A417

Missing Link

Environmental Impact Assessment Scoping Report

May 2019

Table of contents

1. Introduction

1.1. Purpose of the report

1.1.1. This Environmental Impact Assessment Scoping Report has been prepared in accordance with Regulation 10 of the Infrastructure Planning (Environmental Impact Assessment) (EIA) Regulations 2017 (the 'EIA Regulations'). It is submitted by Mott MacDonald Sweco JV on behalf of Highways England to request a Scoping Opinion in respect of the A417 Missing Link Scheme (hereafter referred to as 'the Scheme').

1.1.2. The purpose of this Environmental Impact Assessment Scoping Report is to establish the scope of the Environmental Statement and the level of detail required, and to support the request for a Scoping Opinion under Regulation 10(1) of the EIA Regulations. This report has been completed in accordance with the Design Manual for Roads and Bridges (DMRB) Volume 11[1] and the Planning Inspectorate's (PINS) Advice Note 7[2] to a Scoping Level for all environmental factors (topics) set out in the EIA Regulations.

1.2. Overview of the Scheme

1.2.1. The Scheme would provide a dual carriageway to improve the current "Missing Link" section of single carriageway of the A417 between Cowley roundabout and Crickley Hill.

1.2.2. The Scheme aims to increase capacity by creating a free-flowing link between the Brockworth Bypass and the Cowley roundabout and remove the at-grade junction with the A436 (Air Balloon Roundabout). This Scheme will provide a high-quality dual carriageway, consistent with the A417/A419 corridor between Swindon (M4 Junction 15) and Gloucester / Cheltenham (M5 Junction 11a).

1.3. Legislative context and the need for Environmental Impact Assessment

1.3.1. The Scheme is defined as a Nationally Significant Infrastructure Project (NSIP), under section 14 (1) (h) and section 22 of the Planning Act 2008 (PA 2008) (as

[1] Highways Agency (2009) Design Manual for Roads and Bridges (DMRB) Volume 11 'Environmental Assessment'.
[2] The Planning Inspectorate (2015) Advice Note Seven: Environmental Impact Assessment: Preliminary Environmental Information, Screening and Scoping [online] available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/03/Advice-note-7v4.pdf (last accessed January 2019).

amended by The Highways and Railway (Nationally Significant Infrastructure Project) Order 2013) (Ref 1) by virtue of the fact that:

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

1.3.2. The Scheme has been classified as EIA development as it falls within Schedule 2.10 (f) – construction of roads of the EIA Regulations. Due a number of factors, including the sensitivity of the Scheme location within an Area of Outstanding Natural Beauty (AONB), an Environmental Statement will be prepared to accompany the Development Consent Order (DCO) application to PINS. In accordance with Regulation 8(1)(b) of the EIA Regulations, Highways England has notified the Secretary of State for Transport in a letter to PINS April 2nd, 2019 that an Environmental Statement presenting the findings of the EIA will be submitted with the DCO application.

1.3.3. The Environmental Statement will meet the requirements of Regulation 14 of the EIA Regulations.

1.3.4. Various specific requests are made to scope out certain sub-topics. These are listed in the table in Section 17.

1.4. Planning policy context

National Policy Statement for National Networks

1.4.1. The National Networks National Policy Statement (NPSNN)[3] 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 on development consent for NSIPs in England. The Government recognises in the Appraisal of Sustainability accompanying the NPSNN, that some developments will have some adverse local impacts on noise, emissions, landscape/visual amenity, biodiversity, cultural heritage and water resources. The significance of these effects and the effectiveness of mitigation is uncertain at the strategic and non-locational specific level of the NPSNN. Therefore, whilst applicants should

[3] Department for Transport (2015) National Policy Statement for National Networks [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf (last accessed February 2019)

deliver developments in accordance with Government policy and in an environmentally sensitive way, including considering opportunities to deliver environmental benefits, some adverse local effects of development may remain.

1.4.2. Outside the NSIP regime, Government policy is to bring forward targeted works to address existing environmental problems on the Strategic Road Network (SRN) and improve the performance of the network. This includes reconnecting habitats and ecosystems, enhancing the setting of historic and cultural heritage features, respecting and enhancing landscape character, improving water quality and reducing flood risk, avoiding significant adverse effects from noise and vibration, and addressing areas of poor air quality.

1.4.3. Evidence demonstrating compliance of the Scheme with the NPSNN will be provided within the NPSNN Accordance Table which will be submitted as part of the DCO application within either the Planning Statement or the Case for the Scheme. Any environmental assessment principles outlined in the NPSNN will be taken into account within the Environmental Statement.

1.4.4. The Environmental Statement will also confirm within each of the environmental discipline chapters how the requirements of the NPSNN will be met.

National Planning Policy Framework

1.4.5. The National Planning Policy Framework (NPPF)[4] sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally-prepared plans for housing and other development can be produced.

1.4.6. The NPPF places significant weight on the need to support economic growth and productivity, taking an approach which should allow each area to build on its strengths, counter any weaknesses and address the challenges of the future. Additionally, the NPPF seeks to promote sustainable transport by encouraging solutions which support reductions in greenhouse gas emissions and reduce congestion.

1.4.7. The NPPF does not contain specific policies for NSIPs. These are determined in accordance with the decision-making framework in the PA 2008 (as amended by The Highways and Railway (Nationally Significant Infrastructure Project) Order 2013) and relevant national policy statements for major infrastructure, as well as any other matters that are considered by the Secretary of State to be important and relevant (which may include the NPPF). National policy statements form part

[4] Communities and Local Government (2012) National Planning Policy Framework [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740441/National_Planning_Policy_Framework_web_accessible_version.pdf (last accessed February 2019).

of the overall framework of national planning policy, and may be a material consideration in preparing plans and making decisions on planning applications.

2. The Scheme

2.1. Need for the Scheme

2.1.1. In 2014, the Department for Transport (DfT) announced its five year investment programme for making improvements to the Strategic Road Network (SRN) across England. More than 100 Schemes were identified as part of this Road Investment Strategy (RIS), one of which was the A417 Missing Link between the Brockworth bypass and Cowley roundabout in Gloucestershire.

2.1.2. Together, the A417 and A419 make up one of the south-west's most important road corridors. They link the M5 at Gloucester (Junction 11A) to the M4 at Swindon (Junction 15). They help south-west businesses connect with markets and opportunities in the Midlands and north, and they attract investment for Gloucestershire and its neighbours by linking them to London and the South-East.

2.1.3. Most of the A417/A419 route is dual-carriageway, but there is one section that is not. Known as the Missing Link, this stretch of 5.5 kilometres of single-carriageway on the A417 between the Brockworth bypass and Cowley roundabout restricts the flow of traffic causing pollution and congestion. Delays of 20 minutes or more are not unusual. This results in some motorists diverting onto local roads to avoid tailbacks, causing difficulties for neighbouring communities. Poor visibility and challenging gradients also mean that a disproportionately high number of accidents are seen along this stretch of road.

2.1.4. Upgrading this section of A417 to dual-carriageway, in a way that is sensitive to the surrounding Cotswolds Area of Outstanding Natural Beauty (AONB), will help unlock Gloucestershire's potential for growth, support regional plans for more homes and jobs, and improve life in local communities.

2.1.5. 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.

2.2. Scheme objectives

2.2.1. The Scheme vision is for a landscape-led highways improvement Scheme that will deliver a safe and resilient free-flowing road whilst conserving and enhancing the special character of the Cotswolds AONB; reconnecting landscape and ecology; bringing about landscape, wildlife and heritage benefits, including enhanced visitors' enjoyment of the area; improving local communities' quality of life; and contributing to the health of the economy and local businesses.

2.2.2. The objectives of this Scheme are set out in the Client Scheme Requirements (as detailed in the Scheme Assessment Report[5]). At the time of writing (May 2019), there were several factors associated with the operation and role of the A417/A419 route which were driving the need for the A417 'Missing Link' improvement, from the Client Scheme Requirements as shown below.

- Improve the operation and efficiency of the existing transport networks
- Support economic growth
- Improve connectivity and community cohesion
- Make safety improvements for customers and operational staff
- Deliver capacity enhancements to the 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

2.2.3. Throughout the design and delivery stages, the Scheme should ensure that customers and communities are fully considered. Specifically, this should include:

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

[5] https://highwaysengland.citizenspace.com/he/a417-missing-link/results/a417_missing_link_scheme_assessment_report.pdf

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

2.3. Scheme location

2.3.1. The A417/A419 provides an important link between the Midlands/North and South of England, between Gloucester and Swindon, and as an alternative to the M5/M4 route via Bristol. The A417 Missing Link forms the only 5.5 kilometre section of single carriageway road on the A417/ A419 route, with an at-grade junction located at the 'Air Balloon' public house. The single carriageway section is located between the Cowley roundabout and the base of Crickley Hill on the A417. The location of the Scheme, mitigation areas and land take is found in Appendix A.

2.3.2. The surrounding area of the existing A417 route contains a mix of agricultural land, woodland and common land. The nearest village is Birdlip, situated approximately midway between Cowley roundabout to the east and Brockworth bypass to the west. Farms, private properties and private enterprises are intermittently present either side of the existing A417 over its route, and Crickley Hill Country Park is situated immediately west of the Air Balloon roundabout.

2.3.3. The study area falls within the Cotswolds AONB. The landscape character assessment of the AONB divides the landscape of the study area within the AONB into the following character areas:

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

2.3.4. Additional information on landscape can be found in Chapter 8.

2.3.5. No additional internationally designated sites of nature conservation or heritage value are within the Scheme or within two kilometres of the Scheme. However, nationally and locally designated sites of historical, landscape and nature conservation interest are located within the footprint (or within close proximity) of the Scheme. They are as follows and are shown in the Environmental Constraints Plan Sheets 1 and 2 in Appendix B:

- The Cotswolds AONB is located within the draft Red Line Boundary. 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.

- Seven Scheduled Monuments, which are nationally designated under the Ancient Monuments and Archaeological Areas Act 1979 (as amended) are within one kilometre of the Scheme. They are Crickley Hill Camp, Dryhill Roman villa, three bowl barrows known as Emma's Grove round barrows, Brimpsfield Castle mound, Brimpsfield Castle, Moat and fishpond at Bentham Manor, and two bowl barrows, known as Crippet's Wood round barrows.
- Approximately 27 nationally listed buildings are within 1 kilometre of the Scheme, including one grade I listed building, numerous grade II listed buildings and one grade II* listed building. These are designated under the Planning (Listed Buildings and Conservation Areas) Act 1990.
- One Registered Park and Garden has been identified within the Scheme footprint (Cowley Manor (grade II* listed)).
- Four nationally designated Sites of Special Scientific Interest (SSSI) would be located within one kilometre of the Scheme (Crickley Hill and Barrow Wake SSSI, Bushley Muzzard, Brimpsfield 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 one kilometre of the Scheme. RIGS are designated to recognise and protect important earth science and landscape features.
- Crickley Hill Country Park is located partly within the Scheme Red Line Boundary. This is nationally designated under the Countryside Act 1968 for recreation and leisure opportunities.
- There are seven Key Wildlife Sites (KWS) within one kilometre of the Scheme (Gloucestershire County Council refer to Local Wildlife Sites as 'Key Wildlife Sites'). These are locally designated for their important wildlife.
- The Scheme lies partly within registered common land at Barrow Wake.

2.3.6. Six Noise Important Areas (NIAs) are located within the study area, on the existing A436 and A417.

2.3.7. 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 NO_2 annual mean objective.

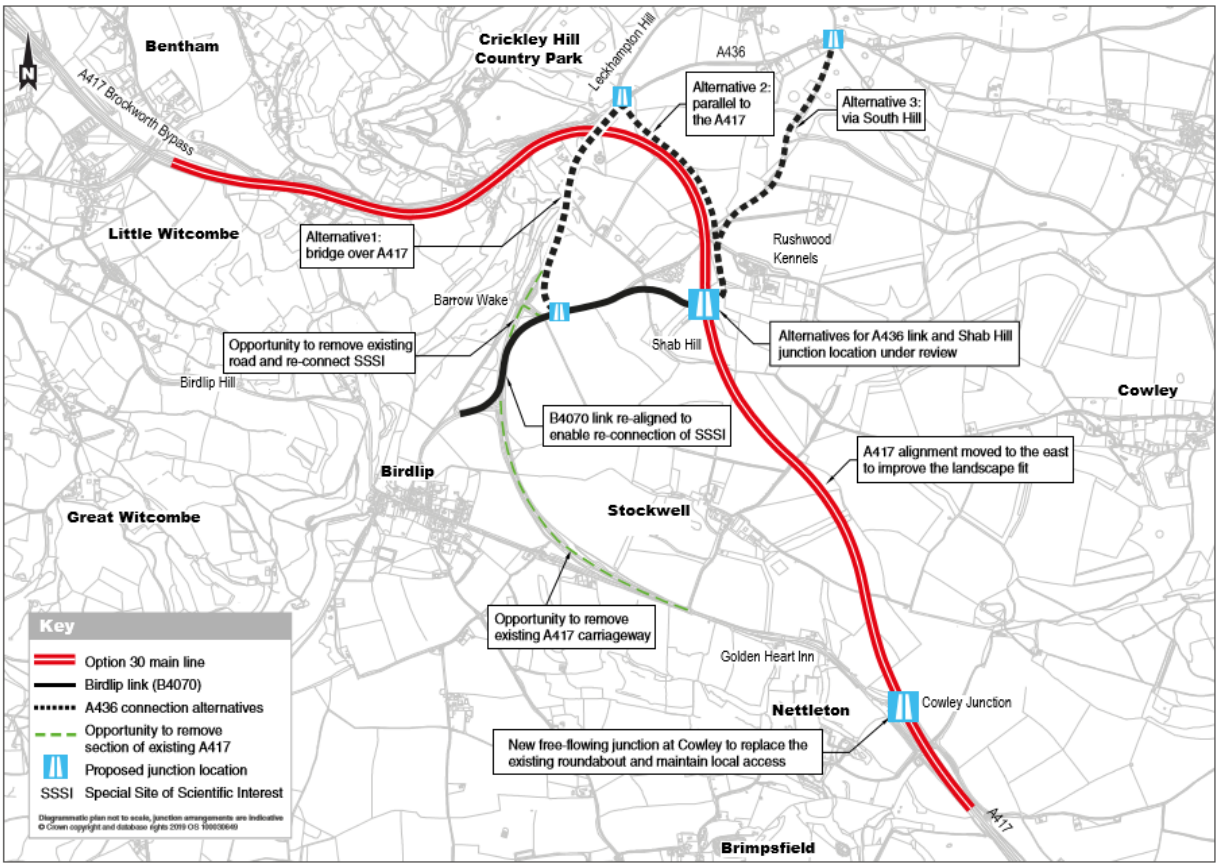
2.4. Scheme description

Preferred route announcement

2.4.1. The preferred route for the Scheme was confirmed by the Secretary of State in March 2019 (see Figure 2.1 below). The Scheme comprises the construction of a new dual carriageway to replace the existing single carriageway section between Brockworth bypass and Cowley Roundabout. It is predominately an

"offline" Scheme but approximately a third of the route follows the existing A417 route corridor at Crickley Hill.

Figure 2.1: A417 Preferred Route Announcement



2.4.2. Figure 2.1 above shows how there are three A436 link road alternative connections, a decision on which A436 link road alternative to proceed with will be made prior to consultation and the assessment in the Environmental Statement. The draft Red Line Boundary is provided in Appendix A and includes land that would be required temporarily and / or permanently for the construction, operation and maintenance of the proposed Scheme. The current draft Red Line Boundary may be subject to change however, it currently captures a reasonable worst-case land take. Other than the A436 Link Road and its connecting junction configuration and Cowley Junction, the Scheme is fixed in its major elements. The Environmental Statement will define the footprint of the proposed Scheme, along with any limits of deviation, and the description will reflect the description of the Scheme within the draft DCO submission. The Environmental Statement will be supported by appropriate figures and design drawings.

2.4.3. This scoping assessment has been based upon the draft Red Line Boundary shown in Appendix A. The design is currently being progressed and features

such as compound locations and environmental mitigation areas will be considered within the Environmental Statement together with the final Scheme design. Sufficient design work has been carried out to enable Highways England to be confident that all compound locations and environmental mitigation which is considered likely to be required can be accommodated within the Scheme boundary.

The Rochdale Envelope

2.4.4. The Planning Inspectorate's Advice Note 9: Using the 'Rochdale Envelope'[6] provides guidance on the flexibility that may be considered appropriate within a DCO application. The advice note acknowledges that there may be aspects of the Scheme that are yet to be fixed and therefore it may be necessary for the EIA to assess likely worse case variations to ensure all foreseeable significant environmental effects have been assessed. Other than the A436 Link Road and its connecting junction configuration, and Cowley Junction, the Scheme is fixed in its major elements. The draft Red Line Boundary has therefore been drawn to allow design flexibility as the design process continues to progress through preliminary design. The preliminary design will need to be sufficiently flexible to provide scope for finalising the detailed design and construction methodology in due course. The draft Red Line Boundary is found in Appendix A. The proposed Scheme design and the accompanying assessment within the Environmental Statement will therefore meet the requirements of Advice Note 9.

2.4.5. This EIA Scoping Report is based on the emerging preliminary design for the Scheme as described below in paragraphs 2.4.6 to 2.4.24. There are currently three alternative design options for the A436 link road (A436 Link Road Alternative 1: bridge over A417, A436 Link Road Alternative 2: parallel to the A417 and A436 Link Road Alternative 3: via South Hill). A decision on the preferred A436 link road alternative will be made in advance of statutory consultation. The Environmental Statement will therefore be based on the Scoping Opinion received from PINS for the Scheme, except for any reference to the discarded A436 Link Road Alternatives.

Proposed Scheme components

2.4.6. The Scheme consists of the following principal elements, which are described in further detail in the sections below:

[6] The Planning Inspectorate (2018) Using the Rochdale Envelope Version 3 [online] available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2013/05/Advice-note-9.-Rochdale-envelope-web.pdf (last accessed February 2019)

- new length of dual carriageway generally following the existing A417 between Brockworth Bypass and Air Balloon, including provision of a Green Bridge
- new length of offline dual carriageway between Air Balloon Roundabout and the existing A417 at Cowley Roundabout
- new all movements grade-separated junction at Shab Hill with a new single carriageway connection to the A436
- new single carriageway connecting the A436 with Birdlip
- new all movements junction near the existing Cowley Roundabout
- removal of sections of the existing A417

2.4.7. The proposed highway cross-section for the proposed A417 is dual carriageway formed of two standard 3.65 metres wide lanes in each direction, 1 metres hard strip provision and a central reserve. A minimum verge width of 2.5 metres would be provided but this would be increased as required to provide the appropriate visibility splays and accommodate any highway features such as signs, vehicle restraint systems, communication equipment and lay-bys.

2.4.8. Street lighting is not currently included in the proposals anywhere on the Scheme but this is subject to further safety assessment during the preliminary design phase. Confirmation of the provision of lighting is to be reported in the Environmental Statement.

2.4.9. The proposed method of surface water disposal for the proposed Scheme is either infiltration or discharge into existing watercourses. The suitability of either of these methods would be confirmed following ongoing ground water monitoring and the preliminary drainage design. Details of the proposed drainage arrangements and the provision of appropriate measures for the treatment to mitigate pollution would be developed in parallel with discussions with the Environment Agency and finalised proposals submitted in the Environmental Statement.

2.4.10. The Scheme affects several Public Rights of Way. The opportunity is being taken to review the Public Right of Way network to improve connectivity and reduce severance caused by the Scheme and the existing A417. Development is to be reported in the Environmental Statement.

Brockworth Bypass to Air Balloon

2.4.11. Starting at the western end, the proposed route follows the existing A417 route corridor to Air Balloon. Initially, the horizontal alignment overlaps with parts of the existing A417 but at Cold Slad, the new dual carriageway diverges from, and then follows to the south of, the existing A417. The vertical alignment through

this section predominately comprises of a 7% straight grade and as a result, the upper section of the A417 on Crickley Hill is in deep cutting of up to 35m.

2.4.12. Direct access from Cold Slad onto the A417 is to be removed to improve safety. As a result, it is necessary to divert Cold Slad traffic to access the A417 via the A436 link road. A new link from Cold Slad Lane to the A436 near Air Balloon is to be created by utilising the existing A417.

2.4.13. A new “green” bridge is proposed to connect Public Rights of Way and provide landscape and ecology connectivity. Development of the form and detail of the structure is ongoing and will be reported in the Environmental Statement.

Air Balloon to Cowley Roundabout

2.4.14. At Air Balloon, the Scheme leaves the existing A417 corridor, initially in an easterly direction as it turns southwards to pass to the east of Birdlip Radio Station and then north of Stockwell Farm. It then connects to the existing A417 near the existing Cowley Roundabout. Over this section, the proposed A417 crosses three local roads and access tracks. These are to be diverted over or under the proposed A417 with new bridges.

2.4.15. One major junction is required for traffic to use the A436 and to access the local area, such as Birdlip village. There is no demand for another major junction, however, a minor junction is provided at the southern end of the Scheme, near the existing Cowley Roundabout, for access to the local area.

2.4.16. The approach taken has been to limit the road junctions to a major junction at Shab Hill and minor junction near the existing Cowley Roundabout. Where practicable, all other side roads and private means of access would be diverted to use these two junctions.

2.4.17. The location identified for the major junction is by Shab Hill Farm as it is on top of the escarpment, thereby reducing geometric alignment issues and minimising the length of the A436 diversion. A “half-cloverleaf” grade separated junction is proposed accommodating free flowing traffic movements with the A436.

2.4.18. A new single carriageway link road is to be provided to connect to the existing A436. Currently, there are three A436 link road alternatives under consideration. Assessment work is ongoing and it is intended that a single alternative is presented for public consultation and for reporting in the Environmental Statement. The three A436 link road alternatives under consideration are:

A436 Link Road Alternative 1: bridge over A417:
From Shab Hill Junction, the A436 link road heads in a westerly direction to connect to the existing A417, which is then utilised to take the A436 north to Air Balloon. A new overbridge is required for the A436 to cross the proposed A417. A new junction is to be provided to connect the A436 with the B4070 link road.

A436 Link Road Alternative 2: parallel to the A417:
From Shab Hill Junction, the A436 heads north alongside the eastern side of the A417 and joins the existing A436 at the A436 / Leckhampton Road Junction; a new roundabout junction is proposed at this location. A new single carriageway link road is required to maintain connectivity with Birdlip Village. From Shab Hill Junction, the B4070 link heads in a westerly direction to connect to the existing A417, which is then utilised to take the B4070 to the existing A417 / B4070 junction.

A436 Link Road Alternative 3: via South Hill:
From Shab Hill Junction, the A436 initially heads north alongside the eastern side of the A417 for around 200m. The A436 then heads in a north easterly direction through Barber wood before joining the existing A436 at the A436 / Ullenwood Road Junction; a new roundabout junction is proposed at this location. With this A436 Link Road Alternative, the B4070 link road is the same as the A436 Link Road Alternative 2.

2.4.19. A free flow “local grade separated“ junction (major / minor) is to be provided at the southern end of the Scheme. This is to comprise of left-in and left-out minor junctions on either side of the A417 that are connected to the nearby Cowley Lane underbridge.

Removal of existing A417

2.4.20. Due to the realignment of the A417 between Air Balloon and Cowley, parts of the existing A417 between Air Balloon and Stockwell Lane are no longer required. The opportunity is being taken to remove these sections and reinstate the landscape and ecology connectivity. Details are to be reported in the Environmental Statement.

Demolition

2.4.21. It is anticipated that the Scheme would require the demolition of one house (Woodside House) and one commercial property (The Air Balloon public house).

2.4.22. More details on the anticipated demolition will be provided within the Environmental Statement and the location will also be indicated on a plan within the Environmental Statement.

Scheme construction

2.4.23. As part of the proposed Scheme, the following elements are likely to be required during construction:

- Temporary traffic management areas, temporary working and storage areas, material stockpiles, construction compounds, haul roads, and provision for site compounds to be used during the constriction period
- Enabling works which may include ecological mitigation for construction and utility diversions

2.4.24. For this report, assumptions associated with the types of construction works required have been made within each of the environmental discipline chapters to inform the assessment of likely significant effects. The assumptions made are using standard and consistent methods which conform to the approach taken across a wide range of Highways England's schemes. The types of construction elements that are likely to form part of the Scheme include the following:

- Pre-construction and mobilisation activities e.g. establishing site compounds, works areas, topsoil storage, etc.
- Earthworks to include noise attenuation bunds
- Diversion of Statutory Undertakers (SU) and Other Apparatus
- Installation of attenuation features
- Ground water management
- Site clearance
- General excavation
- Backfilling and compaction of soil
- Earthworks, i.e. the construction of embankments and the relocation of spoil
- Placing concrete foundations, may include piling
- Laying of asphalt
- Installation of drainage, which will include excavation and placement of pipes and chambers
- Construction of structures, which may include lifting of beams into place
- Landscape and environmental mitigation.

2.4.25. Details of the construction methodology will be included as part of the Environmental Statement, once it has been developed. The Environmental Statement will also describe any phased approach to construction, the likely duration and location of construction activities, the need for night time working, and the anticipated numbers and types of vehicle movements associated with the construction phase. At present the duration of the construction phase is envisaged to last approximately three years with a start date of 2021.

2.4.26. The development of the construction strategy will aim to ensure that adverse effects are reduced to sensitive receptors.

3. Assessment of alternatives

3.1. Scheme history

3.1.1. The A417 Missing Link Scheme has been under consideration for more than 20 years. By 1998, dual-carriageway improvements were completed to over 90% of the length of the A417 / A419 link. This single-carriageway section near Birdlip in Gloucester was not improved as part of those works.

3.1.2. In 2001, the Highways Agency appointed consultants to undertake a study to identify the environmental assets within the area centred on the existing route alignment, prepare a constraints map and identify if options were available to improve this section of road which would have acceptable environmental impacts. In 2003, results were published and supported a surface on-line dualling option.

3.1.3. Four on-line routes were eventually progressed until the resulting route known as the Modified Brown Route was selected to be taken forward as the solution. This Scheme was prepared for public consultation in 2006. However, the consultation did not take place as the Scheme was not included in the Roads Programme. It was identified within the 'longer than ten years' plan and therefore consultation and further development was not progressed.

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

3.1.5. Please see the Scheme Assessment Report[7] for more information on the Scheme's history.

3.2. Options identification and assessment

3.2.1. Initial option sifting was undertaken in accordance with the Transport Analysis Guidance – The Transport Appraisal Process or WebTAG. The sift used the Early Assessment Sifting Tool (EAST), which forms part of Step 6 of WebTAG – Initial Sifting. However, as EAST does not provide a numeric scoring system, the assessment team created a scoring mechanism (EAST+) for the purpose of ranking all the options based on the results of the initial sift. The creation of a

[7] https://highwaysengland.citizenspace.com/he/a417-missing-link/results/a417_missing_link_scheme_assessment_report.pdf

scoring system allowed each option to be directly compared against one another.

3.2.2. An environmental assessment was undertaken for six Scheme options, which were then reduced to two Scheme options as part of the Option Identification process. Subsequently, two Scheme options where selected, which built on the information gathered as part of the environmental assessment. The Scheme Assessment Report[8] outlines the conclusions of the option selection phase, including the comparison of environmental effects which informed option selection.

Sifting of options

3.2.3. EAST is split into five areas of consideration which looks at different aspects of the emerging Scheme options, as follows:

- Strategic
- Economic
- Managerial
- Financial
- Commercial

3.2.4. Each option was measured against the criteria within each aspect above, to provide both a moderation and a direct comparison between the options, before progressing to the next criteria. The overall score for each option was achieved by adding together all the individual scores that the initial Scheme options received when measured against all of the criteria.

3.2.5. It was essential that the sifting process was inclusive and robust and that the initial sift should maximise the range of options being taken forward to the next stage. Therefore, the best performing route options from each corridor were taken (through each escarpment section) into the next element of evaluation, resulting in five corridor options for further evaluation.

3.2.6. From the initial sift of the 30 options within five corridors, there were multiple highly scoring options within single corridors. Therefore, an exercise was undertaken to ensure that a representative route option from each corridor was taken forward, resulting in Options 3, 21, 24, 29, and 30 being taken forward for further assessment.

3.2.7. A further sifting exercise was conducted to re-evaluate surface options only following concerns raised regarding the affordability and value for money of the

[8] https://highwaysengland.citizenspace.com/he/a417-missing-link/results/a417_missing_link_scheme_assessment_report.pdf

tunnelled solutions. Following this exercise Option 12 was also taken forward for further assessment.

Option selection

3.2.8. The two selected options, Option 12 and Option 30, were subject to further environmental, economic, and technical assessment. In late 2018 two A436 link road alternative connections for Option 30 were proposed and were subsequently subject to further environmental, economic, and technical assessment. As per the Preferred Route Announcement in March 2019 (see Figure 2.1) the original Option 30 is known as “A436 Link Road Alternative 1: bridge over A417” and the two late 2018 A436 design alternatives are known as “A436 Link Road Alternative 2: parallel to the A417” and “A436 Link Road Alternative 3: via South Hill”. The results of these assessments, along with the outcomes of consultation, were used to inform the identification of the Preferred Route, which was announced in March 2019.

4. Consultation

4.1. Context

4.1.1. Effective stakeholder engagement and consultation is intrinsic to the Planning Act 2008 (PA 2008) and fundamental to the success of the proposed Scheme.

4.1.2. The proposed Scheme has a wide range of stakeholders (including landowners, statutory consultees, local communities and specialist interest groups) with differing interests that will require varied levels of information. Specific communication activities therefore need to be focussed to meet the needs of particular individuals and groups. This requires an understanding of the stakeholders and their interest in the proposed Scheme.

4.1.3. Stakeholder engagement for the proposed Scheme is based on the following principles:

- Early and ongoing engagement to inform and influence the proposed Scheme development process;
- Seeking an appropriate level of feedback at each stage in the iterative design process and ensuring that comments received are taken into consideration;
- Building of long term relationships with key stakeholders throughout the different stages of the proposed Scheme to help better understand their views;
- Where possible and practicable ensuring concerns are addressed; and
- Ensuring appropriate statutory consultation is undertaken in compliance with requirements of the PA 2008 and associated guidance.

4.2. DCO Consultation Requirements

4.2.1. The DCO process has a number of statutory requirements regarding consultation. These requirements stipulate that certain stakeholder groups and the community must be consulted as part of the pre-application process, as set out in Sections 42 and 47 of PA 2008. Further requirements set out how the proposed Scheme must be publicised and specific documents produced, including a Statement of Community Consultation (SoCC) and a Consultation Report.

4.3. Previous consultation

4.3.1. A value management workshop was hosted by Highways England (August 2015). Attended by both stakeholders and the Highways England integrated project team, the purpose of this workshop was to get input into the value management process and to develop the objectives for the Scheme.

4.3.2. During the Options Identification stage, a steering group was established to share information with critical stakeholders and hold high-level strategic discussions. The group consists of representatives from Gloucestershire County Council, National Trust, Cotswolds Conservation Board, Gloucestershire Wildlife Trust, Gloucestershire Local Nature Partnership, GFirst (the Local Enterprise Partnership for Gloucestershire) and members of the Highways England integrated project team. It meets on a bi-monthly basis, or as required by the needs of the project. Table 4.1 below outlines the meetings held to date with the steering group.

4.3.3. Also during the Options Identification stage, three value management workshops were held (October 2016, April 2017 and September 2017) and attended by stakeholders and the Highways England integrated project team. The purpose was to engage key stakeholders in the optioneering process and to gain a good understanding of opportunities and constraints for the development of the Scheme from stakeholders' perspectives. Table 4.1 below outlines the value management workshops meetings held to date.

4.3.4. During the Option Selection stage, meetings continued with the Scheme's steering group. The role of this group has evolved since Options Identification – it is now called the Strategic Stakeholder Panel. It is a slightly smaller group, made up of Gloucestershire County Council, Cotswold District Council, National Trust, the Cotswold Conservation Board and Gloucestershire Wildlife Trust. Its purpose is to provide advice to the project and help resolve any issues from the Scheme's Technical Working Groups which will be particularly important in helping with developing a more detailed Scheme.

4.3.5. Additional Technical Working Groups have also been set up for communications, engineering, traffic and economics, and landscape, environment and heritage. Meetings have taken place approximately every two months, or as agreed by the group's members, subject to a review of frequency and need. Terms of reference have been developed for each group to ensure the best possible technical input into the Scheme's development. Table 4.2 below outlines consultation held with environmental stakeholders outside of the steering group / strategic stakeholder panel.

Table 4.1: Meetings with the steering group (Strategic Stakeholder Panel)

Date	Stakeholders	Meeting type	Discussion / topics raised
August 2015	Various Stakeholders	Stage 0 Value Management Workshop	Key individuals were brought together to get their input into the value management process and to develop the objectives for the scheme.
05 October 2016	Various Stakeholders	Stage 1 Value Management Workshop - 1	The workshop was 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.
05 April 2016	Various Stakeholders	Stage 1 Value Management Workshop - 2	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. Workshop activities were also undertaken to discuss traffic modelling, a matrix of scheme objectives and sub-objectives and the options under consideration.
07 September 2016	Various Stakeholders	Stage 1 Value Management Workshop - 3	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.
27 April 2018	Gloucestershire County Council Cotswolds Conservation Board National Trust Gloucestershire Wildlife Trust	Steering Group	• Introductions and safety moment • Emerging consultation findings • Next steps to Preferred Route Announcement • Technical Working Groups and Steering Group structure

Date	Stakeholders	Meeting type	Discussion / topics raised
29 June 2018	Gloucestershire County Council Cotswolds Conservation Board National Trust Gloucestershire Wildlife Trust Cotswold District Council	Strategic Stakeholder Panel	• Introductions and safety moment • Terms of reference • Update from consultation analysis and upcoming activity • Update and discussion on technical working group meetings
26 September 2018	Gloucestershire County Council Cotswolds Conservation Board National Trust Gloucestershire Wildlife Trust Cotswold District Council	Strategic Stakeholder Panel	• Introductions and safety moment (Don't be a space invader) • Review and discussion of Technical Working Groups • Project updated: • Designated funds
24 October 2018	Gloucestershire County Council Cotswolds Conservation Board National Trust Gloucestershire Wildlife Trust Cotswold District Council	Strategic Stakeholder Panel	• Introductions and safety moment • Floor opened to National Trust, Cotswold Conservation Board and Gloucestershire Wildlife Trust to elaborate on issues raised in letter of 24 September 2018 • Look ahead to environment, heritage and landscape workshop on 7 November 2018 • Future direction of Strategic Stakeholder Panel including terms of reference and potential for independent chair
28 November 2018	Gloucestershire County Council Cotswolds Conservation Board National Trust Gloucestershire Wildlife Trust Cotswold District Council	Strategic Stakeholder Panel	• Feedback and discussion on • Landscape, Environment and Heritage workshop • Communications working group • Project update including programme and activity for technical working groups

Date	Stakeholders	Meeting type	Discussion / topics raised

07 February 2019	Gloucestershire County Council
	Cotswolds Conservation Board
	National Trust
	Gloucestershire Wildlife Trust
	Cotswold District Council
		Strategic Stakeholder Panel	• DCO presentation and workshop
			• Project update on BICC and preferred route announcement
			• Feedback and discussion on
			  ○ Landscape, Environment and Heritage working group
			  ○ Outputs from Landscape, Environment and Heritage working group and upcoming activities
			• Dates for next meeting and post PRA working relationships

02 May 2019	Gloucestershire County Council
	Cotswolds Conservation Board
	National Trust
	Gloucestershire Wildlife Trust
	Cotswold District Council
		Strategic Stakeholder Panel	• Project update
			  ○ Technical partner update
			  ○ Preferred route announcement – review and feedback
			  ○ Technical working groups – status update
			  ○ Programme governance
			• Preliminary design

Table 4.2: Table 4.2 outlines consultation held with environmental stakeholders outside of the Strategic Stakeholder Panel

Date	Stakeholders	Meeting type	Discussion / topics raised	Outcome
11 April 2017; 31 August 2017	Environment Agency	Stakeholder meeting	Discussions focussed on the history of the Scheme and the process going forward. This included understanding the Environment Agency's concerns with respect to potential impacts of the Scheme on groundwater receptors, with particular reference to the Environment Agency's 2002 objection to the tunnel option proposed at the time. Discussions raised included concerns with respect to potential impacts on the water environment. Discussions also focussed on identifying types of investigations that the Environment Agency would consider as necessary to	It was proposed that a Statement of Common Ground be developed between the Environment Agency and Highways England and Mott MacDonald Sweco Joint Venture. Proposal for groundwater investigations (desk and field) to inform the conceptual model is to be provided to the Environment Agency. Agreement made that a joint working group will be set up to include consultees.

Date	Stakeholders	Meeting type	Discussion / topics raised	Outcome
			resolve uncertainties with respect to hydrogeological baseline.	
14 June 2017	Natural England	Stakeholder meeting	A general discussion around the Scheme together with advice and recommendations regarding protected sites and protected species surveys, including more detailed discussions regarding a proposed bat survey methodology.	Advice received on developing appropriate and robust mitigation strategy
22 June 2017	Historic England and Gloucestershire County Council	Stakeholder meeting	Presentation of the proposed surface and tunnel options.	Representatives highlighted the archaeological importance of the landscape, which could be of potential national significance. As a result, these findings would need to be considered in future evaluation.
27 February 2018	Environment Agency	Stakeholder meeting	The main areas of discussion included a summary of the public consultation programme, and a summary of findings of the sifting assessment of route options. Discussions also focussed on implications of the preferred route options on the water environment.	Environment Agency would provide a response to Highways England by the consultation deadline. Environment Agency provided advice and highlighted concerns on a number of receptors in relation to all route options. Environment Agency expressed concern about potential impacts on Bushley Muzzard SSSI.
20 March 2018	Natural England	Stakeholder meeting	Focussed discussion to aid development of an appropriate and robust mitigation strategy. Meeting to provide Natural England with an update on the status of the Scheme, including public consultation and option selection. Update provided on the proposed ecological surveys was also given. Queries were raised regarding the level of survey effort required for great crested newt.	Natural England provided advice on the New Licencing Policy 4 (NLP4) and connectivity on 28/06/18
4 May 2018	Natural England and Environment Agency	Stakeholder meeting	Aims of the meeting included Scheme updates, discussion of potential risks of the project to the water environment and to receive feedback on risks identified, planned ground investigations and the project going forward.	Potential risks of the Scheme on the water environment were discussed in detail. Further information was requested on project timescales and when further consultation may occur.

Date	Stakeholders	Meeting type	Discussion / topics raised	Outcome
				It was identified from the meeting that Bushley Muzzard should be considered as part of the investigations.
23 May 2018	Environment Agency, Gloucestershire Wildlife Trust, Gloucestershire County Council. Cotswold District Council, Natural England, National Trust and Historic England	Landscape, Environmental and Heritage Working Group	Scheme updates, environmental tasks and programme, designated funds and discussion of key issues.	Stakeholders requested topics to be included for discussion at the next Technical Working Group (TWG) including the Green Bridge, Designated Funds, Greening of Infrastructure, connectivity, Structures, Lighting, Horsbere Brook and alignment up Crickley Hill.
18 July 2018	Gloucestershire Wildlife Trust, Gloucestershire County Council, Cotswold District Council, Cotswold Conservation Board, Natural England, National Trust and Historic England	Landscape, Environmental and Heritage Working Group	Scheme updates, Designated Funds update and discussion on green bridge concept and potential locations.	Applicant requested stakeholders provide information where they are aware of projects that could affect Designated Fund proposals. Discussion regarding the green bridge, its potential need, function and location. Stakeholders had asked whether it would be possible to start using visualisations as part of the Green Bridge discussion.
20 September 2018	Gloucestershire Wildlife Trust, Gloucestershire Local Nature Partnership, Gloucestershire County Council, Cotswold District Council, Cotswold Conservation Board, Natural England, National Trust and Historic England	Landscape, Environmental and Heritage Working Group	Scheme updates, Designated Funds update, green bridge updates and discussion on access.	Discussion about the rate of progression in achieving a landscape-led Scheme. Updates made to the opportunities mapping exercise that was undertaken at Options Identification with focus on the 2 surface options and opportunities and challenges.
7 November 2018	Environment Agency, Gloucestershire Wildlife Trust, Gloucestershire County	Landscape, Environmental and Heritage Working Group	Discussion on A417 Design Principles Register, discussion workshop for Option 12, 30 and A436 Link Road alternative connections and Shab Hill Junction.	Overarching discussions focussed on both route options at the TWG, looking at potential issues, concerns and suggestions. Stakeholders also reviewed

Date	Stakeholders	Meeting type	Discussion / topics raised	Outcome
	Council, Cotswold District Council, Cotswold Conservation Board, Natural England, National Trust and Historic England			environmental considerations for both options. Stakeholder review of the Design Principles Register outlined a number of suggestions to be actioned for next TWG.
15 January 2019	Environment Agency, Gloucestershire Wildlife Trust, Gloucestershire County Council, Cotswold District Council, Cotswold Conservation Board, Natural England, National Trust and Historic England	Landscape, Environmental and Heritage Working Group	Scheme updates, discussion on Design Principles Register, discussion on A436 alternative connections and a workshop regarding the green bridge.	Comments were invited on the Design Principles Register. Discussions were aided by the introduction of an Option 30 Alternatives Matrix. Discussions about the concept and location of a Green Bridge took place. Stakeholders were asked to select 1 'optimal' green bridge location.
12 February 2019	Environment Agency, Gloucestershire Wildlife Trust, Gloucestershire County Council, Cotswold District Council, Cotswold Conservation Board, Natural England, National Trust, Historic England and Matter Architecture.	Landscape, Environmental and Heritage Working Group	Scheme updates, discussions on the A436 alternative connections and green bridge concept and potential locations.	Discussions about the Option 30 Alternatives Matrix looked at the need for additional information on NPSNN compliance of each option. A summary of the environmental review of each green bridge location was provided to stakeholders.
8 March 2019	Environment Agency	Stakeholder meeting	• Inform the Environment Agency about the findings of investigations to date. • Outline the proposed scope of future investigations required to inform the preliminary design and Environment Statement, which will be delivered during the next stage (Stage 3) of the project.	Discussion about the investigations to date and proposed investigations.

Date	Stakeholders	Meeting type	Discussion / topics raised	Outcome
			• Provide an opportunity for the Environment Agency and Lead Local Flood Authority (LLFA) to comment and agree on the proposed scope of these investigations in advance of formally being consulted on the Environmental Scoping Report.	
10 April 2019	Environment Agency	Stakeholder meeting	• Aquatic biodiversity • The scheme so far • Understanding of risks • Mitigation required for risks • Understand the Environment Agency's concerns	Discussions about the aquatic water environment and proposed surveys.

4.3.6. From 15 February to 29 March 2018, non-statutory public consultation was undertaken on possible route options for the A417. Consultation was undertaken in the spirit of statutory consultation and provided an opportunity to communicate the need and benefits of the Scheme, as well as the process of selecting possible route options for the Scheme. The consultation consisted of an invite-only stakeholder preview, 6 public events in and around the Gloucestershire area, 1-2-1 meetings with affected landowners and stakeholder meetings, including a presentation to businesses via GFirst LEP. Feedback was collected via online and hard copy feedback forms. Around 800 people attended public events and almost 2,000 people / organisations provided a formal response to the consultation.

4.4. Proposed consultation

4.4.1. The Preferred Route Announcement (PRA) took place on 14th March 2019. The selection of the preferred route has been influenced by a number of factors including traffic capacity, engineering, safety, economic, social and environmental. Feedback received from the non-statutory route options public consultation that took place in February and March 2018 was also a contributing factor.

4.4.2. The Scheme is progressing towards a period of statutory engagement and consultation. We will engage with the statutory bodies (Natural England, Historic England and the Environment Agency) as well as other relevant environmental stakeholders Cotswolds Conservation Board, Gloucestershire Wildlife Trust, Gloucestershire Local Nature Partnership, National Trust, Cotswold District

Council and Gloucestershire County Council, through the format of an Environmental Technical Working Group (TWG).

4.4.3. The Environmental TWG will be responsible for studying specific Scheme issues, agreeing the proposed environmental assessment methodologies and considering appropriate Scheme solutions on environmental matters between Highways England and key stakeholders. The Environmental TWG will also be responsible for the technical review of the Environmental Impact Assessment (EIA) and associated surveys, development and review of environmental design, mitigation requirements and environmental opportunities and enhancements.

4.4.4. Our ongoing consultation will be the basis for agreeing statements of common ground (SoCG) with a number of stakeholders.

4.4.5. In addition, regular engagement with the Environment Agency, Historic England and Natural England is being undertaken outside the TWG environment to discuss the findings of investigations to date and to agree the scope of future investigations required to appropriately inform the preliminary design and DCO submission.

4.4.6. In summer 2019 Highways England will hold a statutory public consultation, seeking views, comments and feedback on the Scheme. A series of public events and invitation only meetings will be held with key stakeholders, the local community and landowners. Members of the project team will be available at events to discuss the Scheme with members of the public. In addition, a Preliminary Environmental Information (PEI) Report will be available for statutory consultees to comment on.

4.4.7. The public events will be advertised in advance of the consultation and in accordance with the published Statement of Community Consultation (SoCC). A full copy of the SoCC will be made available ahead of the statutory consultation, in accordance with the PA 2008 (as amended by The Highways and Railway (Nationally Significant Infrastructure Project) Order 2013).

4.4.8. The following consultation material will be made available at all meetings and events, on the Scheme website and at public information points:

- Consultation Scheme brochure
- Consultation Scheme questionnaire and freepost envelope
- Poster detailing public events and Scheme website
- Visualisations and fly through videos

4.4.9. All feedback and formal responses received during the statutory public consultation period will be recorded and will appear in summary as part of a Consultation Report.

4.4.10. The feedback and formal responses received during this statutory consultation may influence the final design of the Scheme, ahead of submitting a DCO application to the Secretary of State.

5. Environmental assessment methodology

5.1. Surveys and predictive techniques and methods

5.1.1. Information gathered through desk top studies, environmental walkovers and surveys have been collated to inform this report. The environmental constraints identified within this report have been mapped and are included in Appendix B.

5.2. General Assessment

5.2.1. This Environmental Impact Assessment (EIA) Scoping Report considers the following factors contained in Regulation 5(2) of the EIA Regulations:

a) Population and human health

b) Biodiversity

c) Land, soil, water, air and climate

d) Material assets, cultural heritage and the landscape

e) The interaction between the factors referred to in sub-paragraphs a) to d)

5.2.2. The assessment for each of these factors are covered in one or more environmental assessment chapters in this report. The chapters have been written in accordance with the requirements presented in the Design Manual for Roads and Bridges (DMRB) Volume 11 Section 3[9] and Interim Advice Note (IAN) 125/15[10] and professional judgement, for each of the relevant environmental factors (topics). This is shown in Table 5.1 below.

Table 5.1: Environmental factors and respective DMRB environmental topics

Factors contained within Regulation 5(2) of the Infrastructure Planning (EIA) Regulations	DMRB Topic
(a) Population and human health	Chapter 6 Air Quality; Chapter 12 Noise and Vibration; Chapter 13 Population and Human Health; and, Chapter 14 Road Drainage and the Water Environment.
(b) Biodiversity	Chapter 10 Biodiversity
(c) Land, soil, water, air and climate	Chapter 6 Air Quality; Chapter 9 Geology and Soils;

[9]Highways England (2015) Design Manual For Roads and Bridges (DMRB) Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3.htm
[10]Highways England (2015) Interim Advice Note (IAN) 125/15 Environmental Assessment Update [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian125r2.pdf

	Chapter 14 Road Drainage and the Water Environment; and, Chapter 15 Climate.
(d) Material assets, cultural heritage, and the landscape	Chapter 7 Cultural Heritage; Chapter 8 Landscape and Visual Effects; and, Chapter 11 Material Assets and Waste.
(e) The interaction between the factors referred to in sub-paragraphs (a) to (d)	Chapter 16 Assessment of Cumulative Effects

5.2.3. Each topic has considered the potential environmental effects associated with the construction and operational phases of the Scheme. The Scheme would be unlikely to be decommissioned as it would form an integral part of the Strategic Road Network (SRN). As such, decommissioning has not been considered within this Environmental Impact Assessment Scoping Report, and it is proposed that decommissioning is scoped out of the Environmental Statement. The treatment of the existing A417 is yet to be decided but is likely to either be down-graded for local access, used as part of new non-motorised user routes or removed and the land reinstated to match adjacent usage. Any decommissioning of the existing A417 as part of the Scheme would be considered within the assessment.

Major Accidents and Disasters

5.2.4. The EIA Regulations require an assessment of *'the expected significant adverse effects of the development on the environment deriving from the vulnerability of the development to risks of major accidents and/or disasters which are relevant to the project concerned'*.

5.2.5. The proposed scope of the assessment in relation to major events ('events' being the collective term used for both accidents and disasters) will be in line with the EIA Regulations. The scope of the assessment will cover:

- Vulnerability of the project to risks of major accidents and/or disasters; and,
- Any consequential changes in the predicted effects of that project on environmental factors.

5.2.6. To address the requirements of the EIA Regulations, the factor of Major Accidents and Disasters will be assessed as part of the Environmental Statement. In considering the elements of vulnerability, professional judgement will be applied to develop Scheme specific definitions of major events. Major events that are relevant to and can affect a project, both man-made and naturally occurring, will be identified. Where major events are identified, the potential for any change in the assessed significance of the Scheme on relevant environmental topics will be described in qualitative terms and likely mitigation measures will be included as part of the assessment. The potential receptors of impacts resulting from major events are all reported in the relevant topic

chapters of this report, and as such major events is not included as a standalone chapter. Relevant major events will, therefore, be reported in the project description section of the Environmental Statement, whilst any consequences for receptors will be reported in the applicable topic chapters as appropriate.

5.2.7. With regards to the methodology, the assessment will assess the potential for significant effects (during construction and operation) of major accidents and disasters that:

- could result in impacts upon the proposed Scheme (e.g. fires, flooding); or
- could occur as a consequence of the proposed Scheme (e.g. structure failure/ collapse).

5.2.8. The methodology adopted includes three main stages, as follows:

- **Stage 1**: a long list of possible major events will be developed. This list will draw upon a variety of sources, including the UK National Risk Register of Civil Emergencies[11], the proposed Scheme risk register and the proposed Scheme design hazard assessment log;
- **Stage 2**: a screening exercise will be undertaken to review the long list of major events and to give consideration to their relevance to the proposed Scheme, and therefore whether they should be included on the project specific short list of events requiring further consideration, including by topic specialists; and
- **Stage 3**: where further design mitigation is unable to remove the potential interaction between a major event and a particular topic, the relevant Environmental Statement chapter will identify the potential consequence for receptors covered by the topic, and give a qualitative evaluation of the potential for the significance of the reported effect to be increased as a result of a major event.

5.2.9. Where events identified during this process are not already being considered within existing chapters of the Environmental Statement, they will continue to be reviewed with the design team to ensure the risks are understood and addressed through design as necessary.

Heat and Radiation

5.2.10. Due to the nature of the Scheme, it is considered unlikely that heat and radiation effects associated with the proposals are likely to arise. Further assessment as part of the Environmental Statement has therefore been scoped out.

[11] https://www.gov.uk/government/collections/national-risk-register-of-civil-emergencies

Future Baseline Scenario

5.2.11. A description of the relevant aspects of the current state of the environment (baseline scenario) is included for each environmental factor within Chapters 6 to 16 of this EIA Scoping Report. Within the Environmental Statement, an outline of the likely evolution of the baseline and future baseline scenarios, without implementation of the Scheme and appraising only natural changes, will be included. This will make use of readily available information such as that available from Local Development Plan documents.

5.3. Assumptions and Limitations

5.3.1. There are several assumptions associated with the traffic modelling that has taken place as part of the Scheme, described below. Topic-specific assumptions and limitations have been outlined in each of the individual environmental topic chapters (Chapters 6 to 16).

5.3.2. Should updates to policy, legislation, standards or guidance take place prior to the DCO submission, consideration will be given to applying the new and updated information, in agreement with relevant consultees and also if sufficient time allows for this to be done, and a justification provided in the Environmental Statement.

5.3.3. Conclusions and recommendations may be revised within the Environmental Statement, on the basis of updated information following further research, survey, and investigation. Any changes would be agreed with the relevant consultees.

Scheme Design

5.3.4. This report is based on the Scheme design provided in March 2019 (refer to the Scheme description in paragraphs 2.4.6 – 2.4.24).

South West Regional Traffic Model (SWRTM) assumptions

5.3.5. The base model is for a March 2015 weekday (excluding school holidays and bank holidays). The base model is an average hour model, with the AM model representing an average hour in the period 7am-10am, the inter-peak (IP) an average hour from 10am-4pm, and the PM an average hour from 4pm-7pm.

5.3.6. The model was built using SATURN.

Base model assumptions

5.3.7. The traffic model has been developed in SATURN software to represent three 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 of factoring from modelled periods to daily levels. The development of the highway model has relied on the data used in the SWRTM and some additional surveys carried out in autumn 2016 and spring 2017.

Forecast model assumptions

5.3.8. 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 Transports National Trip End Model (NTEM / TEMPRO v7.2) and Road Traffic Forecasts (RTF) 2018 forecasting data as well as accounting for local developments which have been assessed in an uncertainty log in accordance with WebTAG unit M4.

5.3.9. The traffic forecasts have been undertaken using a variable demand modelling approach that is consistent with that applied in the development of SWRTM.

5.4. Significance criteria

5.4.1. The output of the environmental assessment is to report the likely significance of effects using established significance criteria, as presented within the DMRB Volume 11, Section 2, Part 5[12]. This requires an assessment of the receptor or resource's environmental value (or sensitivity) as shown in Table 5.2 and the magnitude of the Scheme's impacts (change) as shown in Table 5.3.

Table 5.2: Descriptions of the Sensitivity of receptors

Value	Typical Descriptors
Very high	Very high importance and rarity, international scale and very limited potential for substitution.

[12] Highways England (2008) DMRB Volume 11, Section 2, Part 5 HA 205/08 'Assessment and Management of Environmental Effects'.

High	High importance and rarity, national scale, and limited potential for substitution.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution.
Low (or lower)	Low or medium importance and rarity, local scale.
Negligible	Very low importance and rarity local scale.

Source: DMRB Volume 11, Section 2, Part 5, Table 2.1

Table 5.2: Descriptions of the Magnitude of Change of the Schemes impacts

Magnitude of Change	Typical Descriptors
Major	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse).
	Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial).
Moderate	Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements (Adverse).
	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial).
Minor	Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (Adverse).
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial).
Negligible	Low or medium importance and rarity, local scale.
	Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial).
No Change	No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Source: DMRB Volume 11, Section 2, Part 5, Table 2.2

5.4.2. The DMRB states that the approach to assigning significance of effect relies on reasoned argument, professional judgement and taking on board the advice and views of appropriate organisations. For some factors, predicted effects may be compared with quantitative thresholds and scales in determining significance. Each environmental assessment chapter within the Environmental Statement will describe the specific thresholds / criteria used to determine value / magnitude / sensitivity and will align within the general methodology described within this section.

5.4.3. Assigning each effect to one of the five significance categories enables different environmental issues to be placed upon the same scale, to assist the decision-making process at whatever stage the project is at within that process. These five significance categories are set out in Table 5.4 below.

Table 5.4: Descriptions of the Significance of Effect categories

Significance category	Typical descriptors of effects
Very Large	Only adverse effects are normally assigned this level of significance. They represent key factors in the decision-making process. These effects are generally, but not exclusively, associated with sites or features of international, national or regional importance that are likely to suffer a most damaging impact and loss of resource integrity. However, a major change in a site or feature of local importance may also enter this category.
Large	These beneficial or adverse effects are very important considerations and are likely to be material in the decision-making process.
Moderate	These beneficial or adverse effects may be important but are not likely to be key decision-making factors. The cumulative effects of such factors may influence decision-making if they lead to an increase in the overall adverse effect on a resource or receptor.
Slight	These beneficial or adverse effects may be raised as local factors. They are unlikely to be critical in the decision-making process but are important in enhancing the subsequent design of the project.
Neutral	No effects or those that are beneath levels of perception, within normal bounds or variation or within the margin of forecasting error.

Source: DMRB Volume 11, Section 2, Part 5, Table 2.3

5.4.4. For the majority of environmental assessment chapters, the environmental value will be determined for each of the receptors that have been carried forward from the Scoping exercise for further environmental assessment, along with the magnitude of change. Five significance categories can result from the assessment, as defined in Table 5.4. Table 5.5 illustrates how the significance categories are derived, based on the value of the receptor and magnitude of change. It is important to note that significance categories are required for positive (beneficial) as well as negative (adverse) effects. The greater the magnitude of impact, the more significant the effect. For example, the consequences of a highly valued environmental resource suffering a major detrimental impact would be a significant adverse effect. For all environmental assessment chapters, effects that are Moderate Beneficial / Adverse or above will be considered significant.

5.4.5. Chapter 6 Air Quality, Chapter 11 Material Assets and Waste, Chapter 12 Noise and Vibration, Chapter 15 Climate (effects on climate) do not explicitly follow this general approach to determining the significance of effects however, due to the nature of the topics and their methodologies. The criteria used to determine the significance of effects are outlined in these individual chapters.

Table 5.5: Assessing Significance of Potential Effects

	Magnitude of potential impact (Degree of Change)					
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
Environmental Value (Sensitivity)	**Very High**	Neutral	Slight	Moderate or Large	Large or Very Large	Very Large
	High	Neutral	Slight	Slight or Moderate	Moderate or Large	Large or Very Large
	Medium	Neutral	Neutral or Slight	Slight	Moderate	Moderate or Large
	Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
	Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

Source: DMRB Volume 11, Section 2, Part 5, Table 2.4

5.5. Proposed Structure of the Environmental Statement

5.5.1. The Environmental Statement will comprise 4 volumes:

- Non-Technical Summary;
- Main Environmental Statement Text;
- Environmental Statement Figures; and,
- Environmental Statement Technical Appendices.

5.5.2. The main Environmental Statement text is currently anticipated to be structured as below:

- Chapter 1 – Introduction;
- Chapter 2 – The Scheme;
- Chapter 3 – Assessment of Alternatives;
- Chapter 4 – Consultation;
- Chapter 5 – Environmental Assessment Methodology;
- Chapter 6 – Air Quality;
- Chapter 7 – Cultural Heritage;

- Chapter 8 – Landscape and Visual Effects;
- Chapter 9 – Geology and Soils;
- Chapter 10 – Biodiversity;
- Chapter 11 – Material Assets and Waste;
- Chapter 12 – Noise and Vibration;
- Chapter 13 – Population and Human Health;
- Chapter 14 – Road Drainage and the Water Environment;
- Chapter 15 – Climate;
- Chapter 16 – Assessment of Cumulative Effects;
- Chapter 17 – Conclusions; and,
- Chapter 18 – Glossary.

5.5.3. A number of plans would be produced that would support the preparation of the Environmental Statement and the results presented therein and would also be a mechanism for securing the required mitigation. These are likely to include:

- An Outline Environmental Management Plan (OEMP); and,
- An Environmental Masterplan.

5.5.4. The OEMP would provide the framework for recording environmental risks, commitments and other environmental constraints and would identify the structures and processes that would be used to manage and control these aspects.

5.5.5. Following the DCO application and as the design and construction plans are finalised, the OEMP would be refined and expanded into a Construction Environmental Management Plan (CEMP). The CEMP would be substantially in accordance with the OEMP. Towards the end of the construction period the CEMP would be refined into a Handover Environmental Management Plan (HEMP) which would be the main vehicle for passing essential environmental information to the body responsible for the future maintenance and operation of the asset.

5.5.6. The OEMP produced as part of the DCO application will include supplementary outline management plans which would later be included in full within the CEMP. These outline management plans may include, but would not be limited to, a materials and management plan, an outline site waste management plan and an outline traffic management plan.

6. Air quality

6.1. Study area

6.1.1. The study area for the local air quality assessment covers human health receptors and ecologically designated sites within 200m of roads that are expected to be affected by the Scheme.

6.1.2. The local air quality assessment involves estimating the change in pollutant concentrations at sensitive receptors resulting from the operation of the Scheme. Under the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 1 (HA 207/07), affected roads for the local air quality assessment are defined as where:

- Road alignment will change by five metres or more
- Daily traffic flows will change by 1,000 Annual Daily Traffic (AADT) or more
- Heavy Duty Vehicle (HDV) flows will change by 200 AADT or more
- Daily average speed will change by 10km/h or more
- Peak hour speed will change by 20km/h or more.

6.1.3. The regional air quality assessment assesses the change in total emissions resulting from the Scheme. This is required as emissions not only affect local air quality, but also have an impact on a regional, national and international scale. Affected roads for the assessment of regional air quality, in accordance with the DMRB Volume 11, Section 3, Part 1 (HA 207/07), include those that meet the following criteria:

- A change of more than 10% AADT
- A change or more than 10% to the number of HDVs
- A change in the daily average speed of more than 20km/h

6.1.4. At this stage traffic data for the Environmental Statement is not yet available.

6.2. Baseline conditions

6.2.1. Information on air quality in the UK can be obtained from a variety of sources including local authorities, national network monitoring sites and other published sources. For the purposes of this assessment, data has been obtained from the local authorities in the immediate vicinity of the Scheme, which includes Cotswold District Council (CDC), Tewkesbury Borough Council (TBC), Gloucester City Council (GCC), and Cheltenham Borough Council (CBC), the Department for Environment, Food and Rural Affairs (Defra) and Highways England.

Local authority review and assessment

6.2.2. CDC have two AQMAs designated within the borough for exceedances of the nitrogen dioxide (NO_2) annual mean. One of these is located on Thames Street in Lechlade which is over 20 kilometres east of the Scheme. The other is the Birdlip AQMA (Air Balloon Roundabout), designated in 2008, which is located adjacent to the Scheme. The CDC 2018 Air Quality Status Report[13] stated that there were no significant changes in NO_2 levels within this AQMA and that concentrations remain above the annual mean air quality objective as there have been no change in the usage of the roads around the AQMA.

6.2.3. GCC have three AQMAs declared in the borough; these were declared between 2005 and 2007 and are all due to exceedances of the NO_2 annual mean objective. All three AQMAs are located in and around Gloucester city centre.

6.2.4. The entirety of the land within the CBC's jurisdiction was declared an AQMA in 2011 for exceedances of the NO_2 annual mean air quality objective. The Cheltenham Borough AQMA is located approximately 4.5 kilometres north of the A417.

6.2.5. TBC have one AQMA declared within the borough. This is the Tewkesbury Town Centre AQMA which was declared in 2008 for exceedances of the NO_2 annual mean objective. It is approximately 15 kilometres north of the Scheme.

6.2.6. Once the traffic data for the Environmental Statement is available the study area can be defined and this will confirm which of these AQMAs are in the Scheme's affected road network (ARN) and which will be included in the assessment.

Local authority monitoring

6.2.7. There is no automatic monitoring undertaken by CDC, GCC or TBC. CBC undertake automatic monitoring with a single automatic monitor located approximately 6.5 kilometres from the Scheme. This is located in the centre of town at a busy junction and therefore is not representative of conditions within the Scheme boundary or on the surrounding roads which are likely to be affected. There are no Defra Automatic Urban and Rural Network (AURN) sites located nearby with the closest being in Swindon approximately 40 kilometres from the Scheme.

6.2.8. CDC undertook diffusion tube monitoring at 14 sites within the borough in 2017. There was only one monitoring site located within the Birdlip AQMA, although in

[13] Cotswold District Council (2018) 2018 Air Quality Annual Status Report (ASR) for Cotswold District Council [online] available at: https://www.cotswold.gov.uk/media/1638440/asr_cotswold_2018_final.pdf (last accessed February 2019)

previous years there were four diffusion tubes located within the Birdlip AQMA. The location of these tubes were adjacent to the Scheme alignment. There are no other CDC diffusion tubes in close proximity to the Scheme. Table 6.1 below presents the results from these diffusion tubes. The results show an exceedance of the annual mean objective for NO_2 in 2017.

6.2.9. Diffusion tube monitoring is also undertaken by CBC, TBC and GCC. However, there are no diffusion tubes in close proximity to the Scheme within these districts.

Table 6.1: Diffusion tube results

Site name	Site classification	National grid reference		Annual mean NO_2 concentration ($\mu g/m^3$)		
		x	y	2015	2016	2017
Birdlip – Air Balloon	Kerbside	393462	216111	**59.1**	**61.2**	**61.4**
Birdlip – Air Balloon 2	Kerbside	393459	216124	**40.5**	39.8	[a]
Birdlip – Air Balloon 3	Kerbside	393459	216124	39.4	39.2	[a]
Birdlip – Air Balloon, Beer Garden B	Kerbside	393459	216091	**40.5**	**40.4**	[a]

Source: Cotswold District Council 2018 Air Quality Annual Status Report.

Notes: Annual mean objective is $40\mu g/m^3$, bold indicates an exceedance of the objective.
Results for 2017 have 100% data capture.
[a] Diffusion tube discontinued in 2016.

Highways England monitoring

6.2.10. A six-month air quality monitoring survey was undertaken by Highways England from January 2016 to June 2016. The results from monitoring were bias adjusted and annualised in accordance with Defra's Local Air Quality Management Technical Guidance (TG16)[14]. This monitoring survey concluded that NO_2 concentrations within the vicinity of the Scheme are generally well below the annual mean NO_2 air quality objective. The only monitoring location in exceedance of the annual mean objective was at the house opposite the Air Balloon pub within the Birdlip AQMA, the concentration at this site was 41.7µg/m^3. This area is already known to have exceedances of the annual mean objective as demonstrated in the results from the CDC diffusion tube monitoring shown in Table 6.1.

6.2.11. The bias adjusted and annualised results from this monitoring survey are presented below in Table 6.1.

Table 6.2: Project specific diffusion tube monitoring data for NO_2

Site name	Location	Site classification	National grid reference		2016 Annualised NO_2 (µg/m^3)
			X	Y	
A417AB_001_1215	Birdlip GL4 8JL	Roadside	393205	214125	7.7
A417AB_002_1215	Road off A417 towards GL4 8JX (Kennels - on lamp post with no lamp)	Roadside	393802	215431	8.3
A417AB_003_1215	The Willows, Near Crickley Hill opposite A417 to GL3 4UH (on tree)	Roadside	393030	215876	29.1
A417AB_004_1215	House opposite The Air Balloon Pub GL4 8JY (across from pub)	Roadside	393458	216121	41.7
A417AB_005_1215	A436 GL53 9QX (lay-by)	Roadside	394269	216375	19.0
A417AB_006_1215	Ullenwood Cottages, Greenway Lane GL53 9QT (cottages)	Roadside	394413	216847	9.3
A417AB_007_1215	B4070 Ridgeway Close GL4 8BN	Roadside	392618	214415	16.9
A417AB_008_1215	Shurdington Road near roundabout GL3 4PX (mast)	Roadside	390439	216678	18.7

[14] Defra (2016), Local Air Quality Management – Technical Guidance (16).

Site name	Location	Site classification	National grid reference		2016 Annualised NO_2 ($\mu g/m^3$)
			X	Y	
A417AB_009_1215	Shurdington Road (Henley Bank Lane) GL3 4PG	Roadside	390397	216488	11.4
A417AB_010_1215	62 Court Road GL3 (lamp post)	Roadside	389182	216837	13.4
A417AB_011_1215	End of Cedar Road GL3 4DW (lamp post)	Roadside	388598	217247	14.9
A417AB_012_1215	73 Sussex Gardens GL3 3ST (lamp post)	Roadside	387925	217384	20.4
A417AB_013_1215	13 Hucclecote Road GL3 3AE (lamp post - by Victoria Pub)	Roadside	388356	216802	19.4
A417AB_014_1215	Churchdown Lane GL3 3QJ (lamp post)	Roadside	387623	217636	22.6
A417AB_015_1215	14 Millfields GL3 3NH	Roadside	387454	217908	20.4
A417AB_016_1215	Hucclecote Road side of 177 Sussex Gardens GL3 3SS (lamp post)	Roadside	388124	216931	18.0
A417AB_017_1215	Shurdington Road GL51 4UA (lamp post near road)	Roadside	390599	216877	26.5
A417AB_018_1215	BKGD - Near Shab Hill GL4 8JX (Drive past Kennels (No.1), on sign post near corner)	Background	394270	215829	7.3
A417AB_019_1215	Dog Lane Sign GL4 8JX	Roadside	391469	216107	12.9
A417AB_020_1215	76 Mill Lane GL3 4UG (lamp post)	Roadside	390190	216546	13.5
A417AB_021a_1215	Automatic Monitor, The Air Balloon Pub GL4 8JY	Roadside	393431	216092	34.2
A417AB_021b_1215	Automatic Monitor, The Air Balloon Pub GL4 8JY (behind pub)	Roadside	393431	216092	33.9
A417AB_021c_1215	Automatic Monitor, The Air Balloon Pub GL4 8JY (behind pub)	Roadside	393431	216092	35.8
A417AB_022_1215	1 Oak Drive GL3 4OQ	Roadside	388908	217014	12.1

Note: Annual mean objective is 40µg/m^3, bold indicates an exceedance of the objective.

Defra projected background concentrations

6.2.12. In addition to the data above, Defra provides estimates of background pollution concentrations for nitrogen oxides (NO_X), NO_2 and fine particulates (PM_{10}) across the UK for each one kilometre grid square, for every year from 2015 to 2030. Future year projections have been developed on the base year for the background maps, which is currently 2015. The maps include a breakdown of background concentrations by emission source, including road and industrial sources which have been calibrated against 2015 UK monitoring data. This data can be used to provide specific background pollutant concentrations at receptors included within the assessment and to supplement local monitoring data.

6.2.13. Table 6.3 below presents the maximum background concentration for the area covered by the Scheme alignment for the year 2017.

Table 6.3: Defra projected background concentrations for the Scheme (2017)

1km grid square location (OS grid reference)		NO_x	NO_2	PM_{10}
X	Y			
393500	215500	12.0	9.1	13.2

Note: The Scheme covers multiple OS grid squares. Therefore, the results presented above are taken from the grid squares which have the greatest pollutant concentrations for 2017 as this is consistent with the latest year of local authority monitoring.

EU Limit value compliance

6.2.14. Defra's Pollution Climate Mapping (PCM) is used to report UK compliance with the Air Quality Directive. The current published version of the PCM model is developed using a base year of 2015. Considering the current version, and based on the concentrations reported for 2017, no modelled links exceeding 40µg/m^3 are present within 10 kilometres of the Scheme.

6.2.15. There was one PCM link in 2017 exceeding 40µg/m^3 within the ARN during the Options Appraisal stage for the Scheme, this link is the A34 by-pass to the west of Oxford. The concentration in 2017 on this road was 50µg/m^3 but is predicted to reduce to 33µg/m^3 by 2024, which coincides with the opening year of the Scheme.

6.2.16. The PCM link closest to the Scheme is located on Corinium Avenue in Gloucester, which is approximately 5.5 kilometres west of the Scheme. The concentration on this PCM link for 2017 was 32.8µg/m^3, which is well below the annual mean limit value of 40µg/m^3 for NO_2.

6.2.17. There are a limited number of PCM links in the area, and where there are links within nearby towns, concentrations in the PCM model are below the limit values in 2017. The PCM links within the study area will be confirmed once traffic data for the Scheme is available and the ARN is defined.

Summary

6.2.18. Scheme specific and local authority monitoring data show that there are exceedances of the NO_2 annual mean within the Birdlip AQMA which is adjacent to the Scheme. These exceedances have been consistently monitored between 2015 and 2017. There are no other locations in close proximity to the Scheme which have showed monitored exceedances of the air quality objectives.

6.3. Potential impacts

Construction

Human health and ecological receptors

6.3.1. The proposed construction works have the potential to impact upon sensitive receptors within 200 metres of the Scheme as per DMRB 207/07. For human health, receptors include mostly residential properties. For ecology, receptors include Crickley Hill and Barrow Wake Site of Special Scientific Interest (SSSI). The duration of the proposed construction works would be approximately three years. The main risks to sensitive receptors during the construction stage include on-site dust emissions arising from construction activities and vehicle movements.

6.3.2. Dust can be mechanically transported (either by wind or re-suspension by vehicles). It can also arise from wind erosion on material stock piles and earth moving. These impacts are likely to be restricted to within 200 metres of construction activities (as stated in DMRB Volume 11, Section 3, Part 1).

Operation

Human health and ecological receptors

6.3.3. The operational phase of the Scheme has the potential to directly affect ambient concentrations of NO_2 and PM_{10} (for human health receptors) and NO_x (for ecological receptors) as:

- The change in road alignment associated with the Scheme has the potential to introduce a new source of traffic pollution within 200 metres of receptors,

or partially / completely remove existing sources of traffic pollution from within 200 metres of receptors.

- The Scheme has the potential to affect traffic flows and speeds on the road network, and so affect local and regional air quality beyond the physical extent of the Scheme at human health and ecological receptors.

6.3.4. The current extent of the ARN is unknown, the Scheme has the potential to affect ambient concentrations at sensitive receptors, including those located within the AQMAs discussed in Section 6. The potential impact upon receptors will be assessed once traffic data becomes available and the ARN is determined.

6.4. Design, mitigation and enhancement measures

Construction

6.4.1. Construction impacts would be restricted to within 200 metres of construction activities (as stated in DMRB Volume 11, Section 3, Part 1). Appropriate mitigation measures to control dust generation would be included within the Construction Environmental Management Plan (CEMP) for the Scheme. Mitigation measures would include minimising the use of dust generating activities, the use of water as a dust suppressant where appropriate and keeping stockpiles for the shortest time possible.

Operation

6.4.2. Air quality operational mitigation measures would be dependent on identified traffic impacts, which are yet to be determined.

6.5. Description of the likely significant effects

Construction

6.5.1. Significant adverse construction phase effects are unlikely to occur with mitigation measures implemented through the CEMP. However, details of the construction methodology are yet to be developed and will be included within the Environmental Statement once they have been established. Therefore a qualitative assessment in accordance with the requirements of the DMRB will be undertaken following the receipt of more detailed construction information.

Operation

Human receptors

6.5.2. The Scheme has the potential to directly affect ambient concentrations of NO_2 and PM_{10} during the operational phase. Likely significant effects will be determined at sensitive receptors, including those within AQMAs that are within the ARN. The ARN will be determined once traffic data becomes available.

6.5.3. The Birdlip AQMA located at the Air Balloon roundabout is currently in exceedance of the annual mean NO_2 objective. The Scheme has the potential to affect the NO_2 concentrations within this AQMA as traffic will be moved away from the AQMA.

Ecological receptors

6.5.4. The Scheme has the potential to directly affect ambient concentrations of NO_x during the operational phase. Significant effects will be determined based on traffic impacts which are yet to be assessed.

6.6. Assessment methodology

Proposed level and scope of assessment

6.6.1. The scope of assessment during the construction phase will include emissions of NO_2 and PM_{10} from construction plant and vehicles, and dust arising from construction activities. A qualitative assessment of construction phase effects will be undertaken.

6.6.2. If construction traffic is predicted to last for longer than six months, traffic management measures and the effect of additional construction vehicles will be assessed qualitatively.

6.6.3. Based on the potential for change in traffic characteristics on the local and strategic road network and the presence of the Birdlip AQMA, a Detailed Level assessment of operational air quality effects in accordance with DMRB 207/07 will be undertaken.

Policy requirements, guidance and advice

6.6.4. Table 6.4 presents the relevant air quality objectives that the Scheme will be assessed against.

Table 6.4: Air quality objectives and limit values

Pollutant	Averaging period	Air quality objectives and limit values title		Attainment date	
		Concentration	Allowance	Air quality objectives	EU limit values
Nitrogen dioxide (NO_2)	Annual	40 µg/m^3	-	31 December 2005[(a)(b)]	1 January 2010[(c)]
	1 Hour	200 µg/m^3	18	31 December 2005[(a)(b)]	1 January 2010[(c)]
Nitrogen Oxides (NO_X)[(d)]	Annual	30 µg/m^3	-		31 December 2000[(c)]
Particulate (PM_{10})	Annual	40 µg/m^3	-	31 December 2004[(a)(b)]	1 January 2005[(c)]
	24 Hour	50 µg/m^3	35	31 December 2004[(a)(b)]	1 January 2005[(c)]

Notes: [(a)] Air Quality (England) Regulations 2000 as amended in 2002.
[(b)] Air Quality Strategy 2007.
[(c)] EU Directive 2008/50/EEC on ambient air quality and cleaner air for Europe and The Air Quality Standards Regulations 2010 and The Air Quality Standards (Amendments) Regulations 2016. Derogations (time extensions) have been agreed by the EU for meeting the NO_2 limit values in some zones/agglomerations.
[(d)] Designated for the protection of vegetation and ecosystems and referred to as the 'critical level' for NO_x.

6.6.5. Guidance and best practice will be followed to industry standards, alongside compliance with the National Policy Statement for National Networks (NPSNN).

Determination of significant effects

Construction phase

6.6.6. The locations and types of sensitive receptors will be identified in accordance with HA 207/07 and reference made to appropriate Best Practicable Means (BPM) which would be incorporated into the CEMP.

Operational phase

6.6.7. The air quality assessment will take account of the best practice guidance provided by the DMRB 207/07, the Defra Local Air Quality Management Technical Guidance 2016 (TG(16))[14], and the following Highways England guidance:

- Interim Advice Note (IAN) 170/12 'Updated air quality advice on the assessment of Future NO_x and NO_2 projections for users of DMRB Volume 11, Section 3, Part 1, Air Quality'[15]
- IAN 174/13 'Updated advice for evaluating significant local air quality effects for users of DMRB Volume 11, Section 3, Part 1 Air Quality'[16]
- IAN 175/13 'Updated advice on risk assessment related to compliance with the EU Directive on ambient air quality and on the production of Scheme Air Quality Action Plans for users of DMRB Volume 11, Section 3, Part 1 Air Quality (HA207/07)'[17]
- IAN 185/15 'Updated traffic, air quality and noise advice on the assessment of traffic data into speed-bands for users of DMRB Volume 11, Section 3 Part 1 Air Quality'[18]

6.6.8. Further updates to the IANs may be published before work commences on the Environmental Statement. Therefore, the assessment will be undertaken in accordance with the latest IANs available at the time.

6.6.9. The Detailed Level assessment will include:

- An assessment of air quality effects using the advanced dispersion modelling software (ADMS Roads)
- Verification of model outputs with local monitoring data
- Prediction of NO_2 concentrations in the base year. do minimum and do something scenarios at sensitive human health receptors and designated sites

6.6.10. For regional air quality effects, the change in mass emissions that would result from the operation of the Scheme will be quantified. Emissions with and without the Scheme will be compared for opening year and design year (opening year + 15 years) as well as the base year scenario.

6.6.11. The assessment will be desk based and be based upon traffic data generated for the Environmental Statement and use existing baseline data collected by local authorities and Highways England.

[15] Highways England (2013) IAN 170/12 'Updated air quality advice on the assessment of future NOx and NO_2 projections for users of DMRB Volume 11, Section 3, Part 1 Air Quality (HA207/07)' [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian170v3.pdf (last accessed January 2019).
[16] Highways England (2013) IAN 174/13 'Updated advice for evaluating significant local air quality effects for users of DMRB Volume 11, Section 3, Part 1 Air Quality (HA207/07)' [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian174.pdf (last accessed January 2019).
[17] Highways England (2013) IAN 175/13 'Updated air quality advice on risk assessment related to compliance with the EI Directive on ambient air quality and on the production of Scheme Air Quality Action Plans for user of DMRB Volume 11, Section 3, Part 1 Air Quality' [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian175.pdf (last accessed January 2019).
[18] Highways England (2015) IAN 185/15 'Updated traffic, air quality and noise advice on the assessment of link speeds and generation of vehicle data into 'speed-bands' for users of DMRB Volume 11 Section 3 Part 1 Air Quality and Volume 11 Section 3 Part 7 Noise' [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian185.pdf (last accessed January 2019).

Human health and wellbeing

6.6.12. Effects on human health and wellbeing are assessed through the determination of significance of effects. This accounts for the changes in air quality and where air quality thresholds specified for the protection of human health are exceeded.

6.6.13. IAN 174/13 provides advice for evaluating significant local air quality effects for public exposure and designated sites. Evaluation of the significance of local air quality effects will be undertaken in accordance with IAN 174/13, a summary of which is provided here.

6.6.14. Receptors that have a reasonable risk of exceeding an air quality threshold will be assessed in both a do minimum and do something scenario. The difference in pollutant concentrations between the two scenarios is used to describe the magnitude of change in accordance with Table 6.5.

Table 6.5: Magnitude of change criteria

Magnitude of change in concentration	Value of change in annual average NO_2 and PM_{10}
Large (>4)	Greater than full Measure of Uncertainty (MoU) value of 10% of the air quality objective (4µg/m^3)
Medium (>2)	Greater than half of the MoU (2µg/m^3), but less than the full MoU (4µg/m^3) of 10% of the air quality objective
Small (>0.4)	More than 1% of objective (0.4µg/m^3) and less than half of the MoU i.e. 5% (2µg/m^3). The full MoU is 10% of the air quality objective (4µg/m^3)
Imperceptible (</= 0.4)	Less than or equal to 1% of objective (0.4µg/m^3)

Source: IAN 174/13
Notes: MoU = Measure of Uncertainty (10% of the objective)

6.6.15. The number of receptors where changes are greater than imperceptible, and where concentrations exceed the air quality objectives in the do minimum or do something scenario will be compared to the guideline bands presented in Table 6.6.

Table 6.6: Guideline to number of properties constituting a significant effect

Magnitude of change in concentration	Number of receptors with:	
	Worsening of air quality objective already above objective or creation of a new exceedance	Improvement of an air quality objective already above objective or the removal of an existing exceedance
Large (>4)	1 to 10	1 to 10
Medium (>2 to 4)	10 to 30	10 to 30
Small (>0.4 to 2)	30 to 60	30 to 60

6.6.16. Table 6.6 presents guideline bands, setting an upper level of likely non-significance and the lower level of likely significance, for the number of receptors affected by the Scheme. Between these two levels are the ranges where likely significance is more uncertain, therefore professional judgement would be required.

6.6.17. If a Scheme is above the lower level of likely significance, consideration should be given to all the evidence that may support or detract from the conclusion of a significant effect. The information in Table 6.6 will then be used along with the following key criteria to determine the overall evaluation of local air quality significance:

- Is there a risk that environmental standards would be breached?
- Is there a high probability of the effect occurring?
- Would there be a large change in environmental conditions?
- Would the effect continue for a long time?
- Would many people be affected?
- Is there a risk that protected sites, areas, or features would be affected?
- Would it be difficult to avoid, or reduce, or repair, or compensate for the effect?

6.6.18. The Scheme's compliance with EU limit values will be assessed using the latest version of IAN 175/13.

Ecological effects

6.6.19. The potential effects on ecologically designated sites will be assessed through the determination of significance of effects as part of the Environmental Statement. If the assessment of predicted NO_x concentrations at a designated site indicates a potential significant effect because there are NOx concentrations above 30µg/m^3 and they are predicted to change by more than 0.4µg/m^3 nitrogen deposition rates will be calculated. Nitrogen deposition will be calculated based on the approach set out in Annex F of DMRB 207/07.

6.6.20. If following this approach, it is concluded that there may still be a significant effect, a briefing note will be prepared with the scheme ecologist and submitted to Highways England and Natural England in accordance with IAN 174/13.

6.7. Assessment assumptions and limitations

6.7.1. Air quality modelling predictions will be based on the most reasonable, robust and representative methodologies in accordance with best practice guidance. However, there is an inherent level of uncertainty associated with the model predictions, including:

- Uncertainties with traffic forecast
- Uncertainties with vehicle emission predictions
- Uncertainties with background air quality data
- Simplifications made within screening tool calculations or post processing of the data that represent atmospheric dispersion or chemical reactions

6.7.2. In order to best manage these uncertainties, air quality assessment undertaken for the Environmental Statement will be verified using the air quality measurements from the Highways England monitoring survey and any local authority data that is within the ARN study area and has suitable data capture. The verification process will be undertaken in line with best practice guidance produced by Defra.

6.7.3. Uncertainty with vehicle emission factors in future years will be addressed through the application of IAN 170/12.

7. Cultural heritage

7.1. Study area

7.1.1. The cultural heritage assessment is based on a one kilometre study area, although designated heritage assets lying outside the study area and with potential views of the Scheme have also been considered. The list of heritage assets within the study area will be agreed with relevant consultees (Historic England and Gloucestershire County Council Heritage Team) prior to commencement of the Environmental Statement. This study area allows a full understanding of the context and setting of the heritage assets identified; facilitating an assessment of the potential effects of the Scheme during construction and operation upon heritage assets. The extent of the study area is based upon the guidance provided in DMRB Volume 11, Section 3, Part 2.

7.2. Baseline conditions

Archaeological and historical background

7.2.1. Information on nationally designated cultural heritage in the UK has been obtained from Historic England's National Heritage List for England (NHLE). For designated and non-designated local heritage assets, the Gloucestershire County Historic Environment Record (HER) and National Mapping Programme (NMP) have been consulted.

Designated heritage assets

7.2.2. There are seven scheduled monuments within one kilometre of the Scheme:

- Crickley Hill Camp is 300 metres to the north (NHLE 1003586)
- Dryhill Roman Villa is 800 metres to the north (NHLE 1004848)
- Moat and Fishpond at Bentham Manor is 900 metres to the north-west (NHLE 1016764)
- Two bowl barrows, known as Crippet's Wood round barrows are 850 metres to the north (NHLE 1017041)
- Three bowl barrows, known as Emma's Grove round barrows are 85 metres to the south (NHLE 1017079)
- Brimpsfield Castle mound is 600 metres to the south (NHLE 1003343)
- Brimpsfield Castle is 900 metres to the south (NHLE 1003326)

7.2.3. Leckhampton Camp and Tumulus Scheduled Monument (NHLE 1004862) lies approximately 2.5 kilometres to the north of the Scheme. Although the asset lies

outside of the study area, views from it have the potential to be impacted by the Scheme.

7.2.4. There are 27 listed buildings within one kilometre of the Scheme. Of these, one is Grade I listed (Church of St Michael, NHLE 1088482) and one is Grade II* listed (Dovecote circa 3m north of Bridge House, NHLE 1304753). The remaining 25 are of Grade II listing.

7.2.5. The Scheme is within one kilometre of Cowley Manor, a Grade II* registered park and garden.

7.2.6. The Scheme is within one kilometre of Brimpsfield Conservation Area, as designated by the local authority.

7.2.7. There are no world heritage sites, registered battlefields or conservation areas within the study area.

Non-designated heritage assets

7.2.8. Archaeological remains dating to the prehistoric period (10,000 BC – AD 43) that have been recorded within the study area include:

- Mesolithic flints found in excavations on Crickley Hill
- Neolithic settlement at Peak Camp, on the opposite hilltop to Crickley Hill
- Several findspots of Neolithic axes
- Several buried features to the immediate east of, and possibly associated with, Emma's Grove Scheduled Monument, identified by a magnometer survey
- Two Bronze Age bowl barrows at Crippet's Wood
- Two Bronze Age round barrows visible as earthworks to the north-east of Rushwood Kennels
- Several Bronze Age features identified through excavation and geophysical survey prior to the construction of the existing A417
- Iron Age cemetery at Barrow Wake
- An Iron Age farmstead
- Several Iron Age features at Highgate House

7.2.9. Archaeological remains dating to the Roman period (AD 43 – 410) that have been recorded within the study area include:

- Ermin Street, the Roman road connecting Gloucester and Cirencester, thought to be preserved in several places in Birdlip
- A possible Roman mansio (stopping place) at the Royal George Hotel
- Roadside settlement at Birdlip Quarry

- Romano-British site, including buildings, identified by fieldwalking prior to the construction of the existing A417
- Possible Roman settlement associated with the villa
- Possible Romano-British enclosures, visible as earthworks to the north of Stockwell Farm

7.2.10. Archaeological remains dating to the Saxon period (AD 410 – 1066) that have been recorded within the study area are limited to early post-Roman activity at Crickley Hill.

7.2.11. Undesignated archaeological remains dating to the later medieval period (AD 1066 – 1485) that have been recorded within the study area are limited to Stockwell deserted medieval village, identified through earthworks and cropmarks. There is also evidence for medieval ridge and furrow in aerial photographs throughout the study area.

7.2.12. Possible archaeological remains dating to the post-medieval and modern periods (1485 – present) that have been recorded within the study area include:

- 18th century gallows on Birdlip Hill
- 19th century limekiln north of Crickley Hill
- 18th century bridlepath north of Crickley Hill
- Lynchets and trackways visible as earthworks
- Stockwell Farm, which was rebuilt in the late 19th century but may incorporate some of the earlier house
- World War II 'Starfish Site' south of Cheltenham
- World War II military camp, heavy anti-aircraft battery and barrage balloon visible on historic and aerial photography
- World War II military camp and hospital at Ullenwood

Historic landscapes

7.2.13. The historic landscape of the study area is defined by three main areas; the lowland valley to the west of the Scheme is characterised by areas of irregular enclosures with some more regular enclosures, characteristic of agricultural practices that emanate from medieval land management. The escarpment, running broadly north-south above the lowland areas of the Severn Valley, is formed of a rock outcrop of limestone that, as a suitable building stone, has long been quarried. The Cotswold landscape has been influenced by human activity since the Mesolithic period (from 10,000 BC) and cultivated fields have been a feature of the landscape since the Neolithic period (from approximately 3,000 BC); some land divisions may have been established in the Roman period, as the Roman road running through Birdlip was a prominent feature of the landscape and there are a number of rural villas in the area. However, there is

no evidence that the existing Cotswold fields make extensive use of pre-medieval boundaries, which were largely obliterated by open field cultivation which dominated the area during much of the medieval period.

A436 Link Road Alternative 1: bridge over A417

7.2.14. There is no additional baseline information or variations to the baseline information outlined above for this A436 Link Road Alternative.

A436 Link Road Alternative 2: parallel to the A417

7.2.15. There is no additional baseline information or variations to the baseline information outlined above for this A436 Link Road Alternative.

A436 Link Road Alternative 3: via South Hill

7.2.16. There is no additional baseline information or variations to the baseline information outlined above for this A436 Link Road Alternative.

7.2.17. It should be noted that the current HER data that has been analysed does not extend the full one kilometre around this A436 Link Road Alternative. New data will need to be ordered, should this alternative be selected as the preferred A436 Link Road Alternative. For scoping purposes, the current HER data is considered sufficient as the A436 Alternative 3: South Hill is still located within the one kilometre study area. Therefore the current data identifies which known heritage assets would be directly impacted by this A436 Link Road Alternative.

7.3. Potential impacts

Construction

7.3.1. Construction groundworks have the potential to adversely impact both known and unknown archaeological remains across a large area, resulting in an adverse impact. The receptors that could potentially be impacted include:

- Features identified in a geophysical survey carried out in the field to the immediate east of Emma's Grove, possibly associated with the scheduled monument
- Possible Romano-British enclosures, visible as earthworks to the north of Stockwell Farm
- Stockwell deserted medieval village, identified through earthworks and cropmarks
- Remains of a Roman roadside settlement left in-situ at Birdlip Quarry
- Linear features to the south of Barrow Wake identified by the HER

- Roughly parallel cropmarks that are visible on aerial photographs to the west of Shab Hill
- Remains of a Romano-British occupation site left in-situ either side of the existing A417
- Unknown archaeological remains that have not been identified through survey or excavation

7.3.2. Construction will result in the demolition of the Air Balloon Public House, a non-designated heritage asset of low value. The total loss of the building would result in an adverse impact.

7.3.3. During construction, the Scheme would also have an adverse impact on the setting of the following designated assets:

- Crickley Hill Camp Scheduled Monument
- Emma's Grove Scheduled Monument
- Shab Hill Barn (Grade II listed building)

7.3.4. The construction phase could also directly impact what was interpreted as a potential prehistoric enclosure associated with a settlement site, including a possible roundhouse, that was identified in the northern extent of the geophysical survey that was carried out to the west of Emma's Grove Scheduled Monument.

Operation

7.3.5. During operation of the Scheme, the settings of the following assets would be adversely impacted through noise, light and visual intrusion:

- Crickley Hill Camp Scheduled Monument
- Emma's Grove Scheduled Monument
- Shab Hill Barn Grade II listed building

7.3.6. The de-trunking of parts of the existing A417 would beneficially impact the setting of the Grade II listed Milestone and Golden Heart Inn, which would be subject to less noise, light and visual intrusion as a result of the Scheme.

7.4. Design, mitigation and enhancement measures

Construction

7.4.1. Where effects on heritage assets are unavoidable, mitigation would be included within the design. For setting effects this may include planting, screening, noise attenuation and appropriate lighting, with the aim of reducing the impact on heritage assets in the vicinity. Effects (both physical and setting) may be

mitigated through alteration of the Scheme design, or elements of it, such as the placement of bunds, drainage, ponds, landscaping, and planting. Preserving archaeological remains in-situ would be explored during the design process. Best practice measures to limit impacts on heritage assets would be employed during construction through the implementation of a Construction Environmental Management Plan (CEMP).

7.4.2. Temporary road diversions that may be necessary during the construction phase would be directed away from sensitive areas such as Birdlip and Witcombe to reduce temporary increase of noise and visual intrusion on the setting of heritage assets in these areas during that time.

Operation

7.4.3. Below ground archaeological deposits would not be affected by the operation of the new dual carriageway. However, the presence of faster moving traffic and the potential for air, noise and light pollution within the landscape could have an effect on the setting of some heritage assets, including scheduled monuments at Crickley Hill and Emma's Grove and listed buildings such as Shab Hill Barn. Where possible, opportunities for enhancement measures to heritage assets and their settings would be taken. This could take the form of screening vegetation, the placement of bunds, noise attenuation screening or appropriate lighting.

7.5. Description of the likely significant effects

Construction

7.5.1. There is the potential for significant adverse effects resulting from the loss or alteration of known archaeological remains, some of which are of high value, particularly those associated with a scheduled monument. This includes features identified in a geophysical survey to the east of Emma's Grove, as well as features visible as crop marks and earthworks that constitute Stockwell deserted medieval village. There is also the potential for significant effects resulting from the loss or alteration of unknown archaeological remains that may be of high value.

7.5.2. There is the potential for significant adverse effects resulting from the demolition of the low value non-designated heritage asset, Air Balloon public house.

7.5.3. There is the potential for significant adverse effects resulting from setting impacts on the very high value Crickley Hill Scheduled Monument and the medium value Grade II listed Shab Hill Farm.

A436 Link Road Alternative 1: bridge over A417

7.5.4. There is the potential for significant adverse effects resulting from the setting impacts on the very high value Emma's Grove Scheduled Monument during the construction of the A436 overbridge.

A436 Link Road Alternative 2: parallel to the A417

7.5.5. There is the potential for significant effects on what was interpreted as an enclosure associated with a settlement site, including a possible roundhouse, that was identified in the northern extent of the geophysical survey carried out to the west of Emma's Grove. This feature could be associated with the scheduled monument and therefore would be of high significance. Therefore, the construction of the A436 parallel may result in significant adverse effects.

A436 Link Road Alternative 3: via South Hill

7.5.6. The increased land-take away from the mainline of the Scheme has the potential to result in significant adverse effects on unknown archaeological remains, some of which may be of high significance.

Operation

7.5.7. There is the potential for significant adverse effects resulting from setting impacts on the very high value Crickley Hill Scheduled Monument and the medium value Shab Hill Barn.

7.5.8. There is the potential for significant beneficial effects from setting impacts on the medium value Milestone and Golden Heart Inn.

A436 Link Road Alternative 1: bridge over A417

7.5.9. There is the potential for significant adverse effects resulting from setting impacts on the high value Emma's Grove Scheduled Monument, which would be entirely encircled by the new carriageway and its connectivity with its associated landscape permanently severed.

A436 Link Road Alternative 2: parallel to the A417

7.5.10. There is the potential for significant adverse effects resulting from setting impacts on the high value Emma's Grove Scheduled Monument. However, this would be partly offset by the de-trunking of parts of the existing A417, which would open the landscape to the south and improve connectivity between monuments on the escarpment.

A436 Link Road Alternative 3: via South Hill

7.5.11. There is the potential for significant adverse effects resulting from setting impacts on the high value Emma's Grove Scheduled Monument. However, this would be partly offset by the de-trunking of parts of the existing A417, which would open the landscape to the south and improve connectivity between monuments on the escarpment.

7.6. Assessment methodology

Proposed level of scope of assessment

7.6.1. The Environment Statement will include an assessment of the construction effects due to the potential for significant effects upon buried archaeological remains. The Environmental Statement will also include an assessment of the temporary setting effects on designated and non-designated heritage assets from construction activity including the presence of worksites and associated noise.

7.6.2. Furthermore, there are a number of sensitive receptors within close proximity of the Scheme. An assessment of operational effects caused by light, visual and noise intrusion on the setting of these assets will also be required. Below ground archaeological deposits would however not be affected by the operation of the new dual carriageway and are therefore scoped out of further assessment.

7.6.3. This assessment will be undertaken to a DMRB Detailed level and will be used to inform the design of a historic environment strategy. The Detailed assessment will include the results of a geophysical survey, lidar survey, geotechnical ground investigations and a detailed map regression.

Policy requirements, guidance and advice

7.6.4. The method for determining and appraising baseline conditions involved a desk-based study and was undertaken in accordance with the published standards and guidance set out below:

- Highways England (2007) DMRB Environmental Assessment (Volume 11, Section 3, Part 2 - Cultural Heritage)
- Historic England (2008) Conservation Principles: Polices and Guidance
- Historic England (2015) Historic Environment Good Practice Advice in Planning Note 2 (GPA2) – Managing Significance in Decision – Taking in the Historic Environment
- Historic England (2015, updated 2017) Historic Environment Good Practice Advice on Planning Note 3 (GPA3) – The Setting of Heritage Assets

- Standard and Guidance from the Chartered Institute of Archaeologists (2014)

Determination of significant effects

Proposed methodology

7.6.5. The assessment will consider all heritage assets, both designated and non-designated. These include scheduled monuments, listed buildings, registered parks and gardens, conservation areas, non-designated below-ground archaeological remains, locally recorded historically important buildings and historic landscapes. There are no registered battlefields or world heritage sites within the study area.

7.6.6. The assessment will consider both temporary and permanent construction and operational effects on heritage assets. Temporary effects will be from construction related activities, whereas permanent effects can be either physical effects on the integrity of the asset or effects on the setting.

Assessment of value / sensitivity

7.6.7. The value / sensitivity of historic environment receptors will be based upon Table 7.1 below. Assessment of value / sensitivity will be based on a combination of designated status and professional judgement. It will consider the Secretary of State's non-statutory criteria for the scheduling of ancient monuments, assessment criteria adopted by Historic England as part of the Monument Protection Programme (MPP), and the Secretary of State's Principles of Selection Criteria for Listed Buildings[19].

7.6.8. It will also recognise that occasionally some heritage assets have a lower or higher than normal value / sensitivity within a local context. Additionally, the assessment process should consider the component of the heritage asset that is being affected, and the ability of the heritage asset to absorb change without compromising the understanding or appreciation of the resource.

Table 7.1 Criteria for assessing value / sensitivity

Value / Sensitivity	Typical criteria
Very High	World heritage sites, assets of acknowledged international importance, assets that can contribute significantly to acknowledged international research objectives.

[19] Department for Culture, Media and Sport (2010) Principles of Selection for Listed Buildings [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137695/Principles_Selection_Listing_1_.pdf (last accessed January 2019).

Value / Sensitivity	Typical criteria
High	Scheduled monuments, Grade I and II* listed buildings, Grade I and II* registered parks and gardens, registered battlefields, undesignated assets of schedulable quality, undesignated monuments, sites, or landscapes that can be shown to have specific nationally important qualities, and assets that can contribute significantly to national research objectives.
Medium	Grade II listed buildings, Grade II registered parks and gardens, conservation areas, undesignated sites of high importance identified through research or survey, monuments or sites that can be shown to have important qualities in their fabric or historical association.
Low	Undesignated assets – locally listed buildings, archaeological monuments or sites with a local importance for education or cultural appreciation, and which add to local archaeological and historical research. Very badly damaged assets that are of such poor quality that they cannot be classed as high or medium, parks and gardens of local interest.
Negligible	Heritage resources identified as being of no historic, evidential, aesthetic or communal interest; and resources whose importance is compromised by poor preservation or survival, or by contextual associations to justify inclusion into a higher grade.

Source: Based on DMRB (Volume 11, Section 3, Part 2), 2007

Assessment of magnitude of impact

7.6.9. The degree of impact on the heritage asset from the Scheme will be assessed in accordance with the criteria presented in Table 7.2 below.

Table 7.2: Criteria for Assessing the Magnitude of Impact

Magnitude	Criteria
Major	Total loss or fundamental alteration to a heritage asset's significance and/or setting. Addition of new features that substantially alter the setting of a heritage asset.
Moderate	Partial loss or alteration a heritage asset's significance and / or setting. Addition of new features that partially alter setting of a heritage asset to the extent where the significance is impacted.
Minor	Minor loss of an element of a heritage asset and / or its setting. Addition of new features that form largely inconspicuous elements in the setting of a heritage asset to the extent that its significance is slightly impacted.
Negligible	Very minor loss of elements of a heritage asset and / or its setting. Addition of new features that do not alter the setting of a heritage asset.
No Change	No change to the heritage asset.

Source: Based on DMRB (Volume 11, Section 3, Part 2), 2007

Assessment of significance of effect

7.6.10. Effects will be evaluated by combining the assessment of both the value / sensitivity (heritage significance) of an asset, with the magnitude of the impact.

This allows the prediction of the significance of the effect, as shown in Table 7.3. These effects can be beneficial or adverse, and temporary or permanent, depending on the nature of the development, the mitigation measures, and any enhancement measures proposed. In accordance with DMRB guidance, effects with an assessment of Moderate, Large or Very Large are considered to be significant.

Table 7.3 Significance of effects matrix

Value / Sensitivity	Magnitude of Impact					
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
	Very High	Neutral	Slight	Moderate/ Large	Large/ Very Large	Very Large
	High	Neutral	Slight	Slight/ Moderate	Moderate/ Large	Large/ Very Large
	Moderate	Neutral	Negligible/ Slight	Slight	Moderate	Moderate/ Large
	Low	Neutral	Negligible/ Slight	Negligible/ Slight	Slight	Slight/ Moderate
	Negligible	Neutral	Neutral	Negligible/ Slight	Negligible/ Slight	Slight

Source: Based on DMRB (Volume 11, Section 3, Part 2), 2007

7.7. Assessment assumptions and limitations

7.7.1. The site visit undertaken was restricted to external visual inspection from publicly accessible areas only.

7.7.2. Non-designated built heritage assets are often not identified in HER data or other desk-based resources. As such, the extent of non-designated heritage assets along the Scheme cannot be considered to have been fully examined or determined as of yet. This scoping report assessment identifies the potential for significant adverse impacts resulting from the loss or alteration of unknown built heritage assets.

7.7.3. Information provided by the HER can be limited since it depends on previous opportunities for research, fieldwork and discovery. Where nothing of historic interest is shown in an area, this can be down to a lack of targeted research or investigation rather than the genuine absence of sub-surface archaeological deposits. This scoping report assessment identifies the potential for significant adverse impacts resulting from the loss or alteration of unknown archaeological remains.

7.7.4. Documentary sources are rare before the medieval period, and many historic documents are inherently biased. Older primary sources often fail to accurately locate sites and interpretation can be subjective. Professional judgement will be used in the interpretation of older primary sources.

7.7.5. Where archaeological sites have been identified solely from aerial imagery without confirmation from archaeological excavation or supporting evidence in the form of findspots, it is possible the interpretation may be revised in the light of further investigation. The detailed assessment will include evidence from the geophysical survey, lidar survey, geotechnical ground investigations and detailed map regression to supplement the aerial imagery. It should be noted that the absence of indications of archaeological features on aerial imagery does not confirm an absence of sub-surface archaeological deposits, as visibility from the air is dependent upon a complex combination of factors. These include:

- Unsuitable conditions at the time of image capture (such as lighting, ground moisture content and crops or other ground cover)
- Variable quality of photography
- Variable type of photography, such as purpose-flown oblique imagery taken for archaeological purposes or ‘blanket’ vertical aerial photography which is usually at a much smaller scale
- Underlying features being masked by alluvial build up

8. Landscape and visual effects

8.1. Study area

8.1.1. Current good practice indicates that a study area should extend to contain all areas in which visual impacts have the potential to occur based on topographical indications only. This is known as the Zone of Theoretical Visibility (ZTV). The guidance given in the Design Manual for Roads and Bridges (DMRB) Volume 11 Section 3 Part 5 Landscape Effects[20] and IAN 135/10[21], recommends that all receptors within this ZTV or visual envelope within flat landscapes should be assessed up to one kilometre from the Scheme, establishing the study area for the Landscape and Visual Impact Assessment (LVIA). However, given there are areas of higher ground within the vicinity of the Scheme, the study area will be extended beyond one kilometre in places, to include potential far reaching receptors that may afford significant effects from elevated viewpoints including, but not limited to Cooper's Hill and Leckhampton Hill, or from additional viewpoints within the low lying vale to the west.

8.1.2. Environmental stakeholders including Cotswold Conservation Board, National Trust, Historic England, Gloucester County Council, Natural England and Cotswold District Council were contacted prior to undertaking site visits in order to obtain commentary on suitable viewpoints. Maps were included in the communications to indicate the intended viewpoint locations. While a limited number of responses were received, all of these were taken into consideration in the site visits carried out in summer 2018 and winter 2019.

8.2. Baseline conditions

8.2.1. The Scheme sits entirely within the Cotswolds Area of Outstanding Natural Beauty (AONB). The AONB Management Plan[22] guides the management of the AONB to support the 2 primary purposes of conserving and enhancing the natural beauty of the AONB, and increasing the understanding and enjoyment of the special qualities of the AONB.

8.2.2. The baseline conditions have been based on a desk top study and several site visits. Information relating to landscape character within the local area has been

[20] Highways England (1993) Design Manual for Roads and Bridges (DMRB) Volume 11 Section 3 Part 5 Landscape Effects.
[21] Highways England (2010) Interim Advice Note 135/10 (IAN 135/10) Landscape and Visual Effects Assessment.
[22] The Cotswold AONB Partnership (2018) Cotswold AONB Management Plan 2018-2023 [online] available at: https://www.cotswoldsaonb.org.uk/planning/cotswolds-aonb-management-plan/ (last accessed February 2019).

obtained from Natural England's National Character Area (NCA) profiles[23], Gloucestershire County Council[24] and from Cotswolds Conservation Board (CCB)[25].

8.2.3. The CCB documents, including the Management Plan and Position Statement on Tranquillity and Dark Skies[26], make reference to the importance of tranquillity, dark skies and reducing light pollution and excessive noise. The Position Statement includes the Cotswold Light Pollution Map and Tranquillity Map as appendices, prepared by the Council for the Protection of Rural England (CPRE). The maps indicate that the study area is subject to higher levels of light pollution and lower levels of tranquillity to the west consistent with the proximity to Gloucester. The maps indicate the reverse to the east and south, consistent with the more rural context.

8.2.4. Information relating to landscape designations has been obtained from Highways England WebMaps and Defra's MAGIC interactive map[27]. Information relating to Public Rights of Way (PRoW) was obtained from Highways England WebMaps and Gloucestershire County Council's online map[28].

8.2.5. Other key features and designations within the one kilometre study area and their distance from the Scheme are shown in Table 8.1. Ecological and heritage designations are included in Table 8.2 as these form an intrinsic part of the landscape fabric, and their presence therefore contributes to landscape character. The landscape and visual effects chapter addresses where relevant, impacts on the landscape context of, or views from public paths and spaces within these features or designation. For details relating to the ecological and heritage baseline, potential impacts and significant effects, reference should be made to chapters 7 and 10.

[23] Natural England (2014) National Character Area profiles [online] available at: https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making/national-character-area-profiles (last accessed January 2019).
[24] Gloucestershire County Council (2017) Combined landscape character assessment [online] available at: https://data.gov.uk/dataset/9db6b02c-6d03-4be7-85db-81faa642fb6b/gloucestershire-county-council-county-landscape-character-types (last accessed January 2019).
[25] Cotswold Conservation Board (2019) Landscape Character [online] available at: https://www.cotswoldsaonb.org.uk/our-landscape/landscape-character/ (last accessed January 2019).
[26] Cotswold Conservation Board Position Statement Tranquillity and Dark Skies (October 2010) [online] available at: https://www.cotswoldsaonb.org.uk/our-landscape/position-statements-2/ (last accessed February 2019).
[27] Department for Environment, Food and Rural Affairs (Defra) [online] available at: https://magic.defra.gov.uk/ (last accessed January 2019).
[28] Gloucestershire County Council Highways Rights of Way online map (2019) [online] available at: https://www.gloucestershire.gov.uk/roads-parking-and-rights-of-way/public-rights-of-way/rights-of-way-online-map/ (last accessed January 2019).

Table 8.1: Key features and designations within 1km of the Scheme

Key features and designations within 1km of the Scheme	Direction and approximate nearest distance from centreline of the Scheme
Crickley Hill including Country Park, Crickley Hill Camp Scheduled Monument, Crickley Hill and Barrow Wake Site of Special Scientific Interest (SSSI), Registered Common Land, Open Access land, National Trust land, Woodland Trust land, Gloucester Wildlife Trust Reserve and adjacent Ullenwood Cricket Ground and pavilion	Immediately north
Ullen Wood Ancient and Semi-Natural Woodland (ASNW)	0.12km north-east (within Scheme footprint of A436 Link Road Alternative 3: via South Hill)
Barber Wood Woodland Trust land, used by walkers / dog walkers	0.46km north-east (within Scheme footprint of A436 Link Road Alternative 3: via South Hill)
Barrow Wake including Open Access land, Registered Common Land, Crickley Hill and Barrow Wake SSSI, Gloucester Wildlife Trust Reserve and a public car park	Immediately west
Emma's Grove round barrows Scheduled Monument, including surrounding woodland	0.09km south
The Peak, including Open Access Land	0.35km west
Cotswold Way National Trail, which crosses Crickley Hill, Barrow Wake and The Peak	Within Scheme footprint
Gloucestershire Way Long Distance Path, which passes by Emma's Grove	Within Scheme footprint
A number of Listed Buildings including Crickley Hill Farm, Shab Hill Barn, Hill Barn and Harding's Barn near Cowley, Golden Heart Inn and milestone at Nettleton, Brimpsfield Park, Church of St Michael and churchyard monuments at Brimpsfield and several buildings at Birdlip, Little Witcombe and Bentham	Nearest listed buildings to the Scheme are Shab Hill Barn and Crickley Hill Farm (both within 0.15km)
Brimpsfield Castle and Brimpsfield Castle mound Scheduled Monuments	0.5km (mound) to 0.92km (castle) to south-west

8.2.6. The landscape receptors include the landscape character types and areas and constituent landscape elements such as woodlands, farmland and PRoW. Given the AONB designation, landscape sensitivity is considered to be high.

National Landscape Character

8.2.7. The Scheme is located within NCA 107 Cotswolds. Key characteristics of the NCA (Natural England, 2013)[29] include:

[29] Natural England (2013) National Character Area profile: 107. Cotswolds [online] available at: http://publications.naturalengland.org.uk/publication/5900626?category=587130 (last accessed January 2019).

- A dramatic limestone scarp rising above adjacent lowlands with steep combes and outliers illustrating the slow erosion of escarpments. The limestone geology has formed the scarp and dip slope of the landscape, which in turn has influenced drainage, soils, vegetation, land use and settlement;
- Open and expansive scarp and high wold dipping gently to the south-east, dissected by river valleys;
- Arable farming dominates the high wold and dip slope while permanent pasture prevails on the steep slopes of the scarp and river valleys with pockets of internationally important limestone grassland;
- Drystone walls define the pattern of fields of the high wold and dip slope. On the deeper soils and river valleys, hedgerows form the main field boundaries;
- Ancient beech hangers line stretches of the upper slopes of the scarp, while oak / ash woodlands are characteristic of the river valleys. Regular blocks of coniferous and mixed plantations are scattered across the open high wold and dip slope;
- Large areas of common land, important for unimproved calcareous grassland, are characteristic of the scarp and high wold around the Stroud valleys and along the crest of the scarp to Cleeve Hill. Local examples include common land at Barrow Wake and Crickley Hill;
- Rich history from Neolithic barrows, Iron-Age hill forts and Roman roads and villas to deserted Medieval villages, grand country houses, cloth mills and Second World War airfields. The field patterns largely reflect both the medieval open field system, with fossilised areas of ridge and furrow and later planned enclosures;
- 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. Bath stone is also famous and has been used for building since Roman times. Parkland, gardens and historic designed landscapes are features particularly of the dip slope and broad lowland; and
- Prominent natural and built features in the landscape include the City of Bath World Heritage Site (WHS), Brailes Hill, Broadway Tower, Cleeve Hill, the Tyndale monument, Freezing Hill, Kelston Round Hill and Blenheim Palace WHS.

8.2.8. Key characteristics of NCA 106 Severn Avon and Vales (Natural England, 2013)[30] relevant to the western edge of the one kilometre study area include:

[30] Natural England (2013) National Character Area profile: 106. Severn Avon and Vales [online] available at: http://publications.naturalengland.org.uk/publication/1831421?category=587130 (last accessed January 2019).

- Low-lying open agricultural vale landscape made up of vales including Gloucester;
- M5 motorway runs through the eastern edge of the area;
- The small proportion of the NCA that is urban includes towns such as Gloucester and Cheltenham;
- Woodland is sparse, but a well wooded impression is provided by frequent hedgerow trees, parkland and surviving traditional orchards;
- A strong historic time line is visible in the landscape, including the Roman influences at Gloucester;
- Highly varied use of traditional buildings materials including red-brick buildings, grey Lias and Cotswolds stone; and
- Ancient market towns and large villages along rivers with churches standing as prominent features in the relatively flat landscape.

Cotswolds AONB

8.2.9. The AONB landscape is highly valued reflected by the designation. There are 14 Special Qualities of the AONB as presented within the Cotswold AONB Management Plan 2018-2023[31], which include:

- The unifying character of the limestone geology – its visible presence as natural outcrops, its use as a building material.
- The Cotswold escarpment, including views from and to the AONB.
- The high wolds - a large open, elevated predominantly arable landscape with commons, 'big skies' and long-distance views.
- River valleys, the majority forming the headwaters of the Thames, with high-quality water.
- Distinctive dry-stone walls.
- Internationally important flower-rich grasslands, particularly limestone grasslands and ancient broadleaved woodland, particularly along the crest of the escarpment.
- Variations in the colour of the stone from one part of the AONB to another which add a vital element of local distinctiveness.
- The tranquillity of the area and extensive dark skies
- Distinctive settlements, developed in the Cotswold vernacular, high architectural quality and integrity.
- Accessible landscape for quiet recreation, with numerous walking and riding routes, including the Cotswolds Way National Trail.

[31] The Cotswold AONB Partnership (2018) Cotswold AONB Management Plan 2018-2023 [online] available at: https://www.cotswoldsaonb.org.uk/planning/cotswolds-aonb-management-plan/ (last accessed February 2019).

- Rich assemblage of archaeological and historical sites including Neolithic stone monuments, Roman villas and ridge and furrow fields. Remnant historic landscapes include country estates and parks.
- Heritage of cultural associations, including composers, authors, artists and traditional events.

Regional Landscape Character

8.2.10. The Cotswold Landscape Character Assessment[32] identifies 19 different character types within the AONB. The study area for this Scheme falls within four landscape character types (LCT): LCT 2 Escarpment, LCT 7 High Wold, LCT 8 High Wold Valley and LCT 18 Settled Unwooded Vale. Key features of these LCTs and the constituent landscape character areas (LCA) within the study area are defined below.

8.2.11. LCT 2 Escarpment - LCA 2D Cooper's Hill to Winchcombe, which includes:

- Steep exposed and elevated west facing scarp slope, partly cloaked in semi natural broadleaved woodland.
- Generally poor soils and steep sloping relief of the escarpment not suited to arable farming and primarily used for pasture or woodland.
- Escarpment forming dramatic backdrop to Gloucester and Cheltenham, limiting their eastward expansion.
- Large areas of ancient woodland between Cooper's Hill and Birdlip.
- Large enclosed areas of rough grassland on upper slopes and improved pasture in moderately sized hedge enclosures bordering the vale.
- Significant areas of calcareous grassland.
- Numerous archaeological sites border upper slopes such as at Crickley Hill.
- Settlement on escarpment slopes is sparse and limited to scattered linear settlements bordering local roads.

8.2.12. LCT 7 High Wold - LCA 7B Bisley Plateau and 7C Cotswolds High Wold Plateau, which include:

- Broad, elevated, gently undulating plateau with expansive long-distance views
- Elevated areas of plateau surrounded by deeply incised valleys
- Settlements limited to small villages and hamlets, generally within valleys and isolated farmsteads and individual dwellings

[32] The Cotswold AONB Partnership (undated) Landscape Character Assessment [online] available at: https://www.cotswoldsaonb.org.uk/our-landscape/landscape-character-assessment/ (last accessed January 2019).

- Small coniferous and broadleaved plantations and shelterbelts to farms and plantations bordering roads
- Low settlement density results in sense of tranquillity and areas of dark skies
- Evidence of historic occupation of the landscape with many Neolithic and Bronze Age barrows and Iron Age hillforts

8.2.13. LCT 8 High Wold Valley - LCA 8A Toadsmoor, Holy Brook and Upper Frome Valleys and LCA 8C Upper Churn Valley, which include:

- Incised valleys form with often steep, convoluted valley sides forming dramatic landscape features in contrast to the high wold
- Areas of distinctive interlocking spurs indicative of valley formation during glacial period
- Extensive areas of mainly broadleaved woodland cloaking areas of the valley sides, particularly in steeper sections
- Areas of pastoral, open farmland extend between wooded slopes
- Intermittent stone villages occupy secluded areas within valley bottoms

8.2.14. LCT 18 Settled unwooded Vale - LCA 18A Vale of Gloucester Fringe, which includes:

- Soft gently undulating landform, with lower escarpment slopes forming a transitional area between the vale and escarpment
- Cotswolds Escarpment defines the eastern limit of the Vale and provides a dramatic backdrop to vale settlements and landscapes
- Mixed arable and pasture land use with occasional orchards
- Well maintained hedgerows forming a strong landscape pattern
- Limited woodland and ancient woodland cover
- Quiet winding lanes linking villages, hamlets and farms at the foot of the escarpment
- Varied mix of building materials, including use of brick, timber and stone and slate and thatch roofing, but with Oolitic Limestone still prevalent within the vale villages in closer proximity to the Cotswolds Escarpment
- Proliferation of modern ‘suburban’ building styles and materials
- Rural areas bordered by large urban and suburban areas and interspersed with commercial and industrial uses
- Major transport corridors through vale and widespread network of pylons and transmission lines

8.2.15. The Gloucestershire County Council combined landscape character assessment[33] identifies a total of 38 landscape character types. Within the study area, these correspond with the AONB LCTs and further information for the LCTs is obtained from the AONB documents.

Local Landscape Character

8.2.16. More locally, the topography of the landscape varies, with the escarpment forming a dominant feature. The well wooded nature of the area cloaks the rising landform as it climbs steeply from the neighbouring wolds. Away from woodland blocks, scattered trees pepper the grassland slopes towards more low-lying ground where linear belts of trees and shrubs and hedgerows define land parcels. Whilst generally rural in character, transport links traversing the landscape introduce detracting features to the landscape. The A417 is the main feature of this kind, although appears well screened from some areas in views with full leaf cover. There are a number of village settlements and individual houses and farmsteads across the study area. Heritage features are also a key characteristic within the study area with a Roman road through the village of Birdlip and several Scheduled Monument designations including former camps, barrows and an historic castle.

Visual

8.2.17. There are numerous visual receptors located within the likely ZTV for the Scheme. Visual receptors with a high sensitivity to change include people occupying residential properties, users of PRoW and those using recreational features for the enjoyment of the countryside. There are several village settlements as well as many more isolated properties throughout the study area. There are also frequent footpaths traversing the landscape, including two long distance footpaths, the Cotswold Way National Trail 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, Leckhampton Hill, The Peak and Cooper's Hill.

8.2.18. The existing A417 or traffic moving along it, is seen in elevated, panoramic views from the PRoW and publicly accessible land within the escarpment, including from parts of Crickley Hill, Barrow Wake and Cooper's Hill. From The Peak, views are more limited by the cover of woodland and other vegetation, particularly in summer months. Views from The Peak are mainly of sections of

[33] Gloucestershire County Council (2017) Combined landscape character assessment [online] available at: https://data.gov.uk/dataset/9db6b02c-6d03-4be7-85db-81faa642fb6b/gloucestershire-county-council-county-landscape-character-types (last accessed January 2019).

the A417 west of Air Balloon Roundabout. Panoramic views from Leckhampton Hill look south and include a part of the road between Air Balloon Roundabout and the B4070 junction.

8.2.19. From the low-lying vale, the A417 is typically obscured from view from the PRoW, hamlets and scattered properties, by layers of vegetation along boundaries or intervening landform and woodland.

8.2.20. Parts of the existing A417 are visible from a number of PRoW crossing the high wold LCT. However, many views from settlement, which predominantly comprises of scattered properties and farmsteads, are obscured by intervening landform and vegetation.

8.2.21. Residents and users of accessible land and rights of ways used for the enjoyment of the countryside are considered higher sensitivity visual receptors. Users of roads or those undertaking occupational work or at school, are considered lower sensitivity visual receptors.

8.3. Potential impacts

Construction

Potential landscape impacts

8.3.1. Throughout the construction period, there is potential for direct adverse impacts on landscape character due to the presence of construction plant, materials, machinery, construction compounds and the provision of construction lighting within AONB / rural landscape. The addition of new, albeit temporary, features would be at odds with existing landscape character.

8.3.2. There is potential for direct adverse impacts on the local landscape pattern, scale and land cover within the study area due to the removal of key landscape features such as sections of mature woodland or the severance of local field boundary vegetation. Road widening and a substantial cutting immediately to the south of Crickley Hill would impact on the tributary to Norman's Brook and require extensive tree removal, altering landscape character. The cutting would continue to the east and south-east of Emma's Grove, altering the high wold landscape character

8.3.3. The Scheme severs the Gloucester Way Long Distance Path and several PRoW within the high wold. It would cross areas of higher sensitivity at Shab Hill within the high wold, including broadleaf woodland and a dry valley. This would have impacts on landscape character and visual amenity arising from changes to landform and loss of the vegetation. A new link road to the B4070 would be constructed along part of an existing rural lane between Birdlip and Shab Hill, a

new junction formed to replace the Cowley roundabout and several new bridge structures constructed. Additionally, the route crosses a line of mature roadside trees and dry-stone walling near Stockwell which forms a distinctive landscape feature in the area. Loss of or alterations to the existing landscape features could adversely affect local landscape character.

8.3.4. The potential to de-trunk and remove parts of the existing A417 would have impacts on landscape character during construction, arising from the presence of plant, demolition activities and earthworks.

Potential visual impacts

8.3.5. Potential impacts upon the visual amenity baseline would occur for a variety of visual receptors. Impacts would arise from the presence of construction plant and associated activity, including the removal of vegetation and any lighting used within compounds, and at construction sites. The potential for parts of the A417 to be de-trunked and removed also has the potential for visual impacts during construction.

8.3.6. Removal of existing screening vegetation may also result in the opening up of views to the Scheme and adverse visual impacts, from a number of residential properties, PRoW, local roads and receptors with far reaching views, such as from Crickley Hill and Barrow Wake.

Operation

Potential landscape impacts

8.3.7. There is potential for local landscape character to be permanently altered, given the predominantly rural setting of this distinctive designated landscape, amplified by the stark topography along the line of the escarpment.

8.3.8. The presence of a new highway and associated cuttings, embankments, structures and ancillary highways infrastructure including any lighting and operational traffic movements, would be at odds with the surrounding landscape character. There would also be potential adverse impacts on local landscape character and pattern, due to the impact on existing landscape features such as vegetation, a watercourse and dry-stone walls.

8.3.9. The lower lying, western section of the route corridor broadly follows the existing highway, through an area of lower relative current sensitivity and of relatively lower tranquillity. However, road widening and vegetation loss to the south side of the existing A417 and deepening the cutting by Crickley Hill would have potential for adverse landscape impacts.

8.3.10. The Scheme would pass through a presently open and largely undisturbed high wold rural landscape between Air Balloon and the Cowley junction. While some parts of the Scheme within the high wold corridor would be located in areas of comparatively lower tranquillity, there is potential for adverse landscape impacts arising from the new road and ancillary structures.

8.3.11. The Scheme would cross the northern edge of the broadleaf woodland surrounding Emma's Grove Scheduled Monument, an important and valuable area of landscape. The cutting through the rural landscape between Air Balloon and Shab Hill would also result in severance and fragmentation of the existing landscape pattern.

8.3.12. The substantial new grade-separated junction at Shab Hill would be located in part within a secluded valley. There is potential for the valley landform to be permanently altered and for adverse impacts on a relatively tranquil area. There is also potential for the landscape impact of the junction highways infrastructure to extend into a relatively open area of the high wold surrounding the valley.

8.3.13. Sections of the A417, A436 and local roads would be altered, and new junctions and property access created. New earthworks would be created to address level changes. This would have potential to change the width and character of the roads and associated boundary features, resulting in local landscape change. Part of an existing lane would be used for the proposed link road to Birdlip with the potential to recreate a rural road character.

8.3.14. Several new overbridges or underbridges, including a green bridge, would be introduced to a part of the landscape that is relatively void of such structures. In addition, the complex topography through which the Scheme would pass would require a series of cuttings and embankments, as well as new retaining structures, with potential to change local landform and landscape character.

8.3.15. Any PRoW affected by the construction work would be reinstated, although there is potential for parts of some PRoW to be permanently diverted, or to cross the Scheme route via a new structure or signalised crossing. There is potential for beneficial effects where user safety or experience can be improved.

Potential visual impacts

8.3.16. Due to the sensitivity of receptors within a predominantly rural setting, as well as elevated views from parts of the surrounding area, there is the potential for impacts upon visual receptors during operation where views towards the new road and highways infrastructure would be afforded. Where vegetation has been removed, views may be opened up to the new road and moving traffic. Proposed

cuttings and potential false cuttings and embankments have the potential to limit both landscape and visual impacts.

8.3.17. There is potential for any required lighting at junctions to be located in close proximity to the visually prominent top of the scarp, or to impact on rural parts of the high wold and high wold valley. This may lead to increased visual impacts during both daylight hours with the presence of additional vertical elements of the Scheme and night time effects associated with lighting in an otherwise dark landscape.

8.4. Design, mitigation and enhancement measures

Construction

8.4.1. Measures that would contribute to the reduction of construction effects on landscape character and visual amenity and which would be delivered through the Construction Environmental Management Plan (CEMP) include the following:

- Establishing site compounds, haul road selection and material stores away from topographical high points and away from receptors or viewpoints.
- Screening plant or compounds using stored soils or through temporary screening planting.
- Limiting both temporary and permanent land take, where possible.
- Keeping a tidy site, including stockpiled materials and earthworks.
- Delivery of goods on an as-needed basis.
- Limiting works to daylight hours in the most part, with any night works to be kept to a minimum.
- Using minimal, low level and directional lighting for compound security and night works, whilst successfully meeting safety requirements.

8.4.2. Existing trees and vegetation to be retained would be protected with fencing, where deemed necessary, in accordance with BS 5837:2012.

8.4.3. Access for non-motorised users (NMU) via the network of PRoW, open access land and public viewing points would also be maintained where practicable, through temporary diversions along safe, alternative routes. Further details are set out in Chapter 13 Population and Human Health.

Operation

8.4.4. Notable variations in local topography may have the potential to reduce the effect on neighbouring landscape character in localised areas, although substantial landform and planting mitigation measures would still be required. Mitigation planting and earthworks would seek to reduce the long-term effect

upon landscape character, by reflecting local topography and landform and thereby helping the Scheme to settle within the surrounding landscape over time. A key focus of the mitigation measures during design evolution would be the conservation and enhancement of the special character of the Cotswolds AONB, reflecting the character of the local landscape. The design would also seek to avoid direct loss of and intrusion into areas owned and managed for conservation, open access and recreation. The Scheme would be designed to achieve landscape, ecological and heritage benefits, through restoration and creation of elements and features, as well as improved connectivity. In turn, these interventions would support a better visitor experience.

8.4.5. All mitigation design would be consistent with the Scheme objectives, objectives of the Cotswolds AONB Management Plan, the AONB Landscape Strategy and Guidelines and Cotswolds District Council's Cotswolds Design Code.

8.4.6. Considered use of any required lighting is important, such as keeping columns to the necessary height and use of directional luminaires to reduce impacts on nearby settlements and the wider night sky. Should the future lighting assessment determine that lighting is required in any part of the Scheme, measures would be taken to ensure that this does not result in significant adverse impacts on dark skies, tranquillity and views across the landscape.

8.4.7. The use of sensitive design, detailing and a quality materials palette for built infrastructure would also help to reduce the operational landscape effects. For example, new structures should seek to achieve a low solid to void ratio with careful consideration given to colour, form and materials.

8.4.8. Further general approaches to mitigation design would include further modifications of the horizontal and vertical alignment of the route including junctions wherever practicable, keeping it sensitive to the landform as much as possible. This would be strengthened with the use of earth bunds and false cuttings as appropriate, as well as planting to aid the integration of the Scheme with the surrounding landscape. Consideration would also be given to the form of link roads and property access in relation to local landscape character and landscape features.

8.4.9. The planting design would contribute to special character by responding to the existing, typical features of the AONB character types. Examples include: the well-maintained hedgerow pattern of the vale; woodland copses of the high wold valleys; broadleaved plantations and shelterbelts of the high wold; and rough grassland and enclosed woodland of the escarpment. There could be areas where planting may be minimal, reflecting an open character and enabling continuity of views across the landscape. The planting design would be developed through a collaborative, illustrative design process. This would

consider the landscape proposals in combination with mitigation relating to visual and audible amenity, biodiversity, heritage, NMU access and waterbodies.

8.4.10. Whilst planting would not be effective during year one of operation, its screening and integration functions would increase over time as planting establishes and matures.

8.4.11. The mitigation design would also be responsive to the special qualities of the AONB. In particular, opportunities would be sought to extend and connect limestone grasslands and broadleaved woodland, to reinstate dry stone wall boundaries and provide new walls as highway boundary treatments, and to integrate Cotswold Stone into the Scheme structures. Emphasis would be placed on reinforcing the physical and visual connections between landscape areas, heritage assets, areas of biodiversity and PRoW in order to ensure a functioning and connected green infrastructure network. Mitigation would also be considered in the context of the Environmental Designated Funds projects that are proposed independent of the Scheme.

8.4.12. Potential enhancement opportunities include the construction of a green bridge, designed to integrate with and provide connectivity across the landscape; improved interpretation at the sites of Scheduled Monuments associated with the upper scarp; de-trunking of sections of the existing A417; and restoration of boundary features and vegetation beyond the footprint of the Scheme, where this offers the opportunity to contribute to landscape improvements, in combination with biodiversity and heritage improvements.

8.4.13. At the time of writing, the position, form, function and scale of the green bridge is subject to discussion with stakeholders through the Landscape, Environmental and Heritage Technical Working Group meeting. For the purpose of this scoping assessment, the green bridge is assumed to be 50 metres wide and linking Crickley Hill with Barrow Wake.

8.5. Description of the likely significant effects

Construction

Likely significant landscape effects

8.5.1. During construction, there is potential for significant adverse effects upon landscape character. This would be due to the changes to and loss of landscape features such as existing woodland and field boundaries, water bodies, PRoW and built form, to accommodate construction of the new road.

8.5.2. There would also be the addition of new features such as construction plant, machinery and lighting, as well as substantial earthworks, which would be at odds with an otherwise essentially rural scene.

8.5.3. Mitigation measures would be put in place that would reduce the landscape effects as far as possible. However, given the scale and extent of the works in a sensitive landscape, significant adverse effects would be likely to occur during the construction phase.

A436 Link Road Alternative 1: bridge over A417

8.5.4. The construction of the A436 overbridge would give rise to significant adverse effects on landscape character around Air Balloon. Tall cranes may be required to construct the bridge and temporary formwork may be present. Vegetation removal and earthworks to accommodate the bridge footings and to construct the Leckhampton Hill / A436 junction and link roads to Birdlip and Shab Hill would also contribute to significant adverse effects on the landscape character of the local area.

A436 Link Road Alternative 2: parallel to the A417

8.5.5. During construction, there would be significant adverse effects associated with construction of the A436 link road in cutting to the north-east of Air Balloon.

8.5.6. As with A436 Link Road Alternative 1: bridge over A417, there would be significant landscape impacts from this A436 Link Road Alternative arising from the construction of the Shab Hill junction and link road to Birdlip. However, this A436 Link Road Alternative does not require construction of the A436 overbridge and does not retain the A417 link to Birdlip.

A436 Link Road Alternative 3: via South Hill

8.5.7. During construction, there would be potential for significant adverse effects on the landscape character of the Upper Churn valley at South Hill. Construction work would result in the loss of an unsurfaced rural lane, removal of trees and dry-stone walling, impacts on the connectivity of two PRoW and impacts on part of the publicly accessible Barber Wood. Significant impacts may also occur to two properties where a roundabout is constructed on the A436, dependent upon the space requirements for the road infrastructure. It is not known at this stage whether this would result in the loss of the properties.

8.5.8. As with A436 Link Road Alternative 1: bridge over A417, there would be significant landscape impacts from this A436 Link Road Alternative arising from the construction of the Shab Hill junction and link road to Birdlip. However, this

A436 Link Road Alternative does not require construction of the A436 overbridge and does not retain the A417 link to Birdlip.

Likely significant visual effects

8.5.9. During construction, there is potential for significant adverse effects on the visual receptors within the one kilometre study area, as well as some elevated, far reaching views beyond (this would include but not be limited to users of Open Access land and PRoW on open parts of the escarpment). The effects would arise from views to site works, movement of plant and earthworks, as well as removal of vegetation, which would further open up some views. Lighting required for construction and within compounds may also give rise to significant visual effects.

8.5.10. Mitigation measures would be put in place that would reduce the visual effects as far as possible. However, given the scale and extent of the works in a sensitive landscape, significant adverse effects would occur during the construction phase.

A436 Link Road Alternative 1: bridge over A417

8.5.11. The construction of the A436 overbridge would give rise to significant adverse effects on views to the crest of the scarp around Air Balloon. Work to construct the Leckhampton Hill / A436 junction, Shab Hill junction and link roads would also contribute to significant adverse effects on views toward this area, particularly for users of nearby PRoW and accessible open space and occupants of isolated properties in the area.

A436 Link Road Alternative 2: parallel to the A417

8.5.12. Significant adverse visual effects are predicted for users of several PRoW and publicly accessible open space in association with the construction of the cutting for the parallel link to the existing A436.

8.5.13. Compared to A436 Link Road Alternative 1: bridge over A417, significant visual effects may be slightly reduced south of Air Balloon, since this A436 Link Road Alternative does not include an overbridge. However, construction of the Shab Hill junction and link road would give rise to significant visual effects.

A436 Link Road Alternative 3: via South Hill

Significant adverse visual effects are predicted for users of several PRoW and occupants of isolated properties near South Hill, including users of accessible land at Barber Wood.

8.5.14. Compared to A436 Link Road Alternative 1: bridge over A417, significant visual effects may be slightly reduced south of Air Balloon, since this A436 Link Road Alternative does not include an overbridge or link roads in this area. However, as with A436 Link Road Alternative 1: bridge over A417, construction of the Shab Hill junction and link road would give rise to significant visual effects.

Operation

Likely significant landscape effects

8.5.15. During operation, there is potential for significant adverse effects upon landscape character. This would be associated with the presence of the new road and associated infrastructure in a predominantly rural landscape. The Scheme would result in change to part of the Cotswolds AONB, and area of high landscape value and marked changes in local topography.

8.5.16. There would be potential for significant adverse effects upon both audible and visual tranquillity, which may include effects due to permanent lighting.

8.5.17. Effects on loss of existing landscape features would be mitigated as far as possible with replacement planting.

8.5.18. Ground modelling would help to mitigate landscape and visual effects while replacement and additional planting would help to mitigate effects over time. However, not all landscape effects may be fully mitigated for.

A436 Link Road Alternative 1: bridge over A417

8.5.19. The A436 overbridge would be a substantial new structure located at the crest of the escarpment, with potential to result in significant landscape change in this location. However, the bridge would also have significant beneficial effects on the safety of PRoW users following the Cotswolds Way between Crickley Hill and Barrow Wake, or crossing to the Gloucestershire Way.

8.5.20. There would be significant adverse landscape effects associated with the Shab Hill junction and link roads. This would be due to the land take, impacts on vegetated and walled boundaries, changes to the width and character of roads, and creation of new roads through farmland.

8.5.21. A436 Link Road Alternative 1: bridge over A417 may have significant beneficial effects arising from the potential to de-trunk parts of the A417 at Barrow Wake and between the Birdlip and Stockwell junctions. This would be with associated with the potential for restoration of landscape and ecological features, and improvements to PRoW connectivity and audible and visual tranquillity, while enhancing the eastern landscape setting to Birdlip.

A436 Link Road Alternative 2: parallel to the A417

8.5.22. There would be significant landscape effects arising from the creation of the cutting for the parallel link road.

8.5.23. As with A436 Link Road Alternative 1: bridge over A417, there would be significant landscape impacts in this A436 Link Road Alternative, arising from the construction of the Shab Hill junction and link road to Birdlip. However, this A436 Link Road Alternative does not require construction of the A436 overbridge.

8.5.24. This A436 Link Road Alternative may have significant beneficial effects arising from the potential to de-trunk a notable section of the A417 from Air Balloon to the Stockwell junction. This would be with associated with the potential for restoration of landscape and ecological features, and improvements to PRoW connectivity and audible and visual tranquillity, while enhancing the eastern landscape setting to Birdlip.

A436 Link Road Alternative 3: via South Hill

8.5.25. During operation, this A436 Link Road Alternative would have significant adverse effects on the landscape character of the Upper Churn valley at South Hill due to the permanent loss of a rural lane and introduction of a new highway, earthworks and moving traffic in a relatively tranquil part of the landscape.

8.5.26. As with A436 Link Road Alternative 1: bridge over A417, there would be significant landscape impacts in this A436 Link Road Alternative, arising from the construction of the Shab Hill junction and link road to Birdlip. However, this A436 Link Road Alternative does not require construction of the A436 overbridge.

8.5.27. This A436 Link Road Alternative may have significant beneficial effects arising from the potential to de-trunk a notable section of the A417 from Air Balloon to the Stockwell junction. This would be associated with the potential for restoration of landscape and ecological features, and improvements to PRoW connectivity and audible and visual tranquillity, while enhancing the eastern landscape setting to Birdlip.

Likely significant visual effects

8.5.28. During operation, there is potential for significant adverse effects relating to views and visual tranquillity from sensitive visual receptors looking towards the proposed Scheme in year one. Effects would arise where views towards the new road, moving vehicles and highways infrastructure may be afforded, reducing over time with the establishment of mitigation planting.

8.5.29. Planting, where appropriate, along the route corridor would contribute to breaking up the views to passing traffic as well as the road itself. However not all visual effects may be fully mitigated for.

A436 Link Road Alternative 1: bridge over A417

8.5.30. There is potential for significant adverse visual effects associated with the A436 overbridge and road infrastructure and moving traffic around Barrow Wake. This may affect views from parts of Crickley Hill, Barrow Wake and The Peak, and from several local PRoW and isolated residential properties.

8.5.31. However, the potential to de-trunk parts of the A417 may have beneficial effects on views and audible tranquillity for several PRoW within the high wold and residential properties at the east edge of Birdlip.

A436 Link Road Alternative 2: parallel to the A417

8.5.32. There is potential for significant adverse visual effects arising from the cutting required for the A436 link road, from local PRoW and publicly accessible open space.

8.5.33. However, the potential to de-trunk parts of the A417 may have beneficial effects on views and audible tranquillity for several PRoW within the high wold and residential properties at the eastern edge of Birdlip.

A436 Link Road Alternative 3: via South Hill

8.5.34. There is potential for significant adverse visual effects arising from the A436 link road, for users of accessible land at Barber Wood and several PRoW and isolated properties near South Hill.

8.5.35. However, the potential to de-trunk parts of the A417 may have beneficial effects on views and audible tranquillity for several PRoW within the high wold and residential properties at the eastern edge of Birdlip.

8.6. Assessment methodology

Proposed level and scope of assessment

8.6.1. Given that significant adverse effects upon both landscape character and visual amenity are likely during both construction and operation, the Scheme meets the criteria set out in IAN 135/10 Landscape and Visual Effects Assessment, to undertake further assessment to a Detailed level.

Policy requirements, guidance and advice

8.6.2. Guidance and best practice will be followed to industry standards, with particular reference to:

- DMRB Volume 11 Section 3 Part 5 Landscape Effects[34]
- DMRB Interim Advice Note 135/10 (IAN 135/10) Landscape and Visual Effects Assessment[35]
- Guidelines for Landscape and Visual Impact Assessment, third edition (GLVIA 3)[36]
- An Approach to Landscape Character Assessment[37]

Determination of significant effects

Proposed methodology

8.6.3. An assessment of the likely effects of the Scheme on both landscape and visual amenity will be made. The process for assessing significance of effects is the same for both the construction and operational phases. Professional judgement is also an important factor in establishing the magnitude and significance of effects for each receptor.

8.6.4. No single prescribed methodology exists for assessing landscape and visual impact. However, the assessment of landscape and visual effects will follow best practice guidelines as set out in Section 8.6.2 above. This will identify the landscape and visual baseline including value and sensitivity to change, prior to considering the magnitude of change and resulting significance of effects.

8.6.5. A desktop study and walkover survey will be undertaken to review and update the baseline information gathered in previous assessments. This will clarify both the study area and ZTV and allow the project Landscape Architect to undertake a local character assessment to understand the landscape value and associated sensitivity to change of each character area.

Assessment of value / sensitivity

8.6.6. The significance of effect upon landscape character will consider the combination of the magnitude of change against the quality, value and sensitivity

[34] Highways England (1993) DMRB Volume 11 Section 3 Part 5 Landscape Effects.
[35] Highways England (2010) IAN 135/10 Landscape and Visual Effects Assessment.
[36] Landscape Institute and Institute of Environmental Management and Assessment (2013) Guidelines for Landscape and Visual Impact Assessment, Third edition.
[37] Natural England (2014) An Approach to Landscape Character Assessment https://www.gov.uk/guidance/landscape-and-seascape-character-assessments (last accessed January 2019).

to change of the affected landscape. The criteria for assessing landscape sensitivity is presented in Table 8.2 and the criteria for assessing magnitude of impact on landscape is presented in Table 8.3.

Table 8.2: Criteria for assessing landscape sensitivity

Potential Value	Typical Descriptors
High	Landscapes, which by nature of their character, would be unable to accommodate change of the type proposed. Typically, these would be: • Of high quality with distinctive elements and features making a positive contribution to character and sense of place • Likely to be designated e.g. National Park and AONB, but the aspects which underpin such value may also be present outside designated areas, especially at the local scale • Areas of special recognised value through use, perception or historic and cultural associations • Likely to contain features and elements that are rare and could not be replaced
Moderate	Landscapes, which by nature of their character, would be able to partly accommodate change of the type proposed. Typically, these would be: • Comprised of commonplace elements and features creating generally unremarkable character but with some sense of place • Locally designated, or their value may be expressed through non-statutory local publications • Containing some features of value through use, perception or historic and cultural associations • Likely to contain some features and elements that could not be replaced
Low	Landscapes which by nature of their character would be able to accommodate change of the type proposed. Typically, these would be: • Comprised of some features and elements that are discordant, derelict or in • decline, resulting in indistinct character with little or no sense of place • Not designated • Containing few, if any, features of value through use, perception or historic and • cultural associations • Likely to contain few, if any, features and elements that could not be replaced

Source: IAN 135/10

Table 8.3: Criteria for assessing magnitude of impact on landscape

Magnitude	Description
Major Adverse	Total loss or large-scale damage to existing character or distinctive features and elements, and / or the addition of new but uncharacteristic conspicuous features and elements.
Moderate Adverse	Partial loss or noticeable damage to existing character or distinctive features and elements, and / or the addition of new but uncharacteristic noticeable features and elements.

Minor Adverse	Slight loss or damage to existing character or features and elements, and / or the addition of new but uncharacteristic features and elements.
Negligible Adverse	Barely noticeable loss or damage to existing character or features and elements, and / or the addition of new but uncharacteristic features and elements.
No Change	No noticeable loss, damage or alteration to character or features or elements.
Negligible Beneficial	Barely noticeable improvement of character or views by the restoration of existing features and elements, and / or the removal of uncharacteristic features and elements, or by the addition of new characteristic elements.
Minor Beneficial	Slight improvement of character or views by the restoration of existing features and elements, and / or the removal of uncharacteristic features and elements, or by the addition of new characteristic elements.
Moderate Beneficial	Partial loss or noticeable damage to existing character or distinctive features and elements, and / or the addition of new but uncharacteristic noticeable features and elements.
Major Beneficial	Slight loss or damage to existing character or features and elements, and / or the addition of new but uncharacteristic features and elements.

Source: IAN 135/10

8.6.7. Visual receptors will be visited to identify the nature of the existing view and the likely magnitude of change upon that receptor as result of the Scheme. The detailed assessment to be produced as part of the Environmental Statement will address principal representative viewpoints within the study area. This will consider views from prominent public viewpoints and National Trails in key locations and visual receptors with potential to experience significant adverse visual effects. This will include residential properties, PRoW, Open Access land, local roads and recreational areas.

8.6.8. In addition, several elevated views exist outside of the defined study area, including views from Cooper's Hill and Leckhampton Hill.

8.6.9. Visual effect significance will be determined by combining the sensitivity of the visual receptor, in conjunction with the magnitude of change. Magnitude will be assessed on the basis of the scale of the change in view, as well as the duration and distance of visual receptors concerned from the proposed works.

8.6.10. The criteria for assessing visual sensitivity is presented in Table 8.4 and the criteria for assessing magnitude of impact on visual amenity is presented in Table 8.5.

Table 8.4: Criteria for assessing visual sensitivity

Potential Value	Typical Descriptors
High	Residential properties. Users of PRoW or other recreational trails (e.g. National Trails, footpaths, bridleways, etc.).

	Users of recreational facilities where the purpose of that recreation is enjoyment of the countryside (e.g. Country Parks, National Trust or other access land, etc.).
Moderate	Outdoor workers. Users of scenic roads, railways or waterways or users of designated tourist routes. Schools and other institutional buildings, and their outdoor areas.
Low	Indoor workers. Users of main roads (e.g. trunk roads) or passengers in public transport on main arterial routes. Users of recreational facilities where the purpose of that recreation is not related to the view (e.g. sports facilities).

Source: IAN 135/10

Table 8.5: Criteria for assessing magnitude of impact on visual amenity

Magnitude	Description
Major	The project, or a part of it, would become the dominant feature or focal point of the view.
Moderate	The project, or a part of it, would form a noticeable feature or element of the view which is readily apparent to the receptor.
Minor	The project, or a part of it, would be perceptible but not alter the overall balance of features and elements that comprise the existing view.
Negligible	Barely noticeable loss or damage to existing character or features and elements, and / or the addition of new but uncharacteristic features and elements.

Source: IAN 135/10

Significance

8.6.11. The assessment of the significance of effect is undertaken by combining the sensitivity to change of a receptor with an assessment of the magnitude of change (impact) put upon it. The Detailed assessment process will determine the degree of significance of effect for all the identified landscape and visual receptors in accordance with Table 8.6. Effects that are assessed as Moderate, Large and Very Large are deemed to be significant. Effects that are assessed as Slight and Negligible are deemed to be not significant.

Table 8.6: Significance of effect categories

Sensitivity	Magnitude of Impact					
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
	High	Neutral	Slight	Slight / Moderate	Moderate / Large	Large / Very Large
	Moderate	Neutral	Negligible / Slight	Slight	Moderate	Moderate / Large

	Low	Neutral	Negligible / Slight	Negligible / Slight	Slight	Slight / Moderate

Source: Derived from IAN 135/10

8.7. Assessment assumptions and limitations

8.7.1. This assessment has drawn on desk study information together with several site visits undertaken during 2017, 2018 and 2019. The use of landscape designation information as well as understanding the physical features of the local landscape help to understand the likely sensitivity of the landscape character and visual receptors and the potential effects upon those assets.

8.7.2. Further site visits by a qualified Landscape Architect will be undertaken to fully inform the Detailed level assessment. Recording of existing visual condition will be based on accessing the nearest publicly accessible location to private properties. No private property or dwelling will be entered for the purpose of the assessment.

8.7.3. The assessment will not consider effects of the Scheme on the setting of heritage assets. Views will be considered as part of the assessment of effects on visual amenity.

8.7.4. In this chapter, reference to the 'Air Balloon roundabout' refers to the existing roundabout. In the proposed Scheme, the roundabout would be removed, allowing the A417 to pass directly from the escarpment into the high wold landscape. Therefore, when referring to this location in the landscape 'Air Balloon' is used.

8.7.5. The existing A417 includes lighting columns at the Air Balloon Roundabout and Cowley junction. At the time of writing, a lighting assessment had not been undertaken, and in this chapter, it has been assumed that that lighting may re-provided within the Scheme.

8.7.6. Given that significant effects upon both landscape character and visual amenity are likely for the Scheme during both construction and operation, the Scheme meets the criteria set out in IAN 135/10 Landscape and Visual Effects for a Detailed level of assessment. This will build upon the previous work undertaken to date and will be presented in the form of an Environmental Statement chapter.

9. Geology and soils

9.1. Study area

9.1.1. No study area for geology and soils is specified within the Design Manual for Roads and Bridges (DMRB) Volume 11 Section 3 Part 11.

9.1.2. The study area for the assessment of geology and soils encompasses the area over which the Scheme could be reasonably expected to have an effect. With respect to geology and soils this generally only relates to the areas anticipated to be directly disturbed by the proposed physical works and ground disturbance. However consideration of a wider study area outside the Scheme is necessary for the following reasons:

- The presence of potential off-site contamination sources which have the potential to migrate on-site (areas of landfill or historic potentially contaminative land use for example) and any sensitive off-site receptors which may feasibly be affected by the uncontrolled migration of contaminants off-site. Methods of contaminant transport may include migration of leachates and ground gases. Although the setting of the site (both historically and currently) has been primarily agricultural in nature with a lack of urban development, given the highly permeable underlying bedrock and lack of superficial deposits a 500-metre buffer is considered to be reasonable to capture the significant environmental effects of the Scheme. Five-hundred metres from the Scheme is also considered to be appropriate to capture the likely extent of impact pathways.
- BS10175 states “the extent of research into the history of the site will depend upon a number of factors including the complexity of past potentially contaminative uses on and adjacent to the site, the vulnerability of the site geology and local water environment”. Therefore, the study area also extends beyond 1 kilometre from the Scheme boundary for sensitive off-site receptors which have the potential to be impacted by quality or quantity effects on underlying groundwaters as a result of Scheme construction. This includes localised perched groundwaters, any aquifer units located below or down-gradient of the study area and any groundwater source protection zones (SPZs).

9.2. Baseline conditions

9.2.1. An additional source of information used to inform this chapter is the A417 Missing Link Preliminary Sources Study Report (PSSR). This report included a summary of information from a large number of historic reports available from the

Highways Agency Geotechnical Data Management System (HAGDMS) website[38] along with a review of previous Ground Investigations (GI) which have been undertaken within the vicinity of the Scheme, and a Landmark Envirocheck Report.

9.2.2. Where publicly available data has been utilised, the references are included as footnotes.

Geological setting

9.2.3. A number of British Geological Survey (BGS) published maps, geological memoirs and technical documents have been referenced within the PSSR to assess the geology of the Scheme area.

Solid geology

9.2.4. According to the BGS mapping, the topography and landform of the area reflects the underlying geology, which is dominated by the Cotswold Escarpment and dip-slope. The bedrock of the area is characterised by rocks of the Jurassic period comprising (from oldest to youngest) the Lias Group, the Inferior Oolite Group and the Great Oolite Group (predominantly limestones, mudstones, sandstones, siltstones, marls, clays). The escarpment is a significant feature on the landscape defined by the Jurassic Limestone Outcrop at the crest and the Scheme is located on the escarpment. The top of the escarpment is underlain by the Great and Inferior Oolite Groups (the Inferior Oolite is the main scarp-forming rock in this area of the Cotswolds) which dip gently to the south-east. Lower down the escarpment, the Lias Group lies below the Oolite Groups, however it is largely buried by ancient mass movement and instability deposits.

[38] Highways England (2018) Highways Agency Geotechnical Data Management System (HAGDMS) [online] available at: https://data.gov.uk/dataset/highways-agency-geotechnical-data-management-system-hagdms

Superficial and mass movement deposits

9.2.5. The BGS information and previous GI reporting indicates that the majority of the study area does not appear to be underlain by superficial deposits, although a tract of Cheltenham Sand and Gravel is shown to be underlying the western-most section of the Scheme (originating on the existing A417).

9.2.6. According to BGS mapping, the whole of the escarpment is covered by mass movement deposits with localised mass movement deposits also recorded in the relatively shallow valleys on the dip slope. The Scheme would cross the area of landslide deposits associated with the Cotswold Escarpment.

Structural geology

9.2.7. In general, the strata dip very gently (2-5°) to the south-east and east but are subject to local variations.

9.2.8. Mapped and named normal faults in the vicinity of the Scheme comprise the Stockwell, Shab Hill Barn and Shab Hill faults trending roughly north-west to south-east and approximately parallel with each other.

9.2.9. Solution features, fissures and gulls may be present through the Limestone, though generally the Jurassic Limestones are recorded to have limited development of Karst landforms.

Hydrogeology

Superficial deposits

9.2.10. Magic mapping[39] shows that the Cheltenham Sand and Gravel superficial deposits are classified as Secondary A aquifers. The Environment Agency defines a 'Secondary A' aquifer as "*permeable layers capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of base flow to rivers, these are generally aquifers formerly classified as minor aquifers*"[40].

9.2.11. Locally, the mass movement deposits may be perched, or leak to / receive leakage from the underlying bedrock, depending on relative groundwater heads.

[39] Defra (2019) Multi Agency Geographic Information for the Countryside website [online] available at: www.magic.defra.gov.uk

[40] Environment Agency (2019) Aquifer Designation Map (Superficial Deposits) [online] available at: https://data.gov.uk/dataset/ef2399f1-acf4-45a7-abf3-c7369c0c8640/aquifer-designation-map-superficial-deposits

Bedrock

9.2.12. The Great Oolite Group and Inferior Oolite Group are classified as Principal Aquifers[39]. These are separated by a layer of the less permeable Fuller's Earth (although leakage can occur where the Fuller's Earth is thin or faulted). The Environment Agency defines a 'Principal' aquifer as "*layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and / or river base flow on a strategic scale*"[40]. The very top of the Lias Group (Bridport Sand) may also be considered to be a Principal Aquifer due to hydraulic continuity with the base of the Inferior Oolite Group.

9.2.13. The Great and Inferior oolite outcrop is extremely vulnerable to pollution due to the absence of overlying, low-permeability superficial deposits.

9.2.14. The Charmouth Mudstone Formation, Whitby Mudstone Formation, Bridport Sand Formation, Dyrham Formation and Marlstone Rock Formation are classified as a Secondary (undifferentiated) Aquifer[40]. This is defined as "*having been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type*".

Regional hydrogeology

9.2.15. A groundwater divide is understood to be present in the vicinity of the Cotswold escarpment, with aquifers draining to the Thames Catchment to the east (River Churn and its tributaries) and the River Severn to the west (via River Frome and Horsbere Brook)[41]. The Scheme is likely to straddle both the Thames and Severn Catchments.

Abstractions

9.2.16. A major public water supply groundwater source is located at Baunton, around 11 kilometres south-east of the Scheme. The associated groundwater SPZ3 (total catchment) is located immediately adjacent to the southern end of the Scheme and the Scheme encroaches across the SPZ3 boundary.

9.2.17. Most groundwater abstraction takes place from the Great and Inferior Oolite to the south and east, and there is therefore very little data available for boreholes within the study area. Local groundwater abstractions are generally small and

[41] Environment Agency (2019) Catchment Data Explorer [online] available at: http://environment.data.gov.uk/catchment-planning/

used for domestic, agricultural and commercial purposes. There may also be unlicensed abstractions.

9.2.18. There are also a number of surface water extractions from the Frome and Churn.

Groundwater dependent hydrological features

9.2.19. A number of springs and drains are present issuing from the face of the escarpment to form streams that become the headwaters of the River Frome at Nettleton.

9.2.20. Springs generally occur locally at the contact between the more impermeable strata within the Upper Lias and the Inferior Oolite / Bridport Sand, and at the contact between the Fuller's Earth and overlying Great Oolite. Springs may also be structurally controlled or associated with hard bands in the aquifer.

9.2.21. Horsbere Brook, a seasonal stream connected to the River Severn, rises from springs on the escarpment and flows along the incised valley down Crickley Hill. Additional spring-fed streams flow into Witcombe Reservoir, which in turn discharges to Horsbere Brook just upstream of Brockworth, close to the A417 / A46 junction.

Designated sites of geological interest

9.2.22. Crickley Hill and Barrow Wake Site of Special Scientific Interest (SSSI) is located immediately adjacent to the Scheme. The site is partly designated due to the rock exposures along the southern slopes of Crickley Hill which make up a key Jurassic locality showing a major section in the Lower Inferior Oolite. The site was formerly known as Crickley Hill and included a small part of a former site known as Tuffley's Quarry (described as 'a valuable exposure of the Inferior Oolite Group, illustrating the progressive loss of section from the 'Cleeve Hill Syncline' westward towards the 'Birdlip Anticline'). The site is also designated as a Geological Conservation Review site.

9.2.23. Additional designated sites of geological interest that are located within 500 metres of the Scheme include:

- Knap House Quarry, Birdlip SSSI which is designated due to exposures of Middle Jurassic sediments belonging to the Alenian and Bajocian Stages.
- Bushley Muzzard SSSI which is an area of marshland that has the potential to be impacted by changes in groundwater levels / quality and drainage.
- Cotswold Commons and Beechwoods SSSI which includes areas of calcareous pastures (resulting from the underlying limestone bedrock) and disused limestone mines are understood to be present in the area.

9.2.24. The Scheme is located within the Cotswolds Area of Outstanding Natural Beauty (AONB) which is partly designated due to the geology of the area which creates its distinctive landscape.

Soil and geological resources

Soil quality (including agricultural land as a national resource)

9.2.25. Several post-1988 Agricultural Land Classification (ALC) surveys[42] have been undertaken within the vicinity of the Scheme's western footprint (between Crickley Hill and Brockworth either side of the A417). Within the extents of the surveyed area it was confirmed that the majority of the land is Grade 3b, with smaller pockets of Grade 3a best and most versatile (BMV) land. A very small amount of Grade 4 land is also present. Provisional ALC maps (MAFF, 1976)[43] indicate that the majority of land within the study area for the Scheme is Grade 3 (which is either Grade 3a (Good quality) or Grade 3b (Moderate quality) land) with a small amount of Grade 4 (Poor quality) ALC land present[44].

Geological resources and mining

9.2.26. A number of old quarries and gravel pits are indicated on current and historic mapping[45] to the north of the A417 west of the Air Balloon roundabout and to the east of the A417 south and east of the roundabout. Historically, quarrying of Inferior Oolite was a major industrial activity across Crickley Hill and Leckhampton Hill (to the north-east) with records existing from the late 16th Century to the mid-1920s. The Cleeve Cloud member of the Birdlip Limestone Formation was the most important unit used for Building Stone in the Cotswolds, providing a thick succession of massive, uniform oolite.

9.2.27. See Chapter 11 Material Assets and Waste for details of mineral safeguarding areas.

9.2.28. There is the potential for mining instability in Birdlip associated with limestone extraction.

[42] Natural England (2015) *Agricultural Land Classification (ALC) Grades – Post 1988 Survey (polygons)* [online] available at: https://data.gov.uk/dataset/c002ceea-d650-4408-b302-939e9b88eb0b/agricultural-land-classification-alc-grades-post-1988-survey-polygons
[43] www.magic.defra.gov.uk, Multi Agency Geographic Information for the Countryside website, accessed 27/07/18
[44] https://data.gov.uk/dataset/952421ec-da63-4569-817d-4d6399df40a1/provisional-agricultural-land-classification-alc; accessed 27/07/18
[45] https://www.old-maps.co.uk/, accessed 27/07/18

Potential contamination risks

9.2.29. Table 9.1 summarises potentially contaminated land uses and landfills identified using the PSSR data, Magic mapping (including Ordnance Survey (OS) online mapping)[39] within the study area.

Table 9.1: Summary of potentially contaminative land uses and landfills

Land use	Potential contaminants	Location
Crickley Lodge Historic Landfill (6 Individual Cells)	Inert Waste	Adjacent to the northern footprint of the Scheme in the vicinity of Crickley Hill. Adjacent to approximate Ch. 600-1,000m.
Potentially backfilled quarries	Unknown – potentially a range of organic and inorganic contaminants.	Areas adjacent to the north of the existing A417 to the west of the Air Balloon roundabout and to the east of the existing A417 to the south of the roundabout.
Tractor machinery and plant sales	Hydrocarbons, anti-freeze (ethylene glycol), brake fluids (polymerised glycols and ethers).	Crickley Hill Tractors, east of the existing A417 approximate Ch. 1,400m.
Coach hire services		Immediately south of existing A417 (potentially being removed) on Cirencester Road (Ermin Way Works).
Birdlip Quarry Motocross track		Crossed by Scheme at approximate Ch. 5,000m.
General highway use		Chainages currently in highway use.
Made ground associated with construction of the current highway network	Unknown – potentially a range of organic and inorganic contaminants.	Chainages currently in highway use.
Agricultural land use and farms	Animal manure – Heavy metal accumulations in soil. Fertilisers and agrochemicals. Organic contamination.	Chainages currently in agricultural / farm use.

9.3. Potential impacts

Construction

9.3.1. The Crickley Hill and Barrow Wake SSSI (with nationally important geological features) is located immediately adjacent to the Scheme (north of the existing A417 to the west of the Air Balloon Roundabout) and to the immediate west (south of the existing A417). There is the potential for intrusion within the SSSI if the section of the existing A417 between Barrow Wake and the Stockwell access is removed. The Scheme would extend across the escarpment line to the south of the A417.

9.3.2. Some structures, for example the proposed green bridge, are expected to extend within the SSSI boundary and across the escarpment line to the north of the A417

which would result in a permanent adverse impact upon a small section of nationally important geological exposures in this area.

9.3.3. Bushley Muzzard SSSI marshland may be adversely impacted by changes in groundwater levels or quality.

9.3.4. No impacts are anticipated upon the Knap House Quarry or Cotswold Commons and Beechwoods SSSIs.

9.3.5. Site construction may also lead to the temporary and permanent removal of agricultural soils, topsoil or subsoil material. In addition, soil deterioration and consolidation may occur due to vehicle movements and loading, leading to adverse impacts.

9.3.6. There is the potential for the discharge of contaminated or sediment laden groundwater to watercourses following dewatering of excavations or foundation works. During foundation works (piling for example), given the presence of the underlying Principal and Secondary Aquifers and also the SPZ3 (into which the Scheme encroaches) there is the potential for the creation of contamination pathways or driving down of contaminants presenting a risk to groundwater, along with the potential for increased turbidity and quality deterioration within the aquifers, which would result in adverse impacts.

9.3.7. Historic landfill cells are present adjacent to the northern extent of the Scheme in the vicinity of Crickley Hill. The cells are recorded to be filled with inert materials only, however the data is very limited. Any migrating landfill leachates would be likely to flow down-gradient towards the Scheme, and the works associated with the Scheme may therefore intercept potentially contaminated groundwaters.

9.3.8. Contaminant mobilisation during construction activities could potentially cause contamination of soils, groundwater and surface water, particularly in the vicinity of any made ground, (potentially infilled) quarries, and other potential contamination sources. The contamination of soils, groundwater and surface water could also occur through accidental spills and leaks relating to construction plant and fuels or oils.

9.3.9. The removal or remediation of any areas of contaminated soils identified would potentially have a beneficial impact.

Operation

9.3.10. The completed and operational Scheme is not expected to result in any impacts on geology or soils.

9.4. Design, mitigation and enhancement measures

Construction

9.4.1. The Scheme will be designed, as far as possible, to minimise effects relating to geology, soils and contaminated land. Appropriate mitigation measures would be identified based on a review of guidance provided in the English Nature Publication Geological conservation – a guide to good practice [46], in DMRB Volume 11, Section 3 Part 11 Geology and Soils, and by using professional judgement. These would include the following:

9.4.2. Environmental Management Plan: An Outline Environmental Management Plan (OEMP) will be developed as part of the Environmental Statement, which would be used to inform a full Construction Environmental Management Plan (CEMP) to be produced by the appointed Contractor.

9.4.3. Designated sites: Structures would be designed to have minimal impacts on any areas of significant outcrop to reduce encroachment into and loss of areas of the SSSIs.

9.4.4. Loss of agricultural land: For the loss of agricultural land, and BMV land in particular (ALC Grade 3a in this instance), there is no potential for mitigation given the permanent nature of the impact. Where agricultural land is required for works of a temporary nature, the mitigation outlined in paragraph 9.4.6would apply.

9.4.5. Protection of soil structure and quality: The inclusion of a Soils Management Plan (SMP) within the CEMP would ensure works are undertaken in accordance with appropriate guidelines such as Defra's Code of Practice for the Sustainable Use of Soils on Construction Sites[47] and BS3882: 201548, particularly in areas where the reinstatement of agricultural soils would be required temporarily during construction. In addition to topsoil and subsoil stripping and storage, mitigation measures would include the use of geotextile membranes and crushed granular materials along haul routes and in construction compounds and car parking areas. Where importation of topsoil is required for spreading on areas of newly constructed earthworks, this would be selected in accordance with BS 3882.

[46] English Nature (2006), *Geological conservation – a guide to good practice* [online] available at: http://publications.naturalengland.org.uk/publication/83048 (last accessed March 2018).
[47] Defra (2011) *Code of practice for the sustainable use of soils on construction sites* [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69308/pb13298-code-of-practice-090910.pdf (last accessed March 2018) [now withdrawn as of May 2018 but has been referred to in the absence of replacement guidance].
[48] British Standards (2015) BS 3882:2015 Specification for topsoil.

9.4.6. Dust suppression: The CEMP would include detailed measures relating to dust suppression using best practice methods. Dust Suppression is also addressed in Chapter 5 air quality.

9.4.7. Protection of controlled waters (general): General construction works have the potential to directly affect the quality of surface waters and groundwaters, which is covered in more detail in Chapter 13 road drainage and the water environment. Mitigation for water issues associated with soil contamination would include measures to protect the underlying Principal and Secondary Aquifers. The Contractor would take precautions (in-line with all associated pollution prevention guidelines and best practice) comprising the management of excavated materials in line with the CEMP and SMP. This would include measures such as locating stockpiles away from surface watercourses, the use of on-site treatment plant where necessary, the covering of stockpiles or seeding if appropriate, and works to be monitored by a Site Environmental Clerk of Works with an auditing programme to verify environmental performance.

9.4.8. Pollution of controlled waters (foundation works): Foundation works could create vertical pollution pathways. Where piling or penetrative ground improvement is required, the works would be carried out in accordance with Environment Agency guidance[49,50]. If following the Scheme GI, contaminated land is identified in areas of piling or penetrative ground improvement, a foundation works risk assessment would need to be undertaken to determine the likely effects and to identify what mitigation measures would be appropriate for the site, including pile design, concrete class and the use of temporary casing. The discharge of potentially contaminated groundwater would be appropriately managed by the Contractor through the use of appropriate treatment prior to discharge.

9.4.9. Management of construction plant and materials: Working method statements would be in place during construction, reflecting the guidance within the CEMP to ensure environmentally safe working practices on site with respect to the underlying ground and groundwaters. Adjacent areas outside the development boundary would be protected by site fencing to prevent accidental encroachment and damage of topsoil.

9.4.10. Management of contamination risks: The PSSR was prepared to inform the design of the intrusive GI. The GI for the Scheme will include the collection of soil

[49] Environment Agency (2001) *Piling and penetrative ground improvement methods on land affected by contamination: guidance on pollution prevention*. National Groundwater and Contaminated Land Centre Report NC/99/72 [online] available at: http://www.merseygateway.co.uk/publicinquirydocs/Core-docs/CD-256.pdf (last accessed March 2018).
[50] Environment Agency (2002) *Piling into contaminated sites. National Groundwater and Contaminated Land Centre Report* [online] available at: http://webarchive.nationalarchives.gov.uk/20140329082414/http://cdn.environment-agency.gov.uk/scho0202bisw-e-e.pdf (last accessed March 2018).

and groundwater samples for laboratory analysis to enable full determination of risks from contamination to human, environmental and structural / utilities receptors along with waste classification. A qualitative and quantitative Contaminated Land Risk Assessment (CLRA) would be prepared for the Scheme prior to the commencement of construction. This would inform the conceptual site model, identify any unacceptable contamination risks and enable the selection of appropriate mitigation measures to ensure the protection of human and environmental receptors (including controlled waters) during construction. Any mitigation measures required would be incorporated into the CEMP on completion of the CLRA. Following the completion of the CLRA, a Remediation Strategy would be prepared. If areas of contamination are identified, the Remediation Strategy would manage all identified risks and ensure that the Scheme does not result in the creation of additional contamination transport pathways. To mitigate risks associated with potentially contaminated materials the producer would ensure that all material created on site undergoes basic characterisation prior to re-use / disposal and that it is managed in-line with best practice and the waste hierarchy.

9.4.11. Excavations and dewatering: Dewatering of excavations below ground level containing potentially contaminated groundwaters would be appropriately managed on site through the use of appropriate treatment prior to discharge. Discharge to surface waters may require an environmental permit, and also a land drainage consent if the discharge requires the construction of a new culvert in an ordinary watercourse. If contamination is present or suspected, on-site treatment or off-site disposal may be required, and would be detailed within the Remediation Strategy.

9.4.12. There are limited opportunities for additional enhancement in relation to geology and soils for the Scheme given the nature of the development. However, the presence of geological SSSIs in close proximity to the Scheme may present an opportunity for the provision of improvements to areas of these sites should they be impacted in any way.

Operation

9.4.13. No operational mitigation is required as the completed and operational Scheme is not expected to result in adverse impacts on geology and soils.

9.5. Description of the likely significant effects

Construction

9.5.1. The following effects on geology and soils are anticipated to be significant.

9.5.2. Adverse effects on the Crickley Hill and Barrow Wake SSSI which is located adjacent to the Scheme. This SSSI is partially designated for its nationally important geological features comprising the rock exposures along the southern slopes of Crickley Hill which make up a key Jurassic locality showing a major section in the Lower Inferior Oolite with valuable exposures. The SSSI is located immediately to the north of the existing A417 west of Air Balloon Roundabout and to the immediate west of the existing A417 south of Air Balloon Roundabout. The Scheme would extend across the escarpment line and there is the potential for additional intrusion within the SSSI if the section of the existing A417 between Barrow Wake and the Stockwell access is removed. Adverse impacts anticipated include land take and disturbance during construction (of both the road and its associated structures such as the proposed green bridge) potentially leading to permanent loss or alteration of a small section of the nationally important geological exposures located within the study area.

9.5.3. The permanent removal of between 20 and 50 hectares of the BMV Grade 3a (medium value), which would result in a significant, permanent loss of agricultural land of higher economic value and a reduction in the availability of BMV agricultural land at the local, regional and national scale. Temporary effects on agricultural soils such as soil deterioration and consolidation due to storage and handling or due to vehicle movements and loading which can be adequately mitigated are not considered to be significant.

9.6. Assessment methodology

Proposed level and scope of assessment

9.6.1. The scope of the construction works and the potential for significant direct effects on geology and soils warrants further construction stage assessment. Further assessment is required to a DMRB Detailed Level and will be presented within the Environmental Statement.

9.6.2. A GI and ALC / Soil Resources Survey will also be necessary to establish the baseline information of the Scheme area, which will be undertaken prior to the production of the Environmental Statement.

9.6.3. No further assessment for the operational effects of the Scheme on geology and soils will be undertaken as this will be scoped out of the Environmental Statement.

Policy requirements, guidance and advice

9.6.4. The DMRB Volume 11, Section 3, Part 11 Geology and Soils (1994)[51] provides guidance on the assessment of the potential impact of road Schemes on geology and soils and the constraints that existing site conditions can impose on proposed development.

9.6.5. The approach for geology and soils will follow the guidance presented within DMRB Volume 11 Section 2 Part 5 HA (205/08)[52], to a Detailed level, along with professional judgement.

9.6.6. The framework for the assessment of potential land contamination is based on current guidance documents regarding the implementation of Part IIA of the Environmental Protection Act (EPA) 1990 and the assessment of potentially contaminated land, with particular reference to:

- EPA 1990: Part 2A, Contaminated Land Statutory Guidance[53].
- Human Health Toxicological Assessment of Contaminants in Soil[54]
- Model Procedures for the Management of Land Contamination CLR11[55].
- Updated technical background to the Contaminated Land Exposure Assessment (CLEA) Model[56].
- BS 10175:2011+A1:2013, Investigation of Potentially Contaminated Sites. Code of Practice[57].
- BS 8485:2015, Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings[58].
- Groundwater protection guides covering: requirements, permissions, risk assessments and controls (previously covered in GP3)[59].

[51] Highways Agency (2001) DMRB Volume 11, Section 3, Part 6: Land Use [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/11s3p06.pdf (last accessed July 2018)
[52] Highways England (2008) Design Manual for Roads and Bridges Volume 11 Section 2 Part 5 *Assessment and Management of Environmental Effects* (HA205/08) [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section2/ha20508.pdf (last accessed March 2018).
[53] Defra (2012) *Environmental Protection Act 1990*: *Part 2A, Contaminated Land Statutory Guidance*.
[54] Environment Agency (2009) *Human Health Toxicological Assessment of Contaminants in Soil,* Report ref. SC050021/SR2
[55] Department for Environment Food and Rural Affairs / Environment Agency (2004) *Model Procedures for the Management of Land Contamination, Contaminated Land Report 11*
[56] Environment Agency (2009) *Updated technical background to the CLEA Model*, Report ref. SC050021/SR3.
[57] British Standard (2013) BS 10175:2011+A1:2013, *Investigation of Potentially Contaminated Sites*. Code of Practice.
[58] British Standard (2015) BS 8485:2015, *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*.
[59] Environment Agency (2017) G*roundwater protection guides covering: requirements, permissions, risk assessments and controls* (previously covered in GP3).

- Environmental Protection (Duty of Care) Regulations (as amended 2003)[60].

Sensitivity of receptors

9.6.7. The sensitivity (value) of receptors has been determined according to the descriptions provided within Table 9.2.

Table 9.2: Scale for evaluating the value (sensitivity) of receptors

Value (sensitivity)	Typical descriptors
Very High	Very high importance and rarity, international scale and very limited potential for substitution.
High	High importance and rarity, national scale, and limited potential for substitution.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution.
Low (or Lower)	Low or medium importance and rarity, local scale.
Negligible	Very low importance and rarity, local scale.

Source: Taken from DMRB Volume 11 Section 2 Part 5 HA (205/08)

Magnitude of impacts

9.6.8. The magnitude of impact is determined by the predicted deviation from the baseline conditions and the scale of the effect. Quantifiable assessment of magnitude will be undertaken where possible. In cases where only qualitative impact assessment is feasible, the magnitude will be defined as fully as possible. The magnitude of impact will be determined according to the descriptions provided within Table 9.3.

Table 9.3: Scale for evaluating the magnitude of impact

Magnitude of effect	Adverse / beneficial	Typical criteria descriptors
Major	Adverse	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements.
Major	Beneficial	Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.
Moderate	Adverse	Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements.
Moderate	Beneficial	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Minor	Adverse	Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.

[60] The Environmental Protection (Duty of Care) (England) (Amendment) Regulations 2003

Magnitude of effect	Adverse / beneficial	Typical criteria descriptors
Minor	Beneficial	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	Adverse	Very minor loss or detrimental alteration to one or more characteristics, features or elements.
Negligible	Beneficial	Very minor benefit to or positive addition of one or more characteristics, features or elements.
No change	-	No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Source: Taken from DMRB Volume 11 Section 2 Part 5 HA (205/08)

Significance of effect

9.6.9. Subsequent to identifying an appropriate receptor sensitivity and magnitude of impact, the likely significance category and overall significance of effects will be assessed by using the matrix within Table 9.4, along with professional judgement to consider site specific factors that may be of relevance.

9.6.10. Effects that are Moderate Adverse or Beneficial and above would be considered to be significant (highlighted in bold in Table 9.4).

Table 9.4: Scale for evaluating the significance category - effects can be adverse or beneficial

		Magnitude of impact				
Environmental value (sensitivity)		No change	Negligible	Minor	Moderate	Major
	Very high	Neutral	Slight	Moderate or Large	Large or Very Large	Very Large
	High	Neutral	Slight	Slight or Moderate	Moderate or Large	Large or Very Large
	Medium	Neutral	Neutral or Slight	Slight	Moderate	Moderate or Large
	Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
	Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

Source: Taken from DMRB Volume 11 Section2 Part 5 HA (205/08)

9.7. Assessment assumptions and limitations

9.7.1. A Scheme-specific GI will be completed. The GI information along with associated geotechnical and geo-environmental reporting would be used in the completion of the geology and soils Environmental Statement chapter.

9.7.2. The effects of materials import and export in relation to earthworks construction would be considered in Chapter 11 material assets and waste.

9.7.3. The effects of the Scheme upon surface water bodies and groundwater would be considered in more detail in Chapter 14 road drainage and the water environment.

10. Biodiversity

10.1. Study area

10.1.1. The following study areas for this assessment have been used to gather information on ecological receptors with the potential to be affected by the Scheme:

- Two kilometres from the Scheme for internationally designated nature conservation sites, including Special Areas for Conservation (SAC), Special Protection Areas (SPA) and Ramsar Sites in line with DMRB Volume 11, Section 4, Part 1 HD 44/09 'Assessment of Implications (of Highways and / or Roads Projects) on European sites (including Appropriate Assessment)'.
- Thirty kilometres from the boundary of the Scheme for SACs designated for bat populations in line with DMRB Volume 11, Section 4, Part 1 HD 44/09 'Assessment of Implications (of Highways and / or Roads Projects) on European sites (including Appropriate Assessment)'
- Any internationally designated nature conservation sites which are linked hydrologically to watercourses potentially affected by the Scheme.
- One kilometre from the boundary of the Scheme for nationally and locally designated nature conservation sites, including National Nature Reserves (NNR), Site of Special Scientific Interest (SSSI), Local Nature Reserves (LNR), priority habitats, Local Wildlife Sites (LWS) and RSPB Reserves. This study area has been defined by professional judgement to ensure that all potential effects were identified within the zone of influence. Further details will be provided within the Environmental Statement.
- Two kilometres from the boundary of the Scheme for records of protected species and notable species.
- Five hundred metres from the Scheme for preliminary ecological assessments including Extended Phase 1 habitat survey, Habitat Suitability Index (HSI) assessments of waterbodies for Great Crested Newts (GCN) *Triturus cristatus*, and badgers *Meles*. This study area was defined through professional judgement to ensure that all habitats were identified within the vicinity of the Scheme and to inform the forthcoming Phase 2 protected species surveys.
- One and a half kilometres from the boundary of the Scheme for barn owl *Tyto alba* surveys in line with Shawyer (2011).
- One kilometre from the Scheme alignment for landscape scale bat activity in accordance with Berthinussen and Altringham (2015).
- One hundred metres from the Scheme for the assessment of known/potential bat roosts. This study area was defined through professional judgement and agreed with Natural England.

- A 250 metre buffer from the Scheme for other species such as water vole *Arvicola amphibius*, dormouse *Muscardinus avellanarius*, reptiles and wintering and breeding birds. This study area was defined through professional judgement to ensure that all habitats were identified within the vicinity of the Scheme and to inform the forthcoming Phase 2 protected species surveys.
- Two kilometres from the boundary of the Scheme for surveys along watercourses for otter *Lutra lutra* where these watercourses are within 250m of the boundary of the Scheme, in accordance with DMRB Volume 10 Section 1 Part 9 'Nature Conservation Advice in Relation to Otters'.
- Two hundred metres from roads that are expected to be affected by the Scheme for sites affected by changes in air quality with national or international designations for nature conservation. The local Affected Road Network (ARN) for the Scheme is outlined in Chapter 6 Air Quality.

10.2. Baseline conditions

10.2.1. The following baseline conditions apply to all the A436 Link Road Alternatives. Any differences between the A436 Alternatives is discussed under relevant headings below.

10.2.2. This assessment chapter has been informed by a number of sources. Information regarding statutory and non-statutory sites is available from Natural England's MAGIC Interactive Map, with further information available from Natural England and the Joint Nature Conservation Committee (JNCC).

10.2.3. A stage two assessment of a proposed Scheme which partly covered the Scheme currently being considered was undertaken by WSP in 2006. Survey data from this assessment is now over 10 years old and is therefore out of date and site conditions and species populations are likely to have changed during this time. However, it is still considered that this historical data provides valuable background information on the site, especially in the absence of more recent detailed protected species surveys.

10.2.4. Given the date of the WSP survey data, a desk study was subsequently undertaken by MMSJV in 2017 which identified records of protected and notable species within two kilometres of the Scheme, with records obtained from Gloucestershire Environmental Records Centre.

10.2.5. Additional habitat and protected and notable species data has been provided by National Trust and Gloucestershire Wildlife Trust (GWT) for records around Crickley Hill and Barrow Wake.

10.2.6. An Extended Phase 1 Habitat survey was undertaken by suitably qualified MMSJV ecologists between April and June 2017, to assess the current ecological importance of the site and informed the requirement for Phase 2 Surveys.

Designated sites

10.2.7. Cotswolds Beechwood SAC is located within two kilometres of the Scheme . At its closest point it is 426 metres west of the scheme. No additional SACs, SPAs, and Ramsar Sites are identified within two kilometres of the Scheme.

10.2.8. The Wye Valley and Forest of Dean Bat Sites SAC is designated for bat populations and is located 22 kilometres west of the Scheme at its closest point.

10.2.9. Four SSSIs are located within one kilometre of the Scheme. The closest site is Crickley Hill and Barrow Wake SSSI of which a small proportion is located within the Scheme; Cotswold Common and Beechwoods SSSI is located 426 metres west of the Scheme; Bushley Muzzard, Brimpsfield SSSI is located 257 metres southwest; and Knap House Quarry SSSI is located 268 metres west. Leckhampton Hill and Charlton Kings Common SSSI is located 1.5 kilometres north.

10.2.10. A small proportion of Barrow Wake GWT Reserve is located within the Scheme.

10.2.11. Seven Key Wildlife Sites (KWS) are located within one kilometre of the Scheme:

- River Frome Mainstream and Tributaries KWS is located 110 metres southwest; Cowley and Wards Woods KWS is located 461 metres northeast; Coldwell Bottom KWS is located 850 metres northeast; Park Wood (Brimpsfield) KWS is located 730 metres south; Poston, Syde and Ostrich Woods KWS is located 730 metres south and Little Bittomes KWS is located 750 metres south west.

10.2.12. Ullen Woods KWS is discussed under the A436 Link Road Alternative headings below.

10.2.13. Three Ancient and Semi-Natural woodland sites are located within 1 kilometre of the Scheme.

Priority habitats

10.2.14. The survey (and desk study) identified a number of Biodiversity Action Plan (BAP) Priority Habitats located within one kilometre of all Scheme including Ancient Woodland, Deciduous Woodland, Lowland Calcareous Grassland,

Ancient/Species-rich Hedgerows, veteran trees, Traditional Orchards and Lowland Meadows.

10.2.15. Grassland and Woodland National Vegetation Classification, hedgerow, river habitat and river corridor surveys will be undertaken in 2019.

Protected and notable species

10.2.16. Survey for bats, GCN, dormouse, water vole, otter, reptiles and white clawed crayfish, started in 2018 and will finish in 2019. Bat hibernation, winter bird and badger surveys are currently underway and will be completed by April 2019. Surveys for breeding birds, barn owls, aquatic and terrestrial invertebrates and a reptile population survey will start in 2019.

10.2.17. To date initial surveys have confirmed the presence within the study area of nine species of bat, badger, otter, adder *Vipera berus*, grass snake *Natrix natrix*, common lizard *Zootoca vivipara*, and slow worm *Anguis fragilis*. Positive GCN eDNA results have been retuned for two ponds confirming the presence of this species within the zone of influence of the Scheme. Full ecological survey findings will be presented within the Environmental Statement.

A436 Link Road Alternative 1: bridge over A417

10.2.18. The baseline conditions differ to the other A436 Link Road Alternatives as follows:

- Crickley Hill Country Park GWT Reserve, is partially located within this A436 Link Road Alternative.
- Ullen Woods KWS and ancient woodland is located next to this A436 Link Road Alternative.

A436 Link Road Alternative 2: parallel to the A417

10.2.19. This A436 Link Road Alternative is the same as A436 Link Road Alternative 3: via South Hill with exception of:

- Ullen Woods KWS and ancient woodland is located next to this A436 Link Road Alternative.
- A small proportion of Crickley Hill Country Park GWT Reserve, is located within this A436 Link Road Alternative.

A436 Link Road Alternative 3: via South Hill

The baseline conditions differ to the other A436 Link Road Alternatives as follows:

- Ullen Wood KWS and ancient woodland is located 120 metres to the west of this A436 Link Road Alternative at its closest point.
- Crickley Hill Country Park GWT Reserve, is located 120 metres north of this A436 Link Road Alternative.

10.3. Potential impacts

Construction

10.3.1. The following potential construction impacts apply to the Scheme. Any differences between the 3 A436 Link Road alternatives is discussed under the A436 Link Road Alternative headings below.

Designated sites

10.3.2. Significant earthworks may impact on local hydrology which has the potential to impact on habitats within Cotswolds Beechwoods SAC. The Site Improvement Plan for this SAC lists change in species distribution as a threat to the integrity of the site, with shallow rooted beech trees being vulnerable to drought as a result of future climate change. The impact of drought on the shallow rooted trees could be exacerbated as a result of hydrological changes caused by the construction of the Scheme. However, the current assessment indicates that the groundwater supplying the SAC will not be impacted by the Scheme and no adverse effects are likely.

10.3.3. Vegetation clearance and earthworks may damage habitats used by foraging and commuting bats and result in the loss, damage or disturbance of bat roosts. There is a potential that bat roosts affected by the Scheme could be associated with the bat population associated with the Wye Valley and Forest of Dean Bat Sites SAC. There is a potential for species associated with the SAC to use roost sites, foraging and commuting habitat impacted by the Scheme.

10.3.4. Works are partly within the Crickley Hill and Barrow Wake SSSI boundary (Crickley Hill Country Park GWT Reserve). Current design would result in the loss of a very small area of the SSSI. Subsequent refinement work will be undertaken to ensure that there are no works within the SSSI and that the route is either alongside or further removed from the SSSI.

10.3.5. There is the potential for changes in hydrology from construction of major cuttings to affect Bushley Muzzard, Brimpsfield SSSI. Whilst it is considered unlikely, until more detailed information is available on the impacts of construction of cuttings on groundwater flows, there is a potential for changes in hydrology to affect the SSSI. However, the current assessment indicates that the

springs supplying Bushley Muzzard, Brimpsfield SSSI will not be impacted by the Scheme and no adverse effects are likely.

10.3.6. Earthworks may impact on local hydrology which has the potential to adversely impact habitats within Cotswolds Commons and Beechwoods SSSI, including exacerbating the impact of future drought conditions on shallow rooted beech trees (see Cotswolds Beechwoods SAC impacts), and changing hydrology of springs within the SSSI which are noted for their importance to terrestrial molluscs. However, the current assessment indicates that the groundwater supplying the SAC will not be impacted by the Scheme and no adverse effects are likely.

10.3.7. Due to the lack of ecological features no impact is anticipated on Knap House Quarry SSSI, and as Charlton Kings Common SSSI is located 1.5 kilometres from the Scheme, no impact is anticipated.

10.3.8. Works are partially within Barrow Wake GWT Reserve and will result in a minor reduction in habitat within this site, including the loss of a small area of calcareous grassland. There is the potential for increased emissions from construction vehicles and plant resulting in increased nitrogen deposition which could reduce flora diversity within the reserve. There is the potential for an increased risk of pollution incidents including spillages, which could damage habitats within the reserve.

10.3.9. There is the potential for changes in hydrology from construction of major cuttings to affect the River Frome Mainstream and Tributaries KWS. Whilst it is considered unlikely, until more detailed information is available on the impacts of construction of cuttings on groundwater flows, there is a potential for changes in hydrology to affect the KWS. However, the current assessment indicates that the springs supplying the site will not be impacted by the Scheme and no adverse effects are likely.

10.3.10. No direct impacts are anticipated on sites listed on the ancient woodland inventory. Although the A436 Link Road Alternatives are at varying distances from Ullen Woods KWS and ancient woodland, the potential impacts will be the same. Construction activities have the potential for increased emissions from construction vehicles and plant resulting in increased nitrogen deposition which could reduce flora diversity within the reserve. Potential for an increased risk of pollution incidents including spillages, which could damage habitats within the reserve.

10.3.11. Emma’s Grove woodland supports a number of ancient woodland indicator species and is likely to be ancient in origin. Construction will remove a small area of this woodland. Potential for increased emissions from construction vehicles

and plant resulting in increased nitrogen deposition which could reduce flora diversity within the site. Potential for an increased risk of pollution incidents including spillages, which could damage vegetation within the woodland.

Priority habitats

10.3.12. Priority habitats potentially damaged or lost as a result of the Scheme include loss of lowland calcareous grassland, species-rich hedgerows, deciduous woodland, and the loss of a single veteran tree. It is not possible to assess the extent of habitat losses at this stage. Potential for indirect impacts through airborne pollution, run-off and compaction of root systems.

Protected and notable species

10.3.13. Vegetation clearance and site clearance would result in loss, isolation and fragmentation of terrestrial habitats for species including badger, bats, dormouse, barn owl, reptiles, great crested newts, and terrestrial invertebrates. Construction related run-off could indirectly affect the water quality of local water courses inhabited by species such as water vole, otter and GCN. Changes in the drainage conditions due to construction major earthworks, have the potential to damage GCN, otter and water vole habitat. Night works would directly disturb nocturnal species such as bats, badger, barn owl and terrestrial invertebrates as a result of increased lighting pollution, noise and vibration. This disturbance could potentially contribute to the displacement of this species from the area.

Operation

10.3.14. The following potential operational impacts apply to the Scheme. Any differences between the 3 A436 Link Road Alternatives are discussed under the alternatives headings below.

Designated sites

10.3.15. There is the potential for the new road to impact on local hydrology which has the potential to impact on habitats within the Cotswolds Beechwoods SAC. The Site Improvement Plan for the SAC lists change in species distribution as a threat to the integrity of the site, with shallow rooted beech trees being vulnerable to drought as a result of future climate change. The impact of drought on the shallow rooted trees could be exacerbated as a result of hydrological changes caused by the construction of the Scheme. However, the current assessment indicates that the groundwater supplying the SAC will not be impacted by the Scheme and no adverse effects are likely. No impacts from changes in air quality are anticipated due to the distance from the site.

10.3.16. Traffic using the new road could result in the killing and injury of bats associated with the Wye Valley and Forest of Dean Bat Sites SAC (if populations are present on site that are associated with the SAC and key commuting and foraging routes are severed by the Scheme), impacting on commuting and foraging bats.

10.3.17. There is the potential for long-term permanent loss of a very small area of habitat within the Crickley Hill and Barrow Wake SSSI. Only a very small area would be potentially directly impacted. Subsequent refinement work will be undertaken to ensure that there are no works within the SSSI and that the route is either alongside or further removed from the SSSI.

10.3.18. There is the potential for changes in hydrology from the new road to affect the Bushley Muzzard, Brimpsfield SSSI. Whilst it is considered unlikely, until more detailed information is available on the impacts of cuttings on groundwater flows, there is a potential for changes in hydrology to affect the SSSI. However, the current assessment indicates that the springs supplying Bushley Muzzard, Brimpsfield SSSI will not be impacted by the Scheme and no adverse effects are likely. No impacts from changes in air quality associated with traffic are anticipated due to the distance from the site.

10.3.19. There is the potential for the new road to impact on local hydrology with the potential to adversely impact on habitats within the Cotswolds Commons and Beechwoods SSSI, including exacerbating the impact of future drought conditions on shallow rooted beech trees (see Cotswolds Beechwoods SAC impacts), and changing hydrology of springs within the SSSI which are noted for their importance to terrestrial molluscs. However, the current assessment indicates that the groundwater supplying the SSSI would not be impacted by the Scheme and no adverse effects are likely.

10.3.20. No operational impacts are anticipated on Knap House Quarry SSSI and Charlton Kings Common SSSI.

10.3.21. The new road is partially located within the Barrow Wake GWT Reserve and would result in a minor reduction in habitat within the site, including the loss of a small area of calcareous grassland. There is the potential for increased emissions from traffic using the new road resulting in increased nitrogen deposition which could reduce flora diversity within the reserve.

10.3.22. There is the potential for changes in hydrology from the new road to affect the River Frome Mainstream Tributaries KWS. Whilst it is considered unlikely, until more detailed information is available on the impacts of cuttings on groundwater flows, there is a potential for changes in hydrology to affect the KWS. However, the current assessment indicates that the springs supplying the site would not be

impacted by the Scheme and no adverse effects are likely. There is the potential for changes to run-off into the KWS from new highways drainage. No impacts from changes in air quality associated with traffic are anticipated due to the distance from the site.

10.3.23. There is the potential for increased emissions from traffic using the new road resulting in increased nitrogen deposition which could reduce flora diversity within ancient woodlands, including Emma's Grove (not on the ancient woodland inventory) and although the A436 Link Road Alternatives are at varying distances from Ullen Woods KWS and ancient woodland, potential operational impacts would be the same.

Priority habitats

10.3.24. There is the potential for the permanent loss and potential severance of habitats of biodiversity value including semi-natural broad-leaved woodland, semi-improved calcareous grassland and hedgerows. It is not possible to assess the extent of habitat losses at this stage. There is the potential for indirect impacts through airborne pollution associated with traffic resulting in increased nitrogen deposition which could reduce the diversity of habitats.

Protected and notable species

10.3.25. Traffic on the new road has the potential to sever habitat connectivity and kill or injure species such as bats and badger. The creation of a new dual carriageway across an important bat commuting route could result in significant bat mortality from collisions with traffic. Indirect effects on habitats would include adverse effects of air pollution from traffic on the new road, including increased nitrogen deposition which could cause habitats to deteriorate in quality. Any permanent increase in artificial lighting would adversely affect protected species including bats, barn owl and terrestrial invertebrates.

10.4. Design, mitigation and enhancement measures

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

10.4.2. A Construction Environmental Management Plan (CEMP) will be prepared for the Scheme, which would be prepared by the Contractor prior to construction. A Site Waste Management Plan (SWMP) would also be prepared outlining the correct handling, transport, and disposal of waste. ,

Construction

Designated sites

International

10.4.3. Effects on the Cotswolds Beechwoods SAC would be minimised through design, by ensuring that the existing hydrological regime, including groundwater flows, would not be significantly affected by the construction of cuttings and earthworks.

10.4.4. It is not yet known whether mitigation for the works would be required for effects on the Wye Valley Bat Sites SAC, as the bat surveys have not been completed. However, if mitigation is required for this site, this would be implemented as mitigation for the qualifying features of these sites i.e. bat species.

National

10.4.5. Impacts on Bushley Muzzard, Brimpsfield SSSI would be minimised through design, by ensuring that the existing hydrological regime, including groundwater flows, would not be significantly affected by the construction of cuttings.

10.4.6. The alignment of the Scheme will be looked at in detail throughout the design development to amend the route alignment so that there are no works within Crickley Hill and Barrow Wake SSSI and the route is either alongside or further removed from the SSSI boundary.

10.4.7. Effects on the Cotswolds Commons and Beechwoods SSSI would be minimised through design, by ensuring that the existing hydrological regime, including groundwater flows, would not be significantly affected by the construction of earthworks.

10.4.8. No specific mitigation is considered necessary for Leckhampton Hill and Charlton Kings Common SSSI due to the distance of this site from the Scheme (1.5 kilometres north) or Knap House Quarry due to the lack of ecological features within this geological SSSI.

Regional

10.4.9. To minimise adverse impacts on the River Frome Mainstream and Tributaries KWS, measures would be taken to prevent or minimise any sediments entering the ditches, streams or other waterbodies linked to the LWS, using control measures as outlined in CIRIA C532 Control of Water Pollution from Construction Sites. In addition, the drainage assessment and design would

ensure that the existing highways drainage system is adequate to cope with the runoff from areas of additional hard standing.

10.4.10. Impacts on Ullen Wood KWS and ancient woodland from airborne pollutants would be minimised though best practice construction methods. Measures to mitigate the effects of dust on sensitive habitats would include the use of screens and sediment booms. Cutting, grinding or sawing equipment would be fitted with, or used in conjunction with, suitable dust suppression techniques such as water sprays or local extraction (e.g. suitable local exhaust ventilation systems). Materials that have the potential to produce dust would be removed from site as soon as possible, unless being re-used on site. Stockpiles being re-used would be seeded or fenced to prevent wind whipping. All vehicles would be required to switch off engines when stationary to mitigate air pollution, noise and vibration disturbance during construction.

Habitats

10.4.11. A detailed habitat mitigation strategy would be developed to replace any habitats permanently lost as a result of the Scheme. This strategy would replace and enhance lost habitat and will aim to provide an overall net gain in biodiversity as a result of the Scheme. The strategy will include the creation of diverse habitat corridors along the length of the Scheme, providing links to offsite habitats. Biodiversity Units lost and gained will be calculated in accordance with Chief Highway Engineer Memorandum 422/18 as part of the mitigation strategy to achieve a net biodiversity gain.

10.4.12. The loss of priority habitats including ancient woodland, deciduous woodland, hedgerows, ponds, species rich calcareous and neutral grassland and marshy grassland would be avoided where possible. The translocation of priority habitats would be considered, where appropriate. Where priority habitats would be lost, these would be recreated with new areas of habitats incorporated into the landscape design with additional habitat created to achieve a net gain in biodiversity. Retained priority habitats would be protected during construction by putting up screening barriers to protect habitats from dust and pollution.

10.4.13. The loss of the veteran apple tree in the grounds of the Air Balloon pub would be mitigated by the translocation of the hulk of the tree into an area unaffected by the works. The tree is unlikely to survive a translocation, however, this would retain the significant standing deadwood habitat associated with this tree. Replacement apple trees would be planted using appropriate species, either to create a new area of traditional orchard, or to supplement an existing traditional orchard. An investigation would be made into the species of the veteran apple tree to determine if it is an uncommon variety. Propagating cuttings from the tree would be undertaken to grow replacement trees if it is an uncommon variety.

10.4.14. Where hedgerows are required to be removed to facilitate the works, where possible these would be replaced within the same location and any existing gaps planted with appropriate native species. Replacement planting would comprise species-rich continuous intact hedgerows. As an enhancement, existing retained defunct hedgerows along the Scheme corridor would be gapped up with diverse native species. Specific hedgerows may be required to be maintained for protected species mitigation, which would be detailed once the protected species surveys are complete. Translocation of species rich hedgerows would be considered, where appropriate.

10.4.15. During construction, measures to mitigate the effects of dust on sensitive habitats would include the use of screens and sediment booms. Cutting, grinding or sawing equipment would be fitted with, or be used in conjunction with, suitable dust suppression techniques such as water sprays or local extraction (e.g. suitable local exhaust ventilation systems). Materials that have the potential to produce dust would be removed from site as soon as possible, unless being re-used on site. Stockpiles being re-used would be seeded or fenced to prevent wind whipping. All vehicles would be required to switch off engines when stationary to mitigate air pollution, noise and vibration disturbance during construction.

10.4.16. To minimise adverse impacts on watercourses and associated species, measures would be taken to prevent or minimise any sediments entering the freshwater, using control measures as outlined in CIRIA C532 Control of Water Pollution from Construction Sites.

Protected and Notable Species

10.4.17. If the presence of European Protected Species (EPS) is confirmed and effects are predicted, a Natural England licence will be applied for. This licence will specify detailed mitigation to ensure favourable conservation status of the affected species is maintained. The licence conditions and the requirement of 'no net loss in biodiversity' in line with Section 40 of the NERC Act 2006, will guide the landscape planting required for the Scheme. In addition to habitat enhancement for protected species, mitigation and compensation with regards to offsetting habitat loss would also be required.

10.4.18. Vegetation clearance and earthworks would be supervised by a suitably experienced ecologists in areas confirmed to have protected species present or habitat considered to have high potential for protected species. Toolbox Talks (protected species and invasive species with the potential to be encountered on site) would be prepared and delivered onsite to all personnel prior to any works by a suitably experienced ecologist.

10.4.19. All vehicles would be required to switch off engines when stationary to mitigate air pollution, noise and vibration disturbance during construction. During night works, hoods would be used to direct lighting away from features and habitat considered to be suitable for protected species, such as hedgerows, retained scrub and woodland.

General

10.4.20. Ecological toolbox talks and posters would be given to contractors prior to the works commencing to make them aware of the legislation afforded to protected species, and the working practices implemented to minimise effects on the sensitive habitats within the designated sites.

Operation

10.4.21. Replacement habitats would be implemented through planting works in the first season available following completion of construction works. Any opportunities for early planting in areas that would not be affected during construction will be explored.

10.4.22. A minimum five-year aftercare period would follow completion of the works. During this time, maintenance activities would be undertaken to ensure the successful establishment of planting and provision of new habitats.

10.4.23. Mitigation for the loss of significant commuting routes severed by the new road would require the construction of significant mitigation structures. These would need to be designed in accordance with current best practice. Recent studies into the effectiveness of bat mitigation structures identified that bat gantries and similar structures are largely ineffective. Green bridges are the most effective mitigation for severance of commuting routes to minimise effects on bats. Underpasses can also be effective. The location and specification of any bat mitigation structures would be dependent on the results of bat surveys and Scheme design. The current Scheme design includes a green bridge within the vicinity of the Air Balloon roundabout.

Enhancement

10.4.24. The NPSNN states that opportunities for building in biodiversity features should be maximised and the project should show how it has taken advantage of opportunities to conserve and enhance biodiversity. Therefore, enhancement measures for the Scheme would need to be implemented. Potential enhancement measures are likely to include additional replanting of native species-rich hedgerows and trees, additional planting of native broadleaved

woodland, additional creation of species-rich calcareous grassland and the additional provision of nesting and roosting opportunities for bats and birds.

10.4.25. Opportunities for ecological enhancement in addition to the mitigation and compensation measures above which could be undertaken as part of the Scheme are outlined below. Opportunities have been developed and discussed with relevant stakeholders including National Trust, Natural England and GWT.

Downgrading retained sections of the existing A417

10.4.26. Downgrading retained sections of the existing A417 and associated reduced traffic would provide safer crossings for species such as badger and bats. The reduced road width would result in potential opportunities for widened road verges and would provide opportunities for further calcareous grassland creation and would increase the availability of reptile habitat.

Removal of redundant sections of existing A417

10.4.27. The Scheme provides the opportunity to remove the existing A417 carriageway between the B4070 and Barrow Wake. This provides an opportunity for replacing the carriageway with a new area of calcareous (limestone) grassland. The existing Crickley Hill and Barrow Wake SSSI boundary includes an area that is currently occupied by the existing A417 carriageway. Replacing the carriageway with calcareous grassland would reconnect the isolated area of the SSSI to the east of the existing A417 with the habitat at Barrow Wake to the west of the A417. An increase in area of lowland calcareous grassland would benefit species such as reptiles and terrestrial invertebrates by increasing habitat availability and opportunities for dispersal, as well as increasing the area of this priority habitat. A436 Link Road Alternative 2: parallel to the A417 and A436 Link Road Alternative 3: via South Hill, provide further opportunities for the removal of the existing A417 between Cowley Lane and the Air Balloon Roundabout. This provides additional opportunities for creating new areas of priority habitats including lowland calcareous grassland, and additional opportunities for providing better ecological connectivity.

Lowland calcareous grassland creation

10.4.28. Opportunities for new areas of calcareous (limestone) grassland have been identified within the wider landscape surrounding the Scheme through discussions with Natural England, National Trust and GWT. The shallow soils of much of the land around the Scheme have great potential for new calcareous grassland creation. An increase in area of lowland calcareous grassland would benefit species such as reptiles and terrestrial invertebrates by increasing habitat availability and opportunities for dispersal, as well as increasing the area of this priority habitat. This wider habitat creation provides greater opportunities

for species dispersal and together with proposed habitat creation along the new road, would provide a potential wildlife corridor to aid dispersal and connect currently isolated areas of habitat. The increased area of habitat would also provide more resilience for the habitats to future changes such as those associated with climate change.

Broadleaved woodland habitat creation

10.4.29. Opportunities exist in the wider landscape to connect areas of broadleaved woodland through additional linear habitat creation, linked with the proposed A417 verge planting. This would result in an increased availability of broadleaved woodland habitat providing new habitat for bats, dormouse and nesting birds, and would provide greater connectivity between existing woodlands in the wider landscape providing better connectivity for species such as bats. Broadleaved woodland creation would be linked with calcareous grassland creation to create new areas of calcareous grassland along scalloped edges of new linear belts of woodland to create diverse habitats suitable for a range of species.

Great crested newt pond creation

10.4.30. Impacts on the GCN population at Birdlip are anticipated to be minor, with no impacts to any waterbodies. New aquatic habitat creation is not required as part of the mitigation strategy, however, creation of at least one new pond within 500 metres of this identified population would help enhance this population of GCN and make it more resilient to future changes.

10.5. Description of the likely significant effects

Construction

10.5.1. The Scheme has been assessed as potentially having a number of significant effects on biodiversity, however, with the successful implementation of mitigation outlined within this report, likely significant effects are restricted to the receptors outlined below.

Bats

10.5.2. The construction works would result in the clearance of habitat including trees which could be used by roosting bats, and the demolition of buildings which could be used by roosting bats. Habitat clearance may also sever commuting routes and fragment habitats, potentially having a significant impact on the local bat population. Lighting and noise disturbance during construction could also disturb roosting, commuting and foraging bats, potentially leading to roost abandonment. Surveys are ongoing to assess the status of the local bat

population and the importance of local habitats affected by the Scheme. It is likely that most adverse impacts could be mitigated by standard mitigation such as the provision of alternative roost sites and control of construction lighting, noise and vibration.

10.5.3. However, in the absence of detailed survey results a significant impact is possible. If significant commuting routes for Annex II species were severed by the Scheme or if significant roosts, such as maternity or hibernation roosts of Annex II species, were directly impacted this could affect the integrity of a nationally significant population. It is probable that such significant impacts could be minimised and reversed in the long term with appropriate mitigation such as green bridges at crossing points and new roost creation for lost roost sites.

Ancient Woodland and Veteran Trees

10.5.4. The construction would remove a small part of Emma's Grove. This area is not included in the Ancient Woodland Inventory as it is under two hectares. To date access has not been permitted into this area of ancient woodland to survey the extent of habitat to be removed during construction. Until further surveys are undertaken, it is assumed that the area of woodland lost at Emma's Grove is ancient. Therefore, adverse effects are only probable at this stage of the assessment. The proposals would also result in the loss of one veteran tree, an apple within the grounds of the Air Balloon Pub. Therefore, a significant impact is likely on ancient woodland and veteran trees.

A436 Link Road Alternative 1: bridge over A417

10.5.5. Significant effects during construction are the same for A436 Link Road Alternatives 1 and 2.

A436 Link Road Alternative 2: parallel to the A417

10.5.6. Significant effects during construction are the same for A436 Link Road Alternatives 1 and 2.

A436 Link Road Alternative 3: via South Hill

10.5.7. The South Hill link road runs parallel to Ullen Wood ancient woodland and has an increased risk of potential for damage to trees along the edge of this woodland which could damage part of the ancient woodland. As with the other A436 Link Road Alternatives there is anticipated to be a potential for significant impacts on ancient woodland.

Operation

10.5.8. Likely significant effects during operation are anticipated for bats under all three A436 Link Road Alternatives. Due to the increased habitat severance caused by the A436 Link Road Alternative 3: via South Hill , this A436 Link Road Alternative has the greatest potential for adverse effects on bats. However, all A436 Link Road Alternatives have potential for significant effects as outlined below.

Bats

10.5.9. The footprint of the new road would result in the permanent loss of potential roost sites, and the loss of commuting and foraging habitat. Where the new road is constructed across significant bat commuting routes, there would be a significant risk of traffic collisions with commuting bats. The above impacts could have a significant impact on the local bat population, especially where any major roost sites are directly impacted or roost sites and foraging sites are severed by the new road, in particular roosts and commuting habitat used by Annex II species. Artificial lighting could also have a significant impact on roosting, foraging and commuting bats. It is likely that most adverse impacts could be mitigated by standard mitigation such as the provision of alternative roost sites, provision of mitigation features to maintain connectivity and reduce traffic related mortality, and a sensitive lighting design. Habitat losses would be temporary as suitable replacement foraging habitat and roosting habitat would be created as part of the mitigation strategy. However, in the absence of detailed survey results a precautionary approach has been taken and a significant impact is possible. There is potential for significant effects on bats through the severance of commuting and foraging habitat, and risk of killing and injuring bats through collision with traffic. Further surveys needed to assess status of population and likely impacts.

A436 Link Road Alternatives

10.5.10. Significant effects during operation are the same for all A436 Link Road Alternatives.

10.6. Assessment methodology

Proposed level and scope of assessment

10.6.1. The scope of the works and the potential significance of direct and indirect effects warrants further assessment to a Detailed level, in accordance with IAN 130/10, as there is the potential to cause disruption to protected species,

designated sites and sensitive habitats during construction and operational activities.

Policy requirements, guidance and advice

10.6.2. Further assessment will be carried out in accordance with the following guidance, as part of this assessment:

- DMRB Volume 11 Section 3 Part 4 Ecology and Nature Conservation
- HA (2010) IAN 130/10 Ecology and Nature Conservation: Criteria for Impact Assessment
- Chartered Institute of Ecology and Environmental Management (CIEEM 2018) Guidelines for Ecological Impact Assessment in the UK.
- CIEEM Sources of Survey Methods

Determination of significant effects

Proposed methodology

10.6.3. The survey and assessment will be undertaken in accordance with the DMRB Volume 11, Section 3, Part 4 'Ecology and Nature Conservation', IAN 130/10. 'Transport Analysis Guidance' (DfT) which supplements the DMRB guidance, and the Guidelines for Ecological Impact Assessment (EcIA) produced by the Chartered Institute of Ecology and Environmental Management (CIEEM).

10.6.4. In accordance with IAN 130/10, the development of significance criteria has been informed by consideration of aspects of 'Transport Analysis Guidance' (DfT) and informed by CIEEM Guidelines for EcIA which utilise an approach to valuing ecological features that involves the use of professional judgement, based on available guidance and information, together with advice from experts who know the area in which the study area sits and / or the distribution and status of the features that are being considered.

10.6.5. A Habitat Regulations Assessment Screening will also be undertaken due to the presence of internationally designated sites located within 2 and 30 kilometres of the Scheme, in accordance with DMRB HD 44/09. Consistency of information and avoidance of duplication will be ensured between the HRA screening process and within the Environmental Statement.

10.6.6. The value (sensitivity) of ecological features and resources of nature conservation value will be assessed using the criteria outlined in Table 10.9. Following this, the characterisation of ecological impacts will be undertaken in accordance with IAN 130/10, and will include consideration of the value, integrity and conservation status of the resource affected, and a characterisation of the

impact, which will consider: the probability of the impact occurring; the complexity of the impact (direct, indirect, cumulative); the extent of the impact (e.g. the percentage of the resource affected); the size of the impact (e.g. complete loss or numbers of animals affected); the reversibility of the impact; the duration of the impact (permanent or temporary); and, the timing and frequency of the impact (considering seasonal / life cycle constraints). The assessment will consider mitigation measures required and assess the significance of effects of residual impacts. CIEEM Guidance (2018) will be used to help evaluate sites, habitats and species and to assess the effects on ecological integrity to help apply the DMRB method.

10.6.7. The overall significance of effects will be ascertained in accordance with IAN 130/10, as shown in Table 10.10. For the purposes of this assessment, effects of Moderate Adverse or Beneficial and above are considered to be significant.

Table 10.9: Criteria for Determining the Conservation Value of Ecological Receptor Feature

Conservation Value	Criteria
International or European Value	Natura 2000 sites including: SCIs; SPAs; pSPAs; SACs; cSACs or pSACs; and Wetlands of International Importance (Ramsar sites). Biogenetic Reserves, World Heritage Sites and Biosphere Reserves. Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such. Resident, or regularly occurring, populations of species which may be considered at an International or European level where: • the loss of these populations would adversely affect the conservation status or distribution of the species at this geographic scale • the population forms a critical part of a wider population at this scale • the species is at a critical phase of its life cycle at this scale
UK or National Value	Designated sites including: SSSIs; Marine Protected Areas (MPAs) including Marine Conservation Zones (MCZs); and NNRs. Areas which meet the published selection criteria e.g. JNCC (1998) for those sites listed above but which are not themselves designated as such. Areas of key / priority habitats identified in the UK Biodiversity Action Plan (BAP), including those published in accordance with Section 41 of the Natural Environment and Rural Communities Act (2006) and those considered to be of principal importance for the conservation of biodiversity. Areas of Ancient Woodland e.g. woodland listed within the Ancient Woodland Inventory. Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: • the loss of these populations would adversely affect the conservation status or distribution of the species at this scale • the population forms a critical part of a wider population at this scale • the species is at a critical phase of its life cycle at this scale
Regional Value	Areas of key / priority habitats identified in the Regional BAP (where available); areas of key / priority habitat identified as being of Regional value in the appropriate Natural Area Profile (or equivalent); areas that have been identified by regional plans or strategies as areas for restoration or re-creation of priority habitats (for example, South West Nature Map); and areas of key / priority habitat listed within the Highways Agency's BAP.

Conservation Value	Criteria
	Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level and key / priority species listed within the HABAP where: • the loss of these populations would adversely affect the conservation status or distribution of the species at this scale • the population forms a critical part of a wider population • the species is at a critical phase of its life cycle
County or Unitary Authority Area Value	Designated sites including: Sites of Nature Conservation Importance (SNCIs); County Wildlife Sites (CWSs); and LNRs designated in the county or unitary authority area context. Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such. Areas of key / priority habitats identified in the Local BAP; and areas of habitat identified in the appropriate Natural Area Profile (or equivalent). Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: • the loss of these populations would adversely affect the conservation status or distribution of the species across the County or Unitary Authority Area • the population forms a critical part of a wider population • the species is at a critical phase of its life cycle
Local Value	Designated sites including: LNRs designated in the local context. Trees that are protected by Tree Preservation Orders (TPOs). Areas of habitat; or populations / communities of species considered to appreciably enrich the habitat resource within the local context (such as veteran trees), including features of value for migration, dispersal or genetic exchange.

Table 10.10: Significance of effects

Significance Category	Typical Descriptors of Effect
Very Large	An impact on one or more receptor(s) of International, European, UK or National Value. NOTE: only adverse effects are normally assigned this level of significance. They should be considered to represent key factors in the decision-making process.
Large	An impact on one or more receptor(s) of Regional Value. NOTE: these effects are considered to be very important considerations and are likely to be material in the decision-making process.
Moderate	An impact on one or more receptor(s) of County or Unitary Authority Area Value. NOTE: these effects may be important but are not likely to be key decision-making factors.
Slight	An impact on one or more receptor(s) of Local Value. NOTE: these effects are unlikely to be critical in the decision-making process but are important in enhancing the subsequent design of the project.
Neutral	No significant impacts on key nature conservation receptors. NOTE: absence of effects, or those that are beneath levels of perception.

10.7. Assessment assumptions and limitations

10.7.1. This assessment is based on the initial walkover surveys undertaken during 2017 and the results of ongoing targeted ecology surveys which commenced in May 2018. As these surveys are ongoing it is not possible to conclude likely absence where no evidence has been found to date, and where evidence of protected species has been recorded, there is insufficient data to assess the status and importance of the populations of these species. A precautionary approach has therefore been taken in the assessment of potential impacts.

11. Material Assets and Waste

11.1. Study area

11.1.1. Material assets and waste are defined as comprising:

- The provision and use of material resources, including primary, secondary, recycled and manufactured materials.
- The generation and management of waste.

11.1.2. Currently, there is no industry guidance available for defining the study area to be used for material assets and waste assessments. As a result, the study area has been determined through professional judgement by the influence of the Scheme and encompasses the extent of potential effects. The assessment will therefore use two geographically different study areas to examine the use of material resources and the generation and management of waste.

11.1.3. The first study area is based on the area of the completed works within the draft Red Line Boundary, as this constitutes the area within which construction materials would be consumed (used, re-used and recycled) and waste would be generated.

11.1.4. The second study area is focused on an area sufficient to identify suitable waste infrastructure that could accept arisings of waste generated by the Scheme, and feasible sources and availability of construction materials typically required for motorway and all-purpose trunk road projects. Therefore, for the purposes of this assessment this study area focusses on the county of Gloucestershire, within which the Scheme is located.

11.2. Baseline conditions

11.2.1. The information provided below constitutes the baseline conditions for the Scheme.

Use of material resources

11.2.2. Information on the demand for key construction materials within the second study area (Gloucestershire) has been used to provide the baseline for material resources. In addition, information for the UK[61] has also been provided as a national comparison. This information has been determined through a desk-study using a number of readily available resources, in particular from the

[61] Where information is not available for the UK due to the differing governing authorities for England, Wales and Scotland, England has been used to provide the national comparison.

Minerals Products Association, International Steel Statistics Bureau, and Gloucestershire County Council.

11.2.3. Table 11.1 outlines the UK demand, in terms of sales, of minerals and mineral products in 2015/2016.

Table 11.1: UK demand for materials and minerals / mineral products

Mineral	UK demand (year)
Aggregates *Of which:* • Crushed rock • Sand and gravel – land won • Sand and gravel – marine won • Recycled and secondary	225 million tonnes (2015) • 104 million tonnes • 46 million tonnes • 12 million tonnes • 63 million tonnes
Cementitious (including imports) *Of which:* • Cement (including imports) • Other cementitious materials (fly ash, ground clay bricks (GCBs))	13 million tonnes (2015) • 11 million tonnes • 2 million tonnes
Ready-mixed concrete	54 million tonnes (2015)
Concrete products	27 million tonnes (2015)
Asphalt	24 million tonnes (2015)
Dimension stone	1 million tonnes (2015)
Steel	10.9 million tonnes (2016)

Source: Minerals Products Association 2016[62] and International Steel Statistic Bureau 2017[63]

11.2.4. At a regional level, Table 11.2 outlines the most recent publicly available information on the aggregate sales and reserves in Gloucestershire (for 2016). Aggregates produced across Gloucestershire include crushed rock from Carboniferous and Jurassic limestone, sand and gravel mostly made up of sharp sand with small amounts of soft sand, and recycled aggregates from construction, demolition and excavation wastes.

11.2.5. The landbank for crushed rock, at the end of 2016, was 24.32 million tonnes, which indicates that reserves may be available to meet projected demand for just under 17 years (Table 11.2). For sand and gravel the landbank, at the end of 2016, was 4.41 million tonnes, with the remaining length of this landbank being close to six years. Therefore, in regard to the trend in the amount of remaining permitted reserves, in Gloucestershire, these continue to be in decline and now equate to an overall fall of 15% from 2012.

[62] Minerals Products Association (2016) The Mineral Products Industry at a Glance: 2016 Edition [online] available at: http://www.mineralproducts.org/documents/Mineral_Products_Industry_At_A_Glance_2016.pdf (last accessed February 2019)
[63] International Steel Statistics Bureau (2017) Steel Demand [online] available at: http://issb.co.uk/news/news/uk.html (last accessed February 2019)

Table 11.2: Aggregate sales and reserves in Gloucestershire for 2016

Aggregate	Sales	Average 10-year sales	Average 3-year sales	LAA rate (per year)	Reserve	Landbank (remaining years)	Theoretical capacity
All land-won sand and gravel	0.701mt	0.742mtpa	0.573mtpa	0.742mt	4.41mt	5.94yrs	Up to 1.22mtpa
Crushed rock	1.652mt	1.452mtpa	1.540mtpa	1.452mt	24.32mt	16.75yrs	Up to 2.33mtpa
Recycled / secondary aggregates	0.139mt	-	-	0.139mt*	-	-	-

Source: Gloucestershire County Council 6th Local Aggregate Assessment 2016[64]

Notes: *Based on 1 year of data

Mineral safeguarding areas and peat resources

11.2.6. There is a Mineral Safeguarding Area (MSA) for limestone, sandstone, clay and coal, as identified on the policies (proposals) map[65] to the Emerging Minerals Local Plan for Gloucestershire[66], that covers the majority of the County. This MSA is located within the footprint (the first study area) of the Scheme.

11.2.7. There are no peat extraction sites within the footprint (the first study area) of the Scheme.

Generation and management of waste

11.2.8. The most recent information available relating to current waste generation and operational waste facilities in Gloucestershire has been gathered to provide the baseline for this assessment. As stated above, information for the UK[67] has also been provided as a national comparison. Information on the current waste arisings, and the waste management facilities have been determined through a desk-top study, using a number of readily available resources, in particular data from the Environment Agency, Defra, and Gloucestershire County Council.

[64] Gloucestershire County Council (2017) The Sixth Local Aggregates Assessment for Gloucestershire [online] available at: https://www.gloucestershire.gov.uk/media/18811/publication-draft-6th-laa-2016-update.pdf (last accessed February 2019)
[65] Gloucestershire County Council (2018) Policies (Proposals) Map [online] available at: https://www.gloucestershire.gov.uk/planning-and-environment/planning-policy/policies-proposals-map/ (last accessed February 2019).
[66] Gloucestershire County Council (2016) Emerging Minerals Local Plan for Gloucestershire 2018-2032 [online] available at: https://www.gloucestershire.gov.uk/planning-and-environment/planning-policy/minerals-local-plan-for-gloucestershire/emerging-minerals-local-plan-for-gloucestershire-2018-2032/ (last accessed February 2019).
[67] Where information is not available for the UK due to the differing governing authorities for England, Wales and Scotland, England has been used to provide the national comparison.

Waste generation

11.2.9. The latest data from the Environment Agency[68] indicated that Gloucestershire produced over 2.5 million tonnes of waste in 2017 (Table 11.3). England produced over 210 million tonnes of waste in 2017 (Table 11.3), which was managed in 9,264 permitted waste facilities.

Table 11.3: Waste management by type in 2017

Site type	Gloucestershire (tonnes)	England (tonnes)
Landfill	619,000	45,419,000
Transfer	417,000	46,129,000
Treatment (excluding metal recycling sector)	716,000	78,147,000
Metal Recovery	176,000	15,697,000
Incinerated	0	12,992,000
Use of Waste	28,000	168,000
Land Disposal	561,000	13,555,000
Total	**2,517,000**	**212,107,000**

Source: Environment Agency Waste Management for England 2017[68]

11.2.10. With respect to construction and demolition waste, the Environment Agency[68] recorded that 27,000 tonnes of inert construction and demolition waste and 270,000 tonnes of non-inert construction and demolition waste was deposited in landfill in Gloucestershire in 2017. There are no figures available showing how much construction and demolition waste was recovered or recycled, however the figures show that 28,000 tonnes of waste were used in construction (under permits) in Gloucestershire in 2017.

11.2.11. In regard to hazardous waste, Table 11.4 below outlines the quantities managed and deposited in Gloucestershire, in 2017. Of the 67,397 tonnes managed in Gloucestershire, 8,975 tonnes were specified as construction and demolition waste and asbestos, and of the 76,480 tonnes deposited in Gloucestershire, 4,770 tonnes were specified as construction and demolition waste and asbestos.

[68] Environment Agency (2018) Waste Management for England 2017 [online] available at: https://www.gov.uk/government/publications/waste-management-data-for-england (last accessed February 2019)

Table 11.4: Hazardous waste managed and deposited in 2017

Hazardous waste	Gloucestershire (tonnes)	England (tonnes)
Managed	67,397	4,955,623
Deposited	76,480	5,300,769

Source: Environment Agency Waste Management for England 2017[68]

Potential hazardous waste arisings

11.2.12. Sources of contamination have been considered within the first study area (within the boundary of the Scheme). There are no authorised or historic landfills within the study area. However, as indicated in Chapter 9 Geology and Soils, there may be potential contamination risks from general highways use and agricultural land use. For more information on the potential contamination risks see Chapter 9 geology and soils.

Waste management facilities

11.2.13. The Waste Management for England 2016 provides the most up to date information on the remaining capacity of landfill in Gloucestershire. This is shown in Table 11.5.

Table 11.5: Landfill capacity in 2016

Landfill type	Gloucestershire (m^3)
Hazardous Merchant	1,110,000
Hazardous Restricted	-
Non-Hazardous with SNRHW* cell	1,607,000
Non-Hazardous	1,554,000
Non-Hazardous Restricted	-
Insert	0
Total	**4,270,000**

Source: Environment Agency Waste Management for England 2016[68]

* Stable Non-Reactive Hazardous Waste

11.2.14. The most recent data from Gloucestershire County Council on the capacity of their waste management facilities is outlined in their adopted Waste Core

Strategy[69] from 2012, along with the associated evidence base documents that informed the strategy.

11.2.15. The Waste Core Strategy identifies four operational landfills in Gloucestershire; three non-hazardous sites (Hempsted in Gloucester, and Wingmoor Farm West and Wingmoor Farm East near Bishop's Cleve, Tewkesbury Borough), and one hazardous site (Wingmoor Farm East near Bishop's Cleeve, Tewkesbury Borough). The remaining capacity, recorded in March 2009, for non-hazardous waste, was 6,029,500m^3 which equates to at least 10-13 years input, and for hazardous waste was 1,206,200m^3 which equates to 22 years input.

11.2.16. There are also 19 permitted inert landfill / restoration facilities (including quarries) receiving construction and demolition waste within Gloucestershire[70].

11.2.17. The capacity for construction and demolition disposal through permitted facilities in Gloucestershire, in 2010, was estimated to be 1,446,000 tonnes[70].

11.2.18. In addition to permitted construction and demolition waste management sites, inert material is also managed on sites that have an Environment Agency environmental permit exemption. These exempt sites generally comprise land restoration activities such as restoring mineral voids, engineering / landscaping Schemes and for beneficial improvements to land. These sites are an important part of the provision of the capacity for managing inert materials. Although small tonnages of waste from other waste streams (e.g. biodegradable waste) may be managed at locations with an exemption, the largest tonnage of exempt activities is likely to involve construction and demolition material.

11.2.19. In 2007, there were 2,139 exempt sites, listed by the Environment Agency, in Gloucestershire, and it was estimated that there was around 1.25 million m^3 of capacity in the County[70]. These sites are often short-lived, and therefore, should be identified upon commencement of construction.

11.2.20. In regard to recovery and recycling facilities, there are 29 permanent, permitted inert waste recycling and recovery facilities in Gloucestershire[70]. These manage construction and demolition waste, through transfer, treatment, crushing and screening, and storage.

[69] Gloucestershire County Council (2012) Gloucestershire Waste Core Strategy [online] available at: https://www.gloucestershire.gov.uk/media/14056/adopted_wcs_211112-53886.pdf (last accessed February 2019)
[70] Gloucestershire County Council (2010) Waste Core Strategy: Technical Paper WCS-A Waste Data (Update 2010) http://www.gloucestershire.gov.uk/media/8107/technical_evidence_paper_wcs-a_data_-2010_update-43159.pdf (last accessed February 2019)

11.2.21. The capacity for construction and demolition management through permitted facilities in Gloucestershire, in 2010, was estimated to be 504,000 tonnes per annum[70].

11.3. Potential impacts

11.3.1. This section considers the potential impacts of the Scheme.

Construction

Use of material resources

11.3.2. The potential impacts associated with the use of material resources include the reduction in the availability of material resources, and the potential depletion of natural resources. It is outside of the scope of the assessment to consider the environmental effects associated with raw material extraction, and the processing and manufacturing of products, as these are likely to be subject to separate environmental assessments. The use of material resources would also be likely to generate adverse environmental effects through the transportation of materials (for use on-site), however, effects of this are dealt with within Chapter 6 Air Quality and Chapter 12 Noise and Vibration. The types of material resources likely to be required for the construction of the Scheme include the following:

- Steel
- Aggregate
- Cement
- Concrete
- Bitumen
- Wood
- Plastic
- Clay
- Iron
- Fly Ash

11.3.3. Quantities of materials have not been determined at this stage, except for the cut and fill volumes which are presented in Table 11.6. Table 11.6 shows that there is sufficient quantity of cut material to be utilised as fill for the Scheme. Therefore, it is unlikely that fill would need to be imported to site.

Table 11.6: Estimated cut and fill volumes (February 2019)

A436 Link Road Alternative	Cut	Fill	Overall balance
A436 Link Road Alternative 1: bridge over A417	1,505,530m^3	744,630m^3	760,900m^3 (surplus)
A436 Link Road Alternative 2: parallel to the A417	1,454,366m^3	833,650m^3	620,716m^3 (surplus)
A436 Link Road Alternative 3: via South Hill	1,399,841m^3	896,886m^3	502,955m^3 (surplus)

Generation and management of waste

11.3.4. The potential impacts associated with the generation and management of waste from the construction of the Scheme include the temporary occupation of waste management facility space (from treatment of waste) and the permanent reduction to landfill capacity (from disposal of waste). The generation and management of waste would require transport off-site, however as per paragraph 11.3.2, the effects of the transportation of waste is dealt with in Chapter 6 Air Quality and Chapter 12 Noise and Vibration.

11.3.5. Quantities of waste likely to be generated by the construction of the Scheme have not been determined at this stage. However, waste may result from the following:

- Surplus excavated materials (soils or substrata)
- Green waste (from vegetation removal or management)
- Waste from the demolition of existing structures
- Contaminated soils from excavations (which may be classified as hazardous waste)
- Surplus construction materials (for example, concrete, aggregates, asphalt)

11.3.6. As noted in Table 11.6, there would be a surplus of cut material, it is assumed at this stage that this surplus material is suitable re-use on-site in the landscaping for the Scheme. However, due to the quantity of surplus material it is unlikely that all the material could be re-used in the landscaping, and therefore there may be impacts associated with the waste management of this surplus material.

Operation

Use of material resources

11.3.7. It is anticipated that there would be minimal requirements for material resources as part of the maintenance activities during the operational phase. Therefore, there are unlikely to be any impacts from the reduction in the availability of material resources, and the depletion of natural resources.

Generation and management of waste

11.3.8. Maintenance activities associated with the operation of the Scheme would be unlikely to generate significant quantities of waste. Therefore, there are unlikely to be any impacts from the temporary occupation of waste management facility space (from treatment of waste) and the permanent reduction to landfill capacity (from disposal of waste).

11.4. Design, mitigation and enhancement measures

Construction

11.4.1. Measures would be implemented to reduce the effects from the use of material resources and the generation and management of waste by the proposed Scheme during the construction phase. There is substantial overlap in the mitigation for both aspects (material resource use and waste generation), due to the synergy between the re-use of materials and the avoidance of waste generation.

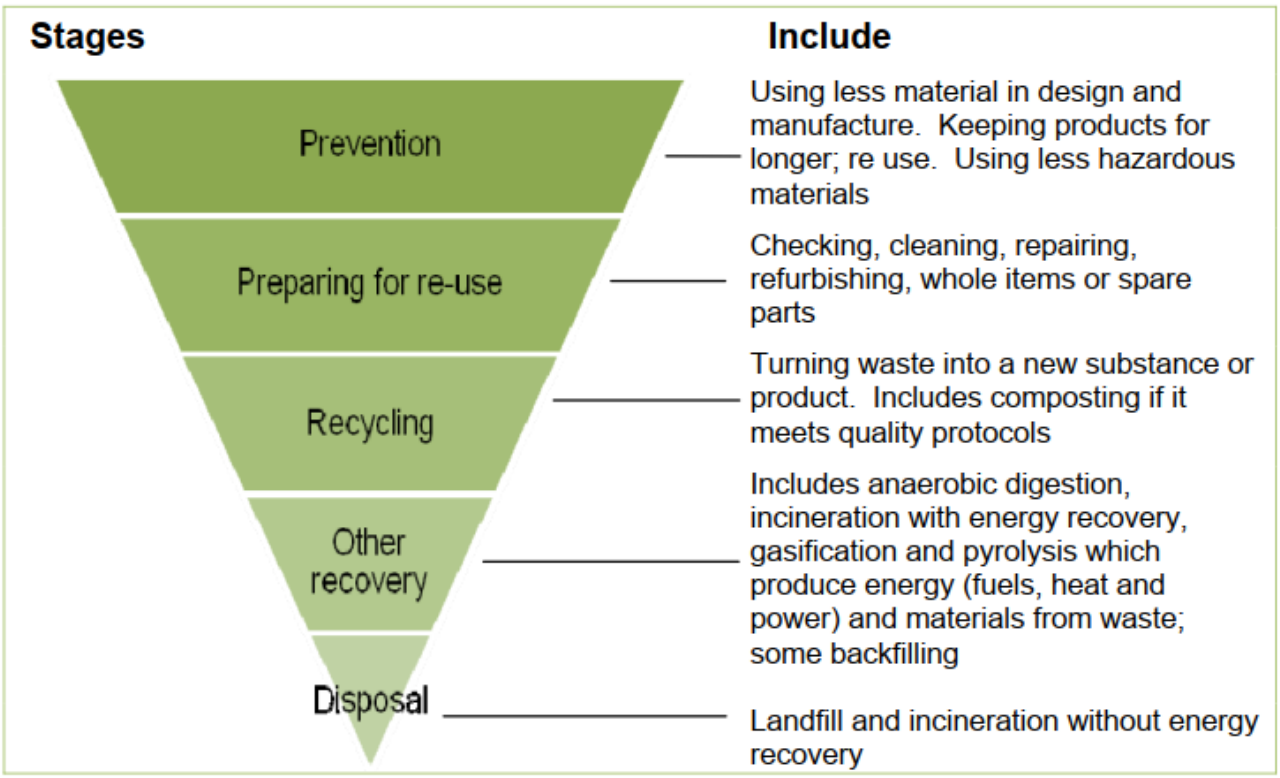
11.4.2. Consideration would be given throughout the development of the Scheme design to minimising the use of virgin materials. This would be achieved through reducing the material requirements within the design itself, through utilising new infrastructure that contains a high proportion of recycled content (where design constraints allow), and by designing to re-use and recycle site-won materials wherever possible.

11.4.3. A Construction Environmental Management Plan (CEMP) would be produced for the proposed Scheme which would detail mitigation measures that would be implemented on-site to ensure efficient use of material resources and reduction of waste arisings, and to reduce the potential impact identified in Section 11.3 above. Mitigation may include (but not limited to) the following measures:

- Materials would be delivered on an ‘as required’ basis to avoid damage or contamination, and therefore limit the likelihood of waste.

- All suitable excavated material would be re-used in the construction of the proposed Scheme and in landscaping features to reduce the requirements to import materials for construction and reduce the need to remove surplus materials from site.
- Where site-won material is not available or suitable for re-use, secondary or recycled materials would be procured where available and practicable.
- Temporary stockpiling of fill materials, prior to incorporation in the proposed Scheme, would be avoided where possible. This ensures double handling and damage is minimised and therefore, avoids the generation of waste.
- Locally sourced materials and suppliers would be identified and used, where practicable.
- Pre-cast elements would be used, where practicable, to ensure efficient use of materials and avoid the generation of waste arisings from cut offs.
- The waste hierarchy (as shown in Figure 11.1 below) would be implemented throughout the construction to minimise disposal and maximise re-use and recycling of waste arisings. Opportunities for re-use and recycling of waste include (but are not limited to):
  - Re-using excavated soils on-site in the landscaping features of the Scheme.
  - Chipping green waste on-site for use in the landscaping for the Scheme.
  - Composting of green waste.
  - Recycling of inert material by crushing, blending and subsequent re-use, as an aggregate.
  - Re-using waste on other nearby Schemes.
  - Re-using waste for uses with clear benefits to the environment, for example in the remodelling of agricultural land or in the restoration of nearby quarries or other excavation sites.
- Facilities would be provided on-site to separate out waste, for example for recycling.

Figure 11.1: Waste hierarchy



Source: Guidance on applying the waste hierarchy[71]

11.4.4. A Site Waste Management Plan (SWMP) would be produced for the proposed Scheme, which would ensure that waste is managed in accordance with the waste hierarchy and other relevant legislative requirements, and would detail information on the waste carriers and waste management facilities that would be used.

11.4.5. Where waste must be taken to a recycling or disposal site, the contractor must ensure that the sites have the appropriate permits to ensure that environmental risks are reduced, such as damage to hydrological systems. In addition, the suitable facility would be located as close to the works as possible to minimise the impacts of transportation, in particular the release of carbon emissions. The appointed Contractor would identify the closest and relevant treatment and disposal sites.

11.4.6. A Materials Management Plan (MMP) would also be produced by the Contractor for the earthworks, if appropriate. This would identify ways to re-use site-won or

[71] Defra (2011) Guidance on applying the waste hierarchy [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69403/pb13530-waste-hierarchy-guidance.pdf (last accessed February 2019)

excavated materials within the construction of the proposed Scheme provided it meets the requirements for the CL:AIRE Code of Practice.

11.4.7. The preparation of a CEMP, SWMP and MMP would ensure that any adverse effects associated with material resource use and waste generation are considered and managed.

Operation

11.4.8. No mitigation or enhancement measures have been identified with respect to the use of material resource or the generation and management of waste for the operation of the proposed Scheme.

11.5. Description of the likely significant effects

Construction

Use of material resources

11.5.1. As outlined in Section 11.3 above, there is sufficient quantity of cut material to be utilised as fill for the Scheme. As such, it is unlikely that fill would need to be imported to site, and therefore, no significant effects from this element of the construction works are anticipated. It is anticipated that material resource use from other elements of the construction works can be appropriately mitigated through the implementation of mitigation measures outlined in Section 11.4. Therefore, no significant effects on material resources are anticipated.

Generation and management of waste

11.5.2. The Scheme would aim to minimise the generation of waste as much as possible, through the implementation of the waste hierarchy (as outlined in Section 11.4 above) and throughout the design process. At this stage, it is assumed that surplus cut materials (identified in Table 11.6) would be suitable for re-use in the landscaping for the Scheme. However, due to the large quantity of surplus cut material, it is unlikely that this could be fully re-used in the landscaping or other construction works. Therefore, there is the potential for significant effects.

11.5.3. Providing waste is managed appropriately, implementing the mitigation measures outlined in Section 11.4 the effects associated with the generation and management of waste can be reduced. However, due to the existing uncertainties regarding the characterisation and quantities of waste anticipated, and its suitability, certainty and justification for reuse, further assessment within the Environment Statement will be necessary.

Operation

11.5.4. Significant effects are considered unlikely during the operation of the Scheme, from both the use of material resources and the generation and management of waste. Refer to Section 11.3 for further information.

11.6. Assessment methodology

Proposed level and scope of assessment

11.6.1. Due to the scale of the Scheme, there is potential for significant direct effects on waste management facilities during construction as a result of waste generation. Therefore, further assessment will be required for waste generation for the construction phase to a Design Manual for Roads and Bridges (DMRB) Detailed level.

11.6.2. No significant effects are anticipated on material resource use during construction and therefore material resources have been scoped out of further assessment.

11.6.3. No significant effects are anticipated on Material resource use and waste generation during operation and therefore Material resource use and waste generation have been scoped out of further assessment.

Policy requirements, guidance and advice

11.6.4. Further assessment will be carried out in accordance with guidance provided in:

- IAN 153 / 11 ‘Guidance on the Environmental Assessment of Material Resources’
- DMRB Volume 11, Section 2, Part 5 ‘Assessment and Management of Environmental Effects’ (HD 2-5 / 08)
- National Policy Statement for National Networks (NPSNN) 2014
- National Planning Policy for Waste 2014
- The Waste Management Plan for England 2013

Determination of significant effects

Proposed methodology

11.6.5. The approach for the DMRB Detailed level assessment for the generation and management of waste will follow the guidance presented in IAN 152 / 11, and will take into account the following:

- The cut and fill balance

- The types and quantities of forecast waste arisings from the Scheme, including the identification of any forecast hazardous waste
- Surplus materials and waste falling under regulatory bodies
- Waste that requires storage on-site prior to re-use, recycling and disposal
- Waste to be pre-treated on-site for re-use within the Scheme
- Wastes requiring treatment or disposal off-site
- The impacts that will arise from the issues identified in relation to materials and waste
- A conclusion about the magnitude and nature of the impacts and whether they are permanent or temporary and direct or indirect
- The identification of measures to mitigate the identified impacts

11.6.6. No industry guidance on significance criteria for the assessment on the generation and management of waste exists. Therefore, an approach to determining the significance of the potential effects has been developed using professional judgement. The significance of effect will be assigned in accordance with the criteria outlined in Table 11.7.

Table 11.7: Effect categories and typical descriptors for the assessment on the generation and management of waste

Significance	Significance category	Description
Not Significant	Neutral	• No reduction or alteration in the capacity of waste infrastructure at a regional scale.
	Slight	• ≤1% reduction or alteration in the regional capacity of waste infrastructure. • Waste infrastructure has sufficient capacity to accommodate waste from a project, without compromising integrity of the receiving infrastructure (design life or capacity) within the region.
Significant	Moderate	• >1% reduction or alteration in the regional capacity of waste infrastructure as a result of accommodating waste from a project. • 1-50% of project waste requires disposal outside of the region.
	Large	• >1% reduction or alteration in the regional capacity of waste infrastructure as a result of accommodating waste from a project. • Sterilises ≥1 mineral safeguarding area and / or peat resource. • >50% of project waste requires disposal outside of the region.
	Very Large	• >1% reduction or alteration in national capacity of waste infrastructure as a result of accommodating waste from a project. • The project would require new (permanent) waste infrastructure to be constructed to accommodate waste.

Notes: 'Region' means the authority comprising the second study area, in this case Gloucestershire.
'Peat resource' refers to existing or potential peat extraction sites
'Sterilise' refers to 'obstruct access to and / or constrain the ability to work primary material resources'

11.7. Assessment assumptions and limitations

11.7.1. The baseline information has been based on publicly information at this stage. Consultation will be undertaken with Gloucestershire County Council to obtain the most recent information held on the capacity of waste management infrastructure to inform the Environmental Statement.

11.7.2. Given the early stages of design, estimates relating to the quantity of materials required are not available nor are there estimates available relating to the quantity of waste arisings anticipated. As such, a qualitative assessment has been carried out at this stage, limited to identifying activities that are likely to require significant quantities of materials, or are likely to produce significant quantities of waste.

11.7.3. Indicative cut and fill volumes for the Scheme are provided in Table 11.6. These volumes have been estimated based on the latest design information available and are likely to change as the design of the Scheme evolves. Therefore, the estimated cut and fill volumes will be reviewed and updated to inform the assessment for the Environmental Statement.

12. Noise and vibration

12.1. Study area

12.1.1. The assessment will follow the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 7 Noise and Vibration (HD213/11) which provides the methodology for the assessment of road projects within the UK.

12.1.2. For operational noise, the methodology requires that the study area is identified as an area within one kilometre of the physical works associated with the Scheme. The study area for each A436 Link Road Alternative, as described in paragraphs 2.4.6 – 2.4.24 above includes a one kilometre area from the physical works for each alternative arrangement respectively. Within this study area, road traffic noise predictions are performed at any sensitive receptor within 600 metres of a road where there is the possibility of a change of 1dB $L_{A10, 18hr}$ upon Scheme opening, or 3dB $L_{A10, 18hr}$ in the long term.

12.1.3. For potential effects due to road traffic noise outside of the one kilometre study area, the methodology requires that sensitive receptors are identified adjacent to roads where the change in road traffic noise level would, as a result of the Scheme, increase or decrease by at least 1dB $L_{A10, 18hr}$ on opening or 3dB in the long term. Consequently, the spatial extents of the assessment extend beyond the physical works associated with the Scheme.

12.1.4. For construction noise, the study area is the same as that defined for the assessment of operational noise effects, although this may be extended to assess the effects from construction traffic on the existing road network and from potential diversion routes.

12.2. Baseline conditions

12.2.1. As baseline noise surveys have not been undertaken at this stage of the Scheme development, existing baseline conditions have been determined through a desk-top study.

12.2.2. Sources included in the desk study are:

- Noise mapping undertaken as part of the requirements of The Environmental Noise (England) Regulations 2006
- Ordnance Survey (OS) mapping
- Consultation with the local authority
- Traffic flows
- Review of any previous surveys and assessments

12.2.3. The existing noise sensitive receptors within the study area of the Scheme include:

- Six Noise Important Areas (NIAs) are located within the study area on the existing A436 and A417
- Approximately 13 footpaths including the Cotswold Way National Trail and four bridleways within 200 metres of the Scheme
- The Crickley Hill and Barrow Wake Site of Special Scientific Interest (SSSI) is located adjacent to the Scheme
- There are six Key Wildlife Sites within one kilometre of the Scheme
- The Cotswold Beechwoods Special Area of Conservation (SAC) is located within one kilometre of the Scheme
- There are no National Nature Reserves (NNRs), Local Nature Reserves (LNRs), RSPB Reserves, or Ramsar sites within one kilometre of the Scheme

A436 Link Road Alternative 1: bridge over A417

- There are approximately 890 residential properties and 85 other noise sensitive properties within the defined study area.

A436 Link Road Alternative 2: parallel to the A417

- There are approximately 890 residential properties and 95 other noise sensitive properties within the defined study area.
- There are approximately 910 residential properties and 105 other noise sensitive properties within the defined study area.

12.3. Potential impacts

Construction

12.3.1. During construction, works have the potential to directly alter the noise and vibration baseline for sensitive receptors for a temporary period. Adverse impacts are likely to be restricted to areas where the existing baseline noise levels are exceeded subject to the application of appropriate mitigation. This would be principally in the vicinity of the Scheme envelope (including any construction compound areas), although could extend along elements of the existing road network, depending on haul routes and the quantity of construction-related traffic.

Operation

12.3.2. The Scheme comprises a combination of offline and online alignments following the existing A417 corridor east of the Air Balloon. There is the potential for changes to traffic flows and road alignment to result in noise changes at noise sensitive receptors that are both currently affected and unaffected by road traffic noise.

12.4. Design, mitigation and enhancement measures

Construction

12.4.1. A Construction Environmental Management Plan (CEMP) would be produced by the appointed Contractor which would include measures to minimise noise and vibration during construction, such as through the timing of works and restrictions on the noisiest of activities, which would be agreed with the local authority. Likely mitigation measures to minimise the impact of noise may include the selection of appropriate plant, shielding of noisy items of plant, appropriate siting of haul routes, enclosures, early construction of bunds, and an appropriate site layout. Likely mitigation measures to minimise the impact of vibration may include the selection of low vibration piling and construction methods (for example, selection of rotary bored instead of vibratory or driven piling techniques).

12.4.2. Further assessment will be required to inform the mitigation strategy following receipt of detailed information on construction activities. This assessment will be undertaken based upon the requirements of BS5228 Parts 1 and 2.

Operation

12.4.3. Mitigation measures will be included in the Scheme design where required which will include a combination of measures such as:

- Acoustic barriers
- Acoustic bunds
- Low noise road surfacing

12.4.4. Where noise changes may still result in significant effects for sensitive receptors, additional measures in the form of secondary glazing may be offered for those properties affected.

12.5. Description of the likely significant effects

Construction

12.5.1. The construction period is expected to last approximately three years, other details of the construction methodology or programme are not available at this stage and therefore it is not possible to accurately predict the likelihood of significant effects due to construction activities.

12.5.2. The greatest risk of potential significant effects would occur at the closest receptor locations during extended periods of any proposed piling works or night works, where sensitivity is greater as a result of lower baseline noise levels.

12.5.3. Further detailed assessment and consideration of mitigation measures will be required to determine potential significant effects from noise and vibration during construction.

Operation

12.5.4. With the implementation of appropriate mitigation as described in Section 12.4, such as the provision of noise barriers / bunds and low noise road surfacing, potential adverse effects would be reduced. Nonetheless, it is considered that there is the potential for significant residual adverse effects to noise and vibration sensitive receptors which warrants further assessment within the Environmental Statement.

12.6. Assessment methodology

Proposed level and scope of assessment

12.6.1. Noise and vibration during construction has the potential to generate adverse effects at nearby receptor locations. Further assessment and design of mitigation measures is necessary to avoid and minimise adverse noise and vibration effects.

12.6.2. The operation of the scheme has the potential to result in adverse noise effects at nearby noise sensitive receptors due to the changes in alignment and traffic flows on the road network. Further assessment and design of mitigation measures is necessary to avoid and minimise adverse noise effects.

12.6.3. DMRB advises airborne vibration has the potential to cause nuisance to receptors for noise exposure levels above 58dB $L_{A10.}$ Further assessment and consideration of disturbance due to airborne vibration during construction will be undertaken and presented in the Environmental Statement.

12.6.4. The new carriageway surfaces would have no significant discontinuities. As such, no changes in ground-borne vibration are expected from operational road traffic, and therefore no adverse effects are anticipated. This is therefore scoped out of the Environmental Statement.

12.6.5. Further assessment of the construction and operational effects is necessary due to the potential for significant effects during construction and operation upon noise sensitive receptors. As such, further assessment is required to a DMRB Detailed Level.

Policy requirements, guidance and advice

12.6.6. The following legislation, standards and best practice guidelines are considered to be relevant to the assessment of the Scheme:

- The National Planning Policy Framework (NPPF) 2018
- The Noise Policy Statement for England (NPSE) 2010
- Planning Practice Guidance (PPG) 2014
- The National Policy Statement for National Networks (NPSNN) 2014
- The Land Compensation Act 1973 Part 1
- The Noise Insulation Regulations 1975 (amended 1988)
- Sections 60 and 61 of The Control of Pollution Act 1974
- The Environmental Protection Act 1990
- British Standard (BS) 5228-1:2009+A1:2014 ‘Code of practice for noise and vibration control on construction and open sites – Part 1: Noise’
- BS5228-2:2009+A1:2014 'Code of construction practice for noise and vibration control on construction and open sites - Part 2: Vibration'
- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 7 ‘Noise and Vibration’ (HD213/11 – Revision 1) 2011
- Interim Advice Note 185/15 ‘Updated traffic, air quality and noise advice on the assessment of link speeds and generation of vehicle data into ‘speed bands’ for users of DMRB Volume 11, Section 3, Part 1 ‘Air Quality’ and Volume 11, Section 3, Part 7 ‘Noise’
- Calculation of Road Traffic Noise (CRTN) 1988
- Guidelines for Noise Impact Assessment, Institute of Environmental Management & Assessment (IEMA) 2014
- World Health Organisation (WHO) Guidelines for Community Noise, 1999
- WHO Night Noise Guidelines for Europe, 2009
- WHO Environmental Noise Guidelines for the European Region, 2018

12.6.7. The above list is not exhaustive and further guidance will be referred to where necessary.

Determination of significant effects

Proposed methodology

12.6.8. The NPSNN requires that 'due regard' must be given to relevant sections of the NPPF, the NPSE and the associated National Planning Policy Guidance on noise. In order to comply with these policies, it will be necessary to determine the Lowest Observed Adverse Effect Level (LOAEL) and Significant Observed Adverse Effect Level (SOAEL) for noise effects. The mitigation strategy will depend upon the magnitude of any impacts at sensitive receptors between LOAEL and SOAEL, in addition to exceedances of SOAEL, the latter being an indication of the occurrence of significant adverse effects.

12.6.9. The requirement for an Environmental Impact Assessment (EIA) to assess significant effects on human health will be addressed under these NPPF and NPSE requirements, and the identification of sensitive receptors at, or above LOAEL which is 'the level above which adverse effects on health and quality of life can be detected' and SOAEL, which is the levels 'above which significant adverse effects on health and quality of life occur'.

12.6.10. Table 12.1 summarises the proposed LOAEL and SOAEL thresholds for noise and vibration at noise sensitive receptors.

Table 12.1 Summary of proposed LOAEL and SOAEL thresholds

Source	Time period	LOAEL	SOAEL	Notes
Construction noise	Day (07:00-19:00 weekday and 07:00-12:00 Saturdays)	Equals existing $L_{Aeq,T}$ noise level	Threshold level determined as per BS 5228:2009 + A2014 Section E3.2	LOAEL is set at a level where construction noise becomes the dominant source. SOAEL is set where construction noise exceeds BS5228 thresholds. Existing noise level shall be determined based on ambient noise monitoring, noise model prediction or estimation based on published noise level datasets.
	Night (23:00-07:00)	Equals existing $L_{Aeq,T}$ noise level	Threshold level determined as per BS 5228:2009 + A2014 Section E3.2	
	Evening and weekends (time periods not covered above)	Equals existing $L_{Aeq,T}$ noise level	Threshold level determined as per BS 5228:2009 + A2014 Section E3.2	
Construction vibration	All time periods	0.3mm/s PPV	1.0mm/s PPV	LOAEL is set at the lowest level of perception, SOAEL is set where levels can be tolerated with prior warning (ref BS5228:2).

Source	Time period	LOAEL	SOAEL	Notes
Operational noise	Day (06:00-24:00)	55dB $L_{A10,18h}$ (façade) 50dB $L_{Aeq,16h}$ (free-field)	68dB $L_{A10,18h}$ (façade) 63dB $L_{Aeq,16h}$ (free-field)	The daytime LOAEL is based on the onset of moderate community annoyance, and the daytime SOAEL is based on the onset of cardiovascular health effects (ref. WHO guidance) and the Noise Insulation Regulations threshold.
	Night	40dB $L_{night,outside}$ (free-field)	55dB $L_{night,outside}$ (free-field)	The night time LOAEL is defined using the WHO Night Noise Guidelines, and the night time SOAEL is equivalent to the levels above which cardio vascular health effects become the major public health concern (ref. WHO Night Noise Guidelines).
Operational vibration	Day/Night	n/a	n/a	Response to operational vibration is closely related to response to operational noise.

Construction noise

12.6.11. BS5228–1:2009+A1:2014 (BSI, 2014) does not define strict criteria to determine the significance of noise effects, although examples of how limits of acceptability have been applied historically and some examples of assessing significance are provided.

12.6.12. The assessment of construction noise will be carried out at selected receptors using BS5228 Example method 1 – The ABC method.

12.6.13. With respect to BS5228 guidance the LOAEL is considered to be the existing ambient noise level (where construction noise becomes the dominant noise source) and SOAEL to be the BS5228 ABC Method threshold.

12.6.14. An adverse impact is one in which noise from construction works exceeds LOAEL. A significant adverse effect is one for which construction noise exceeds SOAEL for an extended period (such as, for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any six consecutive months).

Construction vibration

12.6.15. BS5228 'Code of construction practice for noise and vibration control on construction and open sites – Part 2: Vibration' (BSI, 2014) provides guidance on the human and physical effects of vibration, such as levels at which it will cause complaint or cosmetic damage to buildings. BS5228 does not indicate whether particular vibration levels are significant. However, it does state that "It is likely that vibration of... [1.0mm/s] ...in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents".

12.6.16. The assessment of construction vibration will be carried out at selected receptors using the BS5228 criteria.

12.6.17. With respect to BS5228 guidance the LOAEL is considered to be the level at which vibration is perceptible and SOAEL to be the level vibration in residential environments can cause complaint but can be tolerated if prior warning and explanation is given.

12.6.18. An adverse impact is one in which LOAEL is exceeded. A significant adverse effect is one for which construction vibration exceeds SOAEL for an extended period (such as, for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any 6 consecutive months).

Operational noise

12.6.19. The DMRB HD213/11 describes the effects of road traffic noise in terms of the noise descriptors conventionally used for assessing the impact of road traffic in the UK, such as the statistical noise level $L_{A10,18h}$ over an 18-hour period between 06:00 and 24:00 (the traffic noise index). The CRTN methodology will be followed in the calculation of road traffic noise, which will provide input to the assessment of effects using the DMRB methodology.

12.6.20. The level of road traffic noise from the road network will be predicted using traffic data provided in terms of 18-hour Annual Average Weekday Traffic (AAWT) flow between the hours of 06:00 to 24:00, along with average vehicle speed and percentage of heavy goods vehicles.

12.6.21. Calculations of the road traffic noise level will be carried out for four scenarios:

- Do minimum option in the baseline year
- Do minimum option in the future assessment year
- Do something option in the baseline year
- Do something option in the future assessment year

12.6.22. In the above scenarios, 'do minimum' means traffic growth with committed development only. 'do something' means committed growth with the Scheme.

12.6.23. In accordance with the DMRB HD213/11, for a Detailed Level assessment, the assessment of road traffic noise effects requires the following comparisons:

- The short-term change in road traffic noise upon Scheme opening (do minimum option in the baseline year vs. do something option in the baseline year).
- The long-term change in road traffic noise assuming the Scheme is built (do minimum option in the baseline year vs. do something option in the future assessment year).
- The long-term change in road traffic noise assuming the Scheme is not built (do minimum option in the baseline year vs. do minimum option in the future assessment year).

12.6.24. DMRB classifies the magnitude of a noise impact as no change, negligible, minor, moderate or major with increasing noise level change and applies different criteria in the short-term and long-term. These impacts may be beneficial (noise decrease) or adverse (noise increase). Table 12.2 summarises the classification of magnitude impacts due to changes in road traffic noise.

Table 12.2: Classification of magnitude of short and long-term noise impacts due to changes in road traffic noise

Magnitude of impact	Noise change, $L_{A10,18h}$ dB	
	Short-term	Long-term
No change	0	0
Negligible	0.1 to 0.9	0.1 to 2.9
Minor	1 to 2.9	3 to 4.9
Moderate	3 to 4.9	5 to 9.9
Major	5.0+	10.0+

12.6.25. The assessment of significance of operational noise from the Scheme depends on many factors. Table 12.3 summarises the determination of significance based upon the magnitude of impacts including additional factors.

Table 12.3 Summary of determination of significance of noise effects

Magnitude of impact	Significance	Factors for determining significance
No change	Not Significant	No change or a negligible impact would not cause any discernible effect on receptors and would not give rise to significant adverse effects.
Negligible	Not Significant	
Minor	Unlikely to be Significant in the short term depending on additional factors	As impact magnitude increases from minor to moderate and major, the likelihood of significant adverse effects increases unless there are factors other than noise and vibration that are likely to influence the impact of the noise change. Where noise levels exceed SOAEL then a noise impact is more likely to lead to a significant adverse effect. Conversely where noise levels are below LOAEL then a significant adverse effect is less likely. The classification bands correspond to large ranges in noise level change. Towards the top end of a classification band a noise impact is more likely to be significant and conversely, towards the bottom end of a band a noise impact is less likely to be significant. The short-term magnitude of change is used to determine the starting point of significance. Where a greater impact magnitude following comparison with the long term occurs then this is more likely to be significant and conversely where a lower long-term impact magnitude indicates noise impact is less likely to be significant. Where a Scheme changes the acoustic character of an area (for example by the introduction of a completely new road) then a noise impact is more likely to be significant whereas an alignment change is unlikely to change the acoustic character of an area so is less likely to be significant.
Moderate	Likely to be Significant in the short term depending on additional factors	
Major	Probably Significant in all but exceptional circumstances depending on additional factors	

12.6.26. Residual effects include the provision of any proposed mitigation measures and for operational noise, potential mitigation measures are described in Section 12.4. On the above basis, residual effects are considered to be potentially significant if:

- The noise change is non-negligible (that is a change of 1dB or greater in the short-term) for a receptor exposed to noise above SOAEL, or
- A moderate or major impact in the opening year where LOAEL is exceeded.

12.6.27. In all cases where a potentially significant effect is indicated, professional judgement is used to determine if a significant effect is likely to arise. This includes consideration of the sources of noise, changes in acoustic character and the causes of change in noise levels, the magnitude of the impact in the opening year, the classification of the impact in the long-term, and the noise level in the opening year relative to LOAEL and SOAEL.

Operational vibration

12.6.28. Low frequency noise from vehicle exhausts can induce vibration (rattle) in light building elements, such as windows, known as airborne vibration. DMRB HD 213/11, paragraph A5.28 advises that vibration disturbance most closely parallels exposure to traffic noise levels, and that subject to professional judgement relating to conditions under which the research was undertaken, disturbance from vibration may be quantified along similar lines to nuisance from noise (the original research was restricted to properties within 40 metres of the carriageways where there were no noise barriers or other screening).

12.6.29. DMRB notes that traffic induced airborne vibration is expected to affect a very small percentage of people at noise exposure levels below 58dB L_{A10}.

12.6.30. The new carriageway surfaces would have no significant discontinuities. As such, no changes in ground-borne vibration are expected from operational road traffic, and therefore no adverse effects are anticipated.

12.7. Assessment assumptions and limitations

12.7.1. Existing baseline conditions have been defined by a desk-top study. There is currently no baseline noise environment data in the vicinity of the Scheme. Therefore, baseline noise monitoring will be required at locations representative of sensitive receptors within the Scheme study area. Individual monitoring locations will be selected to provide a suitable overall representation of the baseline noise climate.

12.7.2. In addition, there is currently no information on construction phasing and activities, or traffic movements from construction traffic or diversion routes. This information is required to undertake an assessment of potential construction noise and vibration impacts for the Environmental Statement.

12.7.3. Noise modelling predictions will be completed using forecast traffic information. Forecast traffic data includes an inherent level of uncertainty. Calculations will be undertaken using methodologies in accordance with CRTN, DMRB HD213/11 and current best practice. Forecast traffic flows, speeds and percentage of heavy goods data are available for the Scheme which have informed the discussion on potential effects within this report.

12.7.4. Night-time noise levels will be estimated from daytime noise levels using the Transport Research Laboratory[72] methodology. This approach agrees with guidance and methodology within DMRB HD213/11.

[72]Transport Research Laboratory, Converting the UK traffic noise index LA10,18h to EU noise indices for noise mapping (PR/SE/451/02), 2002 https://webarchive.nationalarchives.gov.uk/20050314182925/http://www.defra.gov.uk/environment/noise/crtn/pdf/noise_crtn.pdf

13. Population and human health

13.1. Study area

13.1.1. No study areas for population and human health are specified in the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 4 (HA 204/08), and the DMRB Volume 11, Section 3, Parts 6, 8 and 9. Therefore, the study areas that will be used for the assessment of population and human health have been defined using professional judgement, based on the extents and characteristics of the Scheme, likely impact pathways the location of the local area and characteristics and sensitivities of communities and associated facilities and amenities. Typically, receptors located beyond the study areas identified below are unlikely to experience significant effects as a result of a road Scheme. However, if any receptors are identified beyond these areas that do have the potential to be significantly affected as a result of the Scheme, they will also be considered. The study areas are as follows:

- **Land use:** The study area for private property and associated land take (residential and business), and development land consists of the footprint of the Scheme under consideration. The study area for community land and community facilities encompasses all open space and community facilities within 250 metres of the Scheme.
- **Severance:** The study area for severance includes communities and community facilities directly connected by walkers, cyclists and horse-riders (WCH) and motorised traveller (MT) routes and all WCH facilities including public rights of way (PRoW), National Trails, long-distance routes, cycleways and footways within 250 metres of the Scheme.
- **Amenity:** The study area comprises all WCH facilities including PRoW, National Trails, long-distance routes, cycleways and footways located within 250 metres of the Scheme.
- **Driver stress:** The study area consists of all roads within 250 metres of the Scheme. The study area for the construction assessment will be extended to include all roads directly affected by traffic management measures.
- **View from the road:** The study area considers views from the sections of the A417 within the footprint of the Scheme.
- **Human health:** Human health effects are considered based on the study area of those sub-topics most likely to affect them. The study area for health and wellbeing effects is confined to the extent of the affected wards.
- **Local economy:** Local economic effects may be felt over a wide area. The study area will encompass the areas under the jurisdiction of GCC, CDC and TDC.

13.2. Baseline conditions

13.2.1. Communities present within the vicinity of the Scheme include Shurdington to the north west, Ullenwood to the north, Seven Springs to the north east, Coberley, Cowley and Cockleford to the east, and Birdlip, Great Witcombe and Little Witcombe to the south west. Numerous hamlets and isolated residential properties are also present within the vicinity of the Scheme.

A436 Link Road Alternative 1: bridge over A417

Land use

13.2.2. Several residential private properties fall within the footprint of this A436 Link Road Alternative. Pinewood and Woodside House are located just south of the A417 and Fernbank is located to the north, all to the west of The Air Balloon Public House. To the north of the A417 and The Air Balloon Public House are the Air Balloon Cottages (two properties). Further south, to the east of Birdlip and just south of the A417 is Castle Hill Cottage.

13.2.3. The Air Balloon Public House is located just south-west of the Air Balloon roundabout. Other businesses in the vicinity include Crickley Hill Tractors Ltd, which is located south of the A417, west of the Air Balloon roundabout. Outside space owned by Rushwood Kennels and Cattery falls within the footprint of this A436 Link Road Alternative at Shab Hill. To the south-east of this A436 Link Road Alternative and directly on the A417 is The Golden Heart Inn Public House.

13.2.4. Within the study area for associated property and land-take, there are 36 separate land titles used for agricultural purposes that are under the management of approximately 30 individual farm businesses. The husbandry of the farms within the study area appears to be predominantly pastoral or arable land-use, although in the absence of specific land use information which will be established as part of the Environmental Statement, this is speculative. Refer to Section 13.7 for the assumptions and limitations for this sub-topic.

13.2.5. Several community facilities are located within 250 metres of this A436 Link Road Alternative. St John Chrysostom Church is located on Dog Lane, north of the A417 in the settlement of Witcombe. FLYUP 417 Bike Park is located south of the A417, also in the settlement of Witcombe. Ullenwood Bharat Cricket Club is located north of the Air Balloon roundabout. Birdlip Primary School and Birdlip and Brimpsfield Cricket Club are both located in the settlement of Birdlip, west of the A417.

13.2.6. With regards to community land, Ullen Wood (a woodland area with walks) is located to the east of this A436 Link Road Alternative, south of the A436. Crickley Hill Country Park is located north of the A417 and Air Balloon roundabout. The facility includes a car park and a visitor centre. Barrow Wake, a scenic viewpoint with walks and a car park, is located to the west of the A417. Emma's Grove, a wooded area with a pathway, is located to the east of the A417, just south of the Air Balloon roundabout. A football pitch is also located to the north-east of the settlement of Birdlip. Both the Cotswold Way and Gloucestershire Way long-distance walking trails also fall within the study area. Effects on the users of these walking routes will be considered within the WCH sub-topic.

13.2.7. There are no areas of development land within the study area of this A436 Link Road Alternative at present.

Severance

13.2.8. There are several community facilities within the study area of this A436 Link Road Alternative as described in paragraph 13.2.5 above. WCH routes and roads used to access these facilities will be considered within the Environmental Statement.

13.2.9. There is one national trail and four long-distance footpaths, two cycle routes, five footways, five restricted byways, six bridleways and 57 footpaths within the study area. Consideration of the main journeys WCHs are likely to make within the study area will be given in the Environmental Statement.

Amenity

13.2.10. There are two existing underpasses for the A417 within the study area, neither of which include provisions such as footways for WCHs. There is also one crossing facility over the A417 to the north-west of Bentham. There are also uncontrolled at-grade crossings at approximately seven locations within the study area including at the Air Balloon roundabout. Amenity along most routes would either be acceptable or good with WCHs required to cross local roads with lower traffic flows and / or barriers provided between people and traffic.

Driver stress

13.2.11. The section of road at the Air Balloon junction suffers from congestion, poor journey time reliability and safety issues due to an inadequate capacity and challenging alignment (limited forward visibility and steep gradients).

View from the road

13.2.12. Views from the existing A417 vary from no view to open views along the Missing Link section, that passes through the Cotswolds Area of Outstanding Natural Beauty (AONB), a high quality scenic landscape. Screening planting and earth bunds restrict the view from the road in places, due to the highly varied topography surrounding this stretch of road, although there are a number of locations where MT are able to experience far reaching views of the surrounding area.

Human health

13.2.13. Table 13.1 provides an overview of the health of the population at ward and national level. Consideration has been given to conditions considered relevant to this Scheme. The human health baseline is the same for all three A436 Link Road Alternatives.

Table 13.1 Human health by ward

Health profile category	Badgeworth ward	Ermin ward	England
Emergency hospital admissions for Chronic Obstructive Pulmonary Disease (COPD) (Standardised Admissions Ratios)	108.4	47.1	100
Respiratory disease as cause of death (all ages) (Standardised Mortality Ratios)	80.7	74.5	100

Source: Public Health England (2016): 'Local Health Reports'.

13.2.14. As shown in Table 13.1 Human health by ward, Badgeworth ward has higher rates of both emergency hospital admissions for Chronic Obstructive Pulmonary Disease (COPD) and respiratory disease as a cause of death when compared to Ermin. However, according to the Badgeworth ward Local Health Report[73], although the emergency admission rate for COPD is higher than the England average, this difference is not substantial. Similarly, the rate for respiratory disease as a cause of death is not considered to be substantially different when compared to England. According to the local health report for Ermin ward,[74] the rate for emergency admissions for COPD is significantly lower than the England

[73] Public Health England (2016): 'Local Health Report – Badgeworth ward'. Available at: http://www.localhealth.org.uk/GC_preport.php?lang=en&s=127&view=map13&id_rep=r03&selId0=4983&nivgeo=ward_2016
[74] Public Health England (2016): 'Local Health Report – Ermin ward'. Available at: http://www.localhealth.org.uk/GC_preport.php?lang=en&s=127&view=map13&id_rep=r03&selId0=7059&nivgeo=ward_2016

average. The rate for respiratory disease as a cause of death is not substantially different to the England average.

13.2.15. Certain groups of the population have an increased susceptibility to health issues. These groups are children (aged under 16 years), older people (over 65 years) and disabled people. According to the 2011 Census, the proportion of children in both Badgeworth (14%) and Ermin (16%) wards is lower than the national average of 19%. The proportion of older people in Badgeworth (29%) and Ermin (19%) wards is higher than the national average of 16%. The proportion of those with a limiting long-term health problem or disability in Badgeworth (21%) is higher than the national average of 18%. The figure for Ermin (13%) is lower than the national average.

13.2.16. There are no healthcare facilities (such as GP surgeries and hospitals) within 250 metres of the Scheme.

13.2.17. Table 13.2 provides an overview of income deprivation at district and national level. Income deprivation concerns those on low incomes who are in receipt of benefits and tax credits[75]. The population is divided into five quintiles, with quintile one being the most deprived and quintile five being the least deprived.

Table 13.2 Population by income deprivation

Location	1 (most deprived)	2	3	4	5 (least deprived)
Cotswold district	0%	7%	20%	30%	43%
Tewkesbury district	2%	14%	16%	32%	36%
England	20%	20%	20%	20%	20%

Source: 2015 Indices of Deprivation, DCLG and 2016 Mid-year population estimate, ONS

13.2.18. Table 13.2 shows that both Cotswold and Tewkesbury district have a low proportion of their populations that fall within the most deprived quintile; 0% and 2%, respectively. This is considerably lower than the national average of 20% in both instances. In terms of the least deprived, both districts have a significantly higher proportion of population that fall within this quintile, when compared to the national average.

13.2.19. The Scheme passes through several areas of open and recreational space and crosses a number of PRoW and other footpaths which may affect access to active recreational pursuits.

[75] Department for Communities and Local Government (2015) The Index of Multiple Deprivation (IMD) 2015 – Guidance [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/464430/English_Index_of_Multiple_Deprivation_2015_-_Guidance.pdf (last accessed May 2018).

Local Economy

13.2.20. Gloucestershire[76] has a population of just over 623,000 of whom 61% are of working age. This is slightly lower than the proportion for Great Britain (at 63%).

13.2.21. The employment rate[77] stands at 80%, compared with 75% in Great Britain, while unemployment is lower (at just under 3%) than the national average (of just over 4%).

13.2.22. The local economy baseline is the same for all three A436 Link Road Alternatives.

A436 Link Road Alternative 2: parallel to the A417

Land use

13.2.23. The baseline for land use is the same as for A436 Link Road Alternative 1: bridge over A417 with the exception of the following:

- A residential property is located to the north of the A436 and east of Ullenwood Manor Road (South House). A further residential property is located to the south of the A436 and west of 'Muddy Path'.
- Several community facilities are located within the settlement of Ullenwood, north of the A436. Star Golf and National Star College (a special educational needs college) are located west of Ullenwood Manor Road, while Cotswold Hills Golf Club is located to the east of this road.
- For community land, Ullen Wood (a woodland area with walks) is located to the north-east of this A436 Link Road Alternative, south of the A436. South Hill, another wooded area, is also within the study area. The land is located to the east of this A436 Link Road Alternative, south of the A436.

Severance

13.2.24. The baseline for severance is the same as for A436 Link Road Alternative 1: bridge over A417, although there are different community facilities within the study area which may have different connecting WCH and roads.

[76] All figures are based on the ONS 2016 mid-year population estimates. See: nomisweb.co.uk
[77] All figures are based on the ONS population survey for 2017. See: nomisweb.co.uk

Amenity, Driver stress, View from the road, Human health and Local Economy

13.2.25. The baseline for amenity, driver stress, view from the road, human health and local economy is the same as for A436 Link Road Alternative 1: bridge over A417.

A436 Link Road Alternative 3: via South Hill

Land use, Severance, Amenity, Driver stress, View from the road, Human health and Local Economy

13.2.26. The baseline for land use, severance, amenity, driver stress, view from the road, human health and local economy is the same as for A436 Link Road Alternative 2: parallel to the A417.

13.3. Potential impacts

Construction

13.3.1. Land required for the Scheme would include land from residential properties along the current A417 and along the route of the Scheme. This would include both temporary and / or permanent land take including the demolition of residential properties.

13.3.2. The Scheme would result in direct impacts to individual farm businesses, with temporary and permanent changes to business practices required as a result of land loss, severance and changes to access.

13.3.3. The Scheme would result in direct impacts on businesses that are located along the route of the Scheme. One business would be demolished during the construction phase. Some land may also be required on either a permanent or temporary basis from the grounds of two further businesses. Businesses that are located adjacent to the Scheme may experience disruption as a result of construction activities.

13.3.4. The Scheme would require land to be permanently taken from community facilities during the construction stage. This would impact users of this community resource. The Scheme may also result in disruption and temporary access impacts for community facilities along the route.

13.3.5. There is the potential for the loss of open space and community land used for recreational purposes during the construction phase due to land take.

13.3.6. Numerous PRoW, footways, long-distance routes and a national trail would be directly impacted during construction, as would several uncontrolled crossings of the A417. Temporarily closing and / or diverting these WCH facilities would change the journey length and time and / or the ability to use these facilities by WCHs, either recreationally, or to access residential properties and / or community facilities, and potentially alter barriers between people and traffic which would result in an increase in severance during construction.

13.3.7. Exposure to noise and dirt and visual intrusion could temporarily alter journey experience and amenity for WCHs.

13.3.8. During construction, the Scheme would also result in traffic management measures including temporary road closures, which is likely to result in increased driver stress for vehicle travellers. Road closures would create severance for those relying on such roads to access residential properties and / or community facilities in settlements in the study area.

13.3.9. Temporary changes to views from the existing road are anticipated due to changes to existing highways infrastructure.

13.3.10. The Scheme may result in both temporary and permanent impacts on PRoW and open and recreational space used for physical exercise. This has the potential to impact the health and wellbeing of users who rely on these areas for physical exercise. Should there be any changes in the levels of noise and air pollution, this may disproportionately impact the health of vulnerable groups more susceptible to change.

13.3.11. The Scheme would require a new construction workforce to deliver it which could be sourced locally. This may have a beneficial effect on employment rates in the study area (depending on the size of the construction workforce required) and an increase in trade. For example, through their use of local hospitality and catering establishments.

Operation

13.3.12. The Scheme would not result in permanent demolition of private property or further land take during the operation stage but may result in changes in permanent access arrangements and routes to some properties and businesses (including individual farms).

13.3.13. Numerous PRoW, footways, long-distance routes and a national trail would be directly impacted permanently, as would several uncontrolled crossings of the A417. Permanently closing and / or diverting these WCH facilities would change the journey length and time and / or the ability to use these facilities by WCHs,

either recreationally, or to access residential properties and / or community facilities which would result in an increase in severance during construction.

13.3.14. Changes to amenity are anticipated for WCHs with unsafe crossings of the A417 permanently closed and alternative diversions provided across the A417, removing barriers between people and traffic. Changes to traffic flows where people and traffic are present are also expected.

13.3.15. Permanent changes to journey experience for WCHs could be experienced with changes relating to exposure to noise and dirt and visual intrusions.

13.3.16. It is anticipated that there would be a reduction in congestion on the A417 as a result of the Scheme, resulting in reduced driver stress. A reduction in fear of potential accidents is anticipated with new safer facilities provided for WCHs.

13.3.17. Permanent changes to views from the existing road are anticipated with the introduction of new highways infrastructure.

13.3.18. The Scheme is likely to improve traffic flow. There is therefore the potential for improved journey times to health care facilities located in Gloucester and Cheltenham throughout operation. There is also the potential for human health to be impacted by any permanent changes to both air quality and noise levels.

13.3.19. Direct operational employment would not be created as a result of the Scheme. However, there may be increased indirect employment opportunities related to reduced congestion and improved journey times.

13.4. Design, mitigation and enhancement measures

Mitigation

Construction

13.4.1. Mitigation measures during construction would include the following:

13.4.2. A Construction Environmental Management Plan (CEMP) would be prepared by the appointed Contractor and implemented during the construction period. The CEMP would ensure that the construction of the Scheme is undertaken in as sensitive a manner as possible with regards to people within the local community.

13.4.3. A Traffic Management Plan (TMP) would be implemented during the construction phase of the Scheme. The TMP would ensure that access is maintained, and disruption is minimised as far as possible, and would include measures to minimise severance by ensuring diversions for pedestrians are well

signed, alternative access arrangements are made, and access to properties are retained.

13.4.4. Prior to construction, the appointed Contractor would register with the National Considerate Constructor's Scheme and a forum would be established to disseminate construction information to landowners, parish councils, local interest groups and the general public, to ensure that the construction of the Scheme is undertaken in as sensitive manner as possible.

13.4.5. Ongoing consultation would be carried out, to take into account the individual needs of landowners and inform mitigation design if agreed, such as the location of replacement access points.

Design measures

Operation

13.4.6. Mitigation measures of relevance during operation include the development of the WCH strategy, in consultation with local user groups and the local community. This will include the provision of overbridges, diverted WCH routes and new WCH routes.

13.4.7. New laybys would also be provided as part of the Scheme.

Compensation

Construction and operation

13.4.8. Compensation would be explored for landowners should individual farm businesses and private property currently in use be directly affected during construction of the Scheme, through the Compulsory Purchase Acquisition mechanism.

13.5. Description of the likely significant effects

Construction

A436 Link Road Alternative 1: bridge over A417

13.5.1. As a result of the need to demolish one residential property and permanently take land from other residential properties in the study area, potential significant adverse effects on private property and land take are considered a possibility.

13.5.2. As this A436 Link Road Alternative would require the demolition of one business during the construction phase, and the temporary and / or permanent land take of further businesses, there is potential for significant adverse effects.

13.5.3. As this A436 Link Road Alternative would result in direct temporary and permanent impacts to individual farm businesses, with land loss, severance and changes to access, there is potential for significant adverse effects.

13.5.4. Without further mitigation, effects on community facilities are likely, potentially resulting in adverse and significant effects on one community facility as a result of land take.

13.5.5. There is the potential for the permanent loss of open space and community land used for recreational purposes during the construction phase. Although impacts are unlikely to be significant, an adverse effect on users would be apparent.

13.5.6. There are not anticipated to be any effects on development land in the study area. Therefore, this sub-topic has been scoped out of further assessment within the Environmental Statement.

13.5.7. This A436 Link Road Alternative could result in temporary and permanent severance with the closure or diversion of numerous WCH routes connecting to community facilities, whilst the presence of traffic management during construction could result in temporary severance for MT accessing facilities. There is the potential for these effects to be significant.

13.5.8. There is the potential for significant adverse effects with numerous WCH facilities likely to be directly affected, resulting in journey length and time increases and a deterioration in facilities and increased severance.

13.5.9. There is potential for significant adverse effects on amenity with numerous WCH facilities likely to be directly affected, resulting in changes to barriers between people and traffic.

13.5.10. Significant adverse effects on driver stress are unlikely following mitigation, although further assessment is needed to confirm this.

13.5.11. Significant adverse effects upon view from the road are unlikely during construction, with traveller's ability to see the surrounding landscape likely to remain similar to the present situation.

13.5.12. This A436 Link Road Alternative may result in both temporary and permanent impacts on PRoW and open and recreational space used for physical exercise, potentially impacting the health and wellbeing of users. Further assessment is required when there is more certainty around air quality, noise and vibration, and

proposed mitigation measures to determine how groups with an increased susceptibility to health issues would be impacted by the Scheme.

13.5.13. Although this A436 Link Road Alternative may give rise to employment via a new construction workforce, this beneficial effect is unlikely to be significant given the size of the Scheme and existing employment rates in the area, further assessment is required to determine the extent of these beneficial effects.

A436 Link Road Alternative 2: parallel to the A417

13.5.14. Potential significant effects are likely to be the same as for A436 Link Road Alternative 1: bridge over A417with the exception of the following:

- As a result of the potential need to take land from two further residential properties in the study area, potential significant adverse effects on private property and land take are considered a possibility.
- Without further mitigation, effects on two further community facilities are likely. This has the potential to result in adverse and significant effects on users of the community facilities as a result of land take.
- There is the potential for the loss of land from one additional area of open space used for recreational purposes during the construction phase. Although impacts are unlikely to be significant, an adverse effect on users would be apparent.

A436 Link Road Alternative 3: via South Hill

13.5.15. Potential significant effects are likely to be the same as for A436 Link Road Alternative 1: bridge over A417.

Operation

A436 Link Road Alternative 1: bridge over A417

13.5.16. There would be no direct effects on private property, individual farm businesses and development land during the operational phase. These sub-topics have therefore been scoped out of further consideration within the Environmental Statement.

13.5.17. There is the potential for significant adverse effects with numerous WCH facilities likely to be directly affected, resulting in journey length and time increases, a deterioration in facilities and increased severance.

13.5.18. There is the potential for significant adverse effects to amenity, with numerous WCH facilities likely to be directly affected, resulting in changes to barriers

between people and traffic. Also changes in traffic flows where WCHs and vehicles are both present.

13.5.19. There is the potential for significant benefits to driver stress, although analysis of traffic data is required to verify this.

13.5.20. Significant adverse effects upon view from the road are unlikely during operation, with traveller's ability to see the surrounding landscape unlikely to remain similar to present.

13.5.21. Improvements in journey times would potentially result in beneficial effects on human health and wellbeing, by improving access to healthcare facilities such as hospitals in Gloucester and Cheltenham, and recreational facilities, including open space. There is also the potential for changes in noise and air quality levels throughout operation which could impact human health.

13.5.22. There is the potential for significant beneficial effects on the local economy as a result of improved traffic flow, reduced congestion and improved vehicular access to key economic centres, including Gloucester and Cheltenham.

A436 Link Road Alternative 2: parallel to the A417

13.5.23. Potential significant effects are likely to be the same as for A436 Link Road Alternative 1: bridge over A417.

A436 Link Road Alternative 3: via South Hill

13.5.24. Potential significant effects are likely to be the same as for A436 Link Road Alternative 1: bridge over A417

13.6. Assessment methodology

Proposed level and scope of assessment

13.6.1. The assessment will be undertaken to a DMRB Detailed Level for the following population and human health sub-topics for the construction and operational phases:

- Land use (construction only)
- Severance
- Amenity
- Driver stress
- View from the road
- Human health
- Local economy

Policy requirements, guidance and advice

13.6.2. The guidance used for the assessment of population and human health is defined in detail in paragraphs 13.6.3 to 13.6.29 below. The sub-topics included in the assessment meet the requirements of the EIA Regulations.

Proposed methodology

Land use

13.6.3. The assessment of effects of the Scheme on residential and business receptors will consider land-take and demolition effects and be undertaken using the guidance contained within DMRB Volume 11, Section 3, Part 6: 'Land Use'.

13.6.4. The assessment will identify the type and number of residential and business properties which might be at risk of demolition as a result of the Scheme. The assessment will also consider the effects of land-take from private properties such as the loss of gardens, garages and other outside space, such as parking, in part or in whole.

13.6.5. The effects on businesses in relation to employment implications and loss of resources or amenities arising from the loss of all or part of a business will be assessed.

13.6.6. An assessment of effects on individual farm businesses will be completed which considers effects of the Scheme on husbandry, severance and major accommodation works for access, water supply and drainage for each farm business within the study area. The assessment of agricultural land (soils) will be completed as part of the Chapter 9 geology and soils.

13.6.7. The assessment of effects on community land (and community facilities) will be undertaken in accordance with DMRB Volume 11, Section 3, Part 6, and consider both direct and indirect effects arising as a result of the Scheme. The assessment will identify community land and resources in the study area, as well as receptors relevant to the topic, and identify the activities relating to the Scheme that could have an effect on those resources and receptors.

13.6.8. For the basis of this assessment, community resources include, but will not be limited to, those outlined in the DMRB Volume 11, Section 3, Part 8: 'Pedestrians, Cyclists, Equestrians and Community Effects'. Resources include doctor's surgeries, hospitals, medical facilities, schools, churches, leisure facilities (for example cinemas) and formal recreation facilities (for example parks, sports and recreation grounds, children's play areas and outdoor sports facilities).

13.6.9. The assessment of development land will be undertaken in accordance with DMRB Volume 11, Section 3, Part 6: 'Land Use', and Part 9: 'Vehicle Travellers' and consider the effects arising as a result of the Scheme. Development sites will be identified through the local authority's local plan. The effects in terms of loss of land and wider economic potential (for example, arising through change in access) will be assessed qualitatively.

13.6.10. The operational assessment for the land use sub-topic has been scoped out of further assessment within the Environmental Statement as all temporary and permanent effects will be captured as part of the construction stage assessment. There would be no direct effects on private property, community land and resources (including businesses and farm businesses) and development land during operation.

Severance

13.6.11. Changes in amenity for pedestrians and other users (specifically cyclists and equestrians) may be such that they affect adversely or beneficially, the degree to which a locality is subject to 'community severance'. The DMRB Volume 11 Section 3 Part 8 outlines community severance as the "*separation of residents from the facilities and services they use within their community*", caused by new or improved roads or by changes in traffic flows. In addition to changes in community severance caused by changes in the ability of pedestrians and other users to travel in the locality of a Scheme, severance may sometimes be caused by the demolition of a community facility or the loss of land used by members of the public.

13.6.12. The severance assessment will consider the effect of the Scheme on key community resources, primarily through assessing the effects on WCH routes and also roads connecting to these resources, as described in the DMRB Volume 11, Section 3, Part 8, Chapter 2: 'Journey length, local travel patterns', using guidance in the DMRB Volume 11, Section 3, Part 8 and professional judgement.

13.6.13. The assessment of journey length and time will be undertaken in accordance with DMRB Volume 11, Section 3, Part 8 and examine the likely detriment or improvement to WCH journeys, including changes to journey length and quality along the length and within the wider vicinity of each WCH facility and consider WCH survey data as appropriate.

Amenity

Amenity is described as the "*relative attractiveness or pleasantness of a route or place*" in DMRB Volume 11, Section 3, Part 8 and as such, the assessment will

consider all relevant assets, routes, communities, community resources and recreational facilities within the study area. The assessment will consider changes to the degree and duration of people's exposure to traffic and to fear of safety for people. The assessment will also consider any alterations to existing barriers between pedestrians and to vehicle traffic and footpath width. Changes to the distance from traffic and to crossing facility provisions will also be assessed. Exposure to noise and dirt, poor air quality, and effects relating to visual intrusion are relevant to amenity, specifically in relation to changes in journey experience.

13.6.14. The criteria in Table 13.3, along with the significance criteria in Table 13.4 and Table 13.5 will be used to assess the significance of effects for amenity by applying professional judgement and guidance within the DMRB Volume 11 Section 3 Part 8[78]. This requires a descriptive approach to be employed indicating the change in amenity and providing a reference to forecast flows. Table 13.3 is only relevant for the amenity sub-topic, as it is the only sub-topic which considers changes to the pleasantness of a journey, and therefore criteria are needed to determine existing amenity. The operational assessment analyses traffic forecasts for the opening year where WCHs are adjacent to / or continuously exposed to traffic with no barrier and considers changes in average annual daily traffic (AADT) values for the without Scheme (do minimum) and with Scheme (do something) scenarios.

Table 13.3: Categories used to describe existing amenity

Category	Description
Very Poor	WCHs required to cross or travel along a major road (that is, an A-road or motorway) with no facilities specifically for WCHs.
Poor	WCHs required to either cross or travel along a minor road (that is, a B-road or local road) in an urban area without any designated WCH facilities; or, cyclists required to travel along minor roads without any designated facilities.
Acceptable	WCHs required to cross or travel along a minor road in a rural area without any designated WCH facilities; or, WCHs are segregated from traffic, but are situated adjacent to a major or minor road; or, WCHs required to cross a major or minor road using a signalised crossing.
Good	WCHs completely separated from traffic.

Source: Developed from DMRB Volume 11 Section 3 Part 8 using professional judgement

[78] Highways Agency (2008) DMRB Volume 11 Section 3 Part 8 'Pedestrians, Cyclists, Equestrians and Community Effects' [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/11s3p08.pdf (last accessed January 2019)

Driver stress

13.6.15. The assessment of effects on driver stress will be undertaken using the guidance contained within DMRB Volume 11 Section 3 Part 9[79]. The DMRB considers that driver stress has three components: frustration, fear of potential accidents, and route uncertainty. A qualitative overview will be provided applying the three-point descriptive scale (low, moderate or high) in line with the DMRB Volume 11 Section 3 Part 9[80] Chapter 4. The construction driver stress assessment will consider the likely scope of works and potential changes to traffic flows, speeds and congestion for roads within the study area, when compared to the baseline. The operational driver stress assessment will use traffic forecast flow outputs from the traffic model applied for the Scheme. The assessment will analyse changes to traffic flows per lane and journey speeds (kilometres per hour) for the design year, during morning (AM) and afternoon (PM) peak hours. It will utilise average annual weekly traffic (AAWT) data and compare traffic data for the without Scheme (do minimum) and with Scheme (do something) scenarios.

13.6.16. A low, moderate and high descriptive scale will be used to provide a qualitative description of driver stress changes from the baseline for MT.

View from the road

13.6.17. The DMRB Volume 11, Section 3, Part 9 considers that the existence of a new road may enable more people to see the surrounding landscape than before or require people to pass through visually unattractive areas. The view from the road assessment will provide a qualitative overview of the views afforded by the Scheme. A description will be provided for traveller's exposure to different types of scenery through which the routes pass, using the four categories below:

- No view: road in deep cutting or contained by earth bunds, environmental barriers or adjacent structures.
- Restricted view: frequent cuttings or structures blocking the view.
- Intermittent view: road generally at ground level but with shallow cuttings or barriers at intervals.
- Open view: view extending over many miles, or only restricted by existing landscape features.

[79] Design Manual for Roads and Bridges Volume 11, Section 3, Part 9 *Vehicle Travellers* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/11s3p09.pdf (last accessed January 2019)
[80] Design Manual for Roads and Bridges Volume 11, Section 3, Part 9 *Vehicle Travellers* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/11s3p09.pdf (last accessed January 2019)

13.6.18. This assessment will consider where any change in views from the Scheme are:

- Beneficial (where there would be a shift in category from no view to restricted, intermittent or open view).
- Adverse (where there would be a shift in category from open view towards intermittent, restricted or no view).
- Neutral (no change in view category) at different sections along the route based on where views have potential to change form the road.

Human health

13.6.19. As there is currently no accepted professional methodology for stating the significance of impacts on human health, a qualitative approach is necessary. The assessment of human health will therefore draw on the conclusions of several population and human health sub-topics to consider effects on equestrians, cyclists, communities and vehicle travellers:

- Land use: The assessment will consider the presence of health care facilities, sport and recreational facilities and open space used for physical activity.
- Severance: The assessment will consider access to health care facilities and land used for recreational purposes (such as parks and open space), and any adverse or beneficial impacts on WCH facilities used for physical activity or recreational purposes that may indirectly impact human health.

13.6.20. This assessment will also consider the potential impacts from other environmental topics such as Chapter 6 air quality, Chapter 12 noise and vibration and Chapter 14 road drainage and water environment.

13.6.21. The most recently available public health data, alongside demographic data (ward, district, regional and national), will be used to highlight sections of the population that may be disproportionately impacted (due to increased susceptibility or vulnerability) by any human health impacts that may arise as a result of the Scheme. The data will be presented in full in the baseline and then referred to where necessary throughout the report. Data will be collected from the Public Health England 'Local Health' website[81] which provides population health data at ward level. Health data will be selected based on conditions that may be impacted by the Scheme. Professional judgement will be used to conclude where there may, or may not, be an overall impact on human health.

13.6.22. The topics considered as part of the human health assessment have used the following guidance, together with professional judgement:

[81] Public Health England (2016): 'Local Health'. Available at: http://www.localhealth.org.uk/#v=map13;l=en

- For air quality:
  - HA 207/07 Air Quality[82]
  - Interim Advice Note (IAN) 185/15 Updated traffic, air quality and noise advice on the assessment of link speeds and generation of traffic data into speed bands for users of DMRB Volume 11, Section 3, Part 1 'Air Quality and Volume 11, Section 3, Part 7 Noise [83]
  - IAN 175/13 Updated air quality advice on risk assessment related to compliance with the EU Directive on ambient air quality and on the production of Scheme Air Quality Action Plans for users of DMRB Volume 11, Section 3, Part 1 'Air Quality [84]
  - IAN 174/13 Updated advice for evaluating significant local air quality effects for users of DMRB Volume 11, Section 3, Part 1 'Air Quality' (HA207/07)[85]
  - IAN 170/12 Updated air quality advice on the assessment of future NOx and NO2 projections for users of DMRB Volume 11, Section 3, Part 1 'Air Quality[86]
- For noise and vibration:
  - HD 213/11 – Revision 1, Noise and Vibration [87]
  - IAN 185/15
- For the road drainage and water environment:
  - HD 45/09 Road Drainage and the Water Environment[88]
- For equestrians, cyclists and community effects:
  - DMRB Volume 11, Section 3, Part 8

[82] Highways Agency (2007) DMRB Volume 11, Section 3, Part 1, HA 207/07, Air Quality [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/ha20707.pdf (last accessed January 2019)
[83] Highways England (2015) IAN 185/15 *Updated traffic, air quality and noise advice on the assessment of link speeds and generation of traffic data into speed bands for users of DMRB Volume 11, Section 3, Part 1 'Air Quality and Volume 11, Section 3, Part 7 Noise* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian185.pdf (last accessed January 2019)
[84] Highways Agency (2013), IAN 175/13: *Updated air quality advice on risk assessment related to compliance with the EU Directive on ambient air quality and on the production of Scheme Air Quality Action Plans for users of DMRB Volume 11, Section 3, Part 1 'Air Quality* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian175.pdf (last accessed January 2019)
[85] Highways Agency (2013) IAN 174/13: *Updated advice for evaluating significant local air quality effects for users of DMRB Volume 11, Section 3, Part 1 'Air Quality (HA207/07)* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian174.pdf (last accessed January 2019)
[86] Highways Agency (2012) IAN 170/12. *Updated air quality advice on the assessment of future NOx and NO2 projections for users of DMRB Volume 11, Section 3, Part 1 'Air Quality* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/ian170.pdf (last accessed January 2019)
[87] Highways Agency (2011) DMRB Volume 11, Section 3, Part 7, HD 213/11 – *Revision 1, Noise and Vibration* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/hd21311.pdf (last accessed January 2019)
[88] Highways Agency (2009) DMRB Volume 11, Section 3, Part 10 HD 45/09 *Road Drainage and the Water Environment* [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf (last accessed January 2019)

- For vehicle travellers:
  - DMRB Volume 11 Section 3 Part 9

Local economy

13.6.23. An assessment of employment and economic output that would be generated by the Scheme will be undertaken. The assessment will include consideration of data surrounding the working age population, employment and unemployment levels, the economically active population and the English Indices of Deprivation 2015. This analysis will be used to inform the qualitative significance of effect rating for this sub-topic. Other economic related effects such as the effects on wider business activity will also be considered here.

Value (sensitivity) of receptors and resources

13.6.24. The sensitivity of receptors and resources is governed by their capacity to absorb the proposed changes arising from the Scheme. It ultimately reflects their vulnerability to the impacts of the proposed activities and their access to additional or alternative resources of a similar nature. If a resource is frequently used, if few alternatives exist, or if receptors have limited capacity to absorb the changes arising from the Scheme, then a receptor is considered to be sensitive to the changes. Criteria describing the sensitivity of receptors for population and human health are identified in Table 13.4 below.

13.6.25. In certain circumstances, receptors or resources may fall within several sensitivity categories. In this situation professional judgement will be used to assign an appropriate sensitivity category.

Table 13.4: Sensitivity criteria for population and human health

Sensitivity	Criteria guidance
Very high	• Very high importance and rarity, international scale and very limited potential for substitution.
High	• High importance and rarity, national scale, and limited potential for substitution.
Medium	• High or medium importance and rarity, regional scale, limited potential for substitution.
Low	• Low or medium importance and rarity, local scale.
Negligible	• Very low importance and rarity, local scale.

Source: DMRB Volume 11 Section 2 Part 5 'Assessment and Management of Environmental effects'[89]

[89] Highways Agency (2008), Assessment and Management of environmental effects [online], available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section2/ha20508.pdf (last accessed January 2019)

Magnitude of impact

13.6.26. To assess the magnitude of an impact, each impact will consider the following indicators:

- Spatial scope – whether impacts would be likely to be felt within the footprint of the Scheme, within the identified study area, or more widely
- Extent – how many receptors are likely to be impacted
- Duration – whether the impacts would be short or long-term
- Reversibility – whether the impact is permanent or temporary

13.6.27. Taking these indicators into consideration, and also mitigation measures that can be applied; the criteria described in Table 13.5 are used as guidelines to assess the magnitude of each impact.

Table 13.5: Magnitude of impact for population and human health receptors

Sensitivity	Criteria guidance
Major Adverse	• Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements.
Moderate Adverse	• Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements.
Minor Adverse	• Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.
Negligible Adverse	• Very minor loss or detrimental alteration to one or more characteristics, features or elements.
No change	• No loss or alteration of characteristics, features or elements; no observable impact in either direction.
Negligible Beneficial	• Very minor benefit to or positive addition of one or more characteristics, features or elements.
Minor Beneficial	• Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Moderate Beneficial	• Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Major Beneficial	• Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.

Source: DMRB Volume 11 Section 2 Part 5 'Assessment and Management of Environmental effects'[90]

13.6.28. Potential impacts do not have to satisfy all of the criteria guidelines within a particular category.

[90] Highways Agency (2008), Assessment and Management of environmental effects [online], available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section2/ha20508.pdf (last accessed January 2019)

Significance of effect

13.6.29. Significance is a product of the magnitude of an impact and the sensitivity of the receptor or resource that is experiencing the impact.

13.6.30. Criteria defining significance of effects for population and human health are not outlined within DMRB Volume 11, Section 3, Parts 6, 8 or 9. However, DMRB Volume 11, Section 2, Part 5: '*Assessment and management of environmental effects*' provides an approach to determining significance of effects as outlined in Chapter 5 environmental assessment methodology; relying on reasoned argument, professional judgement and the views of appropriate organisations. The significance thresholds outlined in Table 5.5 will be followed for the population and human health assessment.

13.7. Assessment assumptions and limitations

13.7.1. There are a number of assumptions associated with the population and human health assessment to date.

13.7.2. Landowner information was collated using land registry data and, in some cases, boundaries may be out of date or incorrect. Landowner information has been frequently updated by the Mott MacDonald Sweco Joint Venture team and is updated on an ongoing basis based on information gathered from site visits, etc. The assessment for the Environmental Statement will use the most up to date land information available.

13.7.3. Full information on individual farm businesses such as the type of husbandry, severance and major accommodation works is not known at this stage and would be obtained as part of work to support the Environmental Statement, through an agricultural questionnaire to landowners initially. The assessment for the Environmental Statement will use the most up to date information available for individual farm businesses to ensure a robust assessment is completed.

13.7.4. Information on community facilities has been primarily drawn from desk-based research. This may not contain the most up to date information, and therefore, the list of baseline community facilities outlined in Section 13.2 should be viewed as an indication of provisions rather than a comprehensive assessment of provisions. The assessment for the Environmental Statement will use the most up to date information available for community facilities to ensure a robust assessment is completed.

13.7.5. Data used to define the baseline social and community conditions has been compiled from existing published sources. Assessments are based on the most recent data available for the study area. The currency of data varies from

dataset to dataset depending on how frequently information is collected. Dates for each dataset are noted in the baseline section where available. Given that the most reputable up to date datasets available have been used to inform the population and human health chapter, there is confidence in the assessment scope.

14. Road drainage and the water environment

14.1. Study area

14.1.1. The study area comprises a one kilometre corridor surrounding the Scheme, extended to include features further downstream (surface water features) or down-gradient (groundwater features) that may also be potentially impacted. In accordance with DMRB Volume 11 Section 2 Part 5 HA 205/08 (Assessment and management of environmental effects), the study area is based on professional judgement to ensure that potential effects are appropriately identified, and it is extended where there are features downstream of the Scheme that may be affected. These features will be included in the assessment as appropriate. In addition, for groundwater, the potential zone of impact during the construction and operational phases will be assessed on the underlying Water Framework Directive (WFD) groundwater bodies.

14.2. Baseline conditions

Summary

14.2.1. The following information summarises the waterbodies within the study area as well as water-dependent designated conservation sites, and other groundwater and surface water receptors.

Groundwater

14.2.2. The study area is underlain by two principal bedrock aquifers: the Great Oolite and Inferior Oolite. These have an Environment Agency vulnerability classification of ‘Major Aquifer High’. Secondary (undifferentiated) aquifers are present within the underlying Lias at the base of the Cotswold escarpment.

14.2.3. A Secondary A aquifer comprising permeable superficial deposits overlies the bedrock at the western extent of the study area.

14.2.4. The Scheme straddles a groundwater divide that lies close to the Cotswold escarpment, roughly following the topographic divide.

14.2.5. Within the Thames catchment to the east of the divide, the Great and Inferior Oolite aquifers drain to the River Churn and its tributaries.

14.2.6. Within the Severn catchment to the west of the divide, the Great and Inferior Oolite, and underlying Lias aquifers drain to Norman’s Brook and its tributaries, Horsbere Brook and the River Frome.

14.2.7. Within the Thames catchment, the Great and Inferior Oolite aquifers are included in the Burford Jurassic groundwater body (No. GB40601G600400) under the WFD[91].

14.2.8. Within the Severn catchment, the Great and Inferior Oolite aquifers along the line of the escarpment are included in the Severn Vale – Jurassic Limestone Cotswolds Edge South groundwater body (No. GB40901G305700)[91]. The Lias aquifers at the base of the escarpment are included in the Severn Vale – Secondary Combined groundwater body (No. GB40902G204900)[91].

14.2.9. The Cycle 2 (2016)[91] status for these groundwater bodies are as follows:

- Burford Jurassic: Quantitative status is 'Good', chemical status is 'Poor', and overall status is 'Poor'.
- Severn Vale – Jurassic Limestone Cotswolds Edge South: Quantitative status is 'Good', chemical status is 'Good', and overall status is 'Good'.
- Severn Vale – Secondary Combined: Quantitative status is 'Good', chemical status is 'Good', and overall status is 'Good'.

14.2.10. There are no drinking water safeguard zones, although the area where the Great and Inferior Oolite outcrop is designated as a Nitrate Vulnerable Zone (NVZ).

14.2.11. The Scheme also crosses zones of Major Aquifer Intermediate, and Minor Aquifer Intermediate vulnerability.

14.2.12. The eastern part of the Scheme lies close to the boundary of a groundwater Source Protection Zone (SPZ) 3 (total catchment) of a public water supply source. The scheme just intersects the SPZ 3 over a short distance to the east and south-east of Stockwell.

14.2.13. Other potential groundwater receptors include numerous springs along the escarpment that supply Norman's Brook and Horsbere Brook, springs within an incised valley that supply the River Frome headwaters, springs on the dip slope supplying the headwaters of the River Churn, and also streams and rivers receiving baseflow.

14.2.14. Licensed and unlicensed groundwater abstractions that do not have SPZs assigned to them may also be present.

[91] Environment Agency (2019) Environment Agency Catchment Data Explorer [online] available at https://environment.data.gov.uk/catchment-planning/ (last accessed January 2019)

14.2.15. The Highways England's Drainage Data Management System (HADDMS)[92] identifies 19 soakaways within the study area, all of which are low priority (Category D status).

14.2.16. HADDMS[92] indicates that there is potential for groundwater flooding to occur at surface west of Crickley Hill Farm.

14.2.17. The Gloucestershire County Council Level 1 Strategic Flood Risk Assessment (SFRA)[93] indicates that no groundwater flooding events are recorded within the Gloucester City Council area.

14.2.18. The Cotswold SFRA Update Final[94] notes that several groundwater flooding incidents have been recorded in the Cirencester area, to the south-east of the Scheme, in addition to a few isolated incidents on the Great Oolite, probably related to springs. There may be localised incidents of groundwater flooding associated with springs emerging from the contact between permeable and impermeable strata.

Surface water

14.2.19. The Cotswold escarpment forms a surface water divide between the River Severn catchment and the River Thames catchment (to the east and south-east of the divide). To the west of the divide, the land within the Scheme drains to the River Severn and its tributaries, including Norman's Brook, Horsbere Brook and the River Frome. To the east and south-east, the land within the Scheme drains to the River Churn, a tributary of the Thames.

14.2.20. Horsbere Brook, Norman's Brook, the River Frome and the River Churn are classed by the Environment Agency as ordinary watercourses within the study area.

14.2.21. The Scheme is located within one kilometre of Flood Zones 2 and 3 for the River Frome and Horsbere Brook at the eastern and western extents of the Scheme respectively[95].

[92] Highways England (2017) Highways England's Drainage Data Management System [online] available at http://haddms.com/ (last accessed January 2019)
[93] Gloucester City Council (2008) Strategic Flood Risk Assessment Level 1 [online] available at: http://www.gloucester.gov.uk/resident/planning-and-building-control/planning-policy/Pages/SFRA---Level-1.aspx. (last accessed June 2017)
[94] Cotswold District Council (2016) Strategic Flood Risk Assessment (Final Update) [online] available at: http://www.cotswold.gov.uk/media/1435300/2016s3821-Cotswold-SFRA-Update-Final-May-2016-v10.pdf (last accessed June 2017).
[95] Environment Agency (2019) Flood Map for Planning [online] available at: https://flood-map-for-planning.service.gov.uk/ (last accessed January 2019).

14.2.22. At the Birdlip junction, the Scheme crosses an area of high surface water flood risk[96] that appears to coincide with the head of a dry valley and may be associated with an ephemeral stream or springs within the dry valley. An area of low surface water flood risk is identified to the north-east of the Scheme at the A436 and Ullenwood Manor Road crossroads associated with a tributary of the River Churn. An area of low to medium surface water flood risk is identified to the north of the Scheme area near Crickley Hill Country Park access road. Areas of low to high surface water flood risk coincide with Norman's brook tributary flowing down Crickley Hill, to the south of the existing road. The level of surface water flood risk increases to high towards Crickley Hill Farm.

14.2.23. WFD surface waterbodies in the Severn Vale Management Catchment include Norman's Bk - source to conf Hatherley Bk (No. GB109054032780)[91] within the Chelt Hatherley and Norman's Brook Operational Catchment, Horsebere Bk - source to conf R Severn (No. GB109054032760)[91] within the Gloucester Trib Operational Catchment and Frome - source to Ebley Mill (No. GB109054032470)[91] within the Frome and Cam Operational Catchment.

14.2.24. WFD surface waterbodies in the Cotswolds Management Catchment include the Churn (source to Perrots Brook) (No. GB106039029810) within the Thames Upper Operational Catchment.

14.2.25. The Cycle 2 (2016)[91] status for these surface water bodies are as follows:

- Norman's BK – source to conf Hatherley Bk: Ecological status of 'Poor', chemical status of 'Good', and overall status of 'Poor'.
- Horsebere Bk – source to conf R Severn: Ecological status of 'Moderate', chemical status of 'Good', and overall status of 'Moderate'.
- Frome – source to Ebley Mill: Ecological status of 'Good', chemical status of 'Good', and overall status of 'Good'.
- Churn – source to Perrots Brook: Ecological status of 'Moderate', chemical status of 'Good', and overall status of 'Moderate'.

14.2.26. HADDMS[92] identifies five priority outfalls within the study area. Three of these were classed as moderate priority (category C status), one as low priority (category D status) and one as risk addressed. HADDMS notes that the medium priority outfall south of the Air Balloon roundabout and the low priority outfall may be soakaways.

[96] Environment Agency (2019) Long Term Flood Risk [online] available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map (last accessed January 2019)

14.2.27. Bushley Muzzard Site of Special Scientific Interest (SSSI) is species-rich wet grassland supplied by localised springs and seepages. It is located down-gradient of the southern end of the Scheme.

14.2.28. Cotswold Commons and Beechwoods Special Area of Conservation (SAC) and SSSI includes areas of moist vegetation dependent on springs and seepages that are associated with some nationally rare invertebrate species. The SSSI extends south-east of Birdlip and includes springs supplying Horsbere Brook.

14.2.29. Witcombe Reservoirs, at the foot of the escarpment, is primarily supplied by spring-fed streams. It discharges to Horsbere Brook.

14.2.30. There are a number of small ponds in the area that may be at least partially groundwater dependent or fed by springs.

14.3. Potential impacts

Construction

Dewatering

14.3.1. Dewatering during earthworks, and the excavation of deep cuttings intersecting the saturated aquifer could locally reduce groundwater levels and divert flow. This may lead to a reduction or cessation of spring flow and baseflow supplying watercourses, as well as adversely impacting on groundwater abstractions.

14.3.2. Dewatering to allow stabilisation of the landslip material on Crickley Hill could significantly affect flow to springs rising from the escarpment, although the water would be returned to Norman's Brook tributary at the toe of the landslip.

14.3.3. A reduction of groundwater levels may cause settlement in areas where water levels are within shallow cohesive deposits.

Deep cuttings and Ground Investigation

14.3.4. Excavation of the deep cutting through Shab Hill and the top of Crickley Hill may act as a pathway that diverts groundwater or surface water between catchments (between local catchments within Severn catchment, and between Severn and Thames catchments). This may impact on resource availability within catchments, and reduce the flows to abstractions, springs and streams.

14.3.5. Both cuttings and boreholes constructed during Ground Investigation (GI) may create pathways through poorly permeable layers between aquifers, for example through the Fuller's Earth separating the Great and Inferior Oolite. The deep cuttings may also create pathways across faults, which previously restricted

groundwater flow. Movement of groundwater between aquifers may affect groundwater levels and flow, leading to a reduction or loss of water supply to abstractions, springs and streams, and potential loss of habitat. There is also the potential for pollution to move between aquifers, leading to pollution at receptors (environmental and abstractions).

14.3.6. Cuttings within the shallow Great Oolite aquifer may intercept groundwater flow if these extend to the saturated zone. This may impact on springs supplying the headwaters of the River Churn or Norman's Brook tributary. Shallow cuttings towards the south-eastern end of the Scheme may intersect the saturated Great Oolite aquifer that springs at Nettleton supplying the headwaters of the River Frome.

14.3.7. The cuttings at Shab Hill may impact on groundwater flows within the Inferior Oolite, potentially affecting ephemeral springs within Coldwell Bottom within the River Churn catchment.

Earthworks, and below-ground structures and piles

14.3.8. Earthworks within the saturated aquifer, including excavation, ground improvement, retaining wall construction and piling associated with embankments and other structures may cause changes in groundwater levels and flow pathways. Below ground works may intercept a significant proportion of, or even the full thickness of the saturated aquifer.

14.3.9. Changes in groundwater levels and flow paths may lead to either a reduction or loss of water supply to abstractions, springs and streams, and potential loss of habitat (which may be permanent). Settlement in areas where affected groundwater levels are within shallow cohesive deposits may also occur as a result. Groundwater mounding up-gradient of below ground structures and piles may cause the emergence of new springs and groundwater flooding.

14.3.10. Contamination of groundwater may occur if in direct contact with construction materials. Aquifer pollution may also affect indirect groundwater receptors such as springs, streams and abstractions. This risk is exacerbated by the rapid travel times and lack of attenuation within the Great and Inferior Oolite aquifers.

14.3.11. Earthworks may create a large increase in suspended solids concentrations in groundwater. This has the potential to pollute the resource, leading to pollution of receptors (environmental and abstractions), including the public water supply source at Baunton. This risk is exacerbated by the rapid travel times and lack of attenuation within the Great and Inferior Oolite aquifers.

14.3.12. Earthworks and structures may create a change in the flood flow pathway. This may have impacts on properties and aquatic environments located in flood

zones. These include farms located within Flood Zones 2 and 3 for both the River Frome and Horsbere Brook, and Bushley Muzzard SSSI, located just north of Flood Zones 2 and 3 for the River Frome. In particular, culverting or realignment of Norman's Brook tributary at Crickley Hill has the potential to create additional flood risk downstream unless appropriate attenuation measures are in place.

14.3.13. Earthworks associated with the alignment up Crickley Hill, including cuttings, retaining walls and piling, may result in a reduction of groundwater flows, and potential loss of escarpment springs that supply Norman's Brook tributary.

14.3.14. Piling associated with the embankment near Stockwell Farm may impact on groundwater flows or create pollution pathways within the Churn catchment.

Alteration of ground levels

14.3.15. Changes to the surface water flood flow pathways may result in the overloading of drainage systems or surface watercourses. This may impact on flood-sensitive receptors proximal to overloaded systems. Again, the Crickley Hill alignment is likely to be of particular concern in this respect.

14.3.16. During construction, there is also a risk of localised flooding within the Scheme area during and following heavy rainfall events. This includes areas identified as at risk of surface water flooding, in particular the high risk of surface water flooding at the dumbbell junction proposed at Shab Hill for A436 Link Road Alternative 1: bridge over A417.

Disturbance or removal of top soils

14.3.17. Exposing the topsoil may result in increased nitrate and other solutes leaching into the underlying aquifer. This has the potential to cause pollution of the resource, leading to pollution at receptors (environmental and abstractions).

Drainage of new areas of hardstanding

14.3.18. The drainage of new areas of hardstanding discharging into outfalls may increase the rate and volume of surface water run-off to surface watercourses, and impact on properties and aquatic environments within flood zones.

14.3.19. New drainage systems may reduce recharge to the underlying aquifer, thereby interrupting flow, leading to a reduction or loss of water supply to abstractions, springs, streams, and wetland, and potential loss of aquatic habitat (which may be permanent).

Run-off of polluted surface water

14.3.20. Run-off that is polluted due to accidental leakage or spillage, or has elevated suspended sediment concentrations, may pollute surface watercourses. This may lead to the pollution of environmental receptors and the potential loss of aquatic habitat, pollution of resource, leading to a loss of surface water abstraction, and pollution of the underlying aquifer due to infiltration through the bed of the watercourse.

14.3.21. Infiltration of run-off to groundwater, given the lack of overlying low permeability superficial deposits over much of the area, may result in the pollution of environmental receptors and potential loss of aquatic habitat, as well as quality impacts on abstractions. Pollution impacts may result in a permanent loss.

Works over, in, or adjacent to watercourses

14.3.22. Works on, in, or adjacent to watercourses (including the creation of culverts) may result in pollution of surface watercourses due to placement of construction materials, plant washing and cleaning areas of hardstanding (suspended solids and dissolved contaminants).

14.3.23. The design would require Norman's Brook tributary to be culverted or realigned along much of its length within the study area. The headwaters of Norman's Brook tributary are culverted underneath a property and flow within a steep sided valley alongside the existing road. Therefore, this will complicate realignment.

14.3.24. Interrupted flows may result in a reduction or loss of water supply to springs, streams and wetland, and the potential loss of aquatic habitat.

Operation

Cuttings and embankments, including earthworks, retaining walls and piling

14.3.25. Below ground works may intercept a significant proportion of, or even the full thickness of the saturated aquifer.

14.3.26. Changes in flow paths within the aquifers may reduce flow to groundwater receptors, resulting in the partial or total loss of springs and depletion of existing watercourses and conversely, the creation of new springs or groundwater flooding due to groundwater mounding up-gradient of the structure.

Groundwater seepage

14.3.27. Seepage into cuttings may create a localised reduction of groundwater levels, leading to a reduction or cessation of local spring flow. This may result in

depletion of existing watercourses and loss of water supply to groundwater receptors, including springs, streams and abstractions.

14.3.28. Localised settlement may occur where affected water levels are within shallow cohesive deposits.

Cutting drainage

14.3.29. The cutting drainage system may divert water from one surface water and groundwater catchment to another (between local surface water catchments within the Severn catchment, and between the Severn and Thames groundwater and surface water catchments). The interruption of flow may lead to a reduction or loss of water supply to abstractions, springs and streams and potential loss of habitat (which may be permanent). The loss of water from one catchment to another, potentially affecting resource availability further down-dip in the confined aquifers.

14.3.30. A change in the groundwater flow regime and flood flow pathway may impact on receptors (properties and environmental) near flood zones. These include farms located near to Flood Zones 2 and 3 for both the River Frome and Horsbere Brook, and Bushley Muzzard SSSI, located just north of Flood Zones 2 and 3 for the River Frome.

Road drainage

14.3.31. Discharge of routine run-off to outfall, or soakaway if required, may cause a long-term degradation of water quality. Discharge of run-off during accidental spills, or collisions, or with elevated suspended solids concentrations, may have a significant impact on water quality.

14.3.32. The pollution of surface watercourses may result in the pollution of environmental receptors and potential loss of aquatic habitat.

14.3.33. An increase in the rate and volume of surface water run-off to surface watercourses may impact on properties and aquatic environments near to flood zones.

14.3.34. A reduction of recharge to the underlying aquifer may result in a reduction or loss of water supply to abstractions, springs, streams, and wetland, and potential loss of aquatic habitat (which may be permanent).

Unanticipated storm event or excessive rainfall

14.3.35. An unanticipated storm event or excessive rainfall may result in the reactivation of springs or excessive stream flow leading to excess flow into cuttings, and the

drainage system being overwhelmed. This could also apply to the road drainage system.

14.3.36. Uncontrolled discharge of drainage water may lead to flooding, or water quality and flow impacts, which have the potential to adversely affect environmental receptors, properties and abstractions.

Alteration of ground elevations

14.3.37. Changes in surface water flood flow pathways may result in overloading of drainage systems or surface watercourses. This may impact on flood-sensitive receptors near to overloaded systems.

14.3.38. Embankments may create barriers to overland flow, potentially altering flood risk areas.

Culverting and realignment of watercourses

14.3.39. A change in the flood flow pathway may impact on properties and aquatic environments close to flood zones. In particular, culverting or realignment of Norman's Brook tributary may result in flooding further downstream without appropriate mitigation to attenuate flows.

14.3.40. An interruption of flow in the watercourse may result in a reduction or loss of water supply to downstream receptors, including abstractions, rivers and wetland, and potential loss of aquatic habitat (which may be permanent).

14.4. Design, mitigation and enhancement measures

Construction

14.4.1. In principle, mitigation would be through the selection of construction methods and the implementation of a Construction Environmental Management Plan (CEMP)

14.4.2. Groundwater and surface water monitoring would continue through construction to confirm that there are no adverse impacts on the water environment as a result of construction. The scope of the groundwater and surface water monitoring programme would be agreed with the Environment Agency and included in the CEMP.

14.4.3. There is the potential for mobilisation of sediment and contaminants from road run-off to the watercourses and aquifers (through infiltration, given the lack of overlying low permeability superficial deposits over much of the area) as a consequence of road construction, although this would be managed by best

practice construction measures to be included within the CEMP in accordance with CIRA Guidelines[97,98,99]. Construction activities associated with the Scheme could increase the risk of a pollution incident at the site of works, associated with contaminated land or spills / leaks of chemicals. However, due to the temporary nature of these effects, and with appropriate mitigation measures and best practice working measures implemented, the risk is considered to be minimal.

14.4.4. Any dewatering discharge from earthworks, or works within eight metres of a watercourse, would require the appropriate risk assessments and consents and licences from the Environment Agency. Dewatering abstraction may also require abstraction licences from the Environment Agency.

14.4.5. Where works lead to temporary changes in the surface water run-off regime by the alteration of ground elevations and overland flow pathways, or where works are to be undertaken in areas at risk of surface water flooding, a temporary surface water drainage strategy incorporating sustainable drainage system (SUDS) measures would be developed and incorporated into the CEMP to ensure that there is no increase in run-off during construction.

Operation

14.4.6. Mitigation measures would be incorporated into the design and the Outline Environmental Management Plan (OEMP).

14.4.7. The OEMP may include a groundwater and surface water monitoring programme to demonstrate no adverse impacts on water receptors arising from the operation of the Scheme.

14.4.8. The drainage design will include appropriate attenuation, taking into account the climate change allowance.

14.4.9. Dry culverts may be required where flood flow pathways, including those for ephemeral streams are affected by the Scheme.

14.4.10. Road drainage will be assessed by Highways Agency Water Risk Assessment Tool (HAWRAT) (routine run-off to outfall), Method C (routine run-off to soakaway) and Method D (spill risk) assessments, where required. These will inform the drainage design so that water quality risks are reduced to an acceptable level. A period of groundwater and surface water quality monitoring may be required prior to construction to determine environmental baseline

[97] CIRIA (2002) Control of Water Pollution from Construction Sites – Guide to Good Practice
[98] CIRIA (2006) Control of Water Pollution from Linear Construction Projects
[99] CIRIA (2015) Environmental Good Practice on Site (C174). 3rd Edition

conditions. Newly designed drainage systems may require a period of monitoring and maintenance during operation to confirm acceptable functionality.

14.4.11. Potential options for enhancement include improved attenuation of pollutants though the use of SuDS such as swales and soakaways in the drainage design.

14.4.12. The design may include additional flood attenuation in the upper parts of the stream catchments, upstream of Flood Zone 3 areas, for example by the creation of wetlands. This may also provide water quality benefits in relation to the attenuation of pollutants within the drainage system, as well as creating opportunities for enhanced biodiversity and amenity value.

14.5. Description of the likely significant effects

Construction

14.5.1. The excavation of cuttings, and construction of retaining walls and piling associated with the Crickley Hill alignment may result in a reduction of groundwater flows, and potential loss of escarpment springs that supply Norman's Brook tributary. Conversely, it may result in the emergence of new springs or groundwater flooding, which could cause a loss or change in habitat. The cutting may also divert water from the Thames catchment to the Severn catchment.

14.5.2. Culverting or realignment during construction, and restoration of Norman's Brook tributary has the potential to create additional flood risk downstream unless appropriate attenuation measures are in place.

14.5.3. Dewatering to allow stabilisation of the landslip material would significantly affect flow to springs rising from the escarpment, although the water would be returned to Norman's Brook tributary at the toe of the landslip.

14.5.4. Excavation of cuttings, retaining walls and piling within the Great Oolite may result in the depletion of groundwater flow to springs, which discharge to the headwaters of the River Frome and River Churn.

14.5.5. Structures, including embankments, bridge piers and culverts may affect flood flow pathways, including those for ephemeral stream flows.

14.5.6. Even with mitigation, excavation, construction of foundations and piling may result in the mobilisation of sediments and contaminants from construction activities to surface water and groundwater. These activities may also create new contamination pathways from surface and between aquifers.

A436 Link Road Alternative 1: bridge over A417

14.5.7. The construction of foundations and piles for the A436 link road bridge may impact on spring flows or water quality supplying Norman's Brook tributary.

A436 Link Road Alternative 2: parallel to the A417

14.5.8. This A436 Link Road Alternative is not anticipated to create any additional impacts on the water environment. It may present less of a risk in terms of dewatering impacts as the mainline cutting through Shab Hill is shallower than in the other two A436 Link Road Alternatives.

A436 Link Road Alternative 3: via South Hill

14.5.9. Excavation of the South Hill cutting may locally reduce groundwater levels and flow supplying ephemeral springs in the dry valley east of the Birdlip junction and springs supplying the River Churn tributary south-east of Star College. It may also affect groundwater quality, particularly with respect to suspended solids.

Operation

14.5.10. Cuttings, retaining walls and piling associated with the Crickley Hill alignment may result in a permanent reduction of groundwater flows, and potential loss of escarpment springs that supply Norman's Brook tributary. Conversely, they may result in the emergence of new springs or groundwater flooding, which could cause a loss or change in habitat. The cutting may also divert water from the Thames catchment to the Severn catchment.

14.5.11. Attenuation measures included in the drainage design have the potential to reduce flood risk in Flood Zone 3 areas downstream of the study area. These may also provide water quality benefits in relation to the attenuation of pollutants within the drainage system, as well as creating opportunities for enhanced biodiversity and amenity value.

14.5.12. Permanent dewatering to maintain the stability of the landslip material may significantly affect flow to springs rising from the escarpment, although the water would be returned to Norman's Brook tributary at the toe of the landslip.

14.5.13. Cuttings, retaining walls and piling within the Great Oolite may result in the depletion of groundwater flow to springs, which discharge to the headwaters of the River Frome and River Churn.

14.5.14. Structures, including embankments, bridge piers and culverts may affect flood flow pathways, including those for ephemeral stream flows.

14.5.15. Cuttings, piling and monitoring boreholes may result in new contamination pathways from surface and between aquifers.

14.5.16. Diversion of water between catchments, may indirectly affect groundwater supply to surface water features and potential cross contamination.

A436 Link Road Alternative 1: bridge over A417

14.5.17. The construction of foundations and piles for the A436 link road bridge are unlikely to permanently impact spring flows supplying Norman's Brook tributary. However, the location of the springs may change.

A436 Link Road Alternative 2: parallel to the A417

14.5.18. This A436 Link Road Alternative is not anticipated to create any additional impacts on the water environment. It may present less of a risk in terms interception of groundwater flow within the Inferior Oolite aquifer as the mainline cutting through Shab Hill is shallower than in the other two A436 Link Road Alternatives.

A436 Link Road Alternative 3: via South Hill

14.5.19. The South Hill cutting may intercept and divert groundwater flow supplying ephemeral springs in the dry valley east of the Birdlip junction and springs supplying the River Churn tributary south-east of Star College.

14.6. Assessment methodology

Proposed level and scope of assessment

14.6.1. Further assessment of the construction and operational effects of the Scheme will be necessary due to the potential for significant effects on the water environment. At present, there is insufficient baseline information available to exclude any aspects from the assessment, and therefore, all water receptors discussed will be scoped into the assessment for the Environmental Statement. A Design Manual for Roads and Bridges (DMRB) Detailed level assessment will be undertaken and presented within the Environmental Statement.

Policy requirements, guidance and advice

14.6.2. Further assessment will be carried out in accordance with the following policy and guidance:

- National Planning Policy Framework (NPPF)[100] and its supporting Planning Practice Guidance (PPG) documents for flood risk and coastal change[101]
- Highways (Environmental Impact Assessment) Regulations 2007[102]
- European Union Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy[103]
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[104]
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015[105]
- The Planning Inspectorate Advice Note Eighteen, The Water Framework Directive[106]
- The Groundwater (Water Framework Directive) (England) Direction 2016[107]
- Groundwater protection guides[108] covering: requirements, permissions, risk assessments and controls, previously covered by: Groundwater protection: principles and practice (GP3)[109]
- The Environment Agency's approach to groundwater protection Version 1.2[110]

[100] Department for Communities and Local Government (2019) National Planning Policy Framework [online] available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 (last accessed February 2019)
[101] Department for Communities and Local Government (2014) Planning Practice Guidance (PPG) Flood risk and coastal change [online] available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change (last accessed January 2019)
[102]Highways, England and Wales (2007) Highways (Environmental Impact Assessment) Regulations 2007 [online] available at: https://www.legislation.gov.uk/uksi/2007/1062/pdfs/uksi_20071062_en.pdf (last accessed January 2019)
[103] European Union (2000) Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy [online] available at: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32000L0060 (last accessed January 2019)
[104] The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 [online] available at: http://www.legislation.gov.uk/uksi/2017/407/made (last accessed January 2019)
[105] The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 [online] available at: http://www.legislation.gov.uk/uksi/2015/1623/pdfs/uksiod_20151623_en_auto.pdf (last accessed January 2019)
[106] The Planning Inspectorate (2017) Advice Note Eighteen, The Water Framework Directive [online] available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2017/06/advice_note_18.pdf (last accessed January 2019)
[107] The Groundwater (Water Framework Directive) Direction (England) 2016 [online] available at: https://www.gov.uk/government/publications/the-groundwater-water-framework-directive-england-direction-2016 (last accessed January 2019)
[108] Environment Agency (2018) Environment Agency groundwater protection guides [online] available at: https://www.gov.uk/topic/environmental-management/water (last accessed January 2019)
[109]Environment Agency (2013) Groundwater protection: Principles and practice (GP3) [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/598799/LIT_7660.pdf (last accessed January 2019)
[110] Environment Agency (2018) The Environment Agency's approach to groundwater protection version 1.2. [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/692989/Envirnment-Agency-approach-to-groundwater-protection.pdf (last accessed January 2019).

- Environment Agency environmental permitting guidance[111]
- Land Drainage Act 1991[112]
- Flood and Water Management Act 2010[113]

14.6.3. The road drainage and water environment assessment for the Environmental Statement will be carried out in accordance with Highways England's technical guidance provided in the DMRB Volume 11, Section 3, Part 10 (HD 45/09)[114].

Determination of significant effects

Proposed methodology

14.6.4. The proposed methodology for the Environmental Statement will follow the guidance provided in DMRB Volume 11, Section 3, Part 10 (HA 45/09) for assessing the significance of effects of the Scheme on road drainage and the water environment. The procedures and the appropriate methods that must be used when assessing the potential effects from road projects on the water environment are described in Chapter 5 of DMRB HD 45/09.

14.6.5. The potential impacts of routine run-off on surface waters will be assessed initially using the Method A Simple Assessment (HAWRAT), in accordance with section 5.6 of HD 45/09. The assessment will take into account the preliminary drainage design and Annual Average Daily Traffic (AADT) forecast data to establish potential impacts of pollutants in routine highway run-off on the watercourses within the study area, and the requirement for mitigation measures to adequately reduce the risk.

14.6.6. The results from the HAWRAT assessment will determine if a Method B Detailed Assessment (as specified within Annex I of HD 45/09) is required to assess the bioavailability of the soluble pollutants using the Biotic Ligand Model (BLM) to determine the water quality impact. This would be informed by baseline water quality monitoring downstream of drainage outfalls, which fail the HAWRAT assessment.

14.6.7. Where drainage is to be discharged via soakaway, the potential impacts of routine run-off to groundwater will be assessed using the Method C qualitative risk assessment approach detailed within Annex I of DMRB HD 45/09. The

[111] Environment Agency (2018) Standard rules: environmental permitting guidance [online] available at: https://www.gov.uk/topic/environmental-management/environmental-permits (last accessed January 2019)
[112] Parliament of the United Kingdom (1991) Land Drainage Act 1991
[113] Parliament of the United Kingdom (2010) Flood and Water Management Act 2010
[114] Highways Agency (2009) Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10 'Road Drainage and the Water Environment' (HD 45/09) [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf (last accessed January 2019)

assessment will take into account the preliminary drainage design and AADT forecast data, recharge data and receiving aquifer characteristics to assess the potential impact of pollution to groundwater, and the requirement for mitigation measures to adequately reduce the risk.

14.6.8. An assessment of pollution impacts on surface waters and groundwater from accidental spillages will be undertaken in line with the Method D assessment detailed within Annex I of the DMRB HD 45/09. Predicted AADT data for the Scheme is also required to inform this assessment.

14.6.9. A simple Flood Risk Assessment (FRA) will be undertaken to assess the risk of all forms of flooding and the potential impacts to and from the Scheme. The FRA will be undertaken in accordance with the requirements of the NPPF and its associated PPG. This may include a Detailed Assessment, which would require hydrological (DMRB HD45/09 Method E) and hydraulic (DMRB HD45/09 Method F) modelling assessments. The Detailed Assessment would incorporate the findings of the Drainage Impact Assessment.

14.6.10. A geomorphological assessment and river modelling would be required to assess potential impacts due to realignment and culverting of Norman's Brook tributary at Crickley Hill.

14.6.11. Due to the lack of information on baseline conditions in the local area, preliminary surface water and groundwater site investigations are ongoing to enable sufficient data to be collected to inform the assessments. The investigations have been designed and implemented with input from the Environment Agency.

14.6.12. A water feature survey commenced in April 2018 to ground truth surface water and groundwater features that may be potentially affected by the Scheme, including abstractions, springs, surface water courses, ponds and wetlands. Spot flow gauging of watercourses has also been undertaken to assist in understanding the catchment hydrology, which has included gauging during an unusually wet spring and dry summer.

14.6.13. A tracer test was undertaken to establish the course of the downstream of Crickley Hill. This tracer test was conducted in response to the Environment Agency suggesting that this watercourse may form part of the headwaters of Norman's Brook rather than Horsbere Brook, as indicated in the Environment Agency's Catchment Data Explorer[91]. The test confirmed that this watercourse is a tributary of Norman's Brook.

14.6.14. A Phase 1 GI has recently been completed to establish general geological and hydrogeological conditions within the study area. This will inform and be complemented by the more comprehensive Phase 2 GI.

14.6.15. A groundwater monitoring and sampling programme would be included in the OEMP, which will include a minimum of one year's data collection to understand seasonal variations. The programme may include further spring or stream gauging and tests to determine aquifer hydraulic parameters and water quality.

14.6.16. The construction and operation of the Scheme could result in potential adverse direct effects on surface waterbodies and groundwater bodies classified under the WFD. Therefore, a WFD assessment will be undertaken to the appropriate level, in accordance with Environment Agency guidance [115].

Assessment of magnitude of impacts and significance of effects

14.6.17. Criteria for determining the value and importance of a feature is set out in Table 14.1 and definitions for the magnitude of impact are given in Table 14.2. The overall significance of effect is determined using Table 5.2 and the definitions provided in Table 14.3. Effects can be Beneficial or Adverse. Effects that are Moderate, Large or Very Large are considered significant effects. Effects that are Slight or Neutral are not considered significant. The potential ecological impacts of routine run-off on surface waters will be assessed using HAWRAT, as advised in Section 5.6 of the DMRB HD 45/09 document.

14.6.18. The assessment methodology is strictly based on the guidance given in DMRB HD 45/09.

Table 14.1 Criteria for estimating the importance of water environment attributes

Importance	Criteria	Typical examples
Very High	Attribute has a high quality and rarity on a regional or national scale.	**Surface water:** European Commission (EC) Designated Salmonid/Cyprinid fishery; WFD Class 'High'; Site protected/designated under EC or UK habitat legislation (SAC, Special Protection Area (SPA), SSSI, Water Protection Zone (WPZ), Ramsar site, salmonid water)/Species protected by EC legislation **Groundwater:** Principal aquifer providing a regionally important resource or supporting site protected under EC and UK habitat legislation; SPZ1 **Flood risk:** Floodplain or defence protecting more than 100 residential properties from flooding
High	Attribute has a high quality and rarity on a local scale.	**Surface water:** WFD Class 'Good' Major Cyprinid Fishery Species protected under EC or UK habitat legislation **Groundwater:** Principal aquifer providing locally important resource or supporting river ecosystem; SPZ2 **Flood risk:** Floodplain or defence protecting between 1 and 100 residential properties or industrial premises from flooding

[115] Environment Agency (2017) Water Framework Directive assessment: estuarine and coastal waters [online] available at: https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters (last accessed January 2019)

Importance	Criteria	Typical examples
Medium	Attribute has a medium quality and rarity on a local scale.	**Surface water:** WFD Class 'Moderate' **Groundwater:** Aquifer providing water for agricultural or industrial use with limited connection to surface water SPZ3 **Flood risk:** Floodplain or defence protecting 10 or fewer industrial properties from flooding
Low	Attribute has a low quality and rarity on a local scale.	**Surface water:** WFD Class 'Poor' **Groundwater:** Unproductive strata **Flood risk:** Floodplain with limited constraints and a low probability of flooding of residential and industrial properties

Table 14.2 Estimating the magnitude of an impact on an attribute

Magnitude	Criteria	Examples
Major Adverse	Results in loss of attribute and / or quality and integrity of attribute	**Surface water:** Failure of both soluble and sediment-bound pollutants in HAWRAT (Method A, Annex I of DMRB 45/09) and compliance failure with Environmental Quality Standards (EQS) values (Method B, Annex I of DMRB 45/09); Calculated risk of pollution from a spillage >2% annually (Spillage Risk Assessment, Method D, Annex I of DMRB 45/09); Loss or extensive change to a fishery; Loss or extensive change to a designated nature conservation site **Groundwater:** Loss of, or extensive change to, an aquifer; Potential high risk of pollution to groundwater from routine run-off – risk score >250 (Groundwater Assessment, Method C, Annex I of DMRB 45/09); Calculated risk of pollution from spillages >2% annually (Spillage Risk Assessment, Method D, Annex I); Loss of, or extensive change to, groundwater supported designated wetlands **Flood risk:** Increase in peak flood level (1% annual probability) >100 mm (Methods E and F, Annex I of DMRB 45/09)
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute	**Surface water:** Failure of both soluble and sediment-bound pollutants in HAWRAT but compliance with EQS values; Calculated risk of pollution from spillages >1% annually and <2% annually; Partial loss in productivity of a fishery **Groundwater:** Partial loss or change to an aquifer; Potential medium risk of pollution to groundwater from routine runoff – risk score 150-250; Calculated risk of pollution from spillages >1% annually and <2% annually; Partial loss of the integrity of groundwater supported designated wetlands **Flood risk:** Increase in peak flood level (1% annual probability) >50 mm
Minor Adverse	Results in some measurable change in attribute's quality or vulnerability	**Surface water:** Failure of either soluble or sediment-bound pollutants in HAWRAT; Calculated risk of pollution from spillages >0.5% annually and <1% annually **Groundwater:** Potential low risk of pollution to groundwater from routine runoff – risk score <150 Calculated risk of pollution from spillages >0.5% annually and <1% annually Minor effects on groundwater supported wetlands **Flood risk:** Increase in peak flood level (1% annual probability) >10mm

Magnitude	Criteria	Examples
Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity	The Scheme is unlikely to affect the integrity of the water environment **Surface water:** No risk identified by HAWRAT (Pass both soluble and sediment-bound pollutants); Risk of pollution from spillages <0.5% **Groundwater:** No measurable impact upon an aquifer and risk of pollution from spillages <0.5% **Flood risk:** Negligible change in peak flood level (1% annual probability) <+/- 10 mm
Minor Beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring	**Surface water:** HAWRAT assessment of either soluble or sediment-bound pollutants becomes Pass from an existing site where the baseline was a Fail condition; Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually) **Groundwater:** Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually) **Flood risk:** Reduction in peak flood level (1% annual probability) >10 mm
Moderate Beneficial	Results in moderate improvement of attribute quality	**Surface water:** HAWRAT assessment of both soluble and sediment-bound pollutants Becomes Pass from an existing site where the baseline was a Fail condition; Calculated reduction in existing spillage by 50% or more (when existing spillage risk >1% annually) **Groundwater:** Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually) **Flood risk:** Reduction in peak flood level (1% annual probability) >50 mm
Major Beneficial	Results in major improvement of attribute quality	**Surface water:** Removal of existing polluting discharge, or removing the likelihood of polluting discharges occurring to a watercourse **Groundwater:** Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring; Recharge of an aquifer **Flood risk:** Reduction in peak flood level (1% annual probability) >100 mm

Table 14.3 Definitions of overall significance of effect

Significance	Examples
Very Large Adverse	Where the Scheme would result in degradation of the water environment because it results in predicted very significant adverse impacts on at least one water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Potential failure of both soluble and sediment-bound pollutants in a High or Good watercourse OR in an EC Designated Salmonid fishery, for both short-term and long-term assessment (Methods A and B)

Significance	Examples
	• Loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) • Calculated risk of pollution from spillages is >2% when discharging into a Good watercourse, >1% for a High watercourse **Groundwater:** • Potential high risk (risk score >250) of pollution in the Groundwater Assessment (Method C, Annex I) to a principal aquifer providing a regionally important resource or supporting a site protected under habitat legislation OR a medium to high risk (risk score >150) to a SPZ1 • Calculated risk of pollution from spillages is >1% when discharging into a SPZ1 or principal aquifer • Potential loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) through interception of groundwater flow or significant change to groundwater level **Flood risk:** • An increase in peak flood levels (1% annual probability) >100 mm increasing the risk of flooding to >100 residential properties
Large Adverse	Where the Scheme would result in a degradation of the water environment because it results in predicted highly significant adverse impacts on a water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Potential short-term (HAWRAT) failure of both soluble and sediment-bound pollutants in a High or Good watercourse OR in an EC Designated Salmonid fishery • Calculated risk of pollution from spillages is >1% for a Good watercourse (or one of lower ecological class) and >0.5% for a High watercourse • Loss or extensive change to a cyprinid fishery • Loss or extensive change to a Local Nature Reserve (LNR) **Groundwater:** • Potential high risk (risk score >250) of pollution to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting LNRs aquifer OR medium risk (risk score 150-250) of pollution of a principal aquifer providing a locally important resource or supporting a site protected under habitat legislation, OR medium to high risk (score >150) to a SPZ2, OR potential low risk (score <150) to a SPZ1 • Calculated risk of pollution from spillages is >0.5% when discharging to a principal aquifer or SPZ1 • Loss or extensive change to an LNR through interception of groundwater flow or change to groundwater level **Flood risk:** • An increase in peak flood levels (1% annual probability) >50 mm increasing the risk of flooding to >100 residential properties OR an increase of >100mm increasing the risk of flooding to 1-100 residential properties
Moderate Adverse	Where the Scheme may result in the degradation of the water environment because it results in predicted moderate adverse impacts on at least one attribute. More than one

Significance	Examples
	attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Potential short-term (HAWRAT) failure of either soluble or sediment-bound pollutants in a High or Good watercourse • Calculated risk of pollution from spillages is >0.5% for a Good watercourse OR >1% for a Moderate or Poor watercourse • Partial loss or change to a fishery • Effect on the integrity of the existing flora and fauna **Groundwater:** • Potential medium risk (score 150-250) to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting LNRs OR potential low risk (score <150) of pollution to a principal aquifer providing a regionally important resource or supporting a river ecosystem OR medium to high risk (score >150) to a SPZ3, OR potential low risk (score <150) to a SPZ2, OR high risk (score >250) for a discharge to unproductive strata • Calculated risk of pollution from spillages is >1% for an aquifer or SPZ3 • Effect on the integrity of the existing flora and flora through interception of groundwater flow or change to groundwater level **Flood risk:** • An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to >100 residential properties OR an increase of >50mm resulting in an increased risk of flooding to 1-100 residential properties
Slight Adverse	Where the Scheme may result in a degradation of the water environment because it results in a predicted slight impact on one or more attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Potential short-term (HAWRAT) failure of either soluble or sediment-bound pollutants in a Moderate or Poor watercourse • Calculated risk of pollution from spillages is >0.5% for a Moderate or Poor watercourse • Temporary loss to, or loss in productivity of, a fishery **Groundwater:** • Potential low risk of pollution (score <150) to a secondary aquifer with limited agricultural use and connectivity to surface waters and local ecology OR low to medium risk (score <250) for a discharge to unproductive strata, OR low risk (score <150) to a SPZ3 • Calculated risk of pollution from spillages is >0.5% for an aquifer or SPZ3 **Flood risk:** • • An increase in peak flood level (1% annual probability) >10 mm resulting in an increased risk of flooding to fewer than 10 industrial properties
Neutral	Where the net impact of the Scheme is Neutral, because it results in no appreciable effect, either positive or negative, on the identified attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:**

Significance	Examples
	• No risk identified by Method A or Method B assessment (Pass both solubles and sediment-bound pollutants) • Calculated risk of pollution from spillages <0.5% annually **Groundwater:** • No predicted change in quality of any type of aquifer and/or its use as a resource • Calculated risk of pollution from spillages <0.5% annually **Flood risk:** • Negligible change in peak flood (1% annual probability) <+/- 10 m
Slight Beneficial	All other situations where the Scheme provides an opportunity to enhance the water environment or provide an improved level of protection to an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Method A assessment of either soluble or sediment-bound pollutants becomes Pass from previous Fail condition for existing discharges • Reduction by 50% or more in existing pollution risk from spillages into High to Poor watercourses (when existing spillage risk is <1%) **Groundwater:** • Reduction by 50% or more in existing pollution risk from spillages into an aquifer (when existing spillage risk is <1%) **Flood risk:** • A reduction in peak flood level (1% annual probability) >10mm resulting in a reduced risk of flooding to 1-100 residential properties
Moderate Beneficial	Where the Scheme provides an opportunity to enhance the water environment because it results in a moderate improvement for an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Method A assessment of both soluble and sediment-bound pollutants becomes Pass from previous Refer or Fail condition for existing discharges • Reduction by 50% or more in likelihood of pollution to watercourses from spillages from existing discharges through retrofitting of pollution control to outfalls into a High to Poor watercourse (existing risk >1%) • Recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat of local nature conservation value i.e. LNR **Groundwater:** • Reduction by 50% or more in existing likelihood of pollution arising from a spillage to an aquifer through retrofitting of pollution control (existing risk >1%) **Flood risk:** • A reduction in peak flood level (1% annual probability) >10 mm resulting in a reduced risk of flooding to >100 residential properties OR a reduction of >50mm resulting in a reduced risk of flooding to 1-100 residential properties
Large Beneficial	It is extremely unlikely that any Scheme incorporating the construction of a new or improved trunk road would fit into this category. However, proposals could have a large positive impact if it is predicted that it will result in a 'very' or 'highly' significant improvement to a water attribute(s), with insignificant adverse impacts on other water

Significance	Examples
	attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface water:** • Removal of an existing polluting discharge through provision of pollution prevention measures, or any other measure, affecting a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) • Reduction by 50% or more in the existing likelihood of pollution arising from a spillage affecting a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) where existing risk >1% **Groundwater:** • Removal of an existing polluting discharge within Zone 1 and 2 of a SPZ and/or a principal aquifer • Reduction by 50% or more in the existing likelihood of pollution arising from a spillage at discharge points within Zone 1 or 2 of a SPZ, principal aquifer and/or a site supporting a habitat protected under habitat legislation (existing risk >1%) • Recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid water) **Flood risk:** • A reduction in peak flood levels (1% annual probability) >50 mm reducing the risk of flooding to >100 residential properties OR a reduction of >100mm resulting in a reduced risk of flooding to 1-100 residential properties

14.7. Assessment assumptions and limitations

14.7.1. This chapter has been prepared using publicly available information only and the assessment presented is based on a desk-based study and the findings of the tracer test.

14.7.2. This chapter does not take into account other ongoing investigations such as the Phase 1 GI, groundwater monitoring and sampling, and the water feature survey. The findings of these will be considered during preliminary design.

14.7.3. It has been assumed that the available information on water quality is representative of the general conditions. Considering the nature of Scheme, it is not considered that the data limitations introduce any significant uncertainties with respect to surface water and flooding risks. However, there remains considerable uncertainty with respect to the assessment of groundwater risks.

15. Climate

15.1. Study area

Effects on climate

15.1.1. The study area to be considered for the construction phase includes the embodied carbon[116] of the materials and the emissions caused by the construction activities and their associated transport. These are defined in terms of lifecycle stages, as detailed in Section 7 of PAS2080:2016 and as follows:

- Products and materials (A1-3) - use of materials for temporary and permanent construction activities
- Construction / installation processes (A5) - construction plant use

15.1.2. The study area to be considered for operation includes the affected road network (ARN) for road user carbon (vehicle emissions) and the carbon used for the maintenance and refurbishment of the Scheme assets, which comprises the embodied carbon of materials, emissions from maintenance activities, and associated transport. Road user carbon, the use of the asset, and vehicle emissions are assessed in line with the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 1 Air Quality (A207/07) and the Transport Analysis Guidance (TAG) Unit A3 Environmental Impact Appraisal, Chapter 4.

15.1.3. These are defined in terms of lifecycle stages, as detailed in Section 7 of PAS2080:2016 and as follows:

- Operational energy use (B6) - operational energy.
- User utilisation of infrastructure (B9) - in use traffic.

15.1.4. The assessment will capture any design changes which have led to a reduction in GHG emissions. It will include any opportunities to further minimise the production of GHG emissions e.g. reuse and recycling of materials on site during the construction period.

15.1.5. Emissions associated with the end of life stage (PAS2080:2016 Stage C1-4), i.e. decommissioning shall not be considered given the uncertainty associated with the length of operation (use stage).

[116] Embodied carbon refers to carbon dioxide emitted during the manufacture, transport and construction of building materials, together with end of life emissions. End of life emissions include demolition, waste processing, waste disposal and any transport emissions during this period.

Vulnerability of the Scheme to climate change

15.1.6. For the purposes of the vulnerability assessment, the study area has been defined as the area occupied by the physical infrastructure assets associated with the Scheme (for example, earthworks, structures, pavement) as described in Chapter 2 the Scheme, as well as affected receptors identified within other environmental factors scoped in to the assessment. This will include the construction process, operation, maintenance and end-users of these assets.

15.2. Baseline conditions

Effects on climate

15.2.1. In this context, existing carbon emissions from a variety of sources in the area are considered, including those from transport infrastructure. From a UK perspective, national greenhouse gas (GHG)[117] emissions in 2016 decreased by 42% from 1990. In 2017, UK net carbon dioxide (CO_2) emissions were estimated at 373 million tonnes, a decrease of 3% in comparison to 2016 levels. In 2017, 27% of UK GHG emissions were from the transport sector which is a 0% change in comparison to 2016[118].

15.2.2. Within Gloucester, the carbon emissions specifically from A roads in 2016 was 61.2 ktCO_2, which represents a 17% decrease since 2005 and an 9% decrease in overall transport emissions[119]. There were 37.9 million vehicles licensed for use on roads in the UK at the end of March 2018. However, in 2018 Q1 registration of ultra-low emission vehicles were up by 11% on 2017 Q1. There has also been a sharp decline in the number of diesel cars being registered for the first time in 2018 Q1, down 33% compared to 2017 Q1[120].

15.2.3. The UK construction industry is the largest consumer of natural resources with an average of over 400 million tonnes of material consumed every year. This

[117] A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range. Greenhouse gases cause the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide and ozone.
[118] Department for Business, Energy and Industrial Strategy (2019): 2017 UK Greenhouse Gas Emissions [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/776083/2017_Final_emissions_statistics_one_page_summary.pdf (last accessed January 2019).
[119] Department for Business, Energy and Industrial Strategy (2018): 2005 to 2016 UK local and regional CO_2 emissions – data tables [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/720677/2005-16_UK_local_and_regional_CO2_emissions.xlsx (last accessed January 2019).
[120] Department for Transport (2018): Vehicle licensing statistics: January to March 2018 report [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/729581/vehicle-licensing-statistics-january-to-march-2018.pdf (last accessed January 2019).

accounts for approximately 10% of the total UK carbon emissions[121]. Therefore, approximately 40.38 million tonnes of CO_2 are attributed to the embodied carbon of construction materials.

Vulnerability of the Scheme to climate change

15.2.4. The Met Office holds historical regional climate information, in which the Cotswolds are included in the midlands region[122]. High-level climate observations for the midlands over a 30-year averaging period between 1981-2010 are presented in Table 15.1.

Table 15.1: Historic climate baseline for the midlands (1981-2010)

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

Source: Met Office Regional Climate Data

Future baseline

Effects on climate

15.2.5. The transport sector is a key driver in projected UK emissions and contribute to an estimated 40% of UK non-traded emission in 2015. The projections show a decline to 2035 (emissions are projected to fall by 15% from 2016 levels). Ninety-seven percent of 2016 final energy consumption in transport was from oil-

[121] Alinden, B. (2014) Embodied Energy and Carbon, ICE [online] available at: https://www.ice.org.uk/knowledge-andresources/briefing-sheet/embodied-energy-and-carbon (last accessed January 2019).
[122] The Met Office (2016) Midlands: Climate [online] available at: https://www.metoffice.gov.uk/climate/uk/regional-climates/mi (last accessed January 2019).

based fossil fuels, however by 2035 this is projected to fall to 92% due to the uptake of electric vehicles and increased use of biofuels[123].

Vulnerability of the Scheme to climate change

15.2.6. The UK Climate Projections developed by the Met Office Hadley Centre include regional climate projection data, for which the Cotswolds is included in the south-west region. The south-west is predicted to experience changes in temperature, rainfall, and frequency of extreme weather events, particularly flooding as a consequence of climate change. These changes are predicted to occur under all three emissions scenarios (i.e. low, medium, and high GHG emissions), which are incorporated into the climate change models. The general trend for the region is for hotter and drier summers, and warmer and wetter winters.

15.2.7. It should be noted that climate projection data corresponding to the 2080s (2070-2099) under a high emissions scenario has been selected in line with the National Policy Statement for National Networks (NPSNN) paragraph 4.41 which states that *"Where transport infrastructure has safety-critical elements and the design life of the asset is 60 years or greater, the applicant should apply the UK Climate Projections 2009 (UKCP09) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level*".

15.2.8. Under the high emissions scenario for the 2080s, estimated changes in climatic conditions are outlined in Table 15.2 below.

Table 15.2: Future climate projections for the 2080s (high emissions scenario)

Climatic conditions	Climate observations
Temperature	The average summer temperature is estimated to increase by 5°C under the central estimate, which represents 'as likely as not' probability of change (50th percentile), and average winter temperature is estimated to increase by 3.4°C (50th percentile).
Rainfall	The average summer rainfall rate is estimated to decrease by 30%, whereas the average winter rainfall rate is estimated to increase by 31% (in the 50th percentile or central estimate for both)
Wind	Climate projections for wind are more uncertain than those for temperature and precipitation, due to inherent difficulty in modelling future wind conditions. However, overall an increase in extreme weather, including wind, is projected.

Source: UKCP18 Climate Projections

[123] Department for Business, Energy & Industrial Strategy (2018): Updated energy and emissions projections 2017 [online] available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/671187/Updated_energy_and_emissions_projections_2017.pdf (last accessed January 2019).

15.3. Potential impacts

Construction

Effects on climate

15.3.1. The duration of the construction works for the Scheme would be approximately three years. Through this period, embodied carbon emissions from the use of construction materials are the main contributor to climate change, with additional GHG emissions arising from the use of plant and transport of materials.

Vulnerability of the Scheme to climate change

15.3.2. During the temporary construction period, climate change is not expected to change the risk of severe weather between now and the start of the period of construction. Furthermore, the rate of change in climate is greater than the time between the present and construction. Therefore, the vulnerability of the Scheme to climate change during construction will be scoped out from further assessment in the Environmental Statement.

15.3.3. The Scheme is still vulnerable to adverse weather conditions irrespective of climate change, these effects will be mitigated with best practice site management and the CEMP.

Operation

Effects on climate

15.3.4. The lifetime of the Scheme is anticipated to be 60 years, with the Scheme opening in 2024. Over this time, the operation of the Scheme has the potential to result in an increase in local GHG emissions due to changes in vehicle distributions and speed limits.

Vulnerability of the Scheme to climate change

15.3.5. During the Scheme's 60-year appraisal period, changes in climate as outlined in Table 15.2 are likely to be experienced in the study area. This has the potential to pose a risk to the Scheme assets such as deformation and deterioration of asphalt surfacing associated with temperature increase and changes in precipitation affecting the foundation strength and deterioration of the road surface, with the potential to lead to an increased flood risk.

15.3.6. Changes in climate also have the potential to pose risks to the environmental receptors detailed throughout this report. For example, increased precipitation may impact the foraging habits and opportunities of bats and result in more

frequent rainfall events leading to higher runoff which could increase pollutant concentrations within the receiving water.

15.4. Design, mitigation and enhancement measures

Construction

Effects on climate

15.4.1. Mitigation measures for effects on climate consist of strategic approaches that drive reduction across all lifecycle stages and encouraging carbon reduction behaviours with those specific to the separate lifecycle stages.

15.4.2. In line with the UK government's carbon reduction plan, the Scheme shall seek to reduce GHG emissions as far as practicable in all cases to contribute to the UK's net reduction in carbon emissions and maximise the potential for reducing GHG emissions. The following high-level options shall be applied and developed when seeking to reduce GHG emissions on projects:

- Step 1 - Avoid and prevent: maximise potential for re-using or refurbishing existing assets to reduce the extent of new construction required; and explore alternative lower carbon options to deliver the project objectives.
- Step 2 - Reduce: apply low carbon solutions (including technologies, materials and products) to minimise resource consumption during the construction, operation, and at end-of-life; and construct efficiently: use techniques (for example, during construction and operation) that reduce resource consumption over the life cycle of the Scheme.
- Step 3 - Remediate: after addressing steps one and two projects will identify, assess and integrate measures to further reduce carbon through on or off-site offsetting or sequestration.

15.4.3. The use of the carbon reduction hierarchy has been tied to good design practice and cost efficiencies on the Scheme.

15.4.4. Mitigation measures to be included in the Construction Environmental Management Plan (CEMP) such as the reduction of raw material usage, recycling the use of local suppliers and ensuring vehicle engines and plant motors are switched off when not in use, would limit emissions as far as practicable. Additional details are set out in Sections 6.4 and 11.4.

15.4.5. Plant equipment and vehicles to be used on the Scheme would be selected based on their relative environmental performance taken from a technical specification.

15.4.6. Construction works would be carried out in accordance with the best practicable means, as described in Section 79 (9) of the Environmental Protection Act (EPA) 1990, to reduce fumes or emissions. This would include all vehicle engines and plant motors to be switched off when not in use.

Vulnerability of the Scheme to climate

15.4.7. A CEMP would be prepared by the appointed Contractor and implemented during the construction period. Adaptation measures included in the CEMP such as ensuring construction materials are covered when stored, and pro-active planning to take into account effects of extreme weather events, including use of an extreme weather alert service, would minimise adverse effects.

Operation

Effects on climate

15.4.8. Further assessment is required to fully understand the change in GHG emissions between the do something and do minimum from the change in vehicles using the Scheme. This will be included in the Environmental Statement, including any required mitigation measures.

Vulnerability of the Scheme to climate change

15.4.9. A Flood Risk Assessment (FRA) will be undertaken and will take into account the Environment Agency's *Climate change allowances* National Planning Policy Framework (NPPF) supporting guidance. In addition, the Scheme drainage design will be designed to accept flows generated by a rainfall event with a 1-in-100 year return period, plus a 40% allowance for climate change, determined in line with Environment Agency guidance.

15.4.10. Further assessment will investigate the potential for effects on the Scheme from climate change. Following this assessment, the requirement for mitigation will be explored. The assessment and required mitigation will be presented within the Environmental Statement.

15.5. Description of the likely significant effects

Construction

Effects on climate

15.5.1. Due to the size of the Scheme, the embodied carbon emissions from the use of construction materials would be the main contributor to climate change, with additional GHG emissions arising from the use of plant and transport of

materials. It is likely that any effects due to embodied carbon emissions can be reduced by implementing mitigation measures as previously outlined in Section 15.4. However, further assessment to be informed following design development is required to confirm this, and will be presented within the Environmental Statement.

Operation

Effects on climate

15.5.2. The life of the Scheme is anticipated to be 60 years with the Scheme opening in 2024. Over this time, the operation of the Scheme has the potential to result in an increase in local CO_2 emissions due to changes in vehicle distributions and speed limits which will impact the local climate which may impact our ability to meet the UK carbon budgets. Further assessment in the Environmental Statement is required.

Vulnerability of the Scheme to climate Change

15.5.3. During the Scheme's 60-year appraisal period, changes in climate as outlined in Table 15.2 are projected to be experienced in the study area. These have the potential to pose a risk to the Scheme assets such as deformation and deterioration of asphalt surfacing associated with temperature increase and changes in precipitation affecting the foundation strength and deterioration of the road surface, with the potential to lead to an increased flood risk.

Summary

15.5.4. The construction phase has the potential to increase CO_2e emissions. The construction site has the potential to be vulnerable to extremes of weather during its three-year construction. Changes in climate also have the potential to pose a risk to the Scheme assets and environmental receptors during the operation of the Scheme. A detailed assessment will therefore be undertaken and presented within the Environmental Statement.

15.6. Assessment methodology

Proposed level and scope of assessment

Effects on climate

15.6.1. The assessment will consider the GHG emission potential throughout the lifecycle of the Scheme for both construction in accordance with PAS 2080 and

operation in accordance with TAG Unit A3 Environmental Impact Appraisal and HA 207/07.

Vulnerability of the Scheme to climate change

Spatial scope

15.6.2. The assessment will consider climate effects on the Scheme assets such as pavements, drainage and geotechnical receptors in addition to the in-combination effects of climate change on the environmental receptors.

Temporal scope

15.6.3. As construction is scheduled for three years only, climate change is not expected to bring about a change in the risk of severe weather between the date of assessment and the start of the period of construction, therefore the vulnerability of the scheme to climate change during construction is scoped out of further assessment.

15.6.4. The operational effects on the Scheme as a result of climate change will be considered. The operational assessment will be informed by the lifespan of key elements within the Scheme design and availability of UK Climate Projections.

Policy requirements, guidance and advice

15.6.5. The following guidance documents will be used to inform the assessment:

- Climate Adaptation Risk Assessment Progress Update[124]
- Institute of Environmental Management and Assessment (IEMA) Environmental Impact Assessment guide to Climate Change Resilience and Adaptation[125]
- IEMA's Guidance on Assessing the GHG Emissions and Evaluating their Significance[126]

[124] Highways England (2016) Climate Adaptation Risk Assessment [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/596812/climate-adrephighways-england.pdf (last accessed January 2019).
[125] IEMA (2015) IEMA Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation [online] available at: https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20(1).pdf (last accessed January 2019).
[126] IEMA (2017) Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance [online] available at: https://www.iema.net/policy/ghg-in-eia-2017.pdf (last accessed January 2019).

- TAG Unit A3 Environmental Impact Appraisal - Chapter 4 Greenhouse Gases[127]
- Design Manual For Roads and Bridges (DMRB) HA 207/07[128]
- PAS 2080 : 2016 Carbon management in infrastructure[129]

Determination of significant effects

15.6.6. There is at present no single accepted methodology for the assessment of climate change for Environmental Impact Assessments (EIAs). As such, a qualitative methodology for assessing the vulnerability of the Scheme to climate change will be produced in line with DMRB Volume 11 Section 2 Part 5.

Proposed methodology

Effects on climate

15.6.7. The assessment of the effects of the Scheme on climate will include an assessment of:

- The GHGs emitted during the lifecycle of the Scheme using the Highways England Carbon Calculator Tool[130].
- Estimated GHG emissions arising from the scheme in comparison with UK carbon budgets, and the associated reduction targets, outlined in Table 15.3.
- An appraisal of GHGs for the Scheme opening year and design year to derive the change in carbon dioxide equivalent (CO_2e)[131] emissions will be assessed in accordance with TAG Unit A3, Chapter 4 Greenhouse Gases and HA 207/07.
- Opportunities for mitigation in the Scheme design.

Table 15.3: UK carbon budgets

Carbon budget	Carbon budget level	Reduction below 1990 levels
3rd carbon budget (2018-2022)	2,544 $MtCO_2e$	37% by 2020
4th carbon budget (2023-2027)	1,950 $MtCO_2e$	51% by 2025
5th carbon budget (2028-2032)	1,725 $MtCO_2e$	57% by 2030

Source: Department for Business, Energy and Industrial Strategy, 2016

[127] Department for Transport (2015) TAG Unit A3 Environmental Impact Appraisal [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/638648/TAG_unit_a3_envir_imp_app_dec_15.pdf (last accessed January 2019).
[128] DMRB Volume 11, Section 3- JHA 207/07 [online] available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/ha20707.pdf (last accessed March 2019)
[129] BSI (2016) PAS 2080:2016 Carbon Management and Infrastructure.
[130] Highways England: Carbon Reporting Tool, v1.03 [online] available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/553866/Task_446_Carbon_Tool_v1.03.xlsm (last accessed April 2019)
[131] Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP).

Vulnerability of the Scheme to climate change

15.6.8. A qualitative methodology for assessing the vulnerability of the Scheme assets to climate change will be produced in line with the EIA Regulations, Schedule 4, Part 55 which has set out how projects will assess the likelihood and consequence of the impact occurring to each receptor, leading to the evaluation of the significance of the effects as follows:

- The impacts (hazards and opportunities) for each receptor shall be identified using the climate projections data. The vulnerability of the project to both normal weather and extreme weather-related disaster scenarios, throughout the project lifecycle, shall be identified and reported.
- Once the climate change impacts (hazards and opportunities) have been identified, a risk assessment of those impacts on the project shall be undertaken using the following framework in Table 15.4 (likelihood categories) and Table 15.5 (consequence of impact).
- Report on the significance of effects using Table 15.6.

Table 15.4: Likelihood categories

Likelihood category	Description (probability and frequency of occurrence)
Very high	The event occurs multiple times during the lifetime of the Scheme (60 years) for example, approximately annually, typically 60 events.
High	The event occurs several times during the lifetime of the Scheme (60 years) for example approximately once every five years, typically 12 events;
Medium	The event occurs limited times during the lifetime of the Scheme (60 years) for example, approximately once every 15 years, typically 4 events.
Low	The event occurs during the lifetime of the Scheme (60 years) for example, once in 60 years.
Very low	The event may occur once during the lifetime of the Scheme (60 years).

Note: Scheme lifetime is considered to include construction and operational stages. Scheme lifetime is taken to be 60 years in line with WebTAG.

Table 15.5: Measure of consequence

Consequence of impact	Description
Very large adverse	• National level (or greater) disruption to strategic route(s) lasting more than 1 week.
Large adverse	• National level disruption to strategic route(s) lasting more than 1 day but less than 1 week OR • Regional level disruption to strategic route(s) lasting more than 1 week.
Moderate adverse	• Regional level disruption to strategic route(s) lasting more than 1 day but less than 1 week.
Minor adverse	• Regional level disruption to strategic route(s) lasting less than 1 day.
Negligible	• Disruption to an isolated section of a strategic route lasting less than 1 day.

Note: Where potential "Beneficial" impacts are identified, projects should seek advice from Highways England's Environmental Advisors. Example: improved resilience as a result of improvement to existing parts of the network.

Table 15.6: Significance matrix

		Measure of likelihood				
		Very low	**Low**	**Medium**	**High**	**Very High**
Measure of consequence	**Negligible**	NS	NS	NS	NS	NS
	Minor	NS	NS	NS	S	S
	Moderate	NS	NS	S	S	S
	Large	NS	S	S	S	S
	Very Large	NS	S	S	S	S

Note: NS= Not significant, S= Significant

Summary

15.6.9. An assessment of project emissions against UK government carbon budgets shall be presented as follows:

Table 15.7: Assessment Reporting Table

Project Stage/ Activity	Net tCO_2e	Relevant Carbon Budgets
Construction	XX	3rd & 4th carbon budget periods (2020-2023)
Operation	XX	4th & 5th carbon budget periods (2024-2032)

15.6.10. The figures presented in Table 15.7 will include any reductions in emissions achieved by the project.

15.7. Assessment assumptions and limitations

15.7.1. Information on the climate baseline and future projections are based on freely available information from third parties, including the historical meteorological variables recorded by the Met Office and the UK Climate Projections (UKCP18) developed by the Met Office. In addition, the assessment has been informed by a selected range of existing climate change research and literature, available at the time of writing this assessment.

15.7.2. Climate projections are not predictions or forecasts but simulations of potential scenarios of future climate, under a range of hypothetical emissions scenarios and assumptions. Therefore, the results from running the climate models cannot be treated as exact or factual, but projection options. They represent internally consistent representations of how the climate may evolve in response to a range of potential forcing scenarios, and their reliability varies between climate variables. Scenarios exclude outlying "surprise" or "disaster" scenarios in the

literature, and any scenario necessarily includes subjective elements and is open to various interpretations. Generally global projections are more certain than regional, and temperature projections are more certain than those for precipitation. Further, the degree of uncertainty associated with all climate change projections increases for projections further into the future.

15.7.3. Highways England has not independently verified the climate projections and does not accept responsibility or liability for any inaccuracies or shortcomings in this information. Should the information sources be modified by the third parties, we assume no responsibility for any of the resulting inaccuracies in any of our reports. Issued reports are relevant to the project information provided and are not intended to address changes in project configuration or modifications which occur over time.

15.7.4. Accordingly, any further research, analysis or decision-making should take account of the nature of the data sources and climate projections and should consider the range of literature, additional observational data, evidence and research available, and any recent developments in these.

16. Assessment of cumulative effects

16.1. Assessment methodology

16.1.1. Combined and cumulative effects result from multiple actions on receptors over time and are generally additive or interactive (synergistic) in nature. Combined and cumulative effects can also be considered as effects that have occurred due to incremental changes caused by additional past, present or foreseeable actions together with the project, identified as:

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

16.1.2. The methodology for assessing combined and cumulative effects has been informed by the following guidance:

- The Planning Inspectorate's (PINS) Advice Note Seventeen[132]
- The Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5[133]

Combined effects methodology

16.1.3. The assessment methodology for combined effects involves the identification of impacts that arise from the interactions between different environmental factors associated with the Scheme.

16.1.4. The significance of construction and operational phase environmental effects will be brought forward from the preceding chapters of the Environmental Statement into matrices, providing an overview of the potential effects on individual receptors. The assessment considers adverse effects, after design mitigation has been considered. The significance of combined effects upon each environmental receptor group would then be made based upon the balance of scores and using professional judgement.

16.1.5. The methodology for the assessment of combined effects would follow DMRB Volume 11 Section 2 Part 5: Assessment and Management of Environmental

[132] The Planning Inspectorate (December 2015) Advice Note Seventeen: Cumulative Effects Assessment. Available at https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf (Last accessed January 2019)
[133] DMRB (August 2008) Assessment and Management of Environmental Effects. Available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section2/ha20508.pdf (Last accessed February 2019)

Effects. For the purposes of the assessment, combined effects that are Moderate (Adverse and Beneficial) and above would be considered significant.

Cumulative effects methodology

16.1.6. The assessment methodology for cumulative effects involves the identification of incremental changes likely to be caused by potential 'different projects' together with the project being assessed.

16.1.7. The assessment of cumulative effects will follow a four-stage approach to cumulative effects assessment from Advice Note Seventeen: Cumulative Effects Assessment[134] (The Planning Inspectorate, 2015). The four stages of assessment include:

- Stage one: Establish the Nationally Significant Infrastructure Project (NSIP's) zone of influence (ZOI) and identify a long list of 'other developments'
- Stage two: Identify a shortlist of 'other development' for the cumulative effects assessment
- Stage three: Information gathering
- Stage four: Assessment

16.1.8. For the purposes of the assessment, the following criteria, based on the type and scale of potential effects generated by a proposed development, would be used to determine 'other developments' contained within the long list (Stage 1). Contained within the Town and Country Planning (Environmental Impact Assessment (EIA)) Regulations 2017 is a Screening Criteria that this criterion is based on. This criterion has been selected as the majority of 'other developments' being considered fall under the Town and Country Planning regime.

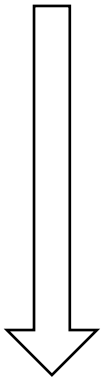
- The development includes more than one hectare of development which is not dwelling house development; or
- the development includes more than 150 dwelling houses; or
- the area of the development exceeds five hectares.

16.1.9. It is important to note that proposed developments that are close to the threshold limits but have characteristics likely to give rise to significant cumulative effects or for which could give rise to a cumulative effect by virtue of its proximity to the Scheme, will also be considered in the assessment, as recommended by PINS.

[134] The Planning Inspectorate (2015) Cumulative effects assessment relevant to nationally significant infrastructure projects [online] available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf (last accessed January 2019)

16.1.10. 'Other development' types are grouped into three tiers, as shown in Table 16.1, and reflects the likely degree of certainty attached to each development. Tier 1 represents the most certainty and Tier 3 reflects the least certainty and most likely to have limited publicly available information to inform assessments.

Table 16.1 Likely degree of certainty assigned to each tier

Tier	Likely degree of certainty	Decreasing level of detail likely to be available
Tier 1	Under construction*. Permitted application(s), whether under the Planning Act 2008 or other regimes, but not yet implemented. Submitted application(s) whether under the Planning Act 2008 or other regimes but not yet determined.	
Tier 2	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has been submitted.	
Tier 3	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has not been submitted. Identified in the relevant Development Plan (and emerging Development Plans – with appropriate weight being given as the move closer to adoption) recognising that much information on any relevant proposals will be limited. Identified in other plans and programmes (as appropriate) which set the framework for future development consents / approvals, where such development is reasonably likely to come forward.	

* Where other projects are expected to be completed before construction of the proposed NSIP and the effects of those projects are fully determined, effects arising from them should be considered as part of the baseline and may be considered as part of both the construction and operational assessment.

Source: Advice Note Seventeen: Cumulative Effects Assessment relevant to nationally significant infrastructure projects (The Planning Inspectorate, 2015).

16.1.11. In accordance with the EIA Regulations, the assessment of cumulative effects should include 'effects with other existing and/or approved projects. However, taking the Precautionary Principle into account, and given the information provided in Table 16.1, the assessment of cumulative effects will consider submitted applications which have not yet been determined (Tier 1), as well as projects on PINs Programme of Projects where a Scoping Report has been submitted (Tier 2).

16.1.12. The Environmental Statement will set out the methodology which recognises the requirements of the National Policy Statement for National Networks (NPSNN) and advice on development of threshold criteria in PINS 'Advice Note Seventeen: Cumulative Effects Assessment', giving particular regard to the size and spatial influence of the proposed developments.

16.1.13. Rather than reporting every interaction, the methodology for the assessment of cumulative effects focuses on the main significant effects, and would aim to differentiate between permanent, temporary, direct, indirect and secondary effects, positive and negative.

16.1.14. Where significant cumulative effects, beyond those identified as residual effects from the Scheme in isolation, have been identified, additional mitigation measures would be developed to avoid significant effects.

16.1.15. The significance of cumulative effects upon each environmental resource would then be made based on the balance of scores and using professional judgement. An on-balance approach would be taken when identifying the overall cumulative effects for the Scheme in conjunction with the other proposed major developments.

Significance criteria

16.1.16. The assessment of significance of the combined and cumulative effects will be determined in accordance with the significance criteria contained in Table 16.2. Typically, the greater the environmental sensitivity or value of the receptor or resource, and the greater the magnitude of impact, the greater the effect. In this way, the consequences of a highly valued resource suffering a major detrimental impact would be a Very Large Adverse effect, as shown in Table 5.2 contained in Chapter 5 of this report, and outlined in DMRB Volume 11, Section 2, Part 5 (HA 205/08).

16.1.17. For the purposes of the cumulative effect's assessment, the value of a resource and magnitude of impact would be determined according to the criteria set within the preceding chapters of the Environmental Statement. The significance of effect is then carried forward from preceding chapters to enable an on-balance assessment of combined significance upon environmental receptors, as well as to identify the significance of cumulative effects with other developments. Typical descriptors of cumulative significance are included within Table 16.2, which reflects this on-balance approach. Overall significance is determined with mitigation included, as shown in Table 5.3 contained within Chapter 5 environmental assessment methodology.

16.1.18. Significance descriptors have also been aligned with the considerations included within PINS Advice Note Seventeen: Cumulative Effects. Accordingly, where impacts are likely to be temporary, the overall significance of effect is considered to be reduced from a permanent impact on a receptor of the same value. Equally, localised and infrequent effects are likely to be of lower magnitude than those that cover a greater geographical scale and / or regularly occur, resulting in a reduced significance of effect. Effects can be additive (such as the loss of two pieces of woodland of one hectare, resulting in two hectares of cumulative woodland loss) or synergistic (two discharges combining to have an effect on a species not affected by discharges in isolation).

16.1.19. Where an effect is Moderate or above (Adverse or Beneficial), it is deemed to be significant.

Table 16.2 Combined and Cumulative Significance Criteria

Significance	Definition
Very Large (Adverse or Beneficial)	Where the combined effects of the Scheme or cumulative effects of the Scheme in association with other existing or more than likely/ near certain future major development upon an individual or collection of environmental receptors would be highly significant. Effects would be: Permanent and far reaching for receptors of very high value.
Large (Adverse or Beneficial)	Where the combined effects of the Scheme or cumulative effects of the Scheme in association with other existing or more than likely/ near certain major future developments upon an individual or collection of environmental receptors would be highly significant. Effects would be: Permanent and far reaching for receptors of high value; Localised for a receptor of very high value; or, Temporary for a receptor of very high value.
Moderate (Adverse or Beneficial)	Where the combined effects of the Scheme or cumulative effects of the Scheme in association with other existing or more than likely/ near certain major development upon an individual or collection of environmental receptors would be significant. Effects would be: Permanent and far reaching for receptors of medium value; Localised for receptors of high value; or, Temporary for a receptor of high value.
Slight (Adverse or Beneficial)	Where the combined effects of the Scheme or cumulative effects of the Scheme in association with other existing or more than likely/ near certain future major developments upon an individual or collection of environmental receptors would be noteworthy but not significant. Effects would be: Permanent and far reaching for receptors of low value; Localised for receptors of medium value; or, Temporary for a receptor of medium value.
Neutral	Where the combined effects of the Scheme or the cumulative effects of the Scheme in association with other existing or more than likely/ near certain future major developments would balance.

Source: Based on DMRB Volume 11 Section 2 Part 5 and professional judgement

Study area

Combined effects

16.1.20. The study area for the assessment of combined effects of the Scheme, for both construction and operation, is defined by the study areas identified within the relevant environmental topic chapters of this report (and of the Environmental Statement), ranging from 200 metres (for air quality during construction) to two kilometres (for biodiversity).

Cumulative effects

16.1.21. The search area for the identification of 'other development' for inclusion in the assessment of cumulative effects reflects a two kilometre ZOI around the

boundary of the proposed Scheme, for both construction and operation. This two kilometre ZOI is large enough to cover the proposed developments likely to contribute to cumulative effects, whilst being proportionate to the scope and scale of the proposed Scheme. The study area for assessment of cumulative effects should be defined on a case-by-case basis reflecting the Scheme in question and the area over which significant effects can be reasonably considered to have the potential to occur from both the proposed Scheme and in combination with other developments. Therefore, a two kilometre search area is considered appropriate for this Scheme.

16.1.22. The study area used to identify the ZOI for environmental receptors included within the cumulative assessment, during both construction and operation, will reflect the individual ZOIs of the environmental topic chapters, outlined in Table 16.3.

Table 16.3: Environmental Topic Zones of Influence

DMRB Topic	Zone of Influence (ZOI)
Air Quality	• Construction and operation: A 200 metre ZOI covers human health receptors and ecologically designated sites that are expected to be affected by the Scheme. • See Chapter 6 air quality for further information.
Cultural heritage	• Construction and operation: A one kilometre ZOI would be used which is the maximum ZOI extent used within the cultural heritage assessment. This study area allows a full understanding of the context and setting of the heritage assets. • See Chapter 7 cultural heritage for further information.
Landscape and visual effect	• Construction and operation: one kilometre ZOI for landscape and visual would include potential far reaching receptors. • See Chapter 8 landscape and visual effects for further information.
Geology and soils	• Construction and operation: The ZOI is defined by the areas that are anticipated to be directly disturbed by the proposed physical works and ground disturbances. A 500 metre buffer is also considered to be reasonable to capture significant environmental impacts outside the Scheme. • See Chapter 9 geology and soils for further information.
Biodiversity	• Construction and operation: A two kilometre ZOI from the Scheme is considered to be appropriate for the assessment of ecological receptors with the potential to be affected by the Scheme. • See Chapter 10 biodiversity for further information.
Materials assets and waste	• Construction and operation: The ZOI is defined by the influence of the Scheme rather than through a set geographical location. The influence of the Scheme involves two study areas. The first study area is based on the quantity of construction materials to be consumed and the second study area identifies suitable waste infrastructure, therefore focuses on the county of Gloucestershire within which the Scheme is located. • See Chapter 11 material assets and waste for further information.
Noise and vibration	• Construction and operation: The ZOI for both construction and operation is 1km. • See Chapter 12 noise and vibration for further information.
Population and human health	• Construction and operation: A 250 metre ZOI for land use, amenity, severance, and driver stress. • See Chapter 13 population and human health for further information.

DMRB Topic	Zone of Influence (ZOI)
Road drainage and the water environment	• Construction and operation: The ZOI encompasses groundwater and surface water features that could potentially be affected by the Scheme. Additionally, for groundwater the potential zone of impact during both construction and operation will be assessed on the underlying Water Framework Directive (WFD) groundwater bodies. • See Chapter 14 road drainage and the water environment for further information.
Climate	• Construction and operation: The ZOI for climate includes the Affected Road Network (ARN) for road user carbon (vehicle emissions) and the carbon used for the maintenance and refurbishment of the Scheme assets, which comprises embodied carbon of materials, emissions from maintenance activities and associated transport. • See Chapter 15 climate for further information.

16.2. Assessment of combined effects

16.2.1. During construction, there is the potential for combined effects to receptors including geology and soils, landscape / townscape, cultural features, communities, vehicle travellers, ecology, and material resources, as a result of the Scheme due to the potential effects reported within the preceding chapters (Chapters 6 to 15). However, during construction temporary effects would be temporary in nature and best practice mitigation measures included in the Construction Environmental Management Plan (CEMP) would ensure that combined effects are reduced as far as possible.

16.2.2. During operation, there is potential for combined effects to receptors including geology and soils, landscape / townscape, cultural features, communities, vehicle travellers, ecology, and material resources, as a result of the Scheme due to the potential effects reported within the preceding chapters (Chapters 6 to 15).

16.3. Assessment of cumulative Effects

16.3.1. The list of proposed developments will be agreed with Cotswold District Council, Gloucester County Council and Tewkesbury Borough Council during the assessment in the Environmental Statement to be produced at the Preliminary Design Stage

16.3.2. During construction, there would be the potential for cumulative effects on all receptors, as a result of both the Scheme with any of the other developments within the vicinity of the Scheme, for which the construction stages overlap.

16.3.3. Once operational there would be the potential for cumulative effects on receptors, including (but not limited to) habitats, protected species, agricultural land, noise and air quality.

16.3.4. The likely residual effects and proposed mitigation for each of the other developments would be identified and incorporated into the cumulative effects

assessment of the Environmental Statement to be produced at the Preliminary Design Stage.

17. Summary

17.1.1. Table 17.1 below summarises the topics scoped in and out of the assessment which will be in the Environmental Statement. For more details please see the individual topic chapters.

Table 17.1: Summary of Scoped in and Scoped out topics

Topic	Stage	Scoped In	Scoped Out
Air Quality	Construction	Human health and wellbeing – In accordance with DMRB. Ecological effects – In accordance with DMRB.	N/A
	Operation	Human health and wellbeing – DMRB Detailed Level. Ecological effects – DMRB Detailed Level.	N/A
Cultural Heritage	Construction	Below ground archaeological remains – to DMRB Detailed Level. Designated and non-designated heritage assets – to DMRB Detailed Level.	N/A
	Operation	Designated and non-designated heritage assets – to DMRB Detailed Level	Below ground archaeological deposits (see Chapter 7, Section 7.6.).
Landscape	Construction	Landscape Character – DMRB Detailed level. Visual Effects – DMRB Detailed level.	N/A
	Operation	Landscape Character – DMRB Detailed level. Visual Effects – DMRB Detailed level.	N/A
Geology and Soils	Construction	Potential effects on all geology and soils receptors – DMRB Detailed Level.	N/A
	Operation	N/A	Potential effects on all geology and soils receptors (see Chapter 9, Section 9.6.3).
Biodiversity	Construction	Protected species, designated sites and sensitive habitats – DMRB Detailed level.	N/A
	Operation	Protected species, designated sites and sensitive habitats – DMRB Detailed level.	N/A
	Construction	Generation and management of waste – DMRB Detailed Level.	Use of material resources (see Chapter 11, Section 11.6.2).

Topic	Stage	Scoped In	Scoped Out
Material Assets and Waste	Operation	N/A	Use of material resources and generation and management of waste (see Chapter 11, Section 11.6.2).
Noise and Vibration	Construction	Construction noise – DMRB Detailed Level. Construction vibration – DMRB Detailed Level.	N/A
	Operation	Operational noise – DMRB Detailed Level. Operational airborne vibration – DMRB Detailed Level.	Operational ground-borne vibration (see Chapter 12 Section 12.6.1 – 12.6.4).
Population and Human Health	Construction	Land use, severance, amenity, view from the road, driver stress – to a DMRB Detailed level. Human health, local economy – qualitative assessments.	N/A
	Operation	Severance, amenity, view from the road, driver stress – to a DMRB Detailed level. Human health, local economy – qualitative assessments.	Land use (see Chapter 13 Section 13.6.10).
Road Drainage and the water environment	Construction	The following ground water and surface water receptors – to a DMRB Detailed level: • Horsbere Bk – source to conf R Severn • River Frome - Source to Ebley Mill • Churn - source to Perrots Brook • Norman's BK – source to conf Hatherley Bk • Watercourses and catchments within vicinity of works or hydraulically connected • Increased flood risk caused by construction activities • All outfalls	N/A
	Operation	The following ground water and surface water receptors – to a DMRB Detailed level: • Horsbere Bk – source to conf R Severn • River Frome - Source to Ebley Mill • Churn - source to Perrots Brook • Norman's BK – source to conf Hatherley Bk	N/A

Topic	Stage	Scoped In	Scoped Out
		• Watercourses and catchments within vicinity of works or hydraulically connected • Increased flood risk caused by construction activities • All outfalls	
Climate	Construction	Effects on climate	Vulnerability of the Scheme to climate (see Chapter 15, Section 15.6.3).
	Operation	Effects on climate and vulnerability of the Scheme to climate.	N/A
Cumulative effects	Construction	Combined Effects and Cumulative Effects – using PINS Advice Note Seventeen.	N/A
	Operation	Combined Effects and Cumulative Effects – using PINS Advice Note Seventeen.	N/A

18. Glossary

Table 18.1 below provides the description of key words used throughout this Environmental Assessment Report.

Table 18.1 Glossary of Terms

Glossary Term	Description
Affected Road Network (ARN)	The extended area of the roads that will be affected by the Scheme with particular reference to air quality effects.
Agricultural Land Classification (ALC)	Agricultural Land Classification provides a means of assessing the quality of farmland. Its assessment is based on physical limitations of the land, such as climate, site characteristics (e.g. gradient) and soil. The assessment gives an indication of the versatility and expected yield of the land. The system classifies agricultural land in five grades. The best and most versatile land is classified as 1, 2 and 3a. The Agricultural Land Classification was developed by the former Ministry of Agriculture, Fisheries and Food (MAFF) in 1988 and revised in 1996.
Air Quality Management Area (AQMA)	Any parts of a Local Authority's area where the air quality objectives are not being achieved, or are not likely to be achieved within the relevant period must be identified and declared an AQMA.
Air Quality Strategy (AQS)	Establishes the UK framework for air quality improvements. The Environment Agency is required to have regard to the Strategy in exercising its pollution control functions. Local authorities are also required to work towards the Strategy's objectives prescribed in regulations for that purpose.
Air quality objectives	Objectives are policy targets often expressed as a maximum ambient concentration not to be exceeded, either without exception or with a permitted number of exceedances, within a specified timescale.
Ambient Noise	Ambient noise is the total sound in a given situation at a given time usually composed of sound from many sources, near and far.
Area of Outstanding Natural Beauty (AONB)	A protected area recognised and classified by the International Union for the Conservation of Nature (IUCN). AONBs in England and Wales fall into Category V – Protected Landscapes and are protected by the Countryside and Rights of Way Act (2000) (CROW Act). AONBs are designated in recognition of their national importance and to ensure that their character and qualities are protected for all to enjoy. Under the CROW Act, Natural England can make orders to designate AONBs or vary the boundaries of existing ones.

Glossary Term	Description
Baseline conditions	The environment as it appears (or would appear) immediately prior to the implementation of the project together with any known or foreseeable future changes that will take place before completion of the project.
Birds Directive	EC Directive on the Conservation of Wild Birds (Birds Directive 1979) as amended (79/409/EEC).
Biodiversity	The biological diversity of the earth's living resources. The total range of variability among systems and organisms at the following levels of organisation: bioregional, landscape, ecosystem, habitat, communities, species, populations, individuals, genes and the structural and functional relationships within and between these different levels.
Biodiversity Action Plan (BAP)	It describes the biological resources of the UK and provides detail plans for conservation of these resources.
British Geological Survey	The British Geological Survey is a government organisation which aims to advance geoscientific knowledge of the United Kingdom landmass and its continental shell by means of systematic surveying, monitoring and research.
Congestion	Traffic experiences periods of excessive breaking and acceleration and is associated with higher vehicle emissions. On motorways this occurs at speeds less than 50mph and / or near complex junctions.
Contaminated Land Exposure Assessment (CLEA)	A CLEA provides methods of assessment that can be used to estimate exposure and assess risks to human health from contaminants in soil. The CLEA model estimates how much of a contaminant people are potentially exposed to if they live, work or play on contaminated sites over long periods.
Contamination Land Risk Assessment (CLRA)	It covers the main hazards that might happen during the construction project and the risk management that is required.
Conservation Area	An area designated by the Local Planning Authority under the Town and Country Planning (Listed Buildings and Conservation Areas) Act 1990 as possessing special architectural or historical interest. The Local Planning Authority will seek to preserve and enhance the character and appearance of these areas.
Conservation Management Plan	A conservation management plan is document that sets out the significance of a heritage asset, and how the significance will be retained in any future use, management, alteration, or repair.
Construction Environmental Management Plan (CEMP)	A CEMP includes the specific measures that will be taken to control and manage the environmental impacts whilst the project is under construction that may otherwise occur for each of the environmental topics, such as noise, air quality, water resources and ecology. In addition, a description of the planned works and

Glossary Term	Description
	the general site arrangements should be included in the CEMP. The Principal Contractor will be responsible for ensuring the measures specified within the CEMP are implemented.
Cotswolds Conservation Board (CCB)	The Cotswolds Conservation Board, established by Parliamentary Order in 2004, is an independent statutory body that works to conserve and enhance the natural beauty of the Cotswolds AONB, to increase understanding and enjoyment of its special qualities, and to foster the social and economic well-being of local communities.
Cultural heritage landscape	The combination of nature and humankind, they express long relationship between people and their natural environment. Certain sites reflect techniques of land use that guarantee and sustain biological diversity.
Cumulative Assessment	An assessment on how the effects of the proposed Scheme would combine and interact with the effects of other developments. It considers the accumulation of, and interrelationship between effects which might affect the environment, economy or community as a whole, even though they may be acceptable when considered on an individual basis with mitigation measures in place.
Decibel (dB)	The **decibel** is a logarithmic unit that expresses the ratio of two values of a physical quantity, often power or intensity. One of these quantities is often a reference value and in this case the **decibel** expresses the absolute level of the physical quantity.
Design Manual for Roads and Bridges (DMRB)	Design Manual for Roads and Bridges is a set of documents published by the Highways Agency. The document provides a comprehensive manual system which accommodates all current standards, advice notes and other published documents relating to the design, assessment and operation of trunk roads (including motorways).
Design Year	15 years after the opening year.
Development Consent Order (DCO)	Development Consent Order is a combination of grant planning permission with range of other separate consents such as Listed Buildings. It can also include rights to compulsorily purchase land
Do minimum network Scheme	The ‘do minimum’ forecast scenario in the opening / design Year is the base road and traffic network against which alternative improvements can be assessed. In many cases, the definition of the ‘do minimum’ is straightforward; it is simply the ‘do nothing’ scenario. However, one or more of the following four cases may arise, in which the ‘do minimum’ differs from the ‘do nothing’:

Glossary Term	Description
	a) The case where works will be carried out regardless of whether or not the 'do something' Scheme is built. b) The case where the existing network may be improved to form a 'do minimum' Scheme which can be tested as an alternative to carrying out major 'do something' improvements. c) The case where traffic conditions can be improved without significant capital expenditure. d) The case where the area covered by the modelled network includes road proposals other than the one under immediate consideration.
Driver Stress	The adverse mental and physiological effects experienced by a driver traversing a road network
Effect	Term used to express the consequence of an impact (expressed as the 'significance of effect'), which is determined by correlating the magnitude of the impact to the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria. For example, land clearing during construction results in habitat loss (impact), the effect of which is the significance of the habitat loss on the ecological resource.
Emissions	Mass of a pollutant per time per vehicle at the point of exhaust and are used as inputs into an air quality model.
Enhancement	A measure that is over and above what is required to mitigate the adverse effects of a project.
Environment Agency	The Environment Agency is responsible for environmental protection and regulation in England and plays a central role in implementing the government's environmental strategy. The Environment Agency is the main body responsible for managing the regulation of major industry and waste, treatment of contaminated land, water quality and resources, fisheries, inland river, estuary and harbour navigations, and conservation and ecology. They are also responsible for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea.
Environmental Designated Funds (EDF)	Funds allocated by the Department for Transport for actions beyond business as usual to help Highways England to invest in retrofitting measures to improve the existing road network and to maximise opportunities to deliver additional improvements as part of new road Schemes. The environment is one of five designated funds.
Infrastructure Planning (Environmental Impact Assessment) (EIA)	The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 revoke and replace the infrastructure Planning (Environmental Impact Assessment) Regulations 2009, and its amendments.

Glossary Term	Description
Regulations 2017 (the 'EIA Regulations')	The regulations transpose the amendments made to the Environmental Impact Assessment (EIA) Directive 2011/92/EU by Directive 2014/52/EU.
European Landscape Convention (ELC)	An international treaty dedicated to the protection, management and planning of all landscapes in Europe. While not an EU directive, the UK government became a signatory to the ELC in 2006, introducing it in March 2007
Farm / Individual farm holdings / Farm business	An area of land that consists of one or more land parcels or group of fields that are managed by a named person or named business entity as an owner, tenant or in any other commercial agricultural capacity, for the production of food, forage or fibre.
Flood Risk Assessment	An assessment of the likelihood of flooding in a particular area so that development needs and mitigation measures can be carefully considered.
Forecast (Traffic)	A model describing a future set of traffic conditions e.g. do minimum, do something, etc.
Habitat	A place where an organism lives; a type of environment inhabited by a particular species and/or community; often characterised by dominant plant forms, physical characters, or a combination of these.
Greenhouse Gas (GHG)	Gasses that once emitted into the atmosphere contribute to the 'greenhouse effect' of warming the planet.
Gloucestershire Local Nature Partnership (GLNP)	The GLNP's Mission Statement is "*To improve the prospects for Gloucestershire's natural environment while demonstrating its vital role in our health & well-being, its significant contribution to a thriving economy and to a better quality of life for all*". The GLNP has a strategic Board consisting of partners covering various sectors and concerns with an interest or influence focused on the natural environment at a county level.
Habitat Directive	EC Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (Habitats Directive 1982) as amended (92/43/EEC).
Habitat Suitability Index (HSI)	A numerical index where a score of 0 and 1.0 are recorded for each habitat value which can include: geographic location, water quality and permanence.
Handover Environmental Management Plan (HEMP)	This is the main vehicle for passing essential environmental information to the client and responsible for future maintenance and operation of the asset.
Heavy Goods Vehicle (HGV)	HGVs are vehicles over 3.5 tonnes and includes rigid and articulate lorries.

Glossary Term	Description
Historic England	The public body that looks after England's historic environment. Championing historic places and helping people understand their value and care for them.
Historic Environment	All aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible, buried or submerged, and landscaped and planted or managed flora.
Impact	Change that is caused by an action; for example, land clearing (action) during construction which results in habitat loss (impact).
Interim Advice Note (IAN)	Interim Advice Notes (IANs) issued by Highways England contain specific guidance in connection with works on motorways and trunk roads in England. IANs should be read in conjunction with the DMRB and the MCHW and may incorporate amendments or additions to documents in these manuals.
Landscape and Ecological Environmental Management Plan (LEMP)	This identifies the landscape and ecological mitigation measures set out in the Environmental Statement for the Scheme and provides information on how the measures will be delivered through landscape works and management in the future.
Landscape Character Area (LCA)	Geographically unique areas where a combination of factors such as topography, vegetation pattern, land use and cultural associations combine to create an area with a distinct, recognisable character.
Landscape Character Type (LCT)	Generic classifications of landscape which share broadly similar combinations of physical and cultural landscape attributes.
Listed Buildings	A building which is considered by the Secretary of State (for Culture, Media and Sport) to be of special architectural or historic interest in accordance with the regime set out in the Town and Country Planning (Listed Buildings and Conservation Areas) Act 1990.
Local Enterprise Partnership (LEP)	The LEP is a partnership between private sector, local authorities, universities and colleges.
Materials Management Plan (MMP)	An MMP manages the recovery of material from the waste stream as opposed to producing new materials/ it also reduces the amount of waste and recyclables delivered to disposal or resource recovery facilities.
Minerals Local Plan	The purpose of a Minerals Local Plan is to provide a policy framework to guide decisions on planning applications for minerals development.
Mitigation	These measures intended to avoid, reduce and, where possible, remedy significant adverse environmental effects.

Glossary Term	Description
National Character Areas (NCAs)	A natural subdivision of England based on a combination of landscape, biodiversity, geodiversity and economic activity. The NCAs are defined by Natural England, the UK government's advisors on the natural environment.
National Planning Policy Framework (NPPF)	The NPPF sets out the Government's planning policies for England.
National Policy Statements	National policy statements are instruments issued under section 52(2) of the Resource Management Act 1991 and state objectives and policies for matters of national significance.
National vegetation classification (NVC)	The NVC assesses the full suite of vascular plant, bryophyte and macro-lichen species with a certain vegetation type.
National Trust	A UK conservation charity founded in 1895, with governance arrangements underpinned by the Charities (National Trust) Order 2005. The charity protects and manages historic places and green spaces, and allows public access to these.
Natural England	Natural England are responsible for: • Helping land managers and farmers protect wildlife and landscapes; • Advising on the protection of the marine environment in inshore waters (0 to 12 nautical miles); • Improving public access to the coastline; • Managing 140 National Nature Reserves and supporting National Trails; • Providing planning advice and wildlife licences through the planning system; • Managing programmes that help restore or recreate wildlife habitats; • Conserving and enhancing the landscape; and, • Providing evidence to help make decisions affecting the natural environment.
Non-Motorised User (NMU)	Someone walking, cycling or a horse rider, or using an electric-powered mobility vehicle.
Lowest Observed Adverse Effect Level (LOAEL)	This the level of noise above which adverse effects on health and quality of life can be detected.
NO_x	Oxides of Nitrogen – which encompasses all nitrogen species although mainly NO and NO_2.
NO_2	Nitrogen Dioxide.
Opening Year	The estimated year that the Scheme would become operational.

Glossary Term	Description
Operation	The functioning of a project on completion of construction.
Outline Environmental Management Plan (EMP)	The Outline EMP provides an over-arching framework for environmental management during design, construction and operation and identifies the environmental risks associated with the implementation of the Scheme. All site work and maintenance must be undertaken in accordance with the EMP.
Publicly Available Specification (PAS)	PAS are streamlined standards, specifications and codes of practice or guidelines developed by sponsoring organisations to meet an immediate market need, produced by The British Standards Institute (BSI).
PAS2080	Publicly Available Specification (PAS) 2080 is a standard for managing infrastructure carbon which provides guidance on how to reduce carbon emission, improve efficiency and decrease the rate of climate change.
Peak Particle Velocity (PPV)	Peak particle velocity refers to the maximum speed of a particular particle as it oscillates about a point of equilibrium that is moved by a passing wave. It is a term used to describe vibration, or elastic movement, resulting from excitation by seismic energy as it passes a particular point.
Planning Inspectorate (PINS)	The Planning Inspectorate deals with planning appeals, national infrastructure planning applications, examinations of local plans and other planning-related and specialist casework in England and Wales.
PM10	Particulate matter with a diameter of 10 microns or less.
Project Control Framework	Project Control Framework supports the implementation of project management within an organisation because: 1. It supports the development and replication of accepted practice; 2. Helps communication within the team because of a common language; 3. Streamlines the use of tools and techniques for key project management processes; 4. Establishes a consistent approach which aid customers understand the project management processes; and, 5. Ensure that focus is maintained on the early stage of the project lifecycle.
Preliminary Sources Study Report (PSSR)	PSSR relates to the preliminary stages of data collection. It can include a detailed summary of factual information included within various reports pertaining to historic data sources.

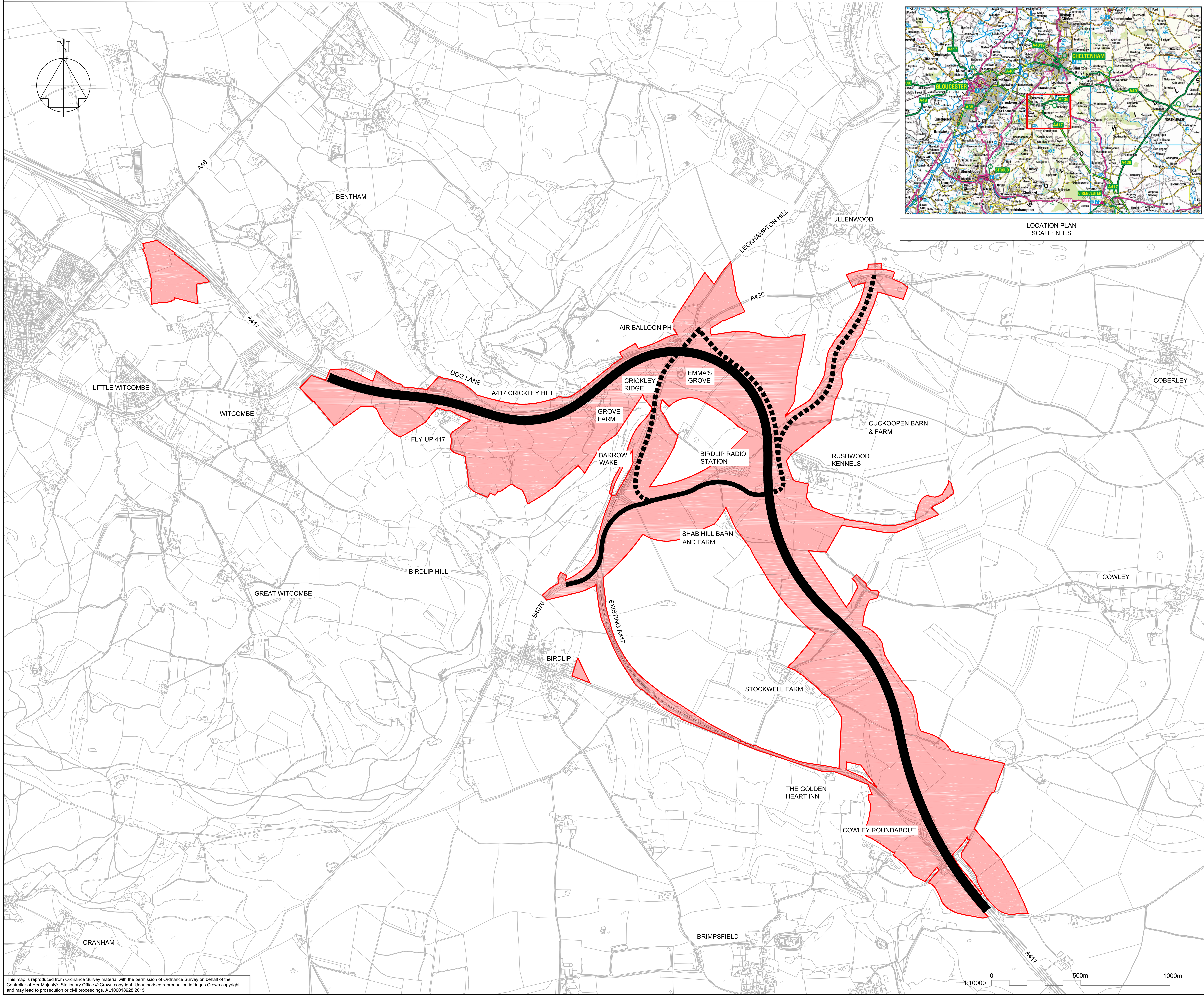
Glossary Term	Description
Public Rights of Way (PRoW)	A right to access land for walking or certain other leisure activities such as cycling, horse riding or for the use of powered wheelchairs. Definitive maps make a legal record of public rights of way in 4 categories: footpaths, bridleways, restricted byways and byways open to all traffic.
Receptor	A defined individual environmental feature that has the potential to be affected by a project.
Registered Park and Garden	A park or garden that has been registered under Historic England's 'Register of Historic Parks and Gardens of special historic interest in England' due to its high level of historic interest.
Scheme	The "Scheme" refers to the "A417 Missing Link scheme to improve the connection between two dual carriageway sections of the A417 at Brockworth and Cowley, please see here for more information: https://highwaysengland.co.uk/projects/a417-missing-link/
Scheduled Monument	A historic building or site that is included in the schedule of monuments kept by the secretary of state for culture, media, and sport. The National Planning Policy Framework sets out the Government's planning policies for England.
Significant Observed Adverse Effect Level (SOAEL)	This is the level of noise above which significant adverse effects on health and quality of life occur.
Site of Special Scientific Interest (SSSI)	A SSSI is a conservation designation denoting a protected area in the United Kingdom, designated due to special interest in its flora, fauna, geological or physiographical features. They are protected by law to conserve their wildlife or geology.
Soils Management Plan	A Soil Management Plan ensures soil sustainability during the construction phase of the development process. The plan can contain information on topsoil and subsoil types, methods for stripping, stockpiling and improving soils, location and content of each soil stockpile, who is responsible for supervising soil management.
Source Protection Zone (SPZs) (Groundwater)	The Environment Agency has designated SPZs for groundwater sources and include wells, boreholes and springs used for public drinking water supply. Zones are set up as pollution prevention measures in areas which are at a high risk, and to monitor the activities of potential polluters nearby.
Special Areas of Conservation (SAC)	Special Areas of Conservation (SACs) are strictly protected sites designated under the EC Habitats Directive. Article 3 of the Habitats Directive requires the establishment of a European network of important high-quality conservation sites that will

Glossary Term	Description
	make a significant contribution to conserving the 189 habitat types and 788 species identified in Annexes I and II of the Directive (as amended). The listed habitat types and species are those considered to be most in need of conservation at a European level.
Statement of Community Consultation (SoCC)	The Statement of Community Consultation (SoCC) is a report prepared to set out how we propose to consult people living in the vicinity of the Scheme about the new proposals.
Strategic Road Networks (SRN)	A strategic road network is made up of motorways and major trunk roads in England and that are managed by Highways England
Site Waste Management Plan (SWMP)	SWMPs encourage the effective management of materials and ensure waste is considered at all stages of a project - from design through to completion. Although no longer a regulatory requirement in England, SWMPs are still considered to be good practice.
Traffic Management Plan	The Traffic Management Plan describes the type and extent of traffic management layouts and arrangements required for the construction of a scheme whilst providing a safe environment for those travelling through the works, as well as those engaged in the construction of the works. The plan will detail proposed access routes for construction traffic and site compound locations.
Transport analysis guidance	Transport analysis guidance is a document produced by the government for projects that require government approval. It provides guidance on a range of topics which include: creating a transport model for the appraisal of the alternative solutions.
Transport appraisal process/ WebTAG	WebTAG involves three stage process: Stage one – option development, identifying the need for intervention and developing options; Stage two – further appraisal – the focus of the analysis is on estimating the likely performance and impact of intervention(s) in detail; and, Stage three – implementation, monitoring and evaluation.
UKCP09	United Kingdom Climate Projections (UKCP) 2009 provides details on observed climate data and a number of different projected climate change scenarios.
World Heritage Site (WHS)	Cultural or natural heritage site of outstanding universal value and of importance to all humanity. World Heritage Sites are designated under the terms of the UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage (1972). In the UK, the Department for Culture, Media and Sport is responsible for the implementation of the World

Glossary Term	Description
	Heritage Convention and to support the achievement of UNESCO's goals and aspirations.
Zone of Theoretical Visibility (ZTV)	In the context of landscaping and investigating the visibility of the Scheme, a study area should extend to all areas in which visual impacts have the potential to occur based on topographical indications only.

Appendix A – Provisional Red Line Boundary

This drawing should not be relied on or used in circumstances other than those for which it was originally prepared and for which Mott Macdonald Sweco JV was commissioned. Mott Macdonald Sweco JV accepts no responsibility for this drawing to any party other than the person by whom it was commissioned. This drawing has been prepared for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Mott Macdonald Sweco JV being obtained. Mott Macdonald Sweco JV accepts no responsibility or liability for the consequences of this drawing being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on this drawing for such other purpose agrees, and will by such use or reliance be taken to confirm his agreement, to indemnify Mott Macdonald Sweco JV for all loss or damage resulting therefrom.



This map is reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationary Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. AL100018928 2015

Notes

THE SCHEME EXTENTS HAS BEEN DEVELOPED WITH THE FOLLOWING ASSUMPTIONS AND EXCLUSIONS:

1. FOOTPRINT IS BASED ON CURRENT CONCEPT DESIGN (INCLUDING ALTERNATIVE ROUTES FOR A436) WHICH IS SUBJECT TO ALTERATIONS. IT INCLUDES LAND REQUIRED EITHER PERMANENTLY OR TEMPORARILY FOR CONSTRUCTION.
2. LAND REQUIRED EITHER PERMANENTLY OR TEMPORARILY FOR ENVIRONMENTAL MITIGATION FEATURES AND NON-MOTORISED USERS IS BEING DETERMINED AND MAY EXTEND OUTSIDE THE SCHEME EXTENTS.
3. A GEOTECHNICAL SITE INVESTIGATION HAS NOT BEEN CARRIED OUT. IT IS ASSUMED ALL EARTHWORKS CAN BE ACCOMMODATED WITHIN THE PROPOSED SCHEME EXTENTS.
4. THE DESIGN OF HIGHWAY ANCILLARIES, STATUTORY UNDERTAKERS EQUIPMENT, DRAINAGE ATTENUATION AND ACCOMMODATION WORKS HAS NOT COMMENCED AND MAY EXTEND OUTSIDE THE SCHEME EXTENTS.

Key to symbols

- Provisional Red Line Boundary
- Indicative Scheme alignment for the Purpose of EIA Scoping
- Indicative alternative alignment for the Purpose of EIA Scoping

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	08/03/19	FIRST ISSUE	KH	LJ	MC
P02	27/03/19	VARIOUS AMENDMENTS	AW	SC	LJ
P03	08/05/19	VARIOUS AMENDMENTS	SM	KJ	LJ

Mott MacDonald Sweco

Client: highways england

Drawing Status: FOR INFORMATION
Suitability: S2

Project Title: A417 MISSING LINK
PCF STAGE 2

Drawing Title: PROVISIONAL RED LINE BOUNDARY

Scale	Designed	Drawn	Checked	Approved
1:10000	Holm, Kristo	Holm, Kristo	Jorgensen, Lars	Casey, Mark
Original Size	Date	Date	Date	Date
A1	08/03/19	08/03/19	08/03/19	08/03/19

Drawing Number: HE PIN | Originator | Volume
HE551505 - MMSJV - LSI -
000 - DR - CH - 00005
Location | Type | Role | Number

Project Ref. No.: HE551505
Revision: P03

pw:\\CSPWInt.grontmij.net:PW UK Production\Documents\Projects\Transportation\HE551505 - A417 MISSING LINK - PCF STAGE 2\Legal\Statutory Instruments\Drgs & Models - 2D drawing\HE551505-MMSJV-LSI-000-DR-CH-00005

Appendix B – Environmental Constraints Plan

N

Shurdington Road Junction (A417/A46)

Witcombe

Birdlip

Ullenwood

Stockwell

Cowley Rbt.

SHEET 2 OF 3

Contains OS data © Crown Copyright and database right 2018

0 0.5 1 Kilometres

Designations

Key to Symbols

- Provisional Red Line Boundary
- Footpath
- Cycle Path
- Restricted Byway
- Bridleway
- Unregistered Road (contiguous with Other Routes With Public Access)
- National Trail - Cotswold Way
- Cotswold Round Long Distance Path
- Gloucestershire Way Long Distance Path
- Gustav Holst Way Long Distance Path
- Other Routes With Public Access
- Waterbodies
- Listed Building
- Buried Archaeology
- Veteran Trees
- Tree Preservation Orders
- Noise Important Area
- Site of Special Scientific Interest (mixed)
- National Nature Reserve
- Gloucestershire Wildlife Trust Reserve
- Woodland Trust Tree Boundaries
- National Trust Land Ownership
- Country Park
- Conservation Area
- Special Area of Conservation
- Registered Common Land
- Ancient Woodland
- Potential Ancient Woodland
- Scheduled Monument
- Historic Landfill
- Open Access Land
- Strategic Nature Area
- Environmentally Sensitive Area
- Air Quality Management Area
- Area of Outstanding Natural Beauty
- Flood Zone 2
- Flood Zone 3

Notes

The environmental constraints datasets were downloaded January 2017. Updates to these datasets may be available and at an appropriate stage the constraints map will be amended.

Rev	Date	Amendment Details	Drw'n	Chk'd	App'd
P04	APRIL 2019	FOURTH REVISION	WG	AM	BM
P03	MARCH 2019	THIRD REVISION	WG	AM	BM
P02	NOVEMBER 2018	SECOND REVISION	SB	AM	BM
P01	JUNE 2018	DRAWING PRODUCED	ER	AM	BM

Mott MacDonald Sweco

Client: highways england

Drawing Status: FIT FOR INFORMATION

Suitability: S2

Project Title: A417 MISSING LINK

Drawing Title: ENVIRONMENTAL CONSTRAINTS PLAN SHEET 1 OF 3

1:8,000	Designed	Drawn	Checked	Approved
	E.RYDER	E.RYDER	A.MASON	B.MULLEY
A1	Date SEPTEMBER 2018	Date SEPTEMBER 2018	Date SEPTEMBER 2018	Date SEPTEMBER 2018

HE PIN: 551505 - MMSJV - EGN - 000 - DR - LX - 00020

Project Ref. No.: 551505

Revision: P04

Document Path: C:\Users\GAR87215\Mott MacDonald\Environmental Planning - Highways - Documents\HES - GIS folder\Projects\A417 Missing Link\03 Map Composition\01 EGN - General\551505-MMSJV-EGN-000-M2-LE-00001-Env Constraints Plan-Sheet 1.mxd

N

Ullenwood

Designations

Key to Symbols

- Provisional Red Line Boundary
- Footpath
- Cycle Path
- Restricted Byway
- Bridleway
- Unregistered Road (contiguous with Other Routes With Public Access)
- National Trail - Cotswold Way
- Cotswold Round Long Distance Path
- Gloucestershire Way Long Distance Path
- Gustav Holst Way Long Distance Path
- Other Routes With Public Access
- Waterbodies
- Listed Building
- Buried Archaeology
- Veteran Trees
- Tree Preservation Orders
- Noise Important Area
- Site of Special Scientific Interest (mixed)
- Gloucestershire Wildlife Trust Reserve
- Woodland Trust Tree Boundaries
- National Trust Land Ownership
- Country Park
- Registered Common Land
- Ancient Woodland
- Potential Ancient Woodland
- Scheduled Monument
- Historic Landfill
- Open Access Land
- Strategic Nature Area
- Environmentally Sensitive Area
- Air Quality Management Area
- Area of Outstanding Natural Beauty

Notes

The environmental constraints datasets were downloaded January 2017. Updates to these datasets may be available and at an appropriate stage the constraints map will be amended.

Rev	Date	Amendment Details	Drw'n	Chk'd	App'd
P01	MAY 2019	DRAWING PRODUCED	WG	RB	BM

Contains OS data © Crown Copyright and database right 2018

0 0.5 1 Kilometres

Mott MacDonald Sweco

Client: highways england

Drawing Status: FIT FOR INFORMATION

Suitability: S2

Project Title: A417 MISSING LINK

Drawing Title: ENVIRONMENTAL CONSTRAINTS PLAN SHEET 2 OF 3

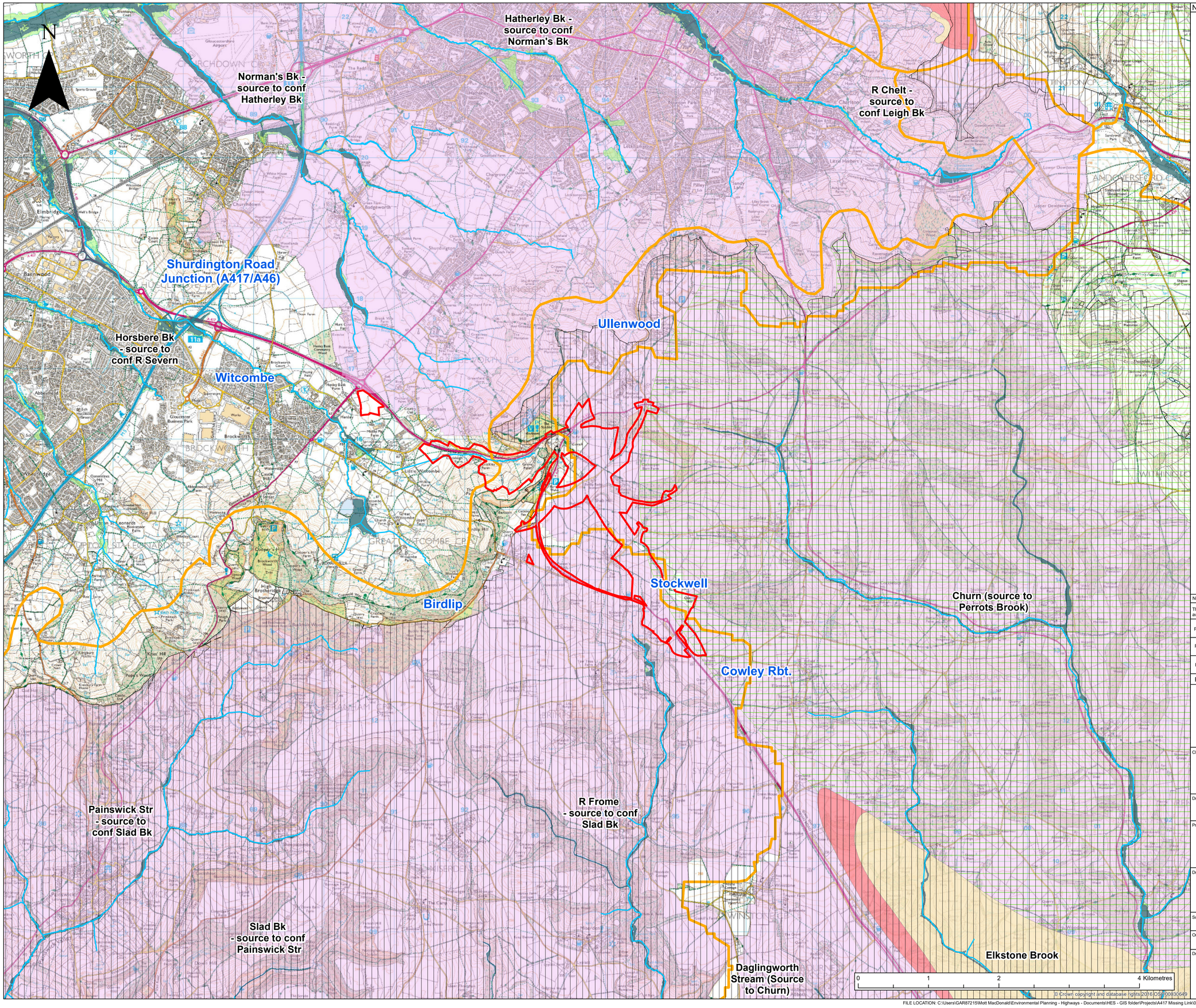
1:4,000	Designed	Drawn	Checked	Approved
	W.GARRETT	W.GARRETT	R.BACK	B.MULLEY
A1	Date MAY 2019	Date MAY 2019	Date MAY 2019	Date MAY 2019

HE PIN: 551505 - | Originator: MMSJV - | Volume: EGN - 000 - DR - LX - 00030

Project Ref. No.: 551505

Revision: P01

Document Path: C:\Users\GAR87215\Mott MacDonald\Environmental Planning - Highways - Documents\HES - GIS folder\Projects\A417 Missing Link\03 Map Composition\01 EGN - General\551505-MMSJV-EGN-000-M2-LE-00003-Env Constraints Plan-Sheet 2.mxd



Notes

Key to symbols:

- Provisional Red Line Boundary
- Waterbodies
- WFD Ground Waterbodies
- Flood Zone 2
- Flood Zone 3
- Nitrate Vulnerable zone - Surface water
- Nitrate Vulnerable zone - Ground water

Source Protection zones

- 1
- 2
- 3

NOTES

The environmental constraints were downloaded January 2017. Updates to these datasets may be available and at an appropriate stage the constraints map will be amended.

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P03	APRIL 2019	UPDATED PROVISIONAL RED LINE BOUNDARY	WG	AM	BM
P02	MARCH 2019	UPDATED PROVISIONAL RED LINE BOUNDARY	SB	AM	JB
P01	JUNE 2018	DRAWING PRODUCED	ER	AM	JB

Mott MacDonald Sweco

Client: highways england

Drawing Status: FIT FOR INFORMATION

Suitability: S2

Project Title: A417 MISSING LINK

Drawing Title: ENVIRONMENTAL CONSTRAINTS PLAN - SHEET 3 OF 3

Scale	Designed	Drawn	Checked	Approved
1:25,000	E.RYDER	E.RYDER	A.MASON	J.BARRET
Original Size	**Date**	**Date**	**Date**	**Date**
A1	JUNE 2018	JUNE 2018	JUNE 2018	JUNE 2018

Drawing Number: HE PIN 551505 - MMSJV - EGN - 000 - DR - LX - 00019 (Location | Originator | Volume | Type | Role | Number)

Project Ref. No.: 551505

Revision: P03

© Crown copyright and database rights 2016 OS 100030649

FILE LOCATION: C:\Users\GAR87215\Mott MacDonald\Environmental Planning - Highways - Documents\HES - GIS folder\Projects\A417 Missing Link\03 Map Composition\01 EGN - General\551505-MMSJV-EGN-000-M2-LE-00002- Env Constraints Plan Sheet 2 (Water).mxd

If you need help accessing this or any other Highways England information, please call **0300 123 5000** and we will help you.