quality within the study area with respect to nitrogen dioxide (NO₂) and Particulate Matter (PM₁₀) for all of the options. The changes in traffic characteristics and pollutant emissions for each of the options are not anticipated to cause an exceedance of NO₂ or PM₁₀ air quality objectives or EU Limit Values. However, increased vehicle numbers on the A417 and the roads through Cheltenham, Gloucester and Stroud would worsen local air quality in these areas, where there are large numbers of properties. All options are predicted to improve air quality at properties within the Birdlip AQMA due to the new road alignments being located further away from the properties and the free-flowing nature of the routes at the currently congested Air Balloon roundabout.
- 11.4.2 The options are predicted to increase regional emissions of oxides of nitrogen (NO_x) and PM₁₀, as a result of the rerouting of vehicles on to the A417 and M5 away from the M40 and A34, which would result in a longer route for vehicles when travelling from the south / south west to Birmingham.
- 11.4.3 The total value of change in air quality Net Present Value (NPV) for each of the options are outlined below. The overall values are negative, indicating overall dis-benefits in NPV.

Table 11.2: Air quality benefits (NPV)

	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Air quality benefits (NPV)	-£1.2 million	-£1.2 million	-£0.8 million	-£1.1 million	-£1.1 million	-£1.1 million

11.5 Greenhouse gases

- 11.5.1 The Greenhouse Gas appraisal has indicated an overall increase in greenhouse gas emissions as a result of all of the options. The NPV of the change in CO₂e emissions over the 60-year appraisal period for each of the options is presented below, with detrimental impacts predicted for all options, due to an increase in vehicle-km travelled when comparing Do Minimum values in the opening year and design year, for each option.

Table 11.3: Change in CO₂e emissions (NPV)

	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Change in CO ₂ e emissions (NPV)	-£24.1 million	-£31.0 million	-£22.2 million	-£33.2 million	-£23.2 million	-£30.6 million

11.6 Landscape

- 11.6.1 All options are situated within the Cotswolds AONB, designated for its high landscape value. The scheme is located within National Character Area 107 Cotswolds and is comprised of an arable and woodland landscape. Elevated views from the top of the escarpment have views westward over falling ground into the neighbouring vale and would likely be affected by the presence of the scheme. The introduction of tunnels within options 3, 21, 24 and 29 would limit the visual prominence of the scheme in the area, however the surface sections of these options would adversely impact the landscape.
- 11.6.2 The westerly route of Option 3 would be aligned online and in a tunnel. However, the surface sections, particularly those off-line and the 2 new junctions would likely have an adverse impact on landscape features, as the scheme has the potential to damage the high-quality landscape of NCA 107. The surface sections would diminish its quality, decreasing tranquillity, disrupting fine and valued views of the area and adversely impacting the scale and pattern of the landscape, leading to a large adverse impact.
- 11.6.3 The majority of Option 21 would be aligned in tunnel, limiting the visual prominence of the scheme. However, the off-line sections of the 2 new junctions would likely have an adverse impact on the surrounding landscape and visual receptors, and the small sections at surface would be at odds with the local pattern and have a wider impact on a landscape of recognised quality, resulting in a moderate adverse impact.
- 11.6.4 Around one third of Options 24 and 29 would run in tunnel however the majority of the routes are off-line with 2 new junctions. This would traverse the local contour profile, cutting through the escarpment, decreasing tranquillity and resulting in views from the top of the scarp looking down upon the scheme. Both options would see a new linear feature traversing the landscape leading to a large adverse impact.
- 11.6.5 Options 12 and 30 would be entirely at surface which, when aligned off-line, would run across an unspoilt rural scene over rising ground. The setting of important historic features would be indirectly affected by the options. For Option 30 the new junction at Shab Hill would increase the level of disturbance of the area as it climbs up through the hillside to the east, opening views of the route as it traverses the escarpment, leading to a large adverse impact. Option 12 would also climb up through the hillside to the east, opening views of the route as it traverses the escarpment, and again as it traverses contours north of Nettleton. The overall significance of impact for Option 12 is also considered to be large adverse.

11.7 Historic environment

- 11.7.1 The tunnel options (options 3, 21, 24 and 29), present the potential for Moderate Adverse impacts on the historic environment, whilst the surface options (options 12 and 30), present the potential for a large adverse impact. Option 3 would

require off-line construction on undisturbed land, considered to be of moderate archaeological potential to be excavated to facilitate the construction of the route. Options 12 and 30 would also have moderate adverse impacts upon archaeological remains during construction groundworks. Option 21 reduces the impact on archaeological remains by largely being in tunnel. However, in areas of new road and tunnel portal for options 21, 24 and 29 there is still predicted to be a moderate adverse impact to archaeology due to the high potential of the surrounding area. The construction of all options has the potential to cause loss or damage to buried archaeological remains.

- 11.7.2 The proximity of the tunnel portals of options 3 and 21 has the potential to cause an adverse impact to the setting of Crickley Hill Camp Scheduled Monument over the potential of associated remains. The portal locations also have the potential to significantly adversely impact the setting of Crickley Hill Camp Scheduled Monument. In addition, the new road and tunnel portals associated with options 3 and 21 have the potential to impact the rural setting of some Grade II listed buildings causing a slight adverse impact.
- 11.7.3 Options 24 and 29 involves a new road and tunnel portals to the east of Little Witcombe and Great Witcombe. Option 24 has the potential to cause a minor adverse impact to the setting of several high value listed buildings and to Brimpsfield Castle and Mound Scheduled Monuments and Brimpsfield Conservation Area. Option 29 should avoid major adverse impacts to the highest value buildings however there would be an adverse impact to surrounding grade II listed buildings including those in Birdlip and the Golden Heart Inn.
- 11.7.4 Options 12 and 30 have the potential to result in a large adverse impact on Emma's Grove Scheduled Monument through construction, and a moderate adverse impact on the setting of Crickley Hill Camp Scheduled Monument and the rural setting of some other listed buildings located east of the existing A417.

11.8 Biodiversity

- 11.8.1 Options 3, 12, 24, 29 and 30 are currently appraised as potentially having a large adverse impact on biodiversity with Option 21 anticipated as having a slight adverse impact on biodiversity.
- 11.8.2 With regards to species, the status of bat species and the importance of populations affected is currently unknown and therefore a large adverse impact cannot be ruled out at this stage. Options 3, 12, 24, 29 and 30 could potentially directly impact on populations of these species, reduce available habitat and result in habitat fragmentation. The new road corridor could also result in mortality of bats in relation to traffic. Options 12 and 30 have the potential to adversely affect the Crickley Hill and Barrow Wake SSSI due to the location of these options in relation to the SSSI.
- 11.8.3 The provision of a green bridge in the vicinity of the Air Balloon roundabout for options 12 and 30 would provide better connectivity over the existing A417 corridor between habitats at Crickley Hill and Barrow Wake SSSI which are

currently isolated by the A417, and this is likely to mitigate for some severance of bat habitat. However, until further surveys are undertaken and the location of important bat commuting routes is known, there is potential for severance of habitat and potential significant impacts on bat populations.

- 11.8.4 Moderate adverse impacts are identified for nesting birds for options 3, 12 and 30 due to potential loss and fragmentation of habitats. Slight adverse impacts are currently identified for Option 21 for species including; bats, nesting birds, barn owl, badger, dormouse, great crested newt, reptiles and terrestrial invertebrates.
- 11.8.5 The majority of Option 21 is within a tunnel section with relatively small areas of above ground works and relatively low levels of potential vegetation clearance. Slight adverse impacts are therefore currently identified for designated sites, broadleaved woodland, lowland calcareous grassland, hedgerows, standing water and watercourses. The proposals could potentially directly result in loss and fragmentation of habitats as well as in-direct impacts associated with air quality changes and hydrological changes.
- 11.8.6 Large adverse impacts are currently identified for options 24 and 29 on Cotswolds Beechwoods SAC / SSSI due to the proximity of the western portal to the edge of the designated site and potential adverse impacts associated with air quality impacting on habitats. Additionally, the impact of tunnels on hydrology is currently unknown and this has potential for significant impacts to habitats. Large adverse impacts are also identified for Bushley Muzzard SSSI as a result of Option 24 with potential for significant impacts to hydrology affecting the wetland habitats within this SSSI.

11.9 Water environment

- 11.9.1 All options may affect the water quality of the groundwater bodies and surface waterbodies with the options all straddling flow divides between surface waterbodies and groundwater bodies. Diversion of water between these catchments may impact on the water resource availability and pose a cross contamination risk. Dewatering and structures below the water table may affect groundwater flow to springs and surface waters by changing the groundwater flow regime, resulting in groundwater mounding and ground settlement within saturated cohesive deposits.
- 11.9.2 All options have the potential to cause adverse impacts on direct groundwater receptors (groundwater bodies) and indirect groundwater receptors (springs, streams, wetland and abstractions) during construction and operation. As a result of the potential adverse impacts and the lack of baseline groundwater information the Environment Agency has placed a holding objection to all tunnelling options (options 3, 21, 24 and 29), subject to refinement of the conceptual groundwater model and design.
- 11.9.3 The assessment score for potential impacts on groundwater receptors would be very large adverse for all options. The impact on surface water receptors would

be slight adverse for all options. Potential impacts during construction would be managed by mitigation measures within the CEMP for all options.

11.10 Conclusions

- 11.10.1 An assessment of potential environmental impacts on air quality, greenhouse gases, landscape, historic environment, biodiversity and the water environment during the operational stage of the A417 Missing Link scheme has been undertaken to a scoping and a proportionate simple level, in accordance with the Design Manual for Roads and Bridges. An environmental appraisal has been completed in accordance with WebTAG Unit A3 Environmental Impact Appraisal (Department for Transport, December 2015). Consultation with Statutory Environmental Bodies has been undertaken.

12. Social appraisal

12.1 Introduction

- 12.1.1 The section below presents a summary of the assessment of potential social impacts during the operational stage of the A417 Missing Link. The assessments have been completed in accordance with WebTAG Unit A4-1 Social Impact Appraisal (Department for Transport, November 2014).
- 12.1.2 A social assessment has also been completed in accordance with Volume 11, Section 3, parts 1-2 and parts 4-11 of the *Design Manual for Roads and Bridges* (Highways England, dates of issue as appropriate to each part).

12.2 Commuting and other users

- 12.2.1 All the options are forecast to result in net journey time benefits, arising from the conversion of the existing single-carriageway section of the A417 to a modern dual-carriageway, with associated junction improvements. The more direct, tunnelled options achieve the greatest net journey time benefit, although substantial benefits are also associated with the 2 surface routes.
- 12.2.2 The majority of journey time benefits are related to changes in journey time of between 2 and 5 minutes (both reductions and increases in time). Changes in time greater than 5 minutes also result in a net benefit. Smaller changes in journey time (below 2 minutes), result in an overall journey time disbenefit, which at least in part can be attributed to forecast increases in traffic on the M5 resulting in minor speed reductions to a large number of trips.
- 12.2.3 The Net Present Value (NPV) for commuting and other users includes benefits from journey time savings, vehicle operating cost impacts and changes in user charges. The calculated NPV for each of the options is positive and indicates that all options will benefit commuters and other users. The NPV values for each of the options are presented in Table 12.1 below.

Table 12.1: Commuters and other users benefits (NPV)

	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Commuters and other users benefits (NPV)	£91.7 million	£33.8 million	£96.8 million	£71.8 million	£89.5 million	£62.4 million

12.3 Reliability impact on commuting and other users

- 12.3.1 Reliability benefits have been assessed using the stress based approach set out in TAG Unit A1.3 Appendix C.5. For all the options, the outcome of the assessment has indicated that high stress levels in the Do Minimum scenario are forecast to significantly reduce with a scheme on the A417 at Air Balloon, which would lead to a moderate beneficial impact for all the options. In accordance with DfT value for money guidance, monetised benefits have been estimated as

being equivalent to a 10% uplift to travel time benefits. The reliability benefits for commuting and other users are set out below for each of the 6 options:

Table 12.2: Reliability benefits (NPV)

	Option 3 Tunnel	Option 12 Surface	Option 21 Tunnel	Option 24 Tunnel	Option 29 Tunnel	Option 30 Surface
Reliability benefits (NPV)	£16.3 million	£11.2 million	£16.6 million	£15.7 million	£15.8 million	£14.1 million

12.4 Physical activity

12.4.1 All options have the potential to result in the realignment of some Non-Motorised User (NMU) routes, including the Cotswold Way National Trail, leading to an increase in journey times. Existing provisions for NMUs will be carefully reviewed and safe, convenient routes will be provided. In addition, retaining NMU routes where possible, and the provision of new high-quality routes such as dedicated crossings, additional cycle paths and footpaths have the potential to increase the number of people choosing alternative modes of transport, resulting in an improvement in the levels of physical activity. On balance, there would be an overall Slight Beneficial impact on physical activity for all options.

12.5 Journey quality

12.5.1 All options are anticipated to slightly improve traveller care for vehicle travellers through the provision of new signs and potentially new laybys, the locations of which would be identified during future stages. The implementation of an appropriate landscape design would restrict views to the wider area for motorists. Stress for those travelling by vehicle is predicted to slightly improve for all options, with a reduction in frustration due to better journey times and reliability and also route uncertainty due to good design and layout of new and existing signs. It is also anticipated that the fear of potential accidents would be reduced through the delivery of new NMU facilities and safety related infrastructure.

12.5.2 For NMUs, journey times and reliability are likely to alter with NMU facilities likely to be directly affected. Barriers between people and traffic and traffic flows for roads alongside NMU facilities are also likely to change. The provision of NMU facilities at appropriate locations would reduce the impacts on journey quality for NMUs. Overall, there would be an overall Slight Beneficial impact on physical activity for all options.

12.6 Accidents

12.6.1 For all of the options a reduction in the number of personal injury accidents, and casualties of all types, is forecast to result from the conversion of the existing single-carriageway section of the A417 to a modern dual-carriageway, with associated junction improvements. Savings on the improved section are offset to a degree by increases in traffic (and accidents) in the A417 corridor although the net result is beneficial.

- 12.6.2 There is some variability in the appraisal results for each of the options although the positive impact on safety is common to all of the options being considered. Variability in results is expected due to the differing impacts on traffic flows that are forecast to result from the options. These are due to the differences in the way connectivity is maintained for each of the options, between the new sections of highway and the existing A417 alignment, and also as a result of the differences in scheme length between the options.
- 12.6.3 The results of the COBALT accident assessment are presented in Table 12.3 below.

Table 12.3: Accident benefits (over 60-year appraisal period)

Option	Accident benefits	Number of PIAs saved	Number of casualties saved		
			Fatal	Serious	Slight
Option 3 – Tunnel	£4,113,900	29.9	1.5	15.2	36.0
Option 12 – Surface	£3,334,400	16.8	1.4	10.9	23.5
Option 21 – Tunnel	£4,239,900	34.4	1.4	16.3	39.5
Option 24 – Tunnel	£6,792,400	65.7	2.7	21.7	83.0
Option 29 – Tunnel	£6,173,400	55.4	2.7	20.4	71.2
Option 30 - Surface	£4,332,500	36.6	2.0	13.1	48.3

Notes All monetary values are rebased to 2010 calendar year profiles for economic calculations

12.7 Security

- 12.7.1 Impacts on security for all options are anticipated to be Neutral, as it is unlikely that there would be any changes to security indicators and therefore freedom from crime.

12.8 Access to services

- 12.8.1 All options are not anticipated to affect access to services within the vicinity of the options and impacts on public transport accessibility would be Neutral.

12.9 Affordability

- 12.9.1 The scheme should reduce highway journey times (and costs) for trunk road traffic. Some local movements will experience increases in journey distance as a result of the scheme. Therefore, impacts on affordability for all options will be Slight Beneficial.

12.10 Severance

- 12.10.1 In all options there is potential for severance to occur to NMU routes, including footpaths, National Trails and cycle paths, which could lead to NMUs being dissuaded from making journeys to community facilities. However, NMU facilities would be retained as appropriate and the provision of replacement and additional facilities such as crossings would at the very least, ensure that severance does not increase for NMUs. The provision of new NMU facilities could have the

potential to reduce existing severance however, without an NMU design in place at this stage, an overall Neutral impact is anticipated. For further information refer to paragraphs 10.1.27 to 10.1.34.

12.11 Option values and non-use values

- 12.11.1 The scheme does not include measures that will substantially change the availability of transport services in the study area.

13. Summary of consultation with stakeholders

13.1 Stakeholder engagement

13.1.1 Identifying and engaging with stakeholders has been an integral element of the options generation and development process as specified in Highways England PCF, Option Identification stage guidelines. The approach taken during this stage of the appraisal process has been to include the 3 main components of the engagement process – consultation, participation and information. These elements are considered and undertaken on an on-going basis with stakeholders.

13.2 Information provision – PCF Stage 0 Strategy, Shaping and Prioritisation

13.2.1 The Stage 0 value management workshop was hosted by Highways England in August 2015. Attended by both stakeholders and the Highways England integrated project team members, the purpose of this workshop was to bring key individuals together to get their input into the value management process and to develop the objectives for the scheme.

13.2.2 Following initial stakeholder identification and engagement at PCF Stage 0, the stakeholders were approached to take part in the stakeholder engagement process for PCF Stage 1.

13.3 Information provision – PCF Stage 1 Option Identification

13.3.1 The strategy for the Option Identification stage was to hold a series of 3 value management workshops. These workshops serve a dual purpose; firstly to keep stakeholders informed of the scheme's progress, and secondly to obtain input from stakeholders into the process of identifying possible route options.

13.3.2 In Stage 1, the first value management workshop was arranged by Highways England on 5 October 2016. The purpose of this workshop was to engage with stakeholders about the scheme progress following the Stage 0 workshop and to explain the stakeholder consultation processes associated with the DCO planning regime.

13.3.3 Value management workshop 1 was also used to identify some of the initial 30 initial options. Activities were undertaken to identify opportunities and constraints that could affect the development and refinement of the scheme and to promote stakeholder discussion about the scheme's objectives and potential route corridor options.

13.3.4 The second Stage 1 value management workshop was held with stakeholders and a number of Highways England integrated project team members on 5 April 2017. The purpose of value management workshop 2 was to provide a further update on the scheme's progress. At the time of the workshop, outline sifting

criteria, fit for a landscape led scheme, had been developed and an initial engineering assessment and EAST Plus sift had been completed. This was presented to stakeholders for information and discussion.

- 13.3.5 Workshop activities were also undertaken to discuss traffic modelling, a matrix of scheme objectives and sub-objectives and the options under consideration.
- 13.3.6 The third value management workshop was held on 7 September 2017. The workshop comprised a series of presentations on the scheme's overall progress, the landscape study, traffic modelling and sifting outputs. This was followed by break-out group discussions to involve stakeholders in the outcomes of the sifting methodology and to seek their opinions on the options being considered.
- 13.3.7 During Stage 1, further stakeholder engagement activities included meetings with a number of bodies and individuals including members of parliament, DfT, local authorities, environmental bodies and others who held an interest in the scheme's development.

13.4 Steering group

- 13.4.1 The steering group was established to share information with critical stakeholders and hold high-level strategic discussions. The group meets on a bi-monthly basis and its terms of reference are:
- To create a forum for high level two-way dialogue to provide wider viewpoints on the environmental, political and economic landscape.
 - To collectively challenge the strategic direction of the project.
 - To monitor and evaluate the project's progress towards the achievement of its objectives.
 - To align and monitor key messaging and positioning of Highways England's key national stakeholders, press, lobbying groups and the local population.
 - To monitor the activity and outputs of working groups, to ensure that they are properly resourced, working efficiently and effectively and delivering in accordance with the project programme.
 - To consider the wider local and regional legacy benefits that the scheme could enable and to determine any actions to facilitate this.
- 13.4.2 The steering group is attended by representatives from the following organisations and chaired by Highways England:
- Gloucestershire County Council
 - National Trust
 - Cotswolds Conservation Board
 - Gloucestershire Wildlife Trust
 - GFirst Local Enterprise Partnership
 - Gloucester Local Nature Partnership
 - Mott MacDonald Sweco JV (Highways England supplier)
- 13.4.3 The steering group has been closely involved in the development of the A417 Missing Link project since its inception in summer 2016 taking a leading role in

the development and finalisation of the vision, scheme objectives and sub-objectives included in Table 2.1.

- 13.4.4 The steering group has also continued to challenge the integrated project team to ensure that the vision and objectives for the scheme are always front of mind, resulting in the project team carrying out a Landscape Study to inform the scheme design, this is something that would normally take place once proposals for the scheme were further developed.
- 13.4.5 The steering group have been engaged in the sifting, traffic modelling and environmental appraisals conducted during Stage 1 providing guidance, support and challenge throughout the process.

13.5 Technical working groups

- 13.5.1 The communications working group is the first of the A417 technical working groups to have been established. It first met on 5th September 2017. The purpose of the group is to discuss:
- Publicity for the scheme and channels of communication
 - Stakeholder engagement
 - Public consultation promotion and methodology
- 13.5.2 Members of the communications working group are:
- Highways England
 - Gloucestershire County Council
 - Tewkesbury Borough Council
 - Cotswold District Council
 - Cotswolds Conservation Board
 - Gloucestershire Wildlife Trust
 - National Trust
 - Mott MacDonald Sweco Joint Venture
 - Copper Consultancy – stakeholder lead for Mott MacDonald Sweco Joint Venture
- 13.5.3 A Community Consultation Plan was developed and issued to members of the communications working group to agree the approach to the route options public consultation, including its promotion and format (in terms of event locations etc).
- 13.5.4 Subsequent calls and face-to-face meetings have taken place since September 2017 in the run up to the route options public consultation and will continue as the scheme progresses.

13.6 Other forms of consultation

- 13.6.1 During stage 1 other forms of stakeholder engagement were carried out including:

Opportunity mapping workshops (May 2017)

13.6.2 The opportunities mapping events were a forum to identify and discuss specific opportunities that align with the scheme vision that could be included in the integral design of the proposed A417 Missing Link highway improvement scheme. This is additional to standard scheme mitigation measures that could be considered within an evolving scheme design.

Political and community leadership events (July 2017)

13.6.3 Highways England extended the best principle practice of early stakeholder engagement to political and community leaders ahead of the A417 route options public consultation.

13.6.4 Between 10th and 13th July 2017, a series of invitation only events were held with community and political leaders with the aim of sharing information on the scheme proposals, the route options selection process and the planning (Development Consent Order) process. The events outlined the timescales and discussed local issues that may be significant when it comes to the refinement of the route selections process. Comments from representatives on wider issues, such as economic growth and environmental protections, were recorded to feed into the process. A discussion around a series of largescale maps to understand any specific opportunities or concerns was also undertaken and fed into the development of route options.

Cowley & Birdlip Parish Council meeting (November 2017)

13.6.5 Following the political and community leadership events Cowley and Birdlip Parish Council held their own meeting attend by approximately 100 local residents in November 2017. Highways England was not present for the meeting but received feedback from the parish council in January 2018.

13.6.6 Some of the key points identified through the meeting include:

- Route identification – there is a general consensus that the new route needs to be placed further away from the village of Birdlip. Residents consider that this will address the noise and pollution at the Hawcote Hill / Parsons Pitch end of Birdlip and also serve to alleviate many of the engineering problems with the current routes such as the sharp bend at the Air Balloon roundabout.
- Noise and pollution – A number of residents agreed that using one or more cut and cover tunnels for the route as it passes residential or agricultural properties would be a long-term solution to any environmental issues.
- Rat running – most residents agreed that if a successful project design is implemented then the need for through traffic to use the village routes will be eliminated. However, there are many concerns that local access should not include the re-opening of the old Ermin way route (Cirencester Road) from Nettleton Bottom to the Village School. Residents who have

resided in the village before the Birdlip bypass was constructed remember the horrific accidents, deaths and traffic problems when this road was the main route for vehicles.

- 13.6.7 The parish council also provided two route options to be reviewed by the project team including an indicative long section through each solution.

13.7 Information provision – PCF Stage 2 Option Selection

- 13.7.1 The planned consultation programme for PCF Stage 2 for the A417 Missing Link consists of:

- Public consultation on shortlisted options for a period of 6 weeks (February 2018 to March 2018)

- 13.7.2 The public consultation will consist of a mix of events, including stakeholder meetings, publicised staffed public exhibitions, closed events with land owners affected by the scheme proposals, publication and distribution of scheme brochures, use of social media and media releases. A feedback form will also be developed to help capture responses to the consultation – this will be available in hard copy and online.

14. Additional economic and environmental appraisals

14.1 Introduction

14.1.1 The assessment and appraisal reported in Chapters 8 to 12 represents the work undertaken in line with the DfT transport appraisal guidance (WebTAG). This work is summarised into the Appraisal Summary Tables in Chapter 15, and produces the BCRs for the scheme.

14.1.2 It is recognised within the guidance that the recommended approaches to assessment are not the limit of the work which can be done to identify economic, environmental and social benefits which the scheme could create or enable.

14.1.3 This chapter discusses supplementary appraisal work of potential economic, environmental and social impacts of the A417 Missing Link scheme. Results of, and reasons not to undertake, a number of supplementary assessments are given below.

14.2 The Road to Growth and the Economic Assessment Tool

14.2.1 In 2016 Highways England produced a Strategic Economic Growth Plan, the Road to Growth. Within this plan, Highways England identified four roles that Highways England have in relation to the economy and the SRN:

- Role 1. Supporting business productivity and competitiveness, and enabling the performance of SRN-reliant sectors
- Role 2. Providing efficient routes to global markets through international gateways
- Role 3. Stimulating and supporting the sustainable development of homes and employment spaces
- Role 4. Providing employment, skills and business opportunities within Highways England's sector

14.2.2 While developing The Road to Growth, a series of Economic Opportunity Areas (EOAs) were identified by Highways England in consultation with Local Enterprise Partnerships (LEPs). EOAs are priority economic locations and growth opportunities that exist around the SRN. EOAs have been identified at either end of the A417 / A419 route, at Cheltenham-Gloucester, and Swindon.

14.2.3 More recent analysis undertaken by Highways England using the Economy Assessment Tool (EAT) in 2017 has shown that overall the local authority areas along the A417 / A419 route²⁹ have a high level of reliance on the SRN. The SRN is highly significant to these areas in supporting business productivity / competitiveness (economic role 1) and in stimulating sustainable development (economic role 3).

²⁹ The local authority areas included in the EAT analysis are Cotswold District, Gloucester City, Swindon Borough, Tewkesbury Borough, and Wiltshire.

14.2.4 These findings support the strategic case for the scheme, and the interaction between the scheme and the EOAs serve as a possible focus for further economic assessment in future stages.

14.3 Tourism sector economic assessment

14.3.1 To support the strategic case for the scheme, reference was made to stakeholder engagement work undertaken in 2016 with G-First LEP, the Gloucestershire Local Enterprise Partnership, as part of the research for Highways England's Strategic Economic Growth Plan, the Road to Growth. A key piece of information shared was that a key sector of the economy in the Gloucestershire area is tourism. Tourism contributes 10% of the total regional economy and it was noted that it is the most important sector for the more rural areas, particularly the Cotswolds.

14.3.2 To support the economic case for the scheme, further analysis could be undertaken in future PCF stages to quantify the economic value of the tourism sector to the South West of England. This could be achieved in combination with consultations being carried out as part of a further TEAM assessment, and would include undertaking consultations with prospective developers and local authority planners and economic development officers to understand the contribution that the study area and proposed scheme could make to the tourism economy of Gloucestershire.

14.4 Transparent Economic Assessment Model appraisal

14.4.1 In the first half of 2017 Mott MacDonald Sweco Joint Venture completed a high level, preliminary assessment of the potential land use and economic development impacts of the A417 Missing Link scheme. The wider economic impacts of Missing Link road were assessed and quantified using the proprietary Transparent Economic Assessment Model (TEAM).

14.4.2 The approach combined desk-based research using publicly available data and primary research. Primary research was undertaken in the form of a site visit and stakeholder consultations with 11 local authority representatives from 6 different local authorities.

14.4.3 The key findings from the site visits and consultations undertaken were:

- A consensus that something must be done to improve the A417
- A417 improvements would have minimal impact on residential land
- There would be a positive impact on productivity and labour in Gloucestershire
- The importance to businesses in Gloucestershire of a solution to the A417
- Benefits to tourism due to increased efficiency of the transport network
- Concerns regarding the extent and further impacts of traffic elsewhere in the road network
- Environmental constraints in the area which may restrict development

- 14.4.4 To estimate the potential wider economic benefits of the scheme, the economic development potential of 17 key employment sites was assessed. The TEAM has been used to quantify the potential wider economic benefits that the A417 Missing Link could unlock in the county of Gloucestershire.
- 14.4.5 This assessment found that of the 17 sites, the development of at least 6 sites can be linked to improvements around the A417 Air Balloon junction. Development of these 6 sites could support approximately 11,500 net additional jobs in the local economy. These jobs could in turn support approximately £0.9bn per annum in gross direct gross value added (GVA), of which over £0.5bn will be net additional to the local economy.
- 14.4.6 Significant qualitative benefits can also be associated with the delivery of this scheme, including the delivery and value of housing, support key employment sectors and enhanced safety on the road network in Gloucestershire.
- 14.4.7 Defining the extent to which the benefits generated from development of these sites can be attributed to the A417 Missing Link improvements was beyond the scope of this study. More detailed analysis would need to be conducted to define the causal links between the scheme and improvements in employment opportunities to define the appropriate level of attribution.

14.5 Landscape monetisation

- 14.5.1 A landscape monetisation assessment was prepared, alongside the qualitative WebTAG appraisal, to supplement the business case for the A417 Missing Link scheme, though at this stage the assessment has not directly contributed to the BCR.
- 14.5.2 Using guidance from the DfT's Value for Money Supplementary Guidance on Landscape, monetisable landscape assets in the form of landscape types were identified and the long-term future monetised impacts of the proposed scheme were assessed in line with the recommendations from the Value for Money Assessment (VfMA). This involved assessing and mapping the study area to reflect the landscape typologies present within the landscape study area. The proposed scheme options were then individually overlaid on the mapped landscape typologies.
- 14.5.3 In the absence of a construction boundary and access route upgrades the scheme options were given an offset of 150m either side of the proposed route in order to assess the footprint of the scheme, as this was representative of the area most affected. The guidance provided in the VfMA assumes the area of impact was 500m either side of the scheme, with 25ha of land per km fully affected and a further 25ha per km partly affected. Off-line sections of the scheme options were assessed with an assumed impact footprint of 50ha per km as per the guidance, and online sections were assumed to have a footprint of 25ha per km due to the context of the existing highways infrastructure and associated impact. In terms of mitigation, at the stage of assessment, an adequate level of information was not available to make an informed judgement

on the potential impact reduction from its incorporation, and therefore mitigation was not calculated in the assessment.

- 14.5.4 The valuation findings showed that Option 21 had the lowest landscape monetisation impact overall due to the option having the longest section of tunnel. However, Option 29 had the lowest impact per km, indicating that although the scheme is longer, it traverses less valuable land types, as per the methodology. Options 12 and 30 were shown to have the largest monetised landscape impact and the second largest impact per km, partly due to the options being entirely surface routes, whereas the other options scored better because of the tunnel segments within their designs.

14.6 Contingent valuation

- 14.6.1 Current appraisal guidance (WebTAG) does not monetise or seek to quantitatively value impacts on the cultural environment, instead relying on qualitative scores. However, similar to the monetisation of landscape method, techniques exist which seek to monetise the value that people place on cultural heritage assets.
- 14.6.2 One technique recognised by the HM Treasury Green Book, Appraisal and Evaluation in Central Government, for valuing non-market impacts is Contingent Valuation. A Contingent Valuation ('Willingness to Pay') approach would elicit a monetary value for the impact of the scheme, which could be reducing the impact of the scheme on the AONB or other natural and cultural assets in the study area.
- 14.6.3 This technique has been used in the economic assessment for the A303 Stonehenge, Amesbury to Berwick Down scheme to estimate the economic benefits of removing (or reducing) the footprint of the strategic road from the Stonehenge, Avebury and Associated Sites World Heritage Site, in combination with a monetisation of landscape assessment.
- 14.6.4 As only one of the options assessed for the A417 scheme has potential to remove any of the existing road from the area, the scope for application of this method on the A417 Missing Link scheme appears limited, however no assessment has taken place during PCF Stage 1.

14.7 Sustainability Decision Model

- 14.7.1 The Sustainable Decision Model (SDM) is a tool that provides a qualitative assessment of sustainability performance at any stage in the design process. It has been undertaken to assist the appraisal of the Stage 1 options for the A417 Missing Link scheme.
- 14.7.2 To input into the SDM process a sustainability workshop was held as part of the first Stage 1 value management workshop. The workshop identified 11 sustainability objectives which encompassed the 3 pillars of sustainability (Economic, Environmental and Social) and aligned with the scheme objectives.

These objectives were scored against each other in the SDM and weighted against a ratings matrix to calculate a final weight for each of the objectives as a percentage. Each of the options were then scored on their performance against each of the objectives and scored based on the current design and assessments. The SDM then automatically weighted these scores (using the weightings calculated for each objective) and produced a sustainability score (out of 7) for each of the options. The SDM was completed a total of 3 times; without any mitigation measures, with basic mitigation measures, and with basic mitigation and environmental enhancement opportunities implemented.

- 14.7.3 From the results, Option 21 had the highest sustainability performance at all levels of mitigation due to it having the longest tunnel, which would buffer the noise generated from the new road therefore having the lowest noise impacts. The long tunnel and wide tunnel portals would reduce the impact of the option on the SSSI and hedgerows, and biodiversity could be reconnected over the tunnel.
- 14.7.4 The SDM showed that 1 of the 2 surface routes, Option 12, would have the poorest sustainability performance at all levels of mitigation. Both options 12 and 30 would sever the Cotswold Way trail and the Gloucestershire way trail without mitigation. They would also require a substantial quantity of cut material and have the highest carbon emissions. The Option 12 safety scoring was also low due to the location of the Barrow Wake junction.
- 14.7.5 Of the other 3 tunnel options, Option 24 scored the worst due to an adverse visual impact on the landscape of the AONB and options 3 and 29 scored similarly with the main difference being the impact on air quality. The second surface route, Option 30, scored better than Option 12 due to the large differences in materials, carbon output, cost and safety. The landscape and ecology aspects of the 2 surface options remained very similar.
- 14.7.6 The SDM will continue to be refined during the progression of the project, as the design becomes more detailed and further assessments are undertaken. It will also be used to compare different aspects of design in order to inform the sifting of options or variations during further PCF Stages, and to increase the sustainability of the scheme.

14.8 Opportunities mapping

- 14.8.1 Opportunity mapping was undertaken to assist the appraisal of the A417 Missing Link scheme.
- 14.8.2 The purpose of the opportunity mapping was to identify measures that go above and beyond the standard mitigation required to avoid any adverse environmental impacts. The opportunities identified would enhance the current baseline condition of the environment in line with Highways England's Environment Strategy focus.
- 14.8.3 A series of workshops were held to inform the opportunity mapping exercise, attended by the A417 project team environmental specialists and a number of

stakeholders, during which a broad range of potential environmental opportunities were identified. With input and feedback from the stakeholders, and referencing relevant elements of the Cotswold Area of Outstanding Natural Beauty (AONB) Management Plan and the Gloucestershire Local Nature Partnership (GLNP) Strategic Nature Areas, a shortlist of opportunities for environmental enhancement was created.

- 14.8.4 The opportunities identified would provide improved biodiversity connectivity, as well as enhanced recreational and cultural access within the Cotswold AONB. The opportunities represent measures that go beyond the core mitigation that is required to deliver the scheme, to enhance the existing environmental conditions in line with the scheme vision and objectives. The output from the opportunity mapping did not provide a sufficient differentiator between the options at Stage 1 but will be utilised in identifying enhanced opportunities to the preferred option during later stages.

14.9 Landscape study

- 14.9.1 A landscape study has been undertaken to inform the PCF Stage 1 appraisal of options for the A417 Missing Link. The overarching purpose of the study is to ensure that the earliest stages of route selection pay sufficient 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. Adequate baseline landscape information was required to robustly identify a shortlist of feasible options that will be taken forward to (PCF) Stage 2 (Option Selection). The level of this baseline landscape information required at Stage 1 is greater than is often the case due to the location of the entirety of all options within a particularly sensitive part of a nationally protected landscape.
- 14.9.2 An important aspect of the study has been to focus on the identification of how well different highway alignment options might generate opportunities for broader scale as well as localised landscape enhancements. This has been 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.
- 14.9.3 To ensure a rounded understanding the description of the landscape focuses on landscape and visual aspects but also takes account of the extent, distribution and connectivity of areas of particular ecological, cultural heritage or recreational importance.
- 14.9.4 The review of the 6 options discusses how well each responds to matters such as the topographical context, changes in landcover, changes in character, changes in relative landscape sensitivity and the interconnectedness of the network of areas that capture what is most important and valuable in the landscape of this part of the Cotswolds AONB. The review of the 6 options also identifies recommendations for route optimisation (to reduce adverse landscape

impacts or take advantage of topographical opportunities) and identifies opportunities for the delivery of landscape enhancements (whether localised to the particular corridor alignment or relating to the potential to contribute to more strategic landscape restoration and connectivity objectives).

- 14.9.5 The study identifies that the route of the current A417 takes advantage of a slightly deeper and slightly less steeply sloping embayment immediately to the south of the peak at Crickley Hill. The Air Balloon roundabout sits at a slightly lower elevation than the sections of scarp crest both to the north and south and the A436 quickly links eastwards into one of the lower lying high wold valleys. No equal or better opportunities exist along the scarp crest elsewhere within the study area. This suggests that the embayment to the south of Crickley Hill does represent not only the best but the only topographical opportunity for a surface route up the scarp.

14.10 Conclusions

- 14.10.1 A number of supplementary studies to the WebTAG assessment and appraisal work have been completed or conceived during Stage 1. These studies have primarily covered areas related to the environmental and economic performance of the scheme.
- 14.10.2 The work undertaken through the EAT and TEAM economic assessments have supported the development of a strong strategic case for the scheme to be constructed. With a reduced number of options in future PCF stages, further TEAM or other similar assessments could identify wider economic benefits to developments local to the scheme, tourism or the Gloucestershire and Wiltshire EOAs specifically attributable to the proposed scheme. Increased benefits would strengthen the economic case for the scheme and potentially increase the adjusted BCRs for the options taken forwards.
- 14.10.3 Studies on landscape monetisation, sustainability decision modelling, opportunities mapping and landscape were undertaken during Stage 1. These studies were originally undertaken with the intention of being included as part of the options sifting under the objective that the options taken forward were to be landscape-led. The results of these studies, however indicated that these elements would not be significant differentiators between the six schemes taken through from the EAST Plus sifting for further appraisal. Instead, these studies are useful foundations for further study in future stages or for improvements to the option designs.
- 14.10.4 The results of the preliminary landscape monetisation study showed a net dis-benefit for the scheme options. This was working with the early options designs and 150m buffer around the option centrelines. With improved maturity of design and the establishment of a red line boundary, the results of the study could be refined.
- 14.10.5 The SDM and opportunities mapping exercised will both continue to be refined throughout future stages. Both have the potential to positively impact on the

design of the scheme in terms of identifying where sustainability, cultural, environmental and heritage access improvements could be made.

- 14.10.6 Similarly to the SDM and opportunities mapping, the landscape study will positively influence the design of options taken forwards. The results of the study have confirmed that no equal or better opportunities exist along the scarp crest elsewhere within the study area for a surface route to cross the escarpment. There are also suggested improvements to the alignments of tunnel and surface options which would be further developed if progressed during future stages.

15. Appraisal summary

15.1 Appraisal summary tables (ASTs)

15.1.1 Appraisal summary tables have been produced in accordance with the DfT's Transport Analysis Guidance (WebTAG) (last updated in July 2016). The summary tables are reproduced in Appendix C of this report.

15.2 Comparison of options

Economics

15.2.1 In the economic assessment summarised in Chapter 9 of this report, Option 21 provides the highest PVB at £386 million over the 60-year appraisal period. The surface Option 12 provides the lowest PVB at £153 million while the PVB's for the remaining 3 tunnelled options are £359 million, £334 million and £357 million for options 3, 24 and 29 respectively. The PVB for the other surface option, Option 30, is £249 million.

15.2.2 However, despite offering lower benefits than the tunnelled options, surface Option 30 is shown to provide the best overall value for money, with a Benefit to Cost Ratio (BCR) of 1.04 when adjusted to include journey time reliability and wider economic benefits. This reflects the substantially lower cost of option 30 compared to the tunnelled options.

15.2.3 Surface Option 12 is the cheapest option that has been considered at this stage but generates the lowest benefits, which results in an initial BCR of 0.55 and an adjusted BCR of 0.68.

15.2.4 Of the tunnelled options, Option 3 provides the best value for money, with an initial BCR of 0.67 and an adjusted BCR of 0.79. Options 24 and 29 provide similar levels of value for money (adjusted BCR values of 0.54 and 0.56 respectively), while the substantially greater cost of Option 21 results in this option achieving the poorest overall value for money (adjusted BCR value of 0.47) despite providing the highest benefits.

15.2.5 Under the current DfT value for money criteria, the initial BCR values for all 6 options represent poor value for money. When considering the adjusted BCR value, 5 of the options still fall within the poor value for money category, with Option 30 moving into the low value for money category.

Safety – accident savings

15.2.6 The COBALT assessment undertaken as part of the A417 scheme appraisal shows that, when compared against the Do Minimum scenario, all 6 options are forecast to provide benefits that arise from a reduction in personal injury accidents (PIAs). The benefits arise from the forecast shift in traffic from poorer quality existing links to the new higher quality links associated with the options. All of the options show benefits on links around the existing Air Balloon junction,

particularly the A417 Crickley Hill and also A417 Barrow Wake, both of which are significantly relieved of traffic as a result of the proposals.

- 15.2.7 There is some variability in the appraisal results for each of the options, although the positive impact on safety is common to all of the options being considered. The largest benefits occur in Option 24, which shows a saving of 3 fatal, 22 serious and 83 slight casualties and a consequent economic benefit of £6.8 million over the 60-year appraisal period. The lowest accident benefits occur with Option 3, which has a saving of 2 fatal, 15 serious and 36 slight casualties, which equates to an economic benefit of £4.1 million. The variability in results is due to the traffic flow differences that arise from the way connectivity would be delivered by the options, between the new sections of highway and the existing A417 alignment, and also as a result of the differences in scheme length between the options.

Safety strategic safety action plan

- 15.2.8 All 6 options, through the removal of the existing single-carriageway section of the A417, 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 trunk road network.
- 15.2.9 All the options present gradients above the desirable maximum of 4%. Mitigating measures would be applied to address safety concerns relating to these gradients
- 15.2.10 Of the tunnel options, options 3, 21 and 24 are noted to have no significant concerns or inappropriate features. Option 29 is noted to have 1 curve with a permitted, but below desirable, radius with a possible impact on visibility that would need to be addressed.
- 15.2.11 All 6 options would give rise to safety considerations that would have to be addressed in the further development of the scheme, with Option 12 giving rise to the greatest number of concerns.

Environment

- 15.2.12 All options are predicted to result in overall benefits with respect to noise. Option 21 has the highest positive benefit of £2.0 million, whilst Option 29 has the lowest positive benefits of £0.6 million. All options are predicted to result in an overall air quality dis-benefit, although all options are predicted to improve air quality within the Birdlip AQMA. Options 3 and 12 have the largest dis-benefit of -£1.2 million and Option 21 has the smallest dis-benefit of -£0.8 million. The greenhouse gas appraisal indicates that all options would lead to an increase in greenhouse gas emissions.
- 15.2.13 Other environmental and social issues have been subject to a qualitative appraisal.

- 15.2.14 Options 3, 12, 24, 29 and 30 have been assessed as having a Large Adverse impact on the landscape and Option 21 would result in a Moderate Adverse impact. Options 3, 21, 24 and 29 present the potential for Moderate Adverse impacts on the historic environment whilst Options 12 and 30 would result in a Large Adverse impact. In the area of biodiversity, options 3, 12, 24, 29 and 30 are anticipated as having an overall Large Adverse impact, whilst Option 21 is anticipated to have a Slight Adverse impact. With respect to the water environment, all options have the potential to have a Very Large Adverse impact on groundwater. Impacts on surface water are anticipated to be Slight Adverse for all options.
- 15.2.15 All options are anticipated to have Neutral impacts associated with security, access to services, severance, affordability and option and non-use values, a Slight Beneficial impact for physical activity. For journey quality, a Slight Beneficial impact has been predicted for options 12 and 30, and a Moderate Beneficial for options 3, 21, 24, and 29.

Summary of comparison

- 15.2.16 The qualitative and quantitative impacts for each option from the Appraisal Summary Tables are given below in Table 15.1. Where there are both quantitative and qualitative impacts, the impact has been represented by the quantitative.

Table 15.1: Combined appraisal summary results

	Impacts	Option 3	Option 12	Option 21	Option 24	Option 29	Option 30	
Economy	Business users & transport providers	£248.4 million	£108.3 million	£271.0 million	£238.0 million	£248.4 million	£170.9 million	
	Reliability impact on Business users	£21.3 million	£14.2 million	£22.0 million	£20.6 million	£21.2 million	£18.5 million	
	Regeneration	N/A	N/A	N/A	N/A	N/A	N/A	
	Wider impacts	£24.8 million	£10.8 million	£27.1 million	£23.8 million	£24.8 million	£17.1 million	
Environmental	Noise	£0.9 million	£1.1 million	£2.0 million	£0.7 million	£0.6 million	£0.8 million	
	Air quality	PM10 NPV: -£0.2 million NOX NPV: -£1.0 million Total value of change in air quality: -£1.2 million	PM10 NPV: -£0.3 million NOX NPV: -£0.9 million Total value of change in air quality: -£1.2 million	PM10 NPV: -£0.2 million NOX NPV: -£0.6 million Total value of change in air quality: -£0.8 million	PM10 NPV: -£0.1 million NOX NPV: -£1.0 million Total value of change in air quality: -£1.1 million	PM10 NPV: -£0.1 million NOX NPV: -£1.0 million Total value of change in air quality: -£1.1 million	PM10 NPV: -£0.3 million NOX NPV: -£0.9 million Total value of change in air quality: -£1.1 million	
	Greenhouse gases	-£24.1 million	-£31.0 million	-£22.2 million	-£33.2 million	-£23.2 million	-£30.6 million	
	Landscape	Large Adverse	Large Adverse	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	
	Townscape	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	
	Historic environment	Moderate Adverse	Large Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Large Adverse	
	Biodiversity	Large Adverse	Large Adverse	Slight Adverse	Large Adverse	Large Adverse	Large Adverse	
	Water environment	Very Large Adverse	Very Large Adverse	Very Large Adverse	Very Large Adverse	Very Large Adverse	Very Large Adverse	
	Social	Commuting and other users	£91.7 million	£33.8 million	£96.8 million	£71.8 million	£89.5 million	£62.4 million
		Reliability impact on commuting and other users	£16.3 million	£11.2 million	£16.6 million	£15.7 million	£15.8 million	£14.1 million
Physical activity		Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	
Journey quality		Moderate Beneficial	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Slight Beneficial	
Accidents		£4.1 million	£3.3 million	£4.2 million	£6.8 million	£6.2 million	£4.3 million	
Security		Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	
Access to services		Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	
Affordability		Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	
Severance		Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	
Option and non-use values		Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	
Public Accounts	Cost to broad transport budget	533.1 million	£276.6 million	£956.5 million	£726.2 million	£742.7 million	£286.4 million	
	Indirect tax revenues	-£51.9 million	-£62.5 million	-£48.6 million	-£64.9 million	-£49.9 million	-£62.9 million	

16. Programme

- 16.1.1 A scheme programme has been developed based on the Highways England Development Consent Order (DCO) Process Map. The latest dates of the scheme programme at the time of issue of this report are summarised below. The construction period will vary depending on the option selected at the next stage of the scheme development.
- 16.1.2 Key programme dates are:
- Commence non-statutory public consultation – February 2018
 - Preferred Route Announcement – autumn 2018
 - Application for Development Consent Order – late 2019
 - Publish Development Consent Order – early 2021
 - Secretary of State decision (latest date) – early 2021
 - Start of construction (entry by negotiation) – mid 2021
 - Scheme open to traffic – mid 2024
- 16.1.3 The scheme open to traffic date will be dependent on the final option taken forward. The current options range in construction between 3 and 5 years.

17. Conclusions

17.1 Introduction

17.1.1 This chapter summarises the assessment work undertaken and concludes on which options should be taken forward for public consultation.

17.2 EAST Plus sifting results

17.2.1 The 30 options initially developed were reduced to 20 options through an analysis of engineering feasibility.

17.2.2 The remaining 20 options were assessed against a modified EAST Plus criteria, and ranked based on their overall score.

17.2.3 The top scoring option for each escarpment corridor was taken through for assessment, with the exception of escarpment corridor A. The 3 routes within escarpment corridor A scored poorly, particularly against environmental objectives, and were therefore discounted. The top scoring option within that escarpment corridor was replaced with Option 30, the highest scoring acceptable surface route.

17.2.4 Results of the economic appraisal on the tunnel options showed that value for money was poor, and estimated costs exceeded the £500 million upper limit of the cost range. To ensure that a second affordable option was taken forward, Option 12, another surface option, was included in the appraisal.

17.2.5 The EAST Plus scores for the 6 shortlisted options against the various measures produced the overall scores below in Table 17.1.

Table 17.1: Table of overall EAST plus scores for the 6 options, listed by option number

Option	Corridor	Surface / tunnel	Overall score (without cost)
3	B	Tunnel	7
12	B	Surface	17
21	C	Tunnel	1
24	E	Tunnel	9
29	D	Tunnel	4
30	B	Surface	15

17.3 Traffic analysis

17.3.1 The traffic models forecast 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, which is reflective of the more direct alignment provided by this tunnelled option. The forecasts for the non-tunnelled Option 12, which provides a less direct alignment compared to the other options, and includes a section with an advisory 50mph speed limit, still show a significant reduction in

journey times compared to the Do Minimum but this option provides the slowest journey time along the A417 of all 6 options.

- 17.3.2 The journey time reductions are forecast to result in an increase in traffic along the A417 / A419 route corridor and in the vicinity of the scheme, as traffic reassigns more efficiently from various alternative routes, both local and longer distance.

17.4 Option estimates

- 17.4.1 The 6 options were costed by the Highways England Commercial Estimating team. The most likely total estimated costs for each option are shown below in Table 17.2.

Table 17.2: Most likely order of magnitude option estimates, 2016 / Q1 base price

Option	Surface / Tunnel	Total scheme price (prices are in millions)
3	Tunnel	£875
12	Surface	£465
21	Tunnel	£1,625
24	Tunnel	£1,210
29	Tunnel	£1,240
30	Surface	£485

17.5 Benefit to cost ratios

- 17.5.1 The BCRs have been calculated in line with the Department for Transport's WebTAG methodology. The Initial and Adjusted BCRs are shown below in Table 17.3.

Table 17.3: Summary of initial and adjusted benefit to cost ratios (BCRs)

Option	Surface / Tunnel	Initial BCR	Adjusted BCR
3	Tunnel	0.67	0.79
12	Surface	0.55	0.68
21	Tunnel	0.40	0.47
24	Tunnel	0.46	0.54
29	Tunnel	0.48	0.56
30	Surface	0.87	1.04

17.6 Road safety assessment

- 17.6.1 The 6 options were assessed in a preliminary road safety assessment. 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

- 17.6.2 All 6 options give rise to safety considerations which will need to be addressed as part of the further development of the project. Option 12 presents the biggest challenges in overcoming elements of the proposed alignment which are below current standards, gradients which are above the desirable maximum and horizontal curves up to 4 steps below the desirable minimum.
- 17.6.3 All the proposed options would be expected to improve road safety, reducing the number of people killed or seriously injured on the route.

17.7 Appraisal summary tables

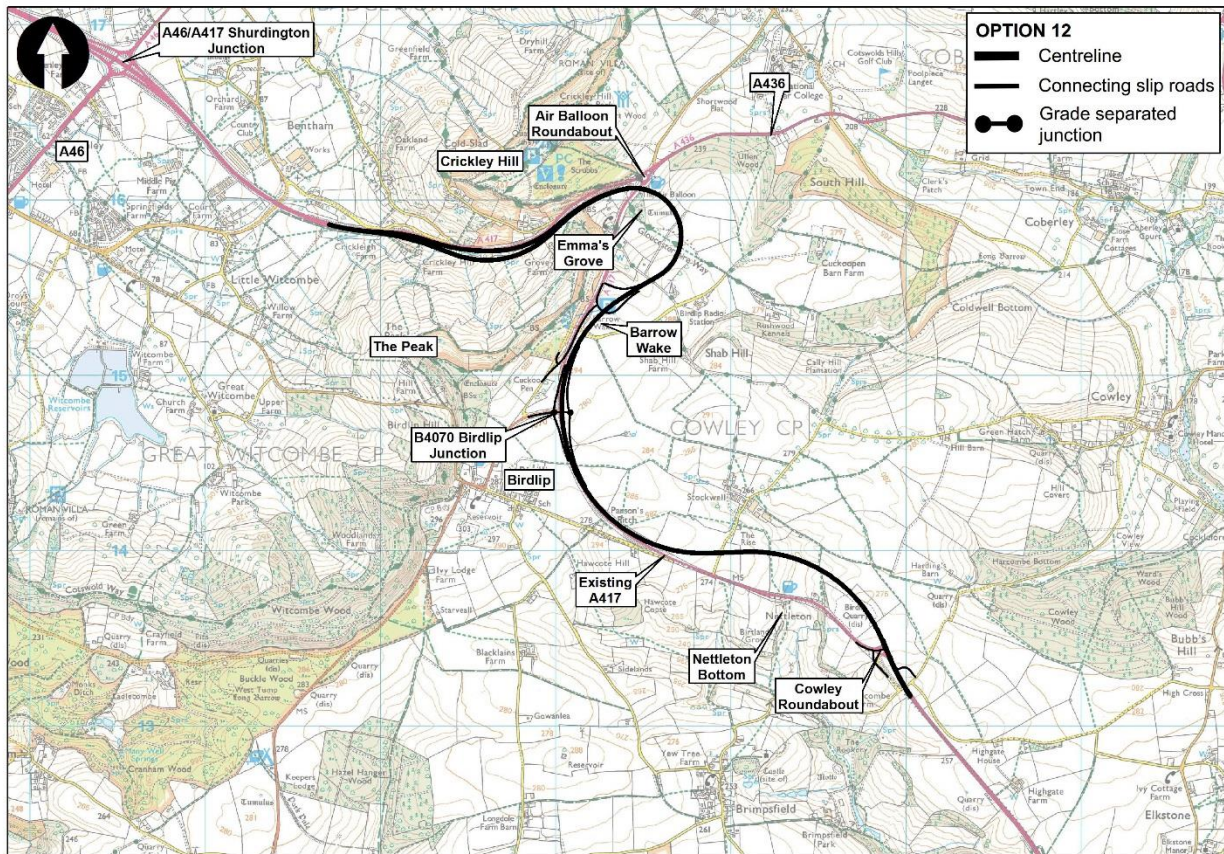
- 17.7.1 Appraisal summary tables with corresponding worksheets have been produced in accordance with the Department for Transport's Transport Analysis Guidance (WebTAG) (last updated in July 2016). The summary tables are reproduced in Appendix C of this report.
- 17.7.2 Comparison between the appraisal summary tables for each option show that the tunnel options, options 3, 21, 24 and 29 outperform the surface options in most of the economy, environmental and social measures.
- 17.7.3 This is achieved at a cost which is substantially higher than for the surface routes, options 12 and 30, with affordability implications for the tunnel options. The additional benefits that the tunnel options bring are disproportionate to their higher costs and does not improve their poor value for money.

17.8 Overall conclusions

- 17.8.1 Highways England considers the routes appraised during PCF Stage 1 to be a range of viable solutions given the engineering, environmental and landscape constraints. No other options to address the current safety and congestion issues have been identified by Highways England or the stakeholders consulted during the course of this work which would not have a similar or greater negative impacts on the environment and landscape.
- 17.8.2 From the appraisal results the tunnel options provide greater benefits than the 2 surface options. They give better environmental and social results by providing a shorter, more direct route through the study area and by removing a section of the new road from the landscape. These results are supported by the environmental studies completed in addition to the WebTAG guidance.
- 17.8.3 However, when the benefits of these options are weighed against their cost, they are shown to exceed the upper limit of the cost range (£500 million) and provide poor value for money; options 3, 21, 24 and 29 all have BCR of less than 1.0. It is implausible that enough benefits applying only to those routes would be identified, or that the costs could be reduced to a sufficient extent, to make them competitive on value terms with the surface routes. On this basis, options containing tunnels will not be progressed to future stages of development.

- 17.8.4 The 2 surface routes, Option 12 and Option 30 are 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 road. These routes are shown below.
- 17.8.5 Option 12 is a surface route (historically known as the Modified Brown Route), with mixture of on-line widening and off-line construction broadly following the route of the existing road whilst bypassing Nettleton Bottom.

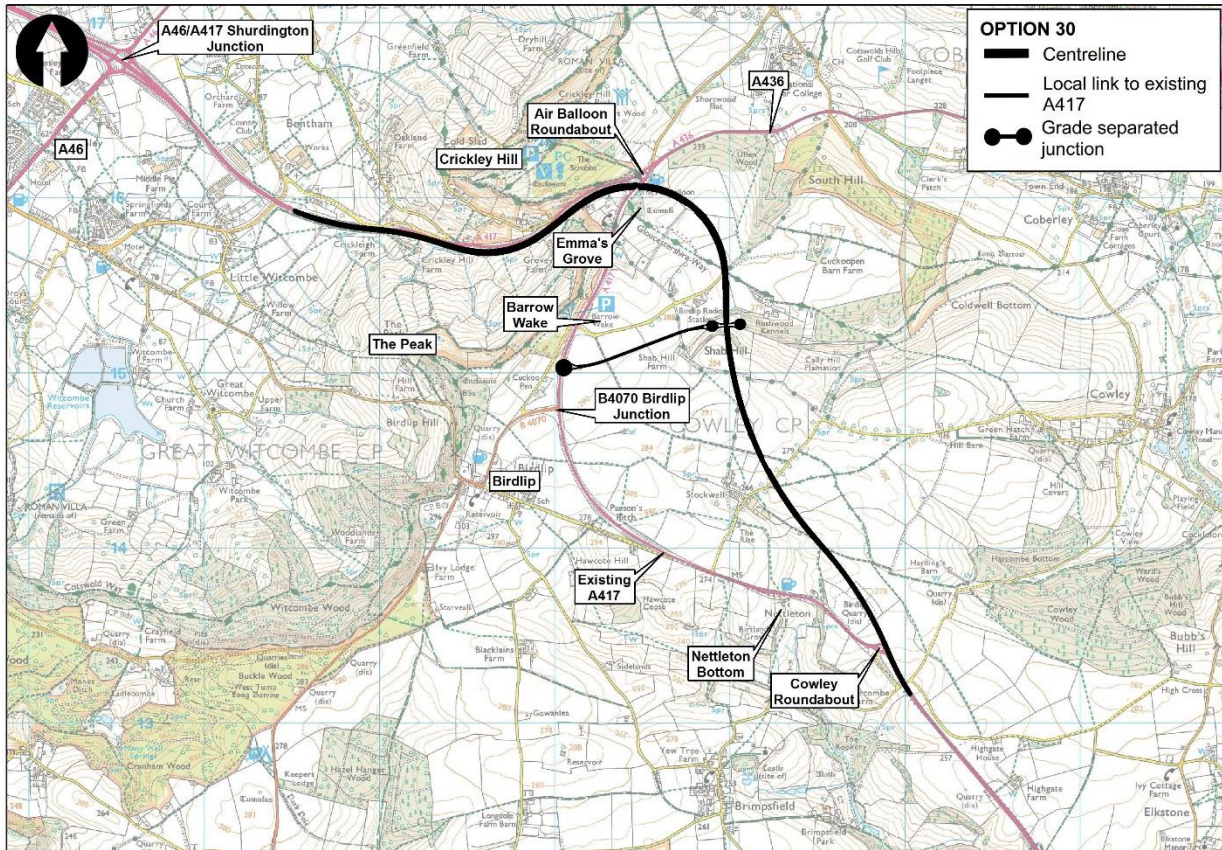
Figure 17.1: Option 12



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17.8.6 Option 30 is a surface route, characterised by a 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 17.2: Option 30



Source: GiGi GIS Portal. Crown Copyright 2016 100030649

17.9 Recommendation

17.9.1 The two affordable options, of the 6 options assessed, Option 12 and Option 30 are to be taken forwards to public consultation and PCF Stage 2. When reviewing the assessment and appraisal of both options it is clear from the Appraisal Summary Tables, the safety assessment and the value for money assessment (BCRs) Option 30 outperforms Option 12.

17.9.2 Between the 2 surface routes, Highways England's preference would be Option 30 because on balance it would:

- have a lower impact on air quality
- be a higher quality road, and be safer for road users
- provide shorter journeys
- deliver greater benefits and the best overall value for money