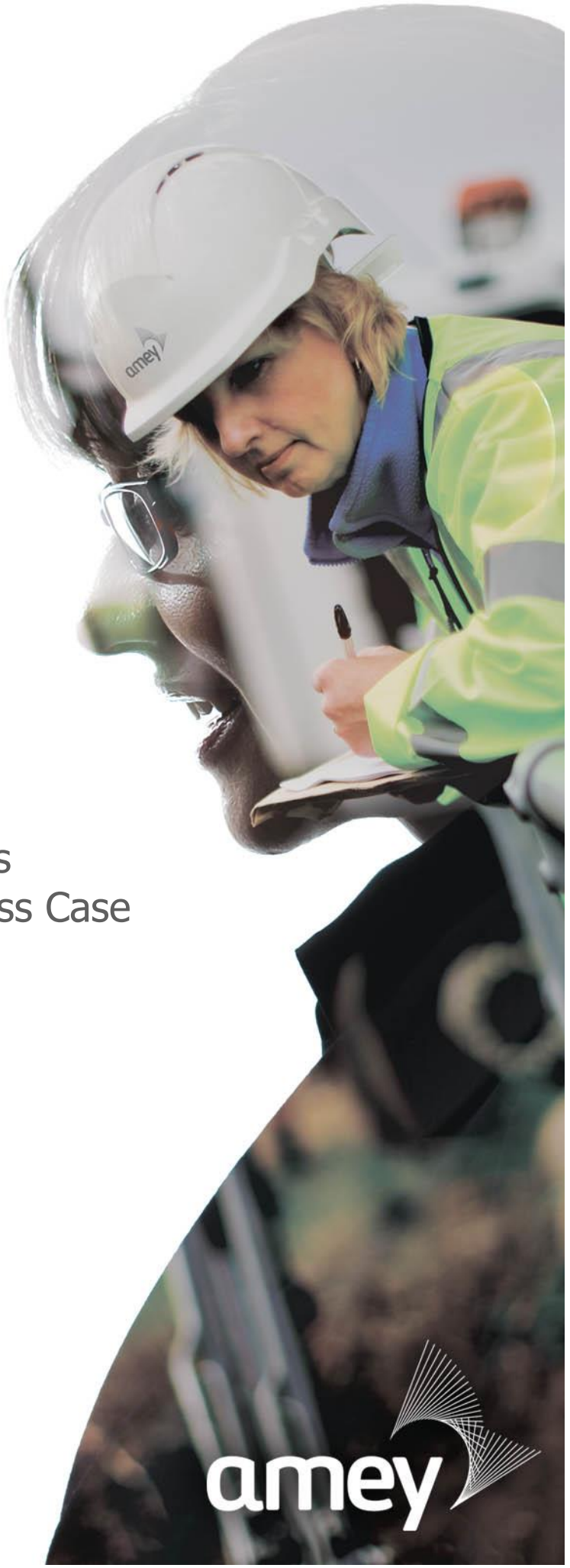
Gloucestershire COUNTY COUNCIL



A419 Stonehouse

Air Quality and Greenhouse Gas Scoping Assessment for Business Case

COGL43048194 /Air Revision 0

April 2017

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Document Control Sheet

Project Name:	A419 Stonehouse
Project Number:	COGL43048194
Report Title:	*Air Quality and Greenhouse Gas Scoping Assessment for Business Case*
Report Number:	*Air Rev 0*

Issue Status/Amendment	Prepared	Reviewed	Approved
Revision 0	Name: Lee Shelton Signature:  Date: 02/05/2017	Name: Stuart Bennett Signature:  Date: 02/05/2017	Name: Matt Winter Signature:  Date: 04/5/2017
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1 Introduction

1.1 Background to the scheme

1.1.1 Amey has been requested by Gloucestershire County Council (GCC) to design improvements to four junctions along the A419 close to Stonehouse with the aim of reducing traffic congestion whilst also providing adequate provision for pedestrians and cyclists. The junctions comprise of the following:

- Chipmans Platt Roundabout
- Oldends Lane Roundabout
- Downton Road Signalised Junction
- Horsetrough Roundabout

1.2 Purpose and scope of report

1.2.1 The purpose of this report is to provide an input into the business case based on permanent air and greenhouse gas effects arising from the proposed scheme. For local air quality, the key requirement of the assessment is to identify the change in pollutant concentrations at receptors in close proximity to the scheme (and if required identify any mitigation measures necessary) and to identify receptors that could potentially qualify under Part 1 and Part 2 of the Land Compensation Act (Ref. 1). For regional air quality and greenhouse gas, the assessment aims to estimate the overall change in emissions to facilitate monetisation.

2 Legislation and Guidelines

2.1 Transport Analysis Guidance

2.1.1 The Department for Transport (DfT) has published guidance entitled 'Transport Analysis Guidance Unit A3 environmental impacts' (Ref. 2) on the appraisal of the environmental impacts of transport schemes. Air quality and greenhouse gas are two of the environmental topics covered and the guidance deals with the impacts on both the built and the natural environment, as well as on people. The guidance discusses the relationship between environmental impact appraisal and environmental impact assessment and the need to tailor the level of appraisal to the stage of development of the proposal.

2.2 Land Compensation Act 1973

2.2.1 Under Part 1 of the Land Compensation Act 1973 compensation can be claimed by people who own and who also occupy property that has depreciated in value (by more than £50) due to physical factors caused by the use of a new or altered road.

2.2.2 The physical factors are: noise, vibration, smell, fumes, smoke, artificial lighting and the discharge on to the property of any solid or liquid substance.

2.2.3 The cause of the physical factors must be due to the use of the new or altered road. For example, if a road is altered, the noise and other adverse effects must arise from the traffic using the altered section of road. Part 1 compensation cannot be claimed for the effects of traffic further down the road where no alteration has taken place.

2.2.4 Under the provisions of the Act, a road is altered only when there is a change to the location, width or level of the carriageway or an additional carriageway is provided beside, above or below an existing one. Part 1 compensation is not payable when the carriageway has simply been resurfaced.

2.2.5 Part 1 compensation is also not payable where part of the affected property has been compulsorily purchased for the construction of the new or altered road. This is because the effect of the use of the road on the value of the rest of the property must be taken into account in calculating the compensation for the part of the property taken.

2.2.6 Loss of view or privacy, personal inconvenience and physical factors arising during the construction of the road are also not included under Part 1 compensation.

2.3 European Union Air Quality

2.3.1 The 2008 ambient air quality directive (Ref. 3) sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health such as particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2). As well as having direct effects, these pollutants can combine in the atmosphere to form ozone, a harmful air pollutant (and potent greenhouse gas) which can be transported great distances by weather systems.

2.3.2 The 2008 directive replaced nearly all the previous EU air quality legislation and was made law in England through the Air Quality Standards Regulations 2010 (Ref. 4).

2.4 National Air Quality Strategy

2.4.1 The UK Government is required under the Environment Act 1995 (Ref. 5) to produce a National Air Quality Strategy (AQS) (Ref. 6). This was last reviewed and published in 2007. The strategy sets out the UK's air quality objectives and recognises that action at national, regional and local level may be needed, depending on the scale and nature of the air quality problem. It prescribes air quality objectives for ten pollutants (benzene, 1,3-butadiene, carbon monoxide, lead, polycyclic aromatic hydrocarbons, nitrogen dioxide, sulphur dioxide, particles – PM_{10} and $PM_{2.5}$ and ozone). It is proposed that a new AQS will be published in 2017.

2.4.2 The AQS includes 'objective values' which the UK Government and devolved administrations expect to be achieved by specific dates, taking into account the costs, benefits, feasibility and practicality of achieving these limits. These values related to this assessment are shown in Table 2:1.

Table 2:1: AQS objectives

Pollutant	Scope	Objective/ Limit Value	Measure as	Date to be achieved by and maintained thereafter		
				AQS	Regs	2008/50 /EC
PM_{10}	Protection of human health	50 µg/m^3 Not to be exceeded more than 35 times a	24-hour mean	31-Dec-04	31-Dec-04	1-Jan-05

		year				
		40 µg/m^3	Annual mean	31-Dec-04	31-Dec-04	1-Jan-05
NO_2	Protection of human health	200 µg/m^3 Not to be exceeded more than 18 times a year	1-hour mean	31-Dec-05	31-Dec-05	1-Jan-10
		40 µg/m^3	Annual mean	31-Dec-05	31-Dec-05	1-Jan-10
NO_x	Protection of vegetation and ecosystems	30 µg/m^3	Annual mean	31-Dec-00	31-Dec-00	19-Jul-01

2.4.3 Part IV of the Environment Act 1995 requires local authorities in the UK to review air quality in their area and designate Air Quality Management Areas (AQMA) if improvements are necessary. Where an AQMA is designated, local authorities are also required to work towards the Strategy's objectives prescribed in regulations for that purpose. An Air Quality Action Plan (AQAP) describing the pollution reduction measures must then be put in place. These plans contribute to the achievement of air quality limit values at local level.

2.5 Climate Change Act

2.5.1 The Climate Change Act (Ref. 7) aims to manage and respond to climate change in the UK by setting legally binding targets, taking powers to meet the targets and establishing clear and regular accountability.

2.5.2 The main aims of the Act are to:

- improve carbon management which helps the move towards a low-carbon economy
- demonstrate international leadership in sharing responsibility for reducing global emissions.

2.5.3 The Act sets a legally binding target of at least 80% reduction in greenhouse gas emissions by 2050 (based on 1990 levels). A target to reduce emissions by 34% by 2020 is also in place. A carbon budgeting system has been put in place to track progress towards these targets as described in the UK Low Carbon Transition Plan (Ref. 8).

2.6 National Planning Policy Framework

2.6.1 The National Planning Policy Framework (NPPF) (Ref. 9) was published on 27 March 2012 and sets out the Government's planning policies for England and how these are expected to be applied. The purpose of the NPPF is to help achieve sustainable development, understood as positive growth.

2.6.2 Section 11 Conserving and Enhancing the Natural Environment considers air quality and pollution and Section 10 Meeting the Challenge of Climate Change, Flooding and Coastal Change highlights that planning plays a key role in mitigation against climate change.

2.6.3 Paragraph 109 states that the planning system should contribute to and enhance the natural and local environment by, among others, preventing new development from contributing to unacceptable levels of air pollution.

2.6.4 Paragraph 124 states that planning policies should sustain compliance with and contribute towards EU limit values and national objectives for pollutants, taking into account the presence of AQMAs and the cumulative impacts on air quality from individual sites in local areas. Planning decisions should ensure that any new development in AQMAs is consistent with the local air quality action plan.

2.6.5 Further guidance on the NPPF is located in the Planning Practice Guidance Notes (PPGN) Ref. 10).

3 Methodology

3.1 Department for Transport TAG Unit A3

3.1.1 This report will undertake the initial stages of environmental air quality and greenhouse gas appraisal from the Department for Transport TAG Unit A3. This will include scoping of the preliminary designs to determine the necessity for air quality appraisal, and the quantification of air quality impacts.

3.2 DMRB HA 207/07

3.2.1 The processes outlined in the Design Manual for Roads and Bridges Volume 11, Section 3 Part 1 HA 207/07 Air Quality (Ref. 11)., and subsequent Interim Advice Notes (IANs), will be used to provide the output for this appraisal.

3.2.2 HA 207/07 describes four levels of assessment: scoping, simple, detailed, and mitigation/enhancement and monitoring. Each level of assessment incorporates two components: local air quality, which is the estimation of the levels of pollutants that could change as a result of the scheme (temporary and permanent) at specific locations; regional air quality, which examines the change in emissions as a result of the operation of the scheme and the impacts this may have over a regional, national or international area.

3.3 Study area

3.3.1 As advised, sensitive receptors relative to the schemes were identified through the use of Geographical Information System data sourced from the Ordnance Survey and processed using appropriate computer software.

3.3.2 For instances where data for the quantitative appraisal is unavailable, such as for the temporary air quality impacts during construction, a qualitative appraisal using professional judgement will be undertaken.

3.3.3 The study area for local assessment is defined in HA 207/07 as 200m from an affected road. HA207/07 defines an affected road as meeting any of the following criteria:

- road alignment will change by 5 m or more
- daily traffic flows will change by 1,000 AADT or more
- Heavy Duty Vehicle (HDV) flows will change by 200 AADT or more

- daily average speed will change by 10 km/hr or more
- peak hour speed will change by 20 km/hr or more

3.3.4 The study area includes all sensitive receptors, such as residential properties and ecologically designated sites, and pays special attention to susceptible groups such as schools, hospitals and nursing homes.

3.3.5 The criteria for regional assessment are defined in HA 207/07 as affected roads meeting any of the following criteria:

- a change of more than 10% in AADT
- a change of more than 10% to the number of heavy duty vehicles
- a change in daily average speed of more than 20 km/hr.

3.4 Determining the baseline

3.4.1 Air quality monitoring in the area of the scheme is currently undertaken by Stroud District Council. In line with LAQM TG (16) (Ref. 12) the council undertakes air quality monitoring at sensitive locations within the council area. The council operates one continuous monitoring station as a background AURN monitor, and also undertakes local passive monitoring through the use of NO_2 passive type diffusion tubes. Data from this monitoring is added to the national dataset to be included in national background air quality datasets.

3.4.2 Modelled background air quality is provided via the DEFRA review and assessment website (Ref. 13) at 1km grid square centres.

3.5 Assessment method

Temporary Effects

3.5.1 HA 207/07 requires that any sensitive receptors within 200m of a construction site should be identified so that mitigation can be applied. Any such mitigation should be designed in to the construction process to be included in the Construction Environmental Management Plan, and be reflective and appropriate to the type and size of construction being undertaken.

Permanent Effects

3.5.2 Those roads within the study area that meet the scoping criterion relating to affected roads will be assessed according to HA 207/07. Where roads are scoped in to the assessment, receptors within the study area will be counted. Exposure at key receptors modelled using supplied traffic data where the effects of the scheme are likely to be highest, and key sensitive receptors from susceptible groups will also be included. Receptors will be identified using professional judgement. Modelling will be undertaken using DMRB Screening Method V1.03c. Department for Transport Emission Factors v7 will be applied through the use of the GAP factor analysis described in IAN 170/12 v3 (Ref. 14).

3.5.3 The assessment of impacts at ecological receptors is not required because no designated sites are located within 200m of affected roads.

3.5.4 The acceleration zone methodology from IAN 185/15 (Ref. 15) will be applied in addition to the modelling described in HA 207/07, extending to 100m from junctions.

3.5.5 Calculations relating to the ratio of NO_X to primary NO_2 will be undertaken according to IAN 170/12 v3 using the Defra NO_X to NO_2 June 2016 calculator.

3.5.6 Verification will be undertaken using local diffusion tube monitoring data from Stroud District Council where tubes are located in an area for which traffic data is available for this scheme.

3.5.7 Measurements across the UK have shown that the 1-hour mean NO_2 objective is unlikely to be exceeded unless the annual mean NO_2 concentration is greater than 60 $\mu g/m^3$. Thus exceedances of 60 $\mu g/m^3$ as an annual mean NO_2 concentration are used as an indicator of potential exceedances of the 1-hour mean objective as stated in paragraph 7.91 of LAQM TG (16).

3.5.8 Similarly, LAQM TG(16) sets out the method by which the number of days in which the PM_{10} 24-hour objective is exceeded, and can be obtained based on a relationship with the predicted annual mean.

3.5.9 As with all modelling, air quality modelling is subject to uncertainty. Meteorological, topographical and behavioural factors can all affect the dispersion of pollutants within a three-dimensional space, as can systematic errors within the model. This introduces a Measure of Uncertainty (MoU). A Root Mean Square Error method is applied to ensure that the model output remains within acceptable levels of error.

3.6 Traffic data

3.6.1 A S-Paramics micro simulation model was provided to Amey from a modelling exercise undertaken by PFA Consulting on behalf of Robert Hitchings Limited. The modelling was undertaken to inform a planning application for a new Ecotricity Business park in the Stonehouse area. Amey was able to verify this model, and so the data will be used for this appraisal.

3.6.2 Annual Average Daily Traffic (AADT) data was provided in order to undertake air quality calculations. Data was provided for the baseline 2012 scenario used in the traffic modelling, an opening year of 2020 and future assessment year of 2035.

3.6.3 The scenarios considered in the assessment reflect the traffic data provided and therefore consist of Do-Minimum (DM) scenarios which predict concentrations without the schemes in place and Do-Something (DS) scenarios which predict concentrations with the schemes in place. The specific scenarios considered in the assessment are:

- Baseline DM 2012
- Opening year DM 2020
- Opening year DS 2020
- Future year DM 2035
- Future year DS 2035

3.6.4 Vehicle speeds will be assigned to each link during traffic modelling according to the speed pivoting and assignment methodology described in IAN 185/15.

3.7 Assessment of Significance

3.7.1 The significance air quality impacts are interpreted as the magnitude of change in annual average concentrations of pollutants, and is based on 10%, 5% and 1% MoU, and according to the number of receptors within these bandings as detailed in IAN 174/13 (Ref. 16) and shown in Table 3:1.

Table 3:1: Scoring criteria for the appraisal summary table

Magnitude of	Number of Receptors with:

Change in NO_2 ($\mu g/m^3$)	**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
Imperceptible (≤ 0.4)	--	--

3.7.2 Professional judgment on significance should also be used dependant on the number of receptors with deteriorating or improving air quality.

3.8 Compliance Assessment

3.8.1 The effect of the scheme on the compliance zone or agglomeration was assessed qualitatively assessed using the information from IAN 175/13 (Ref. 17) as guidance in tandem with the outcomes of the assessment. This provides an opinion on whether the scheme is likely to have an impact on the compliance with the EU Directive 2008/50/EC for Ambient Air Quality.

3.9 Greenhouse Gas

3.9.1 Emissions of greenhouse gas were calculated for specific links attributable to each scheme as follows:

- Chipmans Platt Roundabout
    - Boakes Drive Roundabout to Downtown Road
    - Downtown Road to Wycliffe College
    - Wycliffe College to Horse Trough Roundabout
    - Horse Trough Roundabout to Ebley Road
- Oldends Lane
    - A419 Nastends Lane to Oldends Roundabout
    - A419 Oldends Roundabout to entry to Stonehouse Commercial centre
- Downton Road and Horsetrough Roundabout
    - Boakes Drive Roundabout to Downtown Road

- Downtown Road to Wycliffe College
- Wycliffe College to Horse Trough Roundabout
- Horse Trough Roundabout to Ebley Road
- Horse Trough Roundabout to Ryeford
- B4008: Horse Trough Roundabout to Brown's Ln
- B4008: Brown's Ln to Pearcroft Road
- B4008: Pearcroft Road to Burdett Road
- Downton Rd: A419 to Abbots Way

3.9.2 It should be noticed this is an arbitrary approach to apportioning greenhouse gas emissions to each scheme based on assigning links for which traffic flows were provided to each scheme.

3.9.3 Emissions as fuel consumption were calculated using the formula and parameters given in in TAG Data Book Tables A1.3.8 and A.1.3.9 (Ref. 2). The amount of fuel consumed by different types of vehicle, expressed in litres/km travelled was determined using a function of average speed.

3.9.4 This was combined with the link length and yearly traffic counts to determine the carbon dioxide equivalent (CO_2e) which is a measure of carbon dioxide which includes nitrous oxide, methane and carbon dioxide.

3.9.5 The impact arising from the change in CO_2e emissions was determined using the Greenhouse Gases Workbook.

3.10 Economic Appraisal

3.10.1 As NO_x emissions can cause health problems over long distances through secondary particle formation, values for NO_x emissions are used in economic valuation. As no exceedances of the EU NO_2 annual mean limit value have been predicted at any of the sensitive receptors, changes in NO_x emissions have been valued using the damage cost approach in accordance with DfT TAG Unit A3 Environmental Impact Appraisal.

3.10.2 Valuation of changes in PM_{10} concentrations are also based on the damage cost approach because no exceedances of the daily mean limit value exceedances outside London are likely.

3.10.3

3.10.4 shows the appraisal scoring criteria that was used to assess the change in local air quality for representative receptors. The appraisal score for air quality impacts will be included in the overall business case for the scheme.

Table 3:2: Scoring criteria for the appraisal summary table

Appraisal Rating	Appraisal Score
Large Beneficial	3
Moderate Beneficial	2
Slight Beneficial	1
Neutral	0
Slight Adverse	-1
Moderate Adverse	-2
Large Adverse	-3

3.10.5 For air quality, the TAG Local Air Quality Workbook was used to calculate property weighted NO_2 and PM_{10} concentrations and the number of properties where air quality improves, worsens or stays the same. The TAG Air Quality Valuation Spreadsheet was used to facilitate the calculation of monetary values for air pollution from the schemes.

4 Baseline Conditions

4.1.1 This section will describe the baseline air quality conditions in the area affected by the scheme with reference to DEFRA modelled background concentrations, monitoring undertaken by the responsible authority and an assessment of sensitive locations. Also included is a review of other potential constraints to the schemes such as Air Quality Management Areas (AQMA) and roads for which Defra must report roadside pollutant concentration compliance under the EU Directive on ambient air quality and clean air for Europe (2008/50/EC).

4.2 Background pollutant concentrations

4.2.1 Modelled background pollutant concentrations representing modelled 2017 data from the 2013-based background mapping. These are shown in Figure 4.1, Figure 4.2 and Figure 4.3.

Figure 4.1 Background NO_2 (2017)

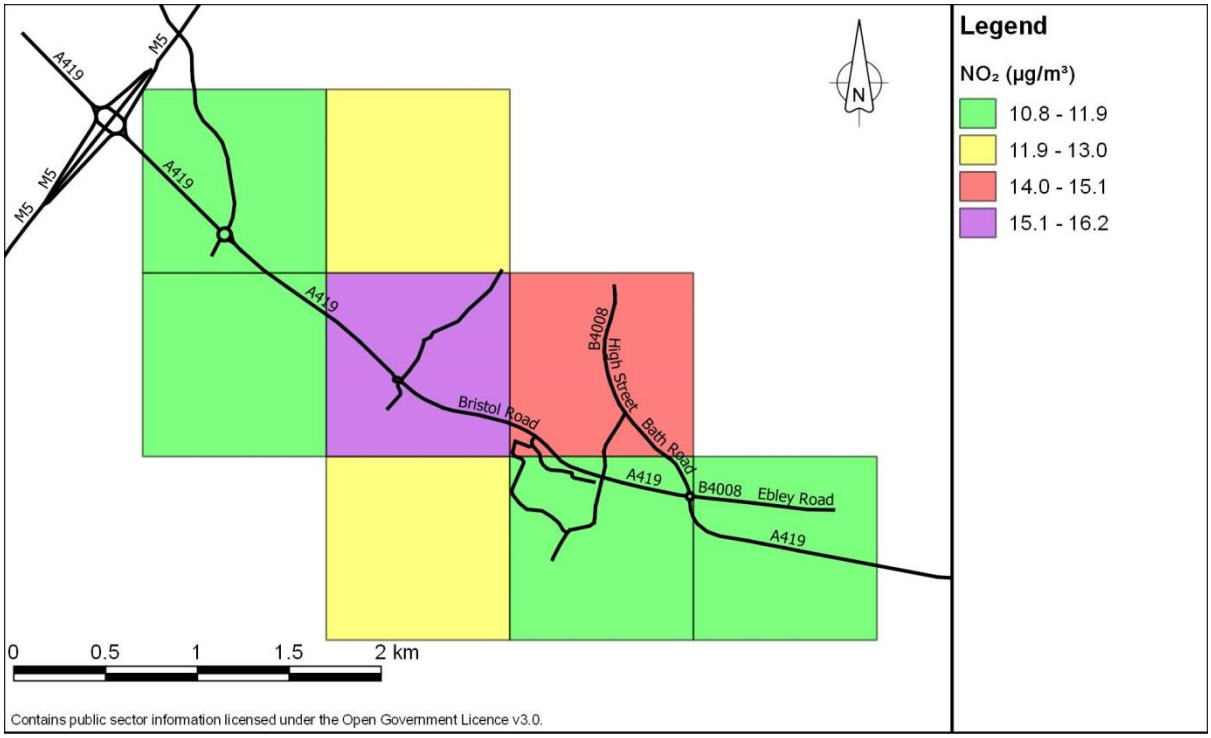


Figure 4.2 Background NO_x (2017)

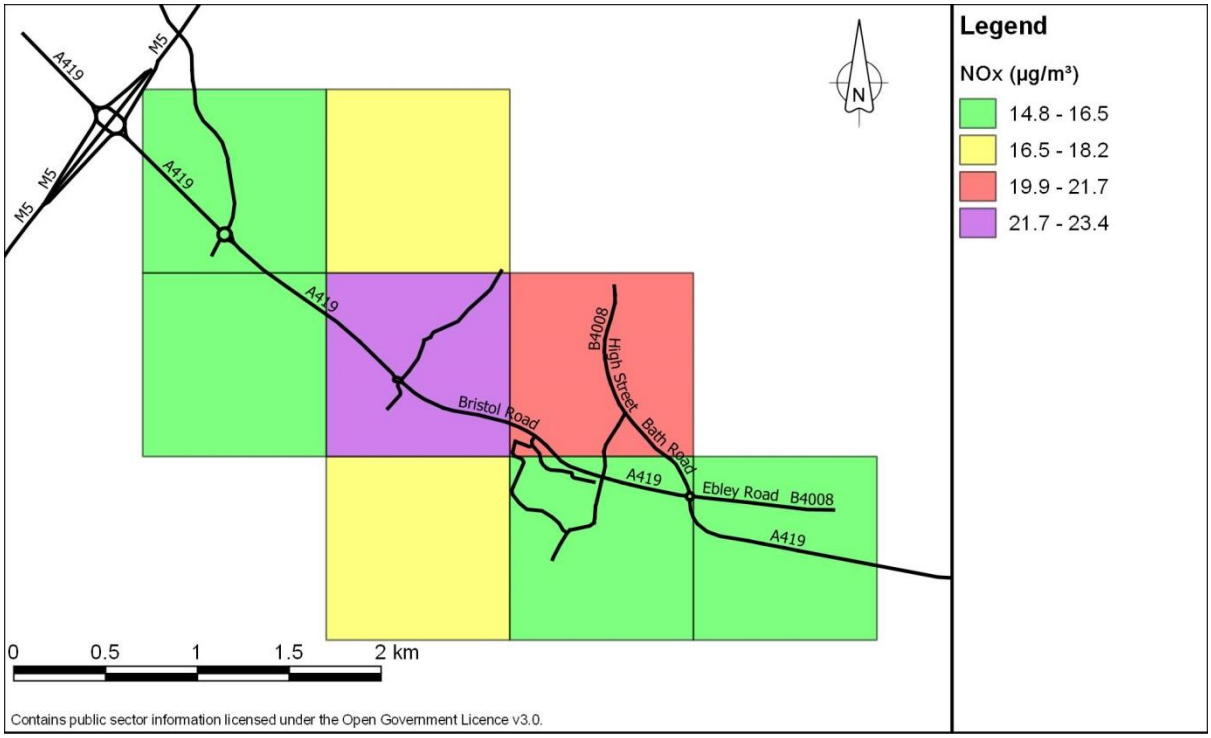
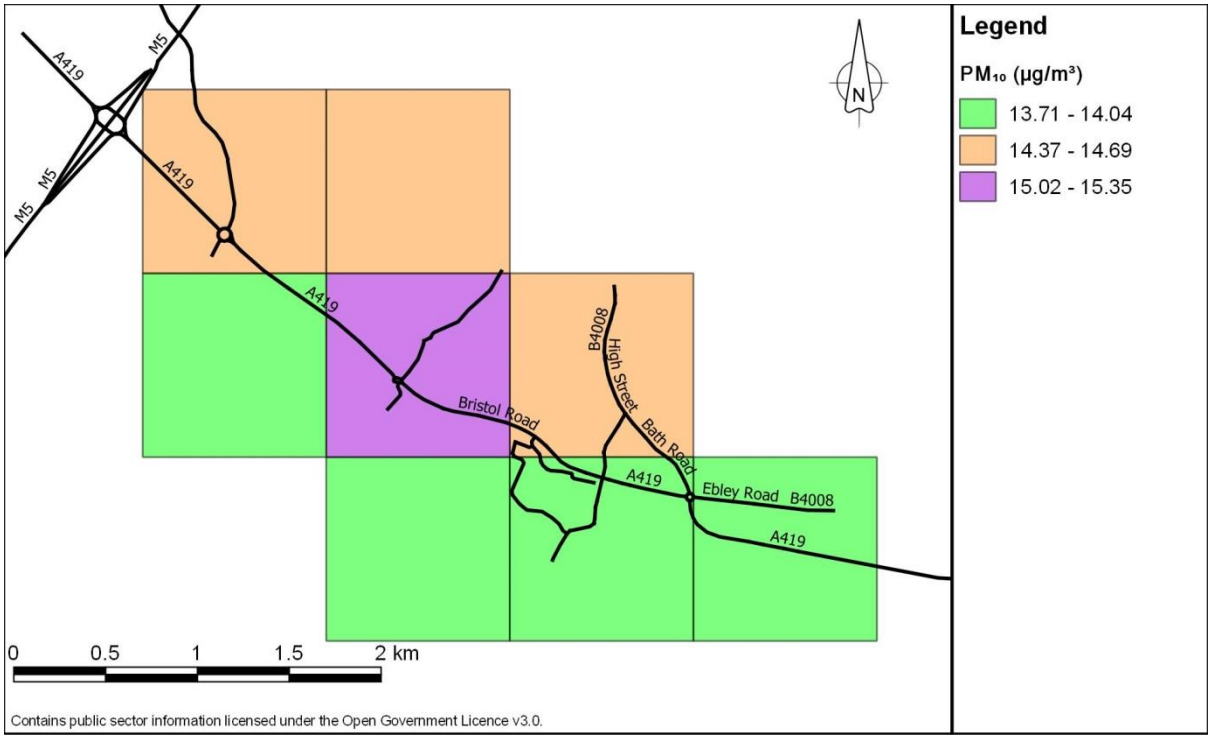


Figure 4.3 Background PM_{10} (2017)



4.2.2 Figure 4.1, Figure 4.2 and Figure 4.3 show that the AQS objective values (Table 2:1) are not exceeded by the background concentration in the study area. The highest concentrations are modelled in the square encompassing Oldends Lane Roundabout.

4.3 Monitored pollutant concentrations

4.3.1 Local Air Quality Management (LAQM) in the area is the responsibility of Stroud District Council who produce the screening, progress and status reports for DEFRA.

4.3.2 The Stroud District Council Updated Screening and Assessment Report 2015 (Ref. 18) and the Air Quality Status Report 2016 (Ref. 19) show that air quality in the area is typical of a semi-rural area in Gloucestershire. The 2015 report recorded two diffusion tubes in the Bowbridge area of Stroud as exceeding the annual limit value for NO_2, which were then within the limit value for the 2016 report. As a result an automatic monitor was set up.

4.3.3 A diffusion tube is located kerbside on Bristol Road within the study area for Downton Road and Horsetrough Roundabout. All monitored concentrations are below the AQS objective for annual average NO2 and a gradual improvement was monitored in the period 2011 to 2015. There are no NO_2 annual means exceeding 60µg/m^3 that would indicate exceedances of the 1-hour objective and limit values.

4.3.4

4.3.5 The diffusion tube results are shown in Table 4:1.

Table 4:1: Diffusion tube monitoring results

Site ID	Site Type	Within AQMA?	Annual Mean NO_2 Concentration (µg/m^3) – Adjusted for Bias				
			2011 Bias adjust. 0.82	2012 Bias adjust. 0.95	2013 Bias adjust. 0.90	2014 Bias adjust. 0.89	2015 Bias adjust. 0.87
Stroud20a	Kerbside	N	21.1	26.1	22.7	20.4	20.9

4.3.6 Stroud District Council does not undertake any monitoring of traffic related PM_{10}, or emissions of SO_2 and benzene that might be associated with industrial emissions.

4.4 Sensitive receptors

4.4.1 Sensitive receptors are defined as locations which are potentially sensitive to local air emissions. Examples include dwellings, hospitals, schools, community facilities, designated areas (e.g. SAC, SPA, SSSI, pSPA and Ramsar) and public rights of way.

4.4.2 For temporary effects, Appendix A shows the scheme locations on along the A419 with 200m buffers applied to the boundaries of each scheme. Ordnance Survey AddressBase data points within the buffers show the distribution of potential receptors to temporary air quality effects from the construction. Appendix A shows there are 514 sensitive receptors within 200 of the site boundary.

4.4.3 For permanent effects, Appendix A shows the locations of the schemes along the A419 with 200m buffers applied to each scheme. Ordnance Survey AddressBase data points within each buffer show the potential receptors to permanent air quality effects for each scheme. It is noted that the buffers for Horsetrough Roundabout and Downton Road signalised junction overlap considerably. Appendix A shows there are 67 sensitive receptors within 200 of the site boundary of the Horsetrough Roundabout, 124 within 200m of Oldends Lane Roundabout, 350 within 200m of the Downton Road signalised junction and 17 within 200m of Chipmans Platt Roundabout.

4.5 EU Directive Compliance Links

4.5.1 Development projects are required to assess the impacts of their scheme on compliance with the EU Directive on ambient air quality (2008/50/EC). IAN 175/13 prepared by the Highways England sets out the assessment approach for identifying and quantifying impacts of a scheme on Defra's 'UK National Compliance Assessment for the EU Directive on ambient air quality'. This approach uses the reported information from Defra's Pollution Climate Mapping (PCM) model and the results obtained in the assessment of air quality.

4.5.2 A review of DEFRA's UK Ambient Air Quality Interactive Map (Ref. 20) shows that there are Compliance Risk Road Network links which could be impacted by the scheme. These are summarised in Table 1.1.

Table 4:2: Compliance Risk Road Network links

HA LINK ID	Defra Link Census ID	Road	Zone/ Agglomeration Ref No	Compliant y/n
73310	57120	A419 Bristol Road	033 South West	y
73841	57120	A419 Bristol Road	033 South West	y
73929	57120	A419 Bristol Road	033 South West	y

HA LINK ID	Defra Link Census ID	Road	Zone/ Agglomeration Ref No	Compliant y/n
73925	57120	A419 Bristol Road	033 South West	y
73921	57120	A419	033 South West	y

4.5.3 All links are compliant with the 2008/50/EC limit values.

4.6 Air Quality Management Areas

4.6.1 There are no AQMAs in the Stroud district on the basis that no exceedances have been predicted in monitoring data collected for the purposes of LAQM by Stroud Council.

5 Air Quality Assessment

5.1.1 For the purposes of assessment, the modifications to Horsetrough Roundabout and Downton Road signalised junction meet the criteria for local assessment for change in AADT and change in road alignment described in HA 207/07. As the two schemes and their 200m buffers overlap considerably, the two junctions have been treated as a single scheme during assessment. Numerous links meet the change in AADT requirement for regional assessment, therefore the whole scheme will be assessed in this manner.

5.1.2 Specific road links at Chiphams Platt Roundbaout and Oldends Roundabout meet the local assessment criteria for change in AADT. Some of the links also meet the change in AADT criteria for regional assessment. Only these links were assessed.

Temporary (Construction) effects

5.1.3 There are 383 sensitive receptors located within 200 m and considering the proximity of the receptors to the construction site. Considering the size of the site, the number of receptors and the potential routes of construction vehicles for each scheme it is considered that the sites should be classified as medium risk for temporary releases of air emissions during construction.

5.1.4 It is recommended that further assessment is undertaken to determine the level of mitigation required to minimise and control any emissions once further detail is available about the construction programme and methods. It is considered that with appropriate implementation of mitigation which is commensurate and to the risk the impacts of the all the schemes will be not significant.

Permanent (Operational) Effects

Sensitive Receptors

There are 383 sensitive receptors located within 200m of the Downton Road and Horsetrough Horsetrough Roundabout junction improvements. These are broken down into 50m bandings as bandings as shown in

5.1.5 Table 5:1.

Table 5:1 Sensitive receptor counts (permanent effects)

Buffer zone (m)	Receptors
0 - 50	56
50 - 100	79
100 – 150	118
150 - 200	130

5.1.6 There are 128 sensitive receptors located within 200m of the Oldends Roundabout improvements. These are broken down into 50m bandings as shown in Table 5:2.

Table 5:2 Sensitive receptor counts (permanent effects)

Buffer zone (m)	Receptors
0 - 50	32
50 - 100	32
100 – 150	25
150 - 200	39

5.1.7 There are 18 sensitive receptors located within 200m of the Chiphams Platt Roundabout improvements. These are broken down into 50m bandings as shown in

Table 5:3 Sensitive receptor counts (permanent effects)

Buffer zone (m)	Receptors
0 - 50	8
50 - 100	6
100 – 150	2
150 - 200	2

5.1.8 Key receptors were identified from each banding, taking care to include the receptors of Wycliffe College, Hopelands Preparatory School and The Grange Care Centre. A diffusion tube operated by Stroud District Council was also included as a key receptor in order to aid verification of the modelled pollutant concentrations at each receptor. These are shown in Table 5:4.

Table 5:4 Sensitive receptors (permanent effects)

Receptor	Distance band (m)	Description	X	Y
ST1	100-150	Hopelands College	380535	205030
ST2	0-50	Wycliffe College - Loosley Halls	380571	204918
ST3	150-200	Wycliffe College - Haywardsfield	380721	205017
ST4	0-50	Wycliffe College - Wards House	380629	204903
ST5	0-50	Cotswold Gables, Browns Lane, Stonehouse, GL10 2JZ	381011	204854
ST6	100-150	Fairfield ,Pearcroft Road Stonehouse, GL10 2JY	380963	204992
ST7	100-150	54 Wharfdale Way, Bridgend, Stonehouse, GL10 2AQ	380277	204834
ST8	150-200	Lyndhurst, Pearcroft Road, Stonehouse, GL10 2JY	381077	204991
Stroud 20a	50-100	Diffusion Tube	380295	204998
Old1	0-50	9 Avenue Terrace, Stonehouse, GL10 3RE	379493	205383
Old2	100-150	Independent Financial Services Uk Ltd, Unit 404,Stonehouse Park, Sperry Way, Stonehouse, GL10 3UT	379191	205396

Receptor	Distance band (m)	Description	X	Y
Old3	150-200	Gerry Dupree & Co Ltd, Unit 17 Springfield Business Centre,Brunel Way, Stroudwater Business Park, Stonehouse, GL10 3SX	379343	205733
Old4	50-100	40 Avenue Terrace, Stonehouse, GL10 3RE	379623	205338
CH1	50-100	Travelodge Hotels Ltd, Chipmans Platt, Stonehouse, GL10 3SQ	378442	206391
CH2	100-150	1 Chipmans Platt, Stonehouse, GL103SQ	378230	206275
CH3	0-50	Pike Lock, Eastington, Stonehouse, GL10 3RT	378402	206078
CH4	150-200	The Grange Care Centre, Bristol Road, Eastington, Stonehouse. GL10 3RT	378708	206257

Predicted Concentrations

Local Air Quality

Annual average NO_2 and PM_{10} predicted concentrations for the baseline, and assessment year are shown in Table 5:55,

Table 5:66,

5.1.9 Table 5:77 and Table 5:8.

Table 5:5 Annual mean nitrogen dioxide opening year (2020)

Scheme	Receptor	DM 2012	DM 2020	DS 2020	DS 2020 change	Magnitude of Change	Appraisal Score

Scheme	Receptor	DM 2012	DM 2020	DS 2020	DS 2020 change	Magnitude of Change	Appraisal Score
Downton/ Horsetrough	ST1	16.0	12.7	12.8	+0.1	Imperceptible	0
Downton/ Horsetrough	ST2	39.2	31.4	32.0	+0.6	Small	-1
Downton/ Horsetrough	ST3	17.8	14.2	14.2	-0.0	Imperceptible	0
Downton/ Horsetrough	ST4	32.4	25.9	26.3	+0.4	Small	-1
Downton/ Horsetrough	ST5	36.6	29.2	28.9	-0.3	Imperceptible	0
Downton/ Horsetrough	ST6	21.8	17.5	17.2	-0.3	Imperceptible	0
Downton/ Horsetrough	ST7	15.5	12.3	12.4	+0.1	Imperceptible	0
Downton/ Horsetrough	ST8	15.3	12.1	12.1	-0.0	Imperceptible	0
Downton/ Horsetrough	Stroud20a	27.2	21.8	22.2	+0.4	Small	-1
Oldends	Old1	26.2	25.2	25.3	+0.1	Imperceptible	0
Oldends	Old2	20.6	20.0	20.0	+0.0	Imperceptible	0
Oldends	Old3	20.3	19.7	19.7	-0.0	Imperceptible	0
Oldends	Old4	22.7	21.9	22.0	+0.1	Imperceptible	0
Chiphams Platt	CH1	19.8	20.0	19.7	-0.3	Imperceptible	0
Chiphams Platt	CH2	16.8	16.2	16.4	+0.2	Imperceptible	0
Chiphams Platt	CH3	17.3	16.8	16.9	+0.1	Imperceptible	0

Scheme	Receptor	DM 2012	DM 2020	DS 2020	DS 2020 change	Magnitude of Change	Appraisal Score
Chiphams Platt	CH4	13.7	13.3	13.3	-0.0	Imperceptible	0

Table 5:6 Annual mean nitrogen dioxide assessment year (2035)

Scheme	Representative Receptor	DM 2012	DM 2035	DS 2035	DS 2035 change	Magnitude of Change	Appraisal Score
Downton/ Horsetrough	ST1	16.0	9.0	9.0	+0.1	Imperceptible	0
Downton/ Horsetrough	ST2	39.2	22.2	22.8	+0.6	Small	-1
Downton/ Horsetrough	ST3	17.8	10.1	10.0	-0.0	Imperceptible	0
Downton/ Horsetrough	ST4	32.4	18.3	18.4	+0.1	Imperceptible	0
Downton/ Horsetrough	ST5	36.6	21.2	21.6	+0.5	Small	-1
Downton/ Horsetrough	ST6	21.8	12.6	12.5	-0.1	Imperceptible	0
Downton/ Horsetrough	ST7	15.5	8.7	8.7	+0.1	Imperceptible	0
Downton/ Horsetrough	ST8	15.3	8.6	8.6	+0.0	Imperceptible	0
Downton/ Horsetrough	Stroud20a	27.2	15.4	15.8	+0.4	Small	-1
Oldends	Old1	26.2	21.6	21.8	+0.2	Imperceptible	0
Oldends	Old2	20.6	17.2	17.1	+0.0	Imperceptible	0

Scheme	Representative Receptor	DM 2012	DM 2035	DS 2035	DS 2035 change	Magnitude of Change	Appraisal Score
Oldends	Old3	20.3	16.8	16.8	-0.0	Imperceptible	0
Oldends	Old4	22.7	18.8	18.8	+0.1	Imperceptible	0
Chiphams Platt	CH1	19.8	11.7	11.4	-0.3	Imperceptible	0
Chiphams Platt	CH2	16.8	15.9	16.2	+0.3	Imperceptible	0
Chiphams Platt	CH3	17.30	18.5	18.7	+0.2	Imperceptible	0
Chiphams Platt	CH4	13.7	7.2	7.2	-0.0	Imperceptible	0

Table 5:7 Particulate matter opening year (2020)

Scheme	Representative Receptor	DM 2012	DM 2020	DS 2020	DS 2020 change	Magnitude of Change	Appraisal Score
Downton/ Horsetrough	ST1	16.0	14.7	14.7	-0.0	Imperceptible	0
Downton/ Horsetrough	ST2	20.5	18.4	18.5	+0.1	Imperceptible	0
Downton/ Horsetrough	ST3	16.4	15.0	15.0	-0.0	Imperceptible	0
Downton/ Horsetrough	ST4	19.0	17.2	17.3	+0.1	Imperceptible	0
Downton/ Horsetrough	ST5	20.9	18.8	18.6	-0.2	Imperceptible	0
Downton/ Horsetrough	ST6	17.4	15.9	15.8	-0.2	Imperceptible	0

Scheme	Representative Receptor	DM 2012	DM 2020	DS 2020	DS 2020 change	Magnitude of Change	Appraisal Score
Downton/ Horsetrough	ST7	15.9	14.6	14.6	-0.0	Imperceptible	0
Downton/ Horsetrough	ST8	15.9	14.7	14.6	-0.0	Imperceptible	0
Downton/ Horsetrough	Stroud20a	18.0	16.3	16.4	+0.1	Imperceptible	0
Oldends	Old1	20.2	18.2	18.2	+0.0	Imperceptible	0
Oldends	Old2	17.6	16.2	16.2	-0.0	Imperceptible	0
Oldends	Old3	17.4	16.0	16.0	-0.0	Imperceptible	0
Oldends	Old4	18.6	16.9	16.9	+0.0	Imperceptible	0
Chiphams Platt	CH1	16.9	15.5	15.6	+0.1	Imperceptible	0
Chiphams Platt	CH2	16.3	14.8	14.9	+0.1	Imperceptible	0
Chiphams Platt	CH3	16.3	14.9	14.9	+0.1	Imperceptible	0
Chiphams Platt	CH4	15.7	14.4	14.4	-0.0	Imperceptible	0

Table 5:8 Particulate matter assessment year (2035)

Scheme	Representative Receptor	DM 2012	DM 2035	DS 2035	DS 2035 change	Magnitude of Change	Appraisal Score
Downton/ Horsetrough	ST1	16.0	14.7	14.7	+0.0	Imperceptible	0
Downton/ Horsetrough	ST2	20.5	18.5	18.7	+0.2	Imperceptible	0
Downton/ Horsetrough	ST3	16.4	15.0	15.0	-0.1	Imperceptible	0

Scheme	Representative Receptor	DM 2012	DM 2035	DS 2035	DS 2035 change	Magnitude of Change	Appraisal Score
Downton/ Horsetrough	ST4	19.0	17.2	17.3	+0.0	Imperceptible	0
Downton/ Horsetrough	ST5	20.9	19.2	19.1	-0.1	Imperceptible	0
Downton/ Horsetrough	ST6	17.4	16.0	15.8	-0.2	Imperceptible	0
Downton/ Horsetrough	ST7	15.9	14.6	14.6	+0.0	Imperceptible	0
Downton/ Horsetrough	ST8	15.9	14.6	14.6	-0.0	Imperceptible	0
Oldends	Old1	18.0	16.4	16.5	+0.1	Imperceptible	0
Oldends	Old2	17.6	16.2	16.2	-0.0	Imperceptible	0
Oldends	Old3	17.4	16.0	16.0	-0.0	Imperceptible	0
Oldends	Old4	18.6	16.9	17.0	+0.0	Imperceptible	0
Chiphams Platt	CH1	16.9	15.9	15.8	-0.0	Imperceptible	0
Chiphams Platt	CH2	16.3	14.8	15.0	+0.2	Imperceptible	0
Chiphams Platt	CH3	16.3	15.0	15.0	+0.1	Imperceptible	0
Chiphams Platt	CH4	15.7	14.4	14.4	-0.0	Imperceptible	0

Regional Air Quality

5.1.10 NO_x emissions for the opening year and assessment year with and without the schemes in place are shown in Table 5:8.

Table 5:9 Regional NO_x Emissions From Air Quality Valuation Spreadsheet (tonnes/year)

Scheme	Links exceeding limit values?	Without Intervention		With Intervention		Change in Emissions	
		Opening Year	Forecast Year	Opening Year	Forecast Year	Opening Year	Forecast Year
Chiphams Platt Roundabout	Yes	n/a	n/a	n/a	n/a	n/a	n/a
	No	3.2	3.3	3.3	3.6	0.1	0.2
Oldends Roundabout	Yes	n/a	n/a	n/a	n/a	n/a	n/a
	No	2.1	2.2	2.2	2.4	0.1	0.2
Downton Road and Horsetrough Roundabout	Yes	n/a	n/a	n/a	n/a	n/a	n/a
	No	4.3	4.5	4.5	4.8	0.3	0.3

n/a limit values not exceeded

Compliance With EU Directive

5.1.11 A summary of the impacts of the scheme on the compliance links is shown in Table 5:10.

Table 5:10 Impacts of the schemes on the compliance links

Inputs				DEFRA PCM Model Compliance Information					Receptor Result			
Scheme	**DEFRA PCM Data**			**Total NO_2 µg/m^3**			**Compliance Info**		**Annual Mean NO_2 concentration µg/m^3**			
HA LINK ID	**Defra Link Census ID**	**Zone/ Agglomerat. Ref No**	**Comp. y/n**	**Proceeding Year 2015**	**Following Year 2016**	**Equivalent Opening Year 2020**	**Maximum modelled Conc in Zone 2015**	**Projected compliance year**	**DM**	**DS**	**Change**	**Equiv PCM DS**
73310 A419 Bristol Road	57120	033 SW	y	34.1	No data	No data	34.1	No data	34.1	34.7	+0.6	34.7
73841 A419 Bristol Road	57120	033 SW	y	34.1	No data	No data	34.1	No data	34.1	34.7	+0.6	34.7
73929 A419 Bristol Road	57120	033 SW	y	34.1	No data	No data	34.1	No data	34.1	34.7	+0.6	34.7
73925 A419 Bristol Road	57120	033 SW	y	34.1	No data	No data	34.1	No data	34.1	34.7	+0.6	34.7
73921 A419	57120	033 SW	y	34.1	No data	No data	34.1	No data	34.1	34.7	+0.6	34.7

Limitations

5.1.12 Given the traffic data supplied, it was necessary to use DEFRA's 2011-based background mapping. The base year for the supplied traffic data was 2012.

5.1.13 The latest modelling year possible using the DMRB Screening Method V1.03c is 2025, therefore this year was used to model the results with the traffic data supplied for the operational year 2035.

5.1.14 The earliest year possible using the NO_X to NO_2 June 2016 calculator is 2013. This year was used with the 2012 traffic data supplied. The latest year in the calculator is 2030, which was used with the traffic data supplied for the operational year 2035. These years are the same for the Sector Removal Tool and Gap Factor Analysis Tool.

Chipmans Platt Roundabout

5.1.15 Alignment changes at Chiphams Platt Roundabout were seen to be insignificant from the supplied designs, so were not included in the assessment.

5.1.16 Traffic volumes at four of the road links were noted to exceed the 1000 AADT limit for change from HA 207/07. These are link 1 to the west, link 2 to the east both on the A419, and links 26 and 27 to the north. The modelled changes in pollutant concentrations at the key receptors were all less than 1 $\mu g/m^3$, well below the levels identified in IAN 174/13 as perceptible to humans. Given all concentration changes are predicted to imperceptible and no exceedances are predicted, the overall effect of the scheme can be considered neutral.

Oldends Lane Roundabout

5.1.17 As with Chiphams Platt, the alignment changes at Oldends Roundabout were seen to be insignificant from the supplied designs so were not included in the assessment.

5.1.18 Traffic volumes at two of the road links exceed 1000 AADT limit for change from HA 207/07. These are link 3 to the west and link 4 to the east, both on the A419. The modelled changes in pollutant concentrations at the key receptors were all less than $1\mu g/m^3$, well below the levels identified in IAN 174/13 as perceptible to humans. Given the mix of deterioration and improvement in the results, the overall effect of the scheme can be considered neutral.

Downton Road and Horsetrough Roundabout

5.1.19 The supplied designs for Downton Road and Horsetrough Roundabout overlapped significantly, as did the buffers. Therefore these two schemes were assessed as one in order to avoid double counting receptors and changes in pollutant concentrations. A number of road links exceeded the 1000 AADT limit from HA 207/07, and alignments in both schemes are planned to change by at least 5m. Due to this, all of the links for which traffic data was available were included in the model.

5.1.20 At most receptors, the modelled changes in pollutant concentrations at the key receptors were all less than 1 µg/m^3, well below the levels identified in IAN 174/13 as perceptible to humans. Slight adverse impacts were predicted at receptors ST2, ST4 and Stroud20a in the opening and assessment year. However, even these predicted concentrations are well under the objective and concentrations are predicted to decline from 2020 to 2035. The overall effect of the Downton Road and Horsetrough Roundabout can therefore be considered neutral.

Greenhouse Gas

5.1.21 Estimated greenhouse gas from the scheme in the opening year and assessment year is shown in Table 5:11.

Table 5:11: Greenhouse Gas Emissions (tonnes CO_2e)

Scheme	DM 2020	DS 2020	DM 2035	DS 2035
Chipmans Platt Roundabout	1,006	887	1,153	996
Oldends Lane	633	656	689	698
Downton Road and Horsetrough Roundabout	1,594	1,607	1,773	1,713

Economic Valuation

Air Quality

5.1.22 Table 5:12 shows the appraisal score for the four schemes in both the short term and the long term. The appraisal rating for the Chipmans Platt Roundabout, Oldends Lane and the Downton Road and Horsetrough Roundabout Downton Road schemes are assessed as neutral with the majority of receptor impacts imperceptible.

Table 5:12 Appraisal rating for the Stonehouse schemes

Scheme	Appraisal Rating		Appraisal Score	
	Short Term	**Long Term**	**Short Term**	**Long Term**
Chipmans Platt Roundabout	Neutral	Neutral	0	0
Oldends Lane	Neutral	Neutral	0	0
Downton Road and Horsetrough Roundabout	Neutral	Neutral	0	0

5.1.23 Table 5:13 below shows the results from the TAG Unit A3 local air quality assessment worksheets.

Table 5:13: Results of TAG Unit A3 Local Air Quality Assessment

Scheme	Net present value of change in air quality (£)
Chipmans Platt Roundabout	-9,538
Oldends Lane	-23,746
Downton Road and Horsetrough Roundabout	-60,401
Combined	**-93,685**

5.1.24 Chipmans Platt Roundabout, Oldends Lane and Downton Road/Horsetrough Roundabout show negative values i.e. a disbenefit in terms of air quality. However, these disbenenfits are an accumulation of imperceptible decreases in air quality and are considered to be small net present values in the context of the each scheme and as a whole.

Greenhouse Gas

5.1.25 Table 5:14 shows the net present value of greenhouse gas emissions for the combined scheme.

Table 5:14: Results of TAG Unit A3 Greenhouse Gas Assessment

Scheme	Net present value of change in greenhouse gas (£)
Chipmans Platt Roundabout	+420,755
Oldends Lane	-29,696
Downton Road and Horsetrough Roundabout	+141,000
Combined	**532,059**

5.1.26 Table 5:14 indicates likely savings in greenhouse gas emissions with the schemes in place. This can be explained by improvements in fuel efficiency relating to the increased speeds achievable with the scheme in place in the opening and assessment years.

6 Mitigation Measures

6.1.1 The predicted concentrations are such that no specific mitigation measures should be considered at the Chipmans Platt Roundabout, the Oldends Lane Roundabout, Downton Road or Horsetrough Roundabout schemes because an adverse impact on the local and regional air quality environment is not expected. The results show that Part 1 claims under the Land Compensation Act are unlikely because they would be unfounded.

7 Summary

7.1.1 An air quality and greenhouse gas assessment was carried out to assess the potential effects during construction and operation in line with DMRB HA207/07 and the NPPF. Potential impacts on local air quality (nitrogen dioxide (NO_2) and particulate matter (PM_{10})), regional air quality (oxides of nitrogen (NO_x)) and greenhouse gas emissions (CO_2) were scoped using the DMRB HA207/07 criteria and where impacts were identified as likely, quantitative assessment completed.

7.1.2 An air quality and greenhouse gas assessment was carried out to assess the potential effects during construction and operation in line with DMRB HA207/07 and the NPPF. Potential impacts on local air quality (nitrogen dioxide (NO_2) and particulate matter (PM_{10})) and regional air quality (oxides of nitrogen (NO_x)) were scoped using the DMRB HA207/07 criteria and where impacts were identified as likely, quantitative assessment completed. Greenhouse gas emissions (CO_2) were scoped using the same criteria.

7.1.3 An assessment of projected traffic data with the schemes in place against the scoping criteria indicated the potential for impacts on local air quality. A quantitative assessment of permanent operational effects and qualitative assessment of temporary construction phase effects on local air quality has therefore been completed. All regional air quality and greenhouse gas impacts were scoped out of the assessment on the basis that impacts are deemed to be minimal.

7.1.4 There are sensitive receptors in the form of two schools and a care home within 300m and residential properties within 50m of all four schemes. There are no designated ecological sites that require assessment. None of the junctions are within Air Quality Management Areas, but the A419 consists of Compliance Risk Road Network (CRRN) links in accordance with the EU Directive on ambient air quality (2008/50/EC). Therefore, the potential impact of the schemes on air quality at these links has been assessed.

7.1.5 The 2008 ambient air quality directive sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health such as NO2 and PM10. Following the 'Simple' assessment level described in DMRB HA207/07, predicted traffic flows have been combined with estimates of background and vehicle emissions to predict NO_2 and PM_{10} concentrations at key sensitive receptors. Predictions have been made using the HA207/07 Air quality Screening Method Spreadsheet and verified using monitoring data. These predictions have been compared with the statutory objectives for acute (short term) and chronic (long term) effects. The significance or measure of uncertainty (MoU) of these local effects has been assessed in accordance with Highways England's interim advice on the desirability of achieving 10% verifications between modelled and monitored concentrations. Temporary, construction phase effects have not been assessed in the absence of detailed information about the construction programme and methods

7.1.6 Downton Road Junction and Horsetrough Roundabout schemes met the criteria for 'Simple' assessment because of changes to the road alignment and AADT. Given the significant overlap of the extents for the two schemes and their resultant buffer zones, the two schemes were assessed together which means the impacts reported are cumulative. Specific links at Chiphams Platt Roundabout and Oldends Roundabout met the criteria for AADT change. These are reported individually.

7.1.7 In the baseline, opening and assessment years none of the long term or short objectives for NO_2 or PM_{10} are predicted to be exceeded with or without the scheme in place.

7.1.8 Background pollutant levels at Oldends Roundabout are elevated, but do not exceed the objective values. This is likely to be due to a cumulative effect of the combined emissions of the roads and the industrial facilities located to the north, though these are in excess of 200m from the roads being assessed.

7.1.9 For opening year 2020 and assessment year 2035, the highest concentrations were predicted at the closest receptors to the north of Bristol Road near to the Downton Road Junction. This applies with and without the scheme in place for both NO_2 and PM_{10}.

7.1.10 In the scheme opening year 2020, concentrations are predicted to fall marginally from the baseline year as improvements in vehicle emissions are off-set by traffic growth. In the opening year, the largest increase in annual average NO_2 concentrations resulting from the scheme was predicted to the north of Bristol Road. This increase was <2% of the objective. For annual average PM_{10}, all predictions were under the objective and impacts imperceptible.

7.1.11 In the scheme assessment year 2035, concentrations are predicted to fall more in relation to the baseline year than the opening year. This is because there is more time for improvements in vehicle emissions technology to be realised in the fleet. In the assessment year, the largest increase in annual average NO_2 concentration resulting from the scheme was predicted close to the north of Bristol Road close to the Downton Road Junction. This increase was <2% of the objective.

7.1.12 The magnitude of change as a result of the schemes is assessed as 'small' at the receptors close to Bristol Road. However, no new exceedances of the objective or worsening of air quality at receptors already exceeding is predicted to occur. For annual average PM_{10}, all predictions were under the objective and impacts imperceptible.

7.1.13 Some minor improvements in air quality were predicted close the Horsetrough Roundabout as a result of changes to the road alignment. However, these improvements are imperceptible.

7.1.14 Several sections of the A419 were identified as CRRN links in accordance with the EU Directive on ambient air quality. However, at this time it was not possible to obtain the required data to undertake the comparison between the local modelling assessment and the PCM data for future year scenarios. As a result, the highest predicted receptor impact (a 2% increase in NO_2 close to Bristol Road) was added to the CRRN link with the highest Defra modelled concentration to indicate the risk of exceedance. It was shown that an exceedance was unlikely but it is recommended that this assessment is revisited post business case when high resolution, link specific data is available for a more recent baseline year and modelled CRRN links data is available from Defra.

7.1.15 The Simple level assessment has determined that no new exceedances of the objective or worsening of local air quality at sensitive receptors already exceeding is predicted to occur. Furthermore, it is considered unlikely that new exceedances will occur at the CRRN links. As a result, it is judged that impacts on local air quality from the scheme will not be significant and can be considered as neutral.

8 References

Ref. 1 United Kingdom Government. Land Compensation Act 1973 (as amended).

Ref. 2 DfT. Transport Analysis Guidance (TAG) Unit A3 – Environmental Impact Appraisal, November 2014.

Ref. 3 European Union, 'Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.'

Ref. 4 United Kingdom Government. Air Quality Standards Regulations, 2010.

Ref. 5 United Kingdom Government. Environment Act, 1995.

Ref. 6 United Kingdom Government. 'The Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007.'

Ref. 7 United Kingdom Government. Climate Change Act, 2008

Ref. 8 United Kingdom Government. UK Low Carbon Transition Plan, 2009

Ref. 9 Department for Communities and Local Government, National Planning Policy Framework, March 2012

Ref. 10 Department for Communities and Local Government. Planning Practice Guidance Notes, https://www.gov.uk/guidance/air-quality--3.

Ref. 11 Highways Agency. Design Manual for Roads and Bridges (DMRB) Volume 11 Section 3 Part 1 HA 207/07 Air Quality, 2007.

Ref. 12 DEFRA. Local Air Quality Management Technical Guidance LAQM.TG (16), 2016.

Ref. 13 DEFRA. Background maps to assist local authorities in support of review and assessment of local air quality, http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

Ref. 14 Highways Agency. 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'.

Ref. 15 Highways Agency. 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'.

Ref. 16 Highways Agency. 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)

Ref. 17 Highways Agency. 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 fir user of DMRB Volume 11, Section 3, Part 1 'Air Quality'

Ref. 18 Stroud District Council. Updated Screening and Assessment Report 2015.

Ref. 19 Stroud District Council. Air Quality Status Report 2016.

Ref. 20 DEFRA. UK Ambient Air Quality Interactive Map. https://uk-air.defra.gov.uk/data/gis-mapping.

Appendix A Sensitive receptors and modelled road links