Further Assessment for Long Row, Main Road, Stratford St. Andrew

November 2015

Prepared by Transport Research Laboratory under contract to Suffolk Coastal District Council.

Local Authority Officer	Mrs Denise Lavender
Department	Environmental Protection
Address	Melton Hill, Woodbridge, Suffolk IP12 1AU
Telephone	(01394) 444350
e-mail	denise.lavender@eastsuffolk.gov.uk
Date	17th November 2015

This is the Further Assessment for the Air Quality Management Area (AQMA) declared at Long Row, main Road, Stratford St. Andrew. The Further Assessment has been produced by Transport Research Laboratory under contract to Suffolk Coastal District Council.

Suffolk Coastal District Council accept the findings of this Further Assessment.

Transport Research Laboratory
Creating the future of transport


FINAL PROJECT REPORT RPN3391

Air Quality Further Assessment of the A12 at Stratford St Andrew

In fulfilment of Part IV of the Environment Act 1995 Local Air Quality Management.

Savage, A., and Turpin, K.

Prepared for: Suffolk Coastal District Council, Environmental Protection

Project Ref:

Quality approved:

Anna Savage	Kevin Turpin
(Project Manager)	(Technical Referee)

Disclaimer

This report has been produced by the Transport Research Laboratory under a contract with Suffolk Coastal District Council. Any views expressed in this report are not necessarily those of Suffolk Coastal District.

The information contained herein is the property of TRL Limited and does not necessarily reflect the views or policies of the customer for whom this report was prepared. Whilst every effort has been made to ensure that the matter presented in this report is relevant, accurate and up-to-date, TRL Limited cannot accept any liability for any error or omission, or reliance on part or all of the content in another context.

When purchased in hard copy, this publication is printed on paper that is FSC (Forest Stewardship Council) and TCF (Totally Chlorine Free) registered.

Contents

List of Figures

List of Tables

Executive Summary

This report constitutes an air quality further assessment conducted by the Transport Research Laboratory (TRL) for the Stratford St. Andrew Air Quality Management Area (AQMA) for Suffolk Coastal District Council. The further assessment report fulfils the requirements of the Local Air Quality Management (LAQM) framework, introduced under Part IV of the Environment Act 1995. Following an air quality detailed assessment conducted by TRL in 2013, the local authority declared an AQMA at 1-5 Long Row, Main Road (A12) in the village of Stratford St. Andrew in June 2014. This AQMA was declared due to exceedences of the annual mean nitrogen dioxide (NO_2) objective.

The further assessment confirmed the results of the detailed assessment in that the annual mean NO_2 objective continues to be exceeded within the Stratford St. Andrew AQMA but is met at other locations in the village. The AQMA is therefore still considered to be valid. Emissions from vehicles driving along the A12 were found to contribute to 80% of modelled NO_x concentrations in the AQMA compared to other local emission sources and the rural background. Of the road component, 53% of NO_x emissions were from lorries and buses compared to 7% from light goods vans and 39% from cars. Heavy duty vehicles only made up 6% of the average daily vehicle flow on the A12.

The further assessment involved a detailed analysis of drive cycle survey data and second by second emissions assessments. The main findings of this element of the study were that:

- Overall, total nitrogen oxide (NO_x) emissions across the survey section were consistent with the typical style of driving, with aggressive driving tending to result in higher emissions and a more passive (smoother) driving style causing the lowest emissions.
- There were no obvious increases in emissions specifically from vehicles turning right out of the fuel station and driving southbound towards the AQMA.
- NO_x emissions were highest at the road links close to the AQMA and speed limit sign.
- The main source of emissions at the AQMA originated from traffic driving in the southbound direction past the AQMA leaving the village rather than the traffic driving northbound.
- Moving the speed limit sign back by 150 metres was shown to reduce emissions in the southbound direction at the AQMA as vehicles accelerated further away from AQMA. However, this effect was countered by increasing emissions in the northbound direction. The survey showed that vehicles reduced their speed towards the new sign position to reach the speed limit and then actually accelerated slightly as they drove down the incline past the AQMA.
- Physically moving the road away from the façade of the properties in the AQMA by 1 metre is unlikely to result in the objective being met at this point.

The conclusion from the further assessment is therefore that a measure should be considered that lessens vehicle acceleration events in the southbound direction without increasing acceleration events in the northbound direction, i.e. essentially by allowing a more passive style of driving. This had the potential to result in the annual mean NO_2 concentration declining at the AQMA to below the objective. Moving the 50 mph speed limit sign to up to 200m from the existing point was not considered sufficient on its own to achieve this but installing average speed cameras in both directions for the length of the current 30 mph controlled zone is likely to result in the objective being met. Alternatively, the desired outcome may also be achieved if the speed limit sign was moved as far out of the village as possible (i.e. more than 300m) alongside the installation of vehicle-activated speed signs in the southbound direction at the start of the AQMA and in the northbound direction, on the opposite side of the road, (at the site of the existing 30 mph sign).

Blank Page

1 Introduction and purpose of the study

Under the Local Air Quality Management (LAQM) framework, introduced under Part IV of the Environment Act 1995 local authorities are required to review and assess concentrations of specified air pollutants against standards and objectives listed in the Air Quality Strategy (AQS) document for England, Scotland, Wales and Northern Ireland (Defra, 2007). In England, the air quality objectives applicable to LAQM are implemented by the Air Quality (England) Regulations 2000 (SI 928) and the Air Quality (England) (Amendment) Regulations 2002 (SI 3043). A summary of the regulated pollutants and the relevant AQS objectives is presented in Appendix A.

Under the LAQM regime, Suffolk Coastal District Council (SCDC) has completed five rounds of review and assessment and is currently undergoing round six. As part of this process, SCDC has declared three Air Quality Management Areas (AQMAs) due to exceedences of the annual mean nitrogen dioxide (NO_2) objective. The first AQMA was declared in May 2006 in the market town of Woodbridge around the junction with The Thoroughfare, Lime Kiln Quay Road and St John's Street. The second AQMA, declared in 2009 centres round a single property on Ferry Lane close to the Port of Felixstowe. Action plans have been developed and are being implemented for both AQMAs. SCDC is now moving to a detailed assessment in the Port of Felixstowe to look at revoking the AQMA on the basis that air pollution has been within statutory limits over the past three years. The most recent AQMA was declared on 18th June 2014 for four properties from 1-5 Long Row, Main Road in Stratford St. Andrew following a detailed assessment in 2013 (Savage and Turpin, 2013).

This further assessment focuses on the AQMA at Stratford St. Andrew (see Figure 4). The 2013 air quality detailed assessment recommended that additional diffusion tubes should be sited in the AQMA and that a more detailed analysis of vehicle emissions should be conducted to help target appropriate mitigation measures. This further assessment therefore presents the findings of this analysis which involved conducting a vehicle drive cycle survey that considered various driving patterns and scenarios. Second by second data were collected which were input into an instantaneous emission model and further analysed to help determine what may be required to meet the annual mean NO_2 objective.

In summary, the purposes of an air quality further assessment are to:

1. Assess whether the current AQMA designation is correct and whether any changes are needed.
2. Calculate when the objective is likely to be met at relevant receptor locations.
3. Determine the contribution of sources to emissions.
4. Determine possible mitigation.

The further assessment report is set out as follows:

- Background to air quality in Stratford St. Andrew (section 2)
- Nitrogen dioxide monitoring results (section 3)
- Drive Cycle Survey (section 4) and modelling Methodology (section 5)
- Results including contribution of sources and timescale to meet objective (section 6)
- Conclusion and proposed mitigation (section 7)

2 Description of Stratford St. Andrew

2.1 Location

Stratford St. Andrew is a small village located on the A12 in the Suffolk Costal district. There are approximately 15 houses located along the A12 itself, a filling station and garage. The speed limit entering the village from the north (Farnham) is 30 mph (see Figure 1) and this increases to 50 mph leaving the village towards the south (see Figure 2).

Figure 1: Approach to Stratford St. Andrew from the north.

Figure 2: 50 mph speed limit leaving village to the south.

2.2 Traffic characteristics

Given the characteristic of weather patterns it is expected that pollutant concentrations to the east of the road to be higher than the west. This is perhaps marginal given the trajectory of the road at this location which runs south west to north east. Under these conditions emissions would tend to disperse more so along the length of the road. A certain amount of recirculation and entrainment of emissions in the proximity of the terraced houses (Long Row) is likely to lead to elevated concentrations.

The average annual traffic flow along this stretch of the A12 is approximately 15,000 vehicles per day as broken down in Table 1. Of these, cars make up 80% of the traffic flow, Light Goods Vehicles (LGVs) make up 14% and Heavy Goods Vehicles (HGVs) and buses/coaches (all Heavy Duty Vehicles) make up 6%.

Table 1: Traffic flow and vehicle composition along the A12 at Stratford St. Andrew, 2013[1].

Grid reference	Annual daily vehicle flow (two way)						
	Motorcycles	Cars and Taxis	Buses and Coaches	LGVs	Rigid HGVs	Artic. HGVs	Total vehicles
635730,260000	82	12,340	82	2143	444	334	15,425

Queueing events can sometimes build up owing to vehicles turning right into and out of the fuel station towards the south. Traffic has been observed to accelerate from the fuel station, towards the AQMA and 50 mph speed limit sign. The speed limit changes from

[1] http://www.dft.gov.uk/traffic-counts/

30 mph to 50 mph as you exit the village at both the northerly and southerly end. At the southerly end, this occurs at a point close to the Long Row Cottages (i.e. the AQMA). Traffic travelling in the opposite direction decelerate from 50 mph down to 30 mph. Under these conditions emissions will increase in the south-westerly direction but decrease in the north-easterly direction.

2.3 Relevant exposure

The nearest properties to the road are a row of four cottages (1-5 Long Row). These are situated 2 metres from the kerb entering the village from the south west (see Figure 3). Other properties in the village are set back from the road. The local authority has had diffusion tubes located on the façade of 1 Long Row since 2011 with triplicate tubes since 2012. Following consultation on the detailed assessment, an AQMA was declared in 2013 for this row of cottages (Figure 4) and the monitoring network was expanded.

Figure 3: Long row cottages, Stratford St. Andrew.

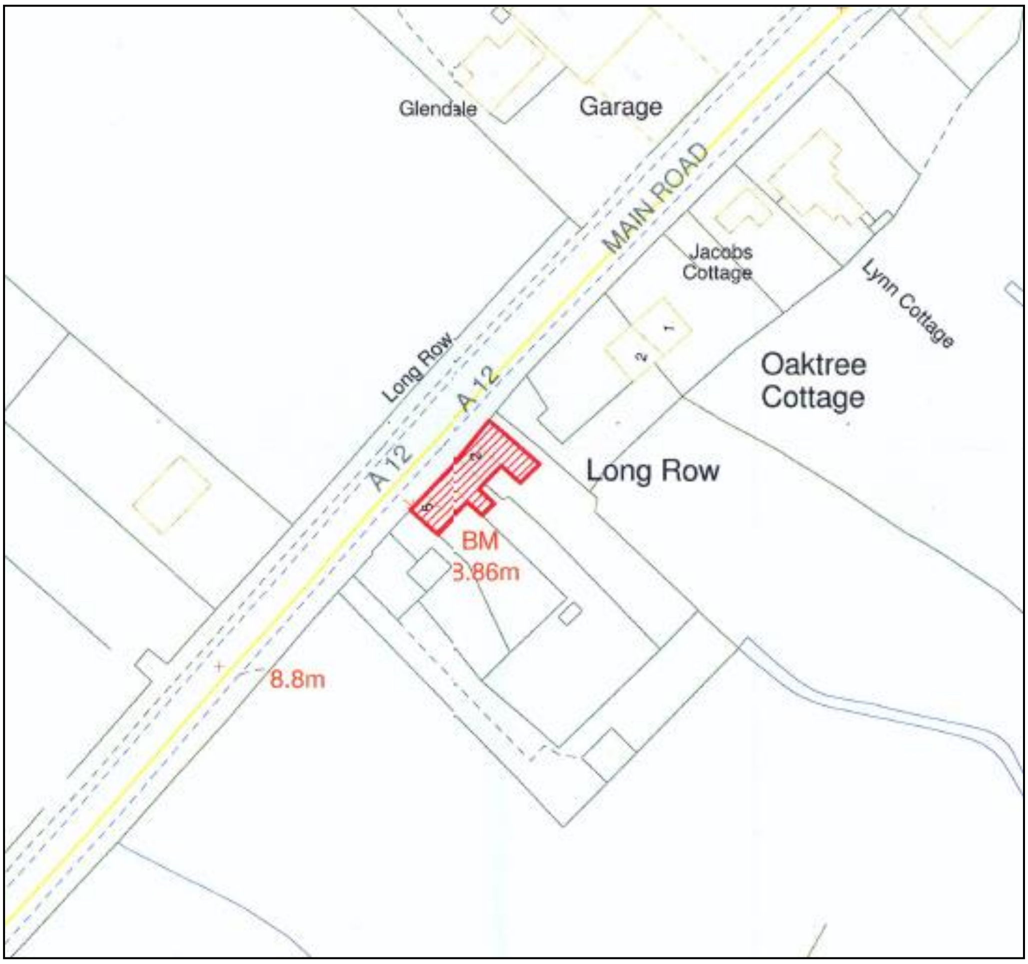

Figure 4: Stratford St. Andrew AQMA (from SCDC AQMA Order)[2]

[2] http://www.suffolkcoastal.gov.uk/assets/Documents/District/Air-quality/StrafordStAndrewAQMAJune2014.pdf

3 Monitoring data

NO_2 diffusion tube monitoring has expanded within the area over the last few years, with eight sites along the A12 in 2013 and 2014, six locations in 2012 and three sites in 2011. Details of diffusion tube site locations are provided in Table 2. These represent worst-case exposure are located on property facades where possible.

A map showing the locations of the diffusion tubes that were operational during 2014 along the A12 is provided in Figure 5.

The diffusion tubes are supplied and analysed by Environmental Scientifics Group (ESG), Didcot, using the 50% TEA (triethanolamine) in acetone method. Diffusion tubes can over or under read and the annual average obtained needs to be corrected to take account of laboratory bias thus improving accuracy. This can be done either by using a combined 'national' bias adjustment factor for the laboratory for the specific year or a local factor from diffusion tubes co-located with automatic monitoring sites. In the absence of any automatic monitoring sites, the local authority using the national bias adjustment factor to correct the data. In 2014 this was 0.81 based on the March 2015 version of the national bias adjustment factor spreadsheet[3].

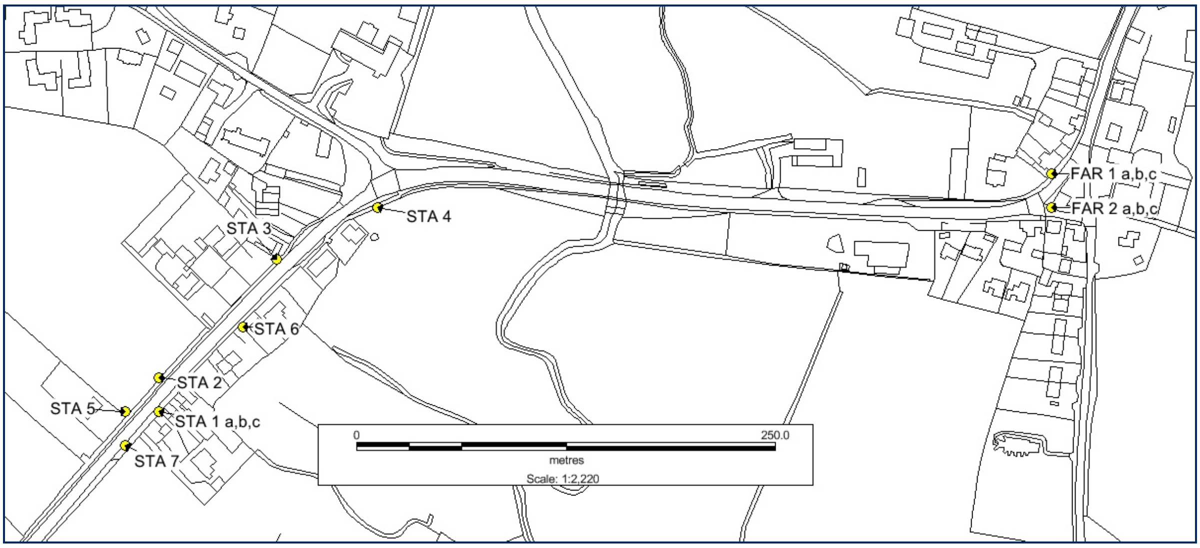

Figure 5: Location of NO_2 diffusion tubes in Stratford St. Andrew and Farnham (A12).

[3] http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

Table 2: Details of diffusion tube monitoring sites in Stratford St. Andrew and Farnham (A12).

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	Site Height (m)	Pollutants Monitored	In AQMA?	Is Monitoring Co-located with a Continuous Analyser (Y/N)	Relevant Exposure? (Y/N with distance (m) from monitoring site to relevant exposure)	Distance to Kerb of Nearest Road (m) (N/A if not applicable)	Does this Location Represent Worst-Case Exposure?
FAR 1 a,b,c	Farnham 1	Roadside	636270	260130	1.76	NO_2	No	N	Y 0m	3	Yes
FAR 2 a,b,c	Farnham 2	Roadside	636270	260110	1.92	NO_2	No	N	Y 0m	2	Yes
STA 1 a,b,c	Stratford St. Andrew 1	Roadside	635740	259990	1.62	NO_2	Yes	N	Y 0m	2	Yes
STA 2	Stratford St. Andrew 2	Roadside	635740	260010	1.78	NO_2	No	N	N 23m	1.72	Yes
STA 4	Stratford St. Andrew 4	Roadside	635870	260110	1.78	NO_2	No	N	N 35m	3.8	Yes
STA 5	Stratford St. Andrew 5	Roadside	635720	259990	1.20	NO_2	No	N	N 38m	2	Yes
STA 6	Stratford St. Andrew 5	Roadside	635790	260040	1.71	NO_2	No	N	Y 0m	6.9	Yes
STA 7	Stratford St. Andrew 5	Roadside	635720	259970	1.56	NO_2	No	N	Y 14m	1.85	Yes

The annual mean NO_2 concentrations measured at the diffusion tube sites during the last four years are given in Table 3 and in Figure 6.

Table 3: Annual mean NO_2 concentrations, 2011-2014.

Site ID	Location	Triplicate or Collocated Tube	Data Capture 2014 (%)	Annual mean concentration (bias correction factor) µg/m^3			
				2014 (0.81)	2013 (0.81)	2012 (0.79)	2011 (0.84)
FAR 1a,b,c	Turret House, The Street, Farnham	Triplicate	100	27.2	29.0	25.8	29
FAR 2a,b,c	Post Office Stores, The Street, Farnham,	Triplicate	100	29.0	31.0	30.7	33
STA 1a,b,c	1 Long Row, Main Road	Triplicate	100	**42.1**	**41.0**	**42.4**	**43**
STA 2	Opposite 1-5 London Row, Main Road	-	100	25.4	27.0	26.1	-
STA 4	Lowestoft Street sign, on bend of Main Road	-	100	14.8	17.0	24.0	-
STA 5	Great Glemham sign, opposite 1-5 London Row	-	100	-	-	18.2	-
STA 6	Jacobs Cottage, Main Road,	-	100	23.0	24.0	-	-
STA 7	30 mph sign, past 5 Long Row, Main Road	-	100	30.5	34.0	-	-

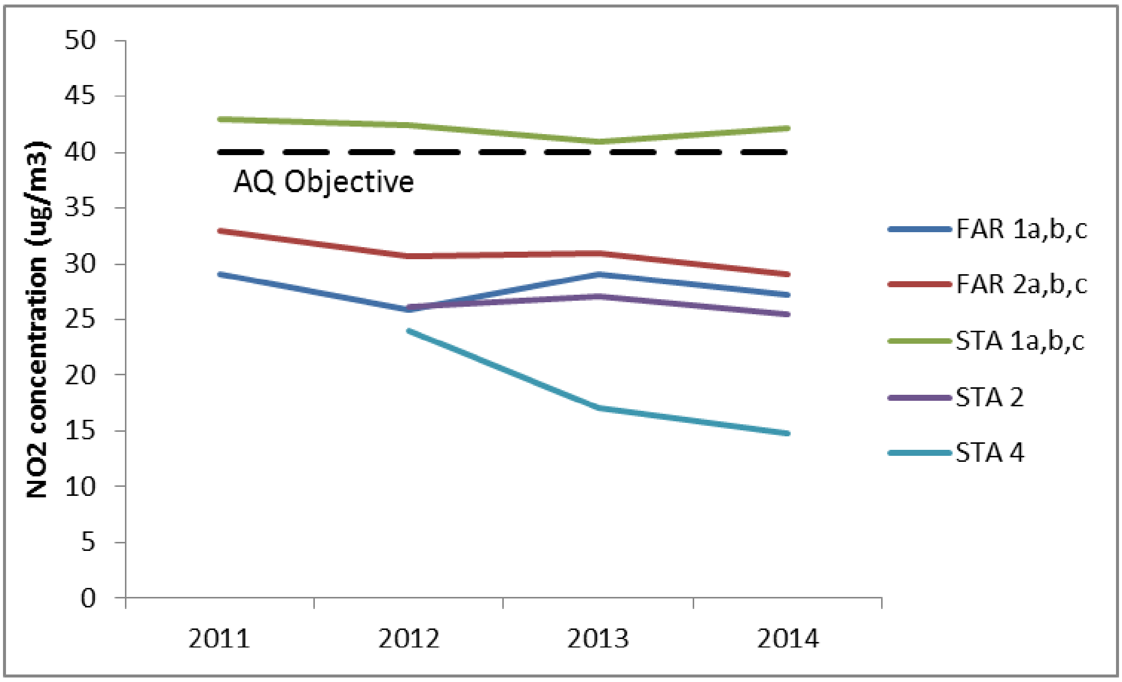

Figure 6: Trends in annual mean NO_2 concentrations.

The results show that the annual mean objective of 40 µg/m^3 was only exceeded at site STA 1, which is located approximately 2 metres from the roadside and directly on the façade of the property at 1 Long Row within the AQMA. Concentrations have declined in the last few years as shown in Figure 6. Concentrations at the other diffusion tube sites were noticeably lower than the objective.

4 Drive Cycle analysis

4.1 Drive cycle survey

The first step in the further assssment was to conduct a drive cycle survey to collect second by second speed data and then to conduct detailed analysis. A survey schedule was designed that allowed drive cycles to be conducted at different times of day in both directions along the A12. A survey car was instrumented with a VBox System[4] that reads the on-board diagnostic output to record a number of parameters that included speed, acceleration and gear selection. The VBox recorder also includes a GPS receiver used to log the location and operation of the instrumented vehicle.

Driving behaviour surveys were conducted on 24th September 2014. The following three profiles or styles of driving behaviour were recorded at different times of the day.

1. Typical style (applying a car following technique). Keeping behind the vehicle in front and mimicking its behaviour in both directions.
2. Passive style. Leaving the village in the south-westerly direction passing through the AQMA. Maintaining the 30 mph speed limit until the 50 mph sign and then accelerating smoothly up to 50 mph. On entering the village from the south-west, slowing down gently to 30 mph as the speed sign is approached.
3. Aggressive style. Leaving the village in the south-westerly direction maintaining a speed of 30 mph and then accelerating as quickly as possible up to 50 mph. In the opposite direction, entering the village at speed and then breaking harshly at the 30 mph sign.

4.2 Scenarios assessed

During the inter-peak (i.e. middle of the day) period only[5], two scenarios were tested whereby the speed limit sign was theoretically moved to 150 metres (scenario 1) and 200 metres (scenario 2) further outside of the existing speed limit designation at the edge of the village. Typical driving style was employed to accelerate to 50 mph at the new designated sign location and vice versa in the other direction. The aim of this was to determine if vehicles accelerated past the cottages, travelling soutbound out of the village and conversely decelerated towards the village so that they were maintaining a steady spead past the AQMA.

An additional scenario was attempted to simulate the impact of installing a speed bump at the 30 mph sign, but it was deemed to be too dangerous to investigate the resulting driving behaviour without first cordoning off the road.

4.3 Data processing and analysis

Over the course of the survey day, 84 independent surveys were driven acrosss both directions. These data (second by second) were downloaded from the in-car recording system and visualised spatially using GIS software. A total of 5,892 data points were recorded during the entire survey. These points are shown in Figure 7.

[4] VBox Automotive. https://www.vboxautomotive.co.uk/index.php/en/
[5] Inter-peak periods typically have less traffic and so make this type of analysis easier and safer to conduct.

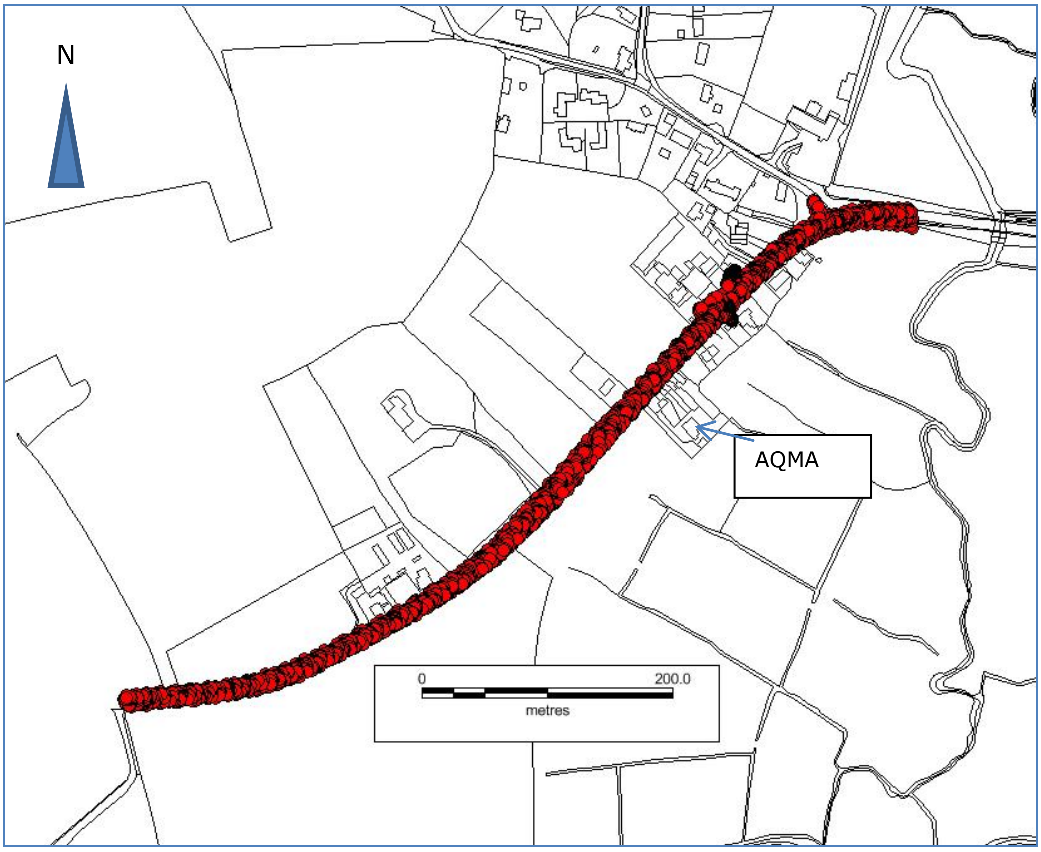

Figure 7: All driving cycle data points collected within Stratford St. Andrew

All logged data were checked in terms of spatial and operational integrity and were then processed into a format suitable for emissions modelling (see Section 5). Data were processed to identify individual driving cycles by time of day with specific driving styles and direction of travel and statistics including relative positive acceleration, deceleration, idling time, average speed at different times of day were calculated.

In this report, vehicles travelling in the northbound direction refer to those travelling essentially north-east into Stratford St. Andrew from Ipswich in the west. Vehicles travelling south-west are termed travelling in the southbound direction from Lowestoft, i.e. leaving the village with the AQMA located on the left.

5 Modelling methodology

5.1 Instantaneous emissions modelling

The initial derivation of emission rates from the drive cycle were analysed on a per vehicle basis (e.g. for a light and heavy vehicle) and then combined with traffic activity data obtained from the Department for Transport (DfT) as given in Table 1 to estimate total emission rates for the AQ analysis.

The PHEM[6] (**P**assenger car and **H**eavy-duty **E**mission **M**odel) was considered the most appropriate tool for this study (Rexeis *et al*., 2005). PHEM calculates the engine power in 1 Hz based on profiles of vehicle speed (the "driving cycle") and road gradient, the driving resistances and the losses in the transmission system. The 1 Hz course of engine speed is simulated based on the transmission ratios and a gear-shift model. Alternatively the course of engine load and/or engine speed can also directly be provided to the emission model. To take transient influences on the emission levels into consideration, the results from the emission maps are adjusted by means of transient correction functions.

All driving cycles were processed through PHEM. A typical output of PHEM is in grams per hour as shown in

Table 4. These values are then converted into grams for every second of the driving cycle based on consecutive paired values.

Table 4: Typical output from PHEM.

Run	Seconds	Avg Spd (miles/h)	Carbon monoxide (g/h)	Hydrocarbons (g/h)	Nitrogen oxides (g/h)	Particulate matter (g/h)	Fuel consumption (g/h)	Carbon dioxide (g/h)
2	0	0	0	0	0	0	0	0
2	1	1.9	73	13	456	8	7797	24570
2	2	5	216	13	665	15	12243	38445
2	3	4	138	3	86	6	875	2550
2	4	8	109	5	152	5	2214	6836
2	5	3.7	183	9	480	11	7764	24306

No emission tests were available for EURO VI in PHEM. Hence, emission factors for this standard were based on (optimistic) prognosis rather than based on engine testing. Every paired speed combination produces a reference value which corresponds to a specific point on the engine emission map. From here, an emission factor is then selected. This produces several thousand output files. A procedure was then developed to produce fleet weighted averaged emission rates (g/s) based on the base traffic data.

The following steps of further post processing were then required to produce fleet weighted emission outputs in a practical format for further modelling and analysis;

[6] PHEM = **P**assenger car and **h**eavy-duty **e**mission **m**odel.

1. Labelling of each emission event (per second) according to direction of travel, driving style and direction using GIS spatial analysis tools.
2. Summating emissions (g/s) for each event.
3. For practical reasons, partitioning all profiles into 15m distance bands to allow for a standardised form of spatial analysis to be conducted.
4. Deriving distance weighted emissions rates (g/km) by dividing (2) by the distance travelled in each zone.
5. Deriving emission rates in g/km/s for input into dispersion modelling (see Section 5.2) by multiplying the emissions by the traffic flow.

5.2 Dispersion modelling

Atmospheric dispersion modelling for the base year of 2014 was undertaken using the Gaussian ADMS-Urban model developed by Cambridge Environmental Research Consultants (CERC)[7]. Modelling was conducted for the stretch of the road close to the AQMA using the emission rates for the most typical existing situation and rates that represented possible solutions.

ADMS uses a number of input parameters to simulate the dispersion of pollutant emissions, predicting pollutant concentrations at specified receptors and across a user-defined area. The input parameters include emission source activity data, local meteorological conditions and site specific characteristics including latitude, boundary layer height and surface roughness.

5.2.1 Maps

Ordnance Survey based Geographical Information System (GIS) data of the model domains and road centrelines were used in the modelling assessment. This enabled accurate road widths to be determined in the MapInfo GIS system.

All maps are from OS Mastermap in this document are reproduced from Ordnance Survey material with the permission of Her Majesty's Stationery Office © Crown Copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings.

5.2.2 Modelled domain and receptors

2014 was selected as the base year for the modelling assessment due to the availability of monitoring data. For the purpose of this assessment, pollutant concentrations have been modelled at the diffusion tube monitoring sites, as given in Table 2 at the specified heights. There are considered to be no additional relevant receptors except for the cottages in the AQMA.

5.2.3 Road geometry and gradient

The geometry of each road link along the road was determined using GIS mapping data. Road width is defined by the kerb-to-kerb measurement (km). The height of

[7] Cambridge Environmental Research Consultants http://www.cerc.co.uk/software/admsroads.htm

surrounding buildings is accounted for in the model wherever a 'street canyon' effect is observed. For atmospheric dispersion modelling assessments, a street canyon is defined by the building heights being greater than the building-to-building road width (aspect ratio greater than 1.0). The street canyon module in ADMS was applied alongside the AQMA to represent the entrainment or suppressed turbulence of emissions at the Long Row cottages.

An assessment of gradient over the study areas was made and it was concluded that there were no roads with a gradient steeper than 1 percent in 10 (10 percent). As the terrain function of ADMS is only sensitive to gradients in excess of 10 percent, the effect of terrain or gradient was not included as part of the model set up. However, the PHEM emission model can accept gradient and a value of +1% was applied in the southbound direction and -1% in the northbound. There is a tendency for gradient effects to cancel each out in terms of emissions.

5.2.4 Background concentrations

To represent sources not explicitly included in the modelling, background values of NO_x and NO_2 for 2014 were taken from the Defra background maps based on 2010 data[8]. The background concentration in the relevant 1 km grid square within the modelled area is 15.5 µg/m^3 for NO_x and 10.7 µg/m^3 for NO_2. SCDC does not have a background monitoring site in Stratford St. Andrew to compare these values. However, these mapped concentrations are lower than those measured at the Woodbridge urban background site.

5.2.5 Atmospheric chemistry

The concentration of NO_2 at a specific location is determined by a combination of emissions, meteorology and atmospheric chemistry. Some NO_2 is emitted directly from vehicle exhaust (this is known as primary NO_2), a high proportion of which is from diesel vehicles. Emissions of NO_X from vehicles are primarily in the form of nitrogen oxide (NO) (AQEG, 2007). Nitrogen oxide undergoes a chemical reaction with oxidants such as ozone (O_3) to produce secondary NO_2. At a roadside location, there is routinely an excess of NO, and thus the limit to the formation of NO_2 is usually determined by the availability of O_3. At heavily trafficked roadside locations, there is not a linear relationship between the transformation of NO_X emissions and NO_2 concentrations.

Nitrogen dioxide concentrations have been derived from the road NO_X concentrations estimated by the ADMS model using the calculator[9] available on the LAQM tools section of the UK Air Quality Archive website.

5.2.6 Meteorological data

The ADMS-Roads model applies hourly sequential meteorological data to calculate atmospheric dispersion. This calculation involves a number of meteorological parameters including wind speed and direction, cloud cover and near surface temperature (the latter two parameters being important for the calculation of atmospheric stability, which affects how pollutants disperse). These parameters were taken from Wattisham, which is a considered to be a suitable site near to the AQMA. The

---

[8] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

[9] http://www.airquality.co.uk/archive/laqm/tools.php

year of 2014 was taken which is a typical year with wind directions predominately from the south west (see Figure 8).

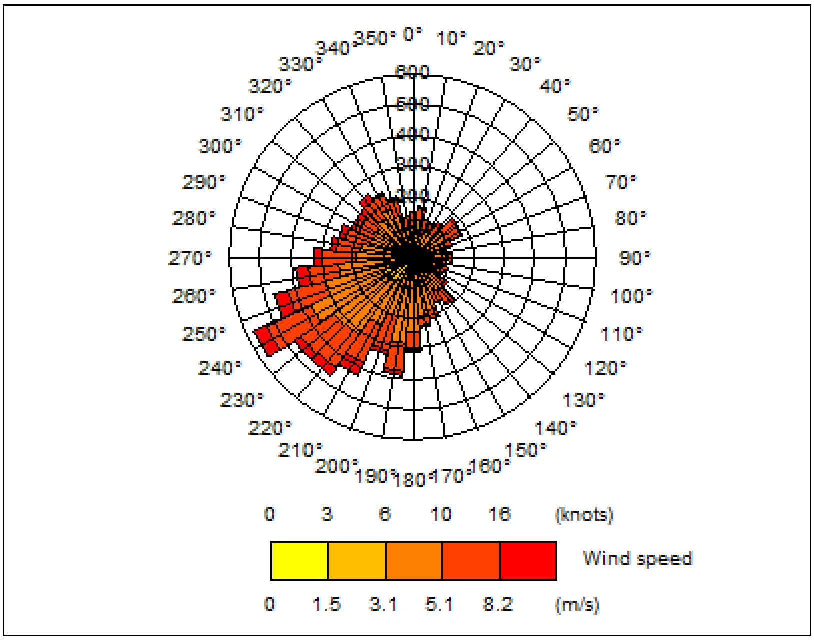

Figure 8: Wind speed and direction data from Wattisham meteorological station.

5.2.7 Surface roughness

The interaction of wind flow with the ground generates turbulence, influencing pollutant dispersion. The strength of this turbulence is dependent on the land use, with urban areas generating higher turbulence than open countryside. The ADMS user guide indicates that a surface roughness length of 1 m is suitable for cities and woodland and 0.5 m is suitable for parkland and open suburbia. This study used a surface roughness of 0.5 m.

The ADMS model allows the user to specify the surface roughness length of the site where meteorological data has been recorded (used when the surface roughness length at the meteorological site differs from that at the area under assessment). In this way, ADMS modifies the meteorological data to accommodate differences in surface roughness between the modelling domain and the geographical area from which meteorological measurements are obtained. The surface roughness length at the meteorological site used in this study was 0.5 metres.

5.2.8 Model verification

Model verification has been undertaken in line with LAQM.TG (09) (Defra, 2009). This process allows uncertainties in model results to be investigated and minimised. Monitored NO_2 concentrations have been converted to road NO_X concentrations using the calculator[10] available on the LAQM tools section of the UK Air Quality Archive website, using the relevant background concentration of NO_x and NO_2. Often an adjustment factor needs to be applied to the modelled road NO_x concentrations to minimise uncertainty in the modelled results. Every effort is made to check and then re-confirm

[10] http://www.airquality.co.uk/archive/laqm/tools.php

the model set up prior to applying any adjustment to modelled results (*e.g.* traffic and queuing activity, road link alignment, receptor locations, road widths, background concentrations *etc.*). However, the verification process often requires the modelled road NO_X to be factored up and the same adjustment is applied to all modelled scenarios. The results of this verification process are given in Section 6.3.

6 Results

6.1 Drive cycle statistics

The average speeds for the three driving styles and two scenarios across all runs in the morning and the afternoon, by direction of travel are summarised in Table 5. The table shows data for the entire route and for those data points collected immediately adjacent to the AQMA.

Across the route, the aggressive driving styles tended to have a higher average speed than the passive and typical driving styles, of 34 miles per hour (55 km/h) across the entire drive cycle (as given in Figure 7). The average speed adjacent to the AQMA at Long Row cottages was generally lower, For example, under typical driving styles, the average speed in the northbound direction was 29 mph and in the southbound direction towards the 50 mph sign this was between 28 mph to the speed limit of 30 mph. The maximum speed recorded under typical driving styles adjacent to the AQMA was 37 mph in the southbound direction.

Table 5 shows average speeds determined following a typical driving style for scenarios representing moving the sign further out of the village. For these, the values for the morning and afternoon periods are similar to driving behaviour conducted during the inter-peak period. At this stage, the results show that average speeds are similar to those in style 1 both across the entire route and adjacent to the AQMA, i.e. there is no obvious reduction in average speed when leaving the village if the speed limit is relocated. However the maximum speed is lower at 31 mph compared to that recorded in style 1.

In fact, the average speed across all three driving styles including the two scenarios is 30.4 mph with a standard deviation of ~2.2 mph. Hence, there would appear to be a reasonable level of consistency regarding average speed.

Table 5: Average speeds by direction, time of day and driving style (values given in miles per hour).

Direction	Time of day	Average speed (mph)				
		Style 1 (typical)	Style 2 (passive)	Style 3 (aggressive)	Scenario 1 (100 m sign)	Scenario 2 (200m sign)
Entire route Northbound	AM	33	31	34	31	32
	PM	32	29	34	31	32
AQMA Northbound	AM	29	28	27	27	28
	PM	29	29	31	27	28
Entire route Southbound	AM	35	33	34	32	31
	PM	29	33	35	32	31
AQMA Southbound	AM	27	30	28	31	29
	PM	30	29	30	31	29

For similar average speeds, transient driving behaviour can have a profound effect on the emissions profile. In other words emissions can vary considerably for similar average speeds. The following analysis is aimed at examining those transient effects.

The number of acceleration, deceleration and idle (stationary) events are illustrated for runs with **typical** driving styles in Figure 9 and Figure 10. Over the entire route, the proportion of acceleration and deceleration events is similar at 50:50 with very little idling time although there are a slightly higher proportion of vehicles accelerating in the southbound direction compared to northbound.

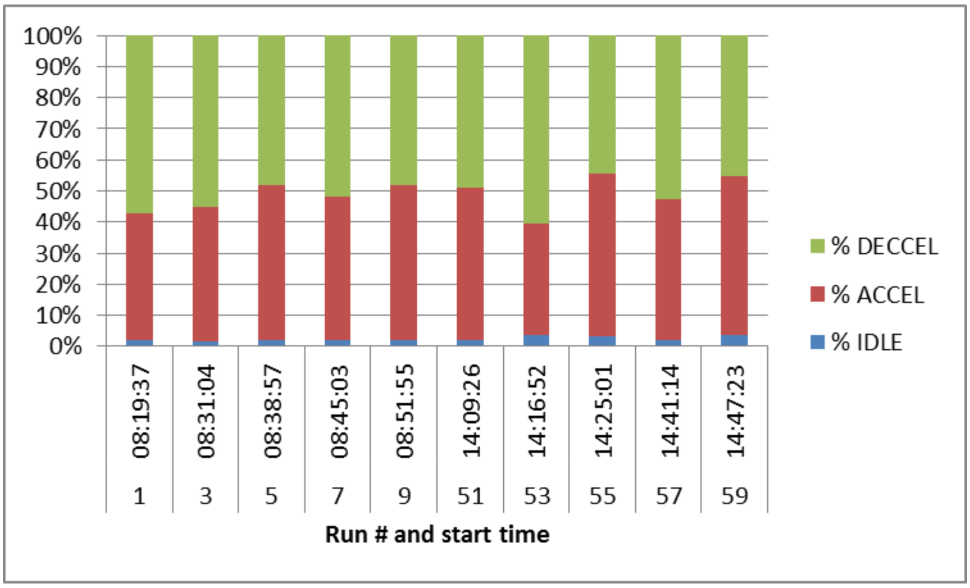

Figure 9: Proportion of acceleration, deceleration and idle time, typical driving style, northbound direction across entire drive cycle route.

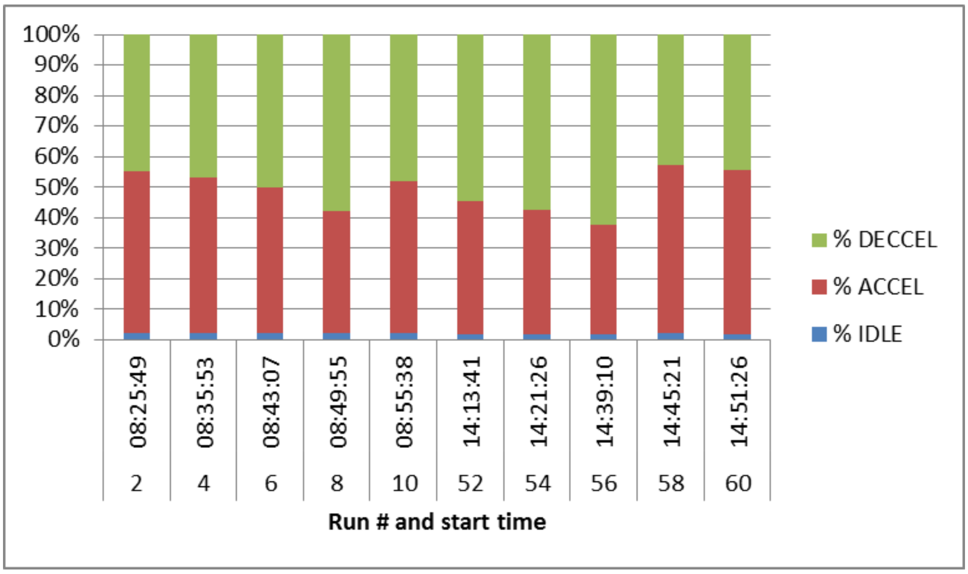

Figure 10: Proportion of acceleration, deceleration and idle time, typical driving style, southbound direction across entire drive cycle route.

Parts of the drive cycle that relate to the section of road adjacent to Long Row cottages show that there are many more acceleration events in the southbound direction (i.e. vehicles leaving the village accelerating from 30 to 50 mph) compared to those vehicles entering the village who are reducing their speed towards the 30 mph sign (see Figure 11 and Figure 12).

Figure 11: Acceleration and deceleration of vehicles travelling northbound close to the AQMA.

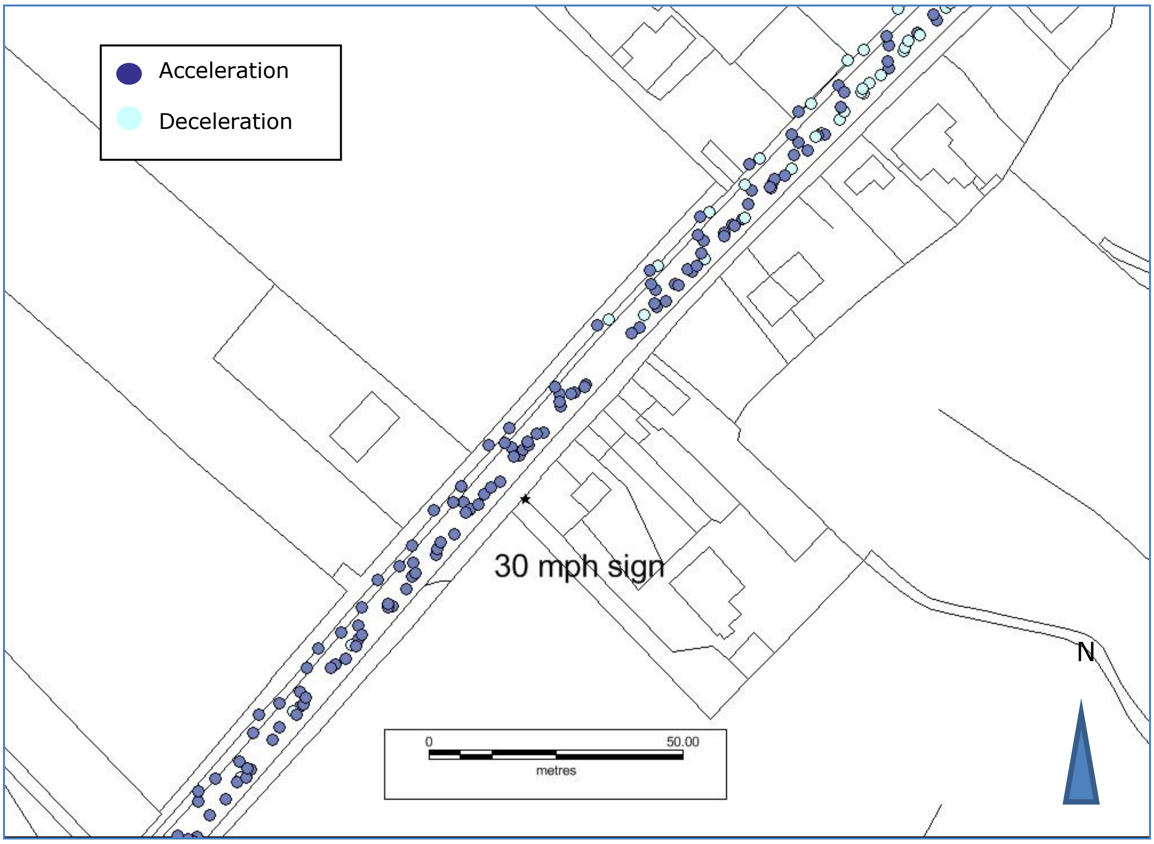

Figure 12: Acceleration and deceleration of vehicles travelling southbound close to the AQMA.

6.2 Emissions Profiles

6.2.1 Overview

This section provides the results of the emissions modelling to determine average emission profiles from the range of driving styles tested. By averaging the emissions within specific distance bands (i.e. every 15 meters) and then summing the result across the complete drive cycle(s), emissions from the light duty and heavy duty vehicles can be distinguished.

Table 6 summarises the results of the emissions modelling according to direction, time-of-day and driving style along the entire survey section of the A12. As expected, the typical driving style emissions are very similar to passive driving. In some cases a passive style of driving is not ideal in terms of emissions because the engine is not being optimised in terms of power demand. This means that driving very cautiously often means using a lower gear and hence the engine is working harder than required. Also, acceleration events may occur from a lower baseline speed which can ultimately cause high emissions. A passive form of driving however means that speed is generally lower which has safety benefits. Adopting an aggressive driving style would tend to increase emissions which would have an adverse effect on air quality.

Table 6: Total NO_x emissions along the A12, Stratford St. Andrew.

Direction (Period)	Driving style	Total NOx emissions (g)	
		Light Duty Vehicles (cars, taxis, LGVs)	Heavy Duty Vehicles (HGV, Buses and Coaches)
EB (AM)	Typical	0.18	3.57
WB (AM)	Typical	0.22	4.04
EB (PM)	Typical	0.20	3.70
WB (PM)	Typical	0.19	3.45
EB (AM)	Passive	0.22	4.17
WB (AM)	Passive	0.20	3.89
EB (PM)	Passive	0.23	3.84
WB (PM)	Passive	0.24	3.78
EB (AM)	Aggressive	0.33	5.35
WB (AM)	Aggressive	0.34	5.15
EB (PM)	Aggressive	0.25	3.91
WB (PM)	Aggressive	0.30	4.24

The results in Table 6 suggest that the lowest emissions occur in the afternoon (PM) period in the southbound direction (i.e. out of the village), by adopting a typical driving style. The second lowest emissions occurred in the northbound direction in the morning (AM) period again when adopting a typical driving style. On the whole this is fairly reassuring because it suggests that the general traffic situation may be optimum in terms of emissions throughout the survey section.

This summary table does not provide an indication of where these emissions occur along the A12. This is an important issue in terms of dealing with managing the situation within the AQMA. A detailed analysis of these emissions is provided in the tables in the sections below. Figures showing these emission profiles for the typical driving style are given in Appendix B.

This detailed analysis was conducted primarily to answer the following questions:

1. Do vehicles turning right into and out of the fuel station in the southbound direction result in higher rates of accelerations and speeds and therefore result in an increase in emissions towards the AQMA?
2. Whether different driving styles result in different emissions at various points in the road. If so, can a suitable measure be identified to encourage a particular driving style with lower emissions and therefore reduce concentrations at the AQMA?
3. Would moving the speed limit sign further south out of the village result in vehicles reducing their tendency to accelerate past the AQMA and therefore could this reduce emissions?

6.2.2 Typical driving style

Morning traffic, northbound direction (Table 7)

The results show that vehicle speed reduces towards the 30 mph sign and then goes below 30 mph once in the AQMA and then gradually rises towards the bend in the road the other side of the village. Between the speed sign and the bend in the road the vehicle speed stays below or near to 30 mph.

On passing the 30 mph speed sign, emissions for light and heavy vehicles appear to be at their lowest point (10% and 20% of the maximum NOx value respectively) approaching the AQMA and then begin to rise in line with increased speed through the survey section.

Table 7: Summary of statistics at points in the road, typical driving (AM period), northbound.

	Typical driving (AM)		
		% of Max NOx value	
Northbound	Average Speed (mph)	LDV	HDV
Speed Sign	33	5%	4%
AQMA	28	10%	20%
Fuel Station	28	13%	25%
Bend in road	29	20%	52%

Afternoon traffic, northbound direction (Table 8)

A very similar speed profile to that of the morning period is observed although speeds are slightly higher through the survey section. The traffic speed appears to comply with the 30 mph through the survey section. NOx emissions are consistently lower than in the morning period particularly for light vehicles. The heavy vehicle emissions profile is similar to that of the morning period but NOx levels at three of the reference sites are slightly lower.

Table 8: Summary of statistics at points in the road, typical driving (PM period), northbound.

Northbound	Typical driving (PM)		
		% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	29	15%	29%
AQMA	29	4%	4%
Fuel Station	27	7%	17%
Bend in road	28	11%	32%

Morning traffic, southbound (Table 9)

The gradient of the speed profile is fairly flat and vehicles appear to be below the 30 mph speed limit up to the bend in the road but then the speed begins to increase towards the 50 mph speed limit sign from the fuel station through the village. This gradual increase in speed from the fuel station has a gradual impact on NOx emissions. In terms of the percentage of the maximum NOx value the relative impact at the AQMA is higher than observed in the northbound direction. This is particularly evident for heavy vehicles where the maximum NOx value observed along the survey section occurs at the 50 mph speed limit sign.

Table 9: Summary of statistics at points in the road, typical driving (AM period), southbound.

Southbound	Typical driving (AM)		
		% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	36	87%	95%
AQMA	32	46%	72%
Fuel Station	31	19%	35%
Bend in road	28	28%	63%

Afternoon traffic, southbound (Table 10)

The speed profile is similar to the northbound direction whereby vehicle speed remains well below the 30 mph speed limit, although there still seems to be a trend where speed generally increases from the bend in the road towards the 50 mph speed limit sign. Again there appears to be a slight dip in the speed as vehicles pass the fuel station and then an increase towards the AQMA.

This driving behaviour has a commensurate impact on NOx emissions. Emissions increase slightly as the vehicle accelerates out of the bend, decreases slightly on approach to the fuel station and then there is a general increase in the NOx emissions as the vehicle accelerates towards the 50 mph sign. There would appear to be a slight dampening effect of the acceleration events during this period of the day. This is seen by comparing the percentage of the maximum NOx emission value at the four marker locations with the morning period. It is also observed that the average speed at each of the marker locations is slightly lower than in the morning. The distribution of the emissions according to the survey drive cycle is fairly balanced apart from the speed sign where vehicles accelerate more so.

Table 10: Summary of statistics at points in the road, typical driving (AM period), southbound.

	Typical driving (PM)		
		% of Max NOx value	
Southbound	Average Speed (mph)	LDV	HDV
Speed Sign	33	73%	86%
AQMA	29	25%	46%
Fuel Station	28	27%	51%
Bend in road	28	27%	48%

6.2.3 Passive Driving Style

This section discusses the conclusions drawn if a more passive driving style were to be adopted. By definition a passive driving style suggest something slightly more benign than what might be termed "typical". In other words the surveyor attempts to adopt a style considered to be on the cautious side.

Table 11 to Table 14 provide the average speed at the various marker locations which would be expected to be below the village speed limit of 30 mph. The only deviation from this being an exceedance observed passing the 50 mph speed limit sign (i.e. in the southbound direction).

As described previously, the passive style of driving did not result in reducing overall emissions through the surveyed section. However it does have an effect on emissions at the four marker locations. In terms of the percentage of the maximum NOx value, passive driving would appear to have a greater impact in the southbound direction (i.e. when compared to the typical style). At the AQMA the NOx emission with respect to the maximum value reduced by over 25%. There was no discernible effect in the northbound direction at the AQMA. This would suggest that if vehicle speeds were to be managed in a passive sense in the southbound direction **only**, then this would effectively reduce emissions at the AQMA. This is a reasonable conclusion to have some form of traffic calming in one direction only, but how could this be achieved without introducing further acceleration events which would have an adverse effect on emissions? This could be achieved by installing average speed cameras or vehicle activated cameras to encourage smoother driving styles.

Table 11: Summary of statistics at points in the road, passive driving (AM period), northbound.

	Passive driving (AM)		
		% of Max NOx value	
Northbound	Average Speed (mph)	LDV	HDV
Speed Sign	29	7%	15%
AQMA	28	11%	33%
Fuel Station	28	7%	21%
Bend in road	28	12%	37%

Table 12: Summary of statistics at points in the road, passive driving (PM period), northbound.

	Passive driving (PM)		
		% of Max NOx value	
Northbound	**Average Speed (km/h)**	**LDV**	**HDV**
Speed Sign	30	11%	32%
AQMA	29	8%	24%
Fuel Station	27	9%	28%
Bend in road	27	18%	50%

Table 13: Summary of statistics at points in the road, passive driving (AM period), southbound.

	Passive driving (AM)		
		% of Max NOx value	
Southbound	**Average Speed (mph)**	**LDV**	**HDV**
Speed Sign	32	49%	76%
AQMA	29	20%	42%
Fuel Station	27	21%	46%
Bend in road	28	13%	40%

Table 14: Summary of statistics at points in the road, passive driving (PM period), southbound.

	Passive driving (PM)		
		% of Max NOx value	
Southbound	**Average Speed (km/h)**	**LDV**	**HDV**
Speed Sign	32	92%	99%
AQMA	28	14%	33%
Fuel Station	28	15%	36%
Bend in road	26	11%	32%

6.2.4 *Aggressive Driving Style*

The aggressive style of driving was found to result in the highest emissions across the entire surveyed area. This is understandable as emissions are essentially the result of acceleration events; the harder the acceleration, the higher the emissions and the longer the acceleration event the higher the emissions.

At each reference location, the results show that the aggressive form of driving style actually had a positive effect on the percentage of the maximum NOx value compared to typical driving. The results are actually slightly more encouraging than adopting a passive style of driving at the AQMA in northbound direction in the morning and evening periods. A similar pattern is also shown for light and heavy duty vehicles in the southbound direction.

In the northbound direction the percentage of the maximum NOx value at the speed sign is low (similar to typical) which indicates that vehicles are decelerating at this point (see Table 15 and Table 16). In the southbound direction, aggressive acceleration resulted in

NOx emissions value being 100% (i.e. maximum) for light duty vehicles in the morning period and 100% for HDVs in the evening at the speed limit sign (see Table 17 and Table 18). This clearly indicates the tendency for vehicles to accelerate hard up to the speed sign and that this acceleration event is included within the AQMA.

These prolonged deceleration events in the northbound direction were found to actually reduce emissions compared to acceleration events and could then potentially improve air quality. However, the Council is unlikely to promote aggressive styles of driving as on the grounds of safety alone, promoting this type of driving can be discounted.

Table 15: Summary of statistics at points in the road, aggressive driving (AM period), northbound.

	Aggressive driving (AM)	% of Max NOx value	
Northbound	**Average Speed (mph)**	**LDV**	**HDV**
Speed Sign	39	2%	6%
AQMA	27	2%	7%
Fuel Station	25	9%	36%
Bend in road	29	9%	37%

Table 16: Summary of statistics at points in the road, aggressive driving (PM period), northbound.

	Aggressive driving (PM)	% of Max NOx value	
Northbound	**Average Speed (km/h)**	**LDV**	**HDV**
Speed Sign	40	2%	9%
AQMA	28	1%	4%
Fuel Station	25	9%	40%
Bend in road	28	10%	37%

Table 17: Summary of statistics at points in the road, aggressive driving (AM period), southbound.

	Aggressive driving (AM)	% of Max NOx value	
Southbound	**Average Speed (mph)**	**LDV**	**HDV**
Speed Sign	31	100%	97%
AQMA	27	14%	43%
Fuel Station	26	6%	17%
Bend in road	21	7%	23%

Table 18: Summary of statistics at points in the road, aggressive driving (PM period), southbound.

Southbound	Aggressive driving (PM)		
		% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	33	94%	100%
AQMA	30	10%	35%
Fuel Station	29	9%	30%
Bend in road	26	9%	36%

6.2.5 Scenario testing

This section examines the impact of two scenarios that were tested as part of the drive cycle surveys during the early afternoon periods. This was considered acceptable given the similarity of the temporal traffic characteristics observed on this section of the A12. The two scenarios involve estimating what would happen to emissions at the AQMA if the speed sign was to be relocated 150m (scenario 1) and 200m (scenario 2) south of its current location. This is perhaps more important in the southbound direction as if the speed sign is further away from the AQMA then are drivers more likely to reserve acceleration until the vehicle is closer to the speed sign.

The results in northbound direction during the evening are shown in Table 19. Compared to the typical traffic situation it would appear that the percentage of the maximum NOx value increased as a result for both light and heavy duty vehicles. This is probably caused by vehicles being conditioned to the speed further out of the village and then actually accelerating rather than decelerating down the incline past the AQMA.

Table 19: Summary of statistics at points in the road, scenario 1 (sign moved 150m), northbound.

Northbound	Typical driving (150m)		
		% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	26	14%	51%
AQMA	27	8%	29%
Fuel Station	27	5%	20%
Bend in road	24	10%	41%

The results are slightly more encouraging in the opposite direction (southbound). Table 20 shows that the percentage of the maximum NOx value at the AQMA for light duty and heavy duty vehicles reduced by 14% and 13% respectively (compared to typical). This would suggest that there is a tendency to hold back on acceleration as vehicles travel up the incline towards the new speed sign location.

Table 20: Summary of statistics at points in the road, scenario 1 (sign moved 150m), southbound.

Southbound	Typical driving (150m)	% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	26	12%	38%
AQMA	28	10%	33%
Fuel Station	27	12%	35%
Bend in road	28	10%	34%

The results appear to be similar if the speed sign was moved a further 50m back to 200m south of the current sign. The result of this would appear to suggest that the percentage of the maximum NOx value would increase in the northbound direction more so at the AQMA. This is probably due to the heightened effect of the traffic slowing at the speed sign and then accelerating down the incline through the AQMA (Table 21).

Table 21: Summary of statistics at points in the road, scenario 2 (sign moved 200m), northbound.

Northbound	Typical driving (200m)	% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	29	4%	12%
AQMA	28	16%	55%
Fuel Station	27	7%	26%
Bend in road	27	8%	35%

In the southbound direction the survey results showed that the resulting impact on NOx emissions are slightly less promising than setting the sign at 150m with higher maximum NOx emissions at the speed sign an AQMA for some reason (Table 22).

Table 22: Summary of statistics at points in the road, scenario 2 (sign moved 200m), southbound.

Southbound	Typical driving (200m)	% of Max NOx value	
	Average Speed (mph)	LDV	HDV
Speed Sign	30	27%	54%
AQMA	30	15%	38%
Fuel Station	30	12%	32%
Bend in road	28	15%	46%

No driving cycles were conducted to consider moving the speed sign even further away (for example 300m or more). However, it may be the case that if the sign was moved so it wasn't visible from the cottages (past the bend in the road in the southbound direction), then vehicles would be less likely to start to accelerate at the AQMA and be driving in a more optimal typical or passive style.

6.2.6 Summary

The following conclusions can be drawn from this detailed consideration of the emission profiles:

- Overall, the total emissions across the survey section agreed with the style of driving, with aggressive driving typically resulting in higher emissions and passive driving causing the lowest emissions.
- Although the general traffic was found to increase speed past the fuel station towards the speed limit sign in the southbound direction, there were no obvious increases in emissions from vehicles that turned right into and out of the fuel station and accelerated southbound.
- Emissions were highest at the road links close to the AQMA and speed limit sign and the main issue at the AQMA originated from **traffic driving in the southbound direction through the AQMA leaving the village.**
- Moving the speed limit sign back by 150 m was shown to reduce emissions in the southbound direction at the AQMA as vehicles tended to start accelerating further away from AQMA as they drive up the incline towards the new sign position. However, this may be countered by increasing emissions in the northbound direction. This is because the survey showed that vehicles reduced their speed towards the new sign position to reach the speed limit and then actually accelerated slightly as they drive down the incline past the AQMA.

The conclusion from the emissions assessment is therefore that a measure should be introduced that could successfully lessen vehicle acceleration in the southbound direction without increasing acceleration in the northbound direction, i.e. by allowing a more passive style of driving.

6.3 Modelled concentrations

The model verification process showed that there was relatively good agreement between modelled and measured road NO_x concentrations at the diffusion tubes closest to the target area (AQMA). The model was found to over-read at two sites (STA1 and STA7) to the south of the road and under-read at STA5 and STA6 (north of the road). Plotting the relationship of these data provided an adjustment factor of 0.9469 as shown in Figure 13. This factor was applied to the modelled road NO_x concentrations at all sites as shown in Table 23. The NOx to NO_2 calculator was used to determine the modelled NO_2 concentrations by assuming the background concentrations for this site. These modelled NO_2 concentrations showed a good agreement with the measured concentrations, with less than 15% difference at all diffusion tube sites, or approximately +/- 2µg/m^3 uncertainty[11].

[11] Based on the annual mean NO_2 objective

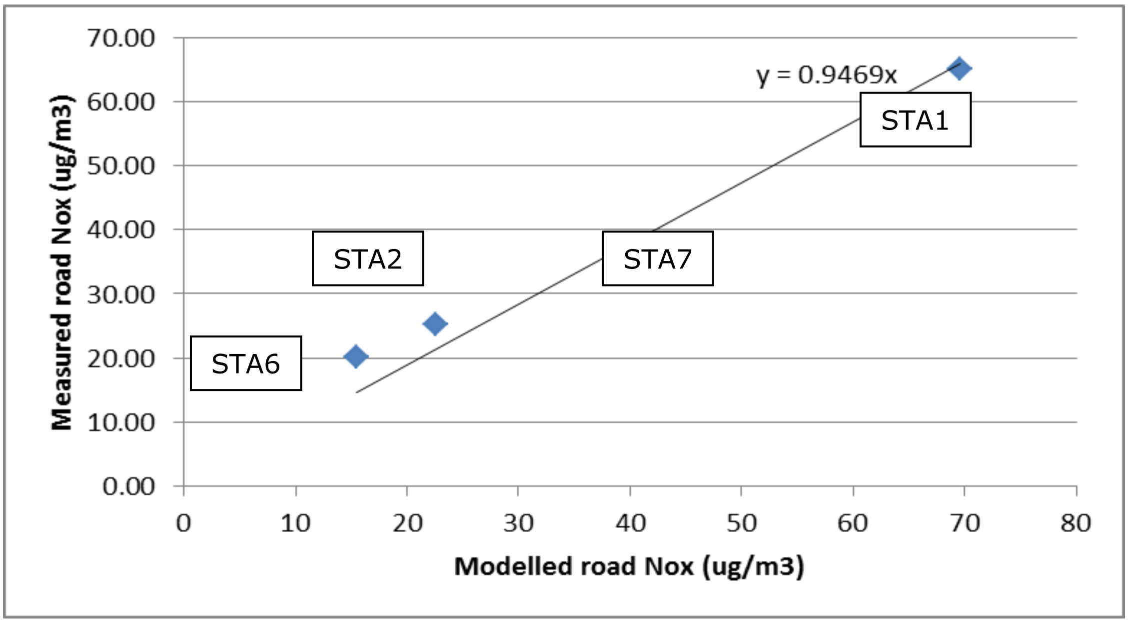

Figure 13: Relationship between modelled and measured annual mean road NO_x concentrations.

Table 23: Model verification at selected diffusion tube sites.

Receptor	Annual mean concentration (µg/m³)						
	Background NOx	**Modelled Road NOx**	**Measured Road NOx**	**Adjusted Modelled Road NOx**	**Modelled NO2**	**Measured NO2**	**% Diff**
STA1	15.5	69.62	65.01	65.92	**42.43**	42.10	1%
STA2	15.5	22.59	25.21	21.40	23.59	25.40	-7%
STA6	15.5	15.46	20.13	14.64	20.32	23.00	-12%
STA7	15.5	41.30	36.50	39.11	31.62	30.50	4%

The modelled results of the typical driving situation and the two scenarios deemed the most appropriate given the results of emissions analysis are given in Table 24. These two scenarios are presented here as having the most beneficial impact on emissions. The other scenarios or forms of driving were discounted on the basis of increased emissions or safety concerns.

In summary, the following three situations have been modelled:

- Typical driving – An average of the emission rates chosen from typical driving styles across the morning and afternoon periods in both the northbound and southbound directions.
- Passive (optimistic) driving – The lowest emission rates from the passive driving style taken for the southbound direction and typical emission rates assumed for the northbound.
- Passive (pessimistic) driving – The highest emission rates from the passive driving style taken for the southbound direction and typical emission rates assumed for the northbound. It is noted that for one link (close to the speed limit

sign, the highest passive emission rate was actually higher than the typical driving rate).

Table 24: Modelled concentrations at diffusion tube sites with three scenarios.

Receptor	Annual mean concentrations (µg/m^3)					
	Typical		Passive (optimistic)		Passive (pessimistic)	
	Adjusted Modelled Road NOx	Modelled NO_2	Adjusted Modelled Road NOx	Modelled NO_2	Adjusted Modelled Road NOx	Modelled NO2
STA1	65.92	**42.43**	32.51	28.72	44.02	33.72
STA2	21.40	23.59	13.38	19.7	16.80	21.38
STA6	14.64	20.32	14.22	20.11	16.00	20.99
STA7	39.11	31.62	19.08	22.48	44.31	33.84

The results of the air quality modelling show that assuming typical driving, the annual mean objective of 40 µg/m^3 is exceeded at the STA1 diffusion tube only (within the AQMA). However, the model results for both the scenarios show that this objective could be met if measures were put in place to encourage more passive driving styles in the southbound direction for traffic directly passing the AQMA.

Following discussions with the County, a consideration was made to the likely impact of physically moving the road 1 metre further away from the relevant receptors in the AQMA. Dispersion modelling was conducted to estimate the impact on receptors located at various distances away from the road source from STA1. The modelling results found that the annual mean objective was still likely to exceed the objective if the road was moved 1 m further away (the modelled value was 41.5 µg/m^3) but by 2 m, the objective may be met.

6.4 Contribution of Sources

One of the requirements of a further assessment report is to assess the contribution of the main sources to NO_x and/or NO_2 concentrations. This assessment been conducted at the worst case site (STA1) and at STA6 which has the lowest concentrations. In terms of NO_x, the predominant contribution is from vehicle emissions on the main road (A12). When compared to all other sources given within the mapped background file, this contribution is 83% at STA1 and 54% at STA6. Figure 14 and Figure 15 illustrate this breakdown of sources in more detail for both sites – for the main road, local minor roads, other sources in the area (e.g. domestic heating, rail, industrial emissions) and rural sources from outside of the area. In terms of modelled NO_2 concentrations, the road component contributes to slightly less than that for NO_x, (70% at STA1) but is still the dominant source of emissions.

Although heavy duty vehicles (HDVs) only contribute to 6% of the vehicle flow on the A12, their contribution to modelled road NO_x emissions is high compared to emissions from other vehicle types. At site STA1 in the AQMA, HDVs were found to contribute to 53% of the modelled road NO_x concentrations compared to 47% from LDVs (of which

39% are from cars). This breakdown of contribution by vehicle type is given in Figure 16.

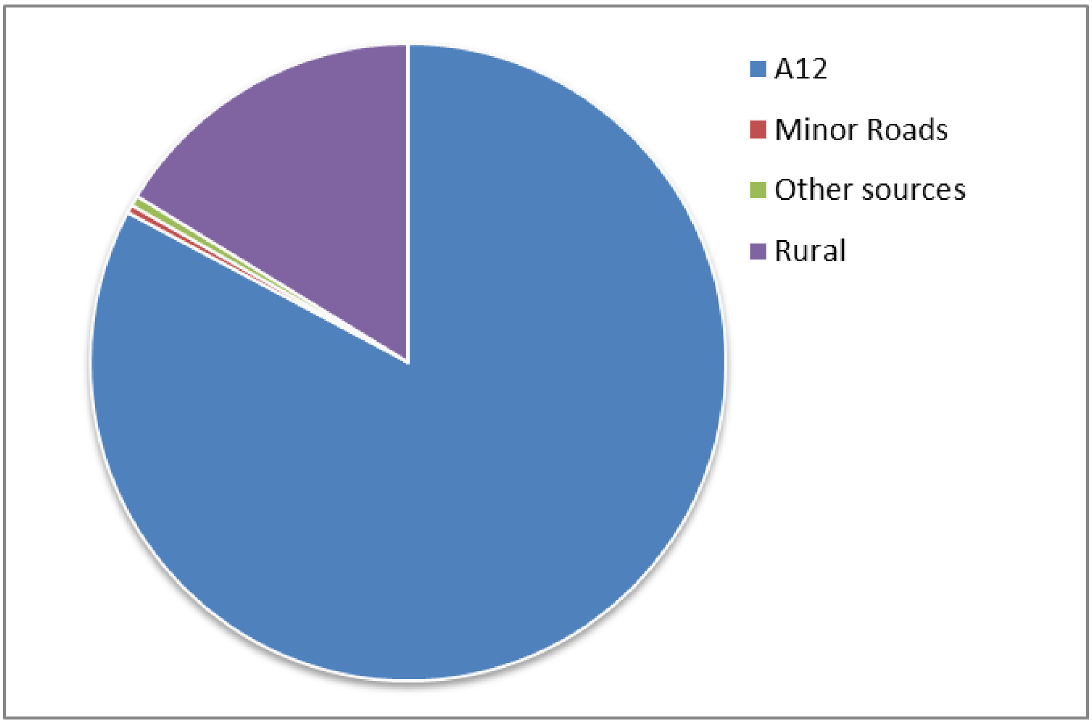

Figure 14: Contribution of sources to total modelled NO_x concentrations, STA1.

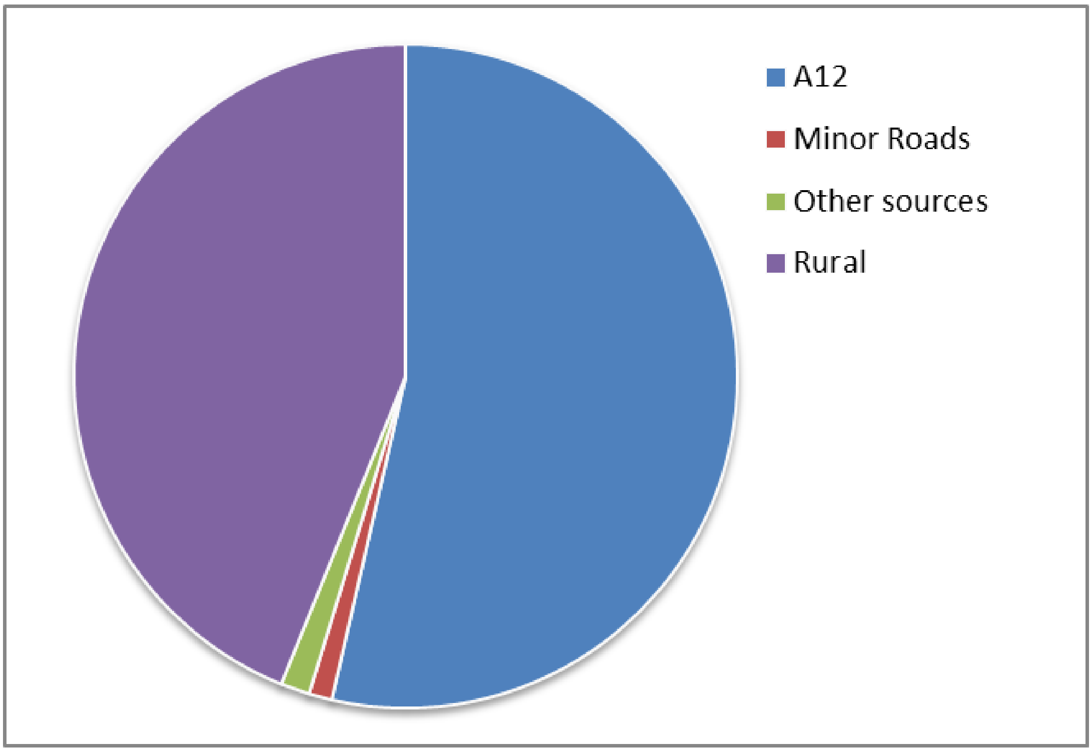

Figure 15: Contribution of sources to total modelled NO_x concentrations, STA6.

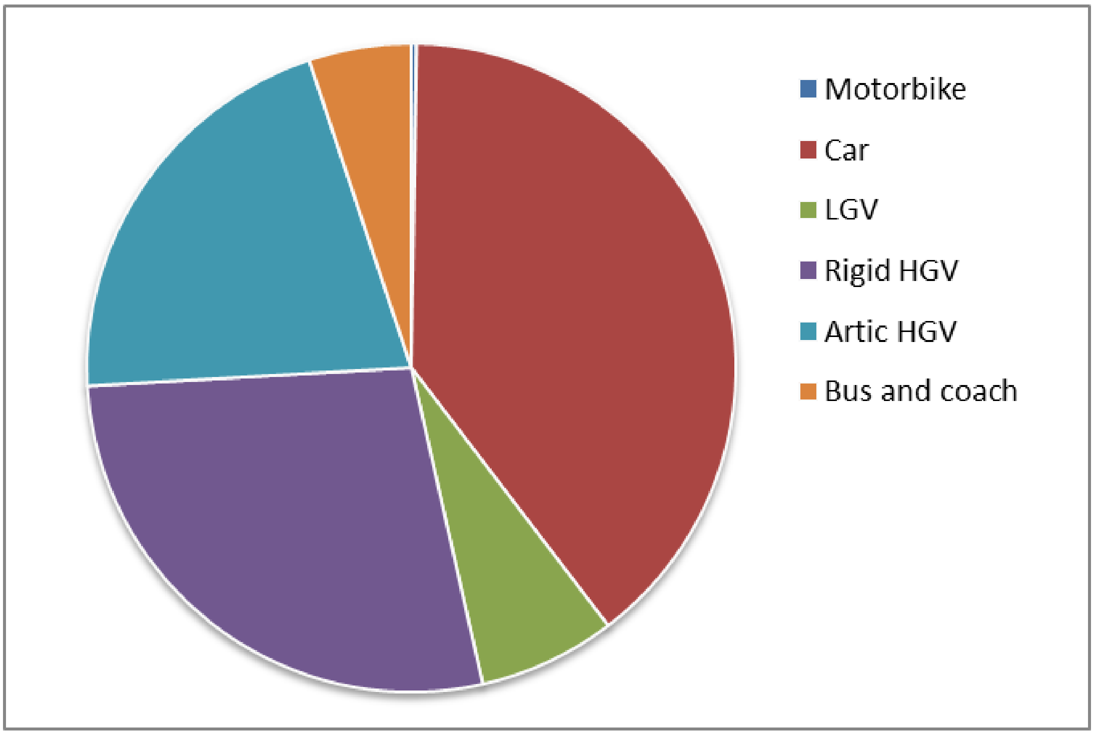

Figure 16: Contribution from emissions from vehicle types to modelled road NOx concentrations, STA1.

6.5 Timescale to meet annual mean objective

Application of Defra's forecasting concentration tools[12] suggest that the annual mean NO_2 objective will be met in the AQMA by 2016 based on the 2014 measured concentration at diffusion tube STA1. These forecasts are based on the performance and infiltration into the vehicle fleet of Euro 5/V and Euro 6/VI emission standards. The forecast does not however account for the fact that, in a real world situation, a proportion of these vehicles are not performing as expected and emissions are tending to increase as a result. This is shown in Stratford St Andrew by the fact that measured concentrations at STA1 were higher in 2014 than in 2013.

On this basis it is strongly recommended that intervention is taken locally to improve the respiratory health risk factors with the AQMA. If the local authority take on board the recommendations in the report to encourage passive driving styles, then it is likely that that the annual mean objective will be met within the year.

[12] http://laqm.defra.gov.uk/technical-guidance/index.html

7 Conclusion and proposed mitigation

The further assessment has shown that the annual mean NO_2 objective continues to be exceeded within the Stratford St. Andrew AQMA but is met at other locations in the village. The main source of NOx emissions is from vehicles driving along the A12 (both light duty and heavy duty vehicles). As part of this assessment, a number of detailed analysis were conducted to assess the existing driving situation and model the impact of various scenarios or driving styles to assist the Council in identifying suitable mitigation measures to meet the annual mean NO_2 objective at the AQMA.

Physically moving the road away from the façade of the properties in the AQMA by 1 metre was not shown to result in the objective being met at this point. Therefore the recommendations of the further assessment were that the most effective treatment of the traffic to reduce emissions and meet the objective at the AQMA would be to install a measure that smoothed the driving style to be more passive. If this type of driving style could be achieved in the southbound direction without increasing emissions in the northbound direction, then the results of the further assessment has shown that the objective is likely to be met at the AQMA.

There are a number of measures that could be considered as a means to encourage drivers to drive in a more passive and smoother style. Based on the analysis, average speed cameras are considered to be the most effective means to achieve this. To achieve maximum benefit, these should be installed in both directions within the 30 mph controlled zone. An alternative solution that may also give the desired outcome (but that wasn’t analysed as part of this study) could be to move the existing 50 mph speed limit sign to more than 300 m away in the southbound direction. This measure alone is unlikely to result in the objective being met and should be considered alongside installation of vehicle activated signs, one located at the start of the AQMA in the southbound direction and the existing 30 mph speed limit sign on the northbound direction could also be replaced by a vehicle activated 30 mph sign. In addition to this, the current 50 mph speed limit sign should be changed to a 30 mph sign. This would help to reduce acceleration events both north and southbound at the location of the AQMA.

References

Defra (2007). The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. Defra, London.

Defra (2009). Local Air Quality Management Technical Guidance LAQM.TG (09). Department for Environment, Food and Rural Affairs. Defra, London.

Savage and Turpin (2013). Air Quality Detailed Assessment for Stratford St. Andrew. Prepared for Suffolk Coastal District Council.

Suffolk Coastal District Council (2014). 2014 Air Quality Progress Report. In fulfilment of Part IV of the Environment Act 1995 Local Air Quality Management. Dec 2014.

Glossary of terms and abbreviations

AADT	Annual Average Daily Traffic
ADMS	Atmospheric Dispersion Modelling System
AQEG	Air Quality Expert Group
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
CERC	Cambridge Environmental Research Consultants
Defra	Department for Environment, Food and Rural Affairs
ESG	Environmental Scientifics Group
HDV	Heavy Duty Vehicle (includes buses and HGVs)
HGV	Heavy Goods Vehicle (over 7.5 tonnes)
GIS	Geographic Information System
LAQM	Local Air Quality Management
LDV	Light Duty Vehicle (under 7.5 tonnes)
LGV	Light Goods Vehicle (between 3.5 tonnes and 7.5 tonnes)
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_X	Total Oxides of Nitrogen
O_3	Ozone
Pb	Lead
PHEM	Passenger car and Heavy-duty Emission Model
$PM_{10}/PM_{2.5}$	Particulate matter less than 10 microns or 2.5 microns in diameter
SCDC	Suffolk Coastal District Council
TEA	Triethanolamine
TRL	Transport Research Laboratory

Appendix A Air Quality Objectives

Table A1: Summary of Air Quality Strategy (AQS) Objectives (Defra, 2007).

Pollutant	Objective	Compliance date
NO_2	Hourly mean concentration should not exceed 200 µg/m^3 more than 18 times a year. Annual mean concentration should not exceed 40 µg/m^3.	31 December 2005
Particulate matter, expressed as PM_{10}	24-hour mean concentration should not exceed 50 µg/m^3 more than 35 times a year. Annual mean concentration should not exceed 40 µg/m^3. *Scotland:* 24-hour mean concentration should not exceed 50 µg/m^3 more than 7 times a year. Annual mean concentration should not exceed 18 µg/m^3.	31 December 2004 31 December 2005 31 December 2010
Particulate matter, expressed as $PM_{2.5}$	*UK urban areas* Target of 15% reduction in concentrations at urban background. Annual mean concentration should not exceed 25 µg/m^3. *Scotland:* Annual mean concentration should not exceed 12 µg/m^3.	Between 2010 and 2020 31 December 2004
Benzene	Running annual mean concentration should not exceed 16.25 µg/m^3. *Scotland & Northern Ireland:* Running annual mean concentration should not exceed 3.25 µg/m^3. *England & Wales:* Annual mean concentration should not exceed 5 µg/m^3.	31 December 2003 31 December 2010 31 December 2010
1,3-butadiene	Running annual mean concentration should not exceed 2.25 µg/m^3.	31 December 2003
CO	Maximum daily running 8-hour mean concentration should not exceed 10 mg/m^3. In Scotland it is expressed as a running 8-hr mean.	31 December 2003
PAHs	Annual mean concentration of B(a)P should not exceed 0.25 ng/m^3	31 December 2010
Lead (Pb)	Annual mean concentration should not exceed 0.5 µg/m/^{3}. Annual mean concentration should not exceed 0.25 µg/m^3.	31 December 2004 31 December 2008
SO_2	Hourly mean of 350 µg/m^3 not to be exceeded more than 24 times a year. 24-hour mean of 125 µg/m^3 not to be exceeded more than 3 times a year. 15-min mean of 266 µg/m^3 not to be exceeded more than 35 times a year.	31 December 2004 31 December 2005
Ozone (O_3)	Running 8-hour concentration of 100 µg/m^3 not to be exceeded more than 10 times a year	31 December 2005

Appendix B Emission profiles – typical driving style

These figures show average speed (in km/h) verses NO_x emissions – separately for light duty vehicles (LDV) and heavy duty vehicles (HDV) for north and southbound journeys along the drive cycle. The figures indicate the position of the speed limit sign, AQMA, fuel station and the bend in road in both directions.

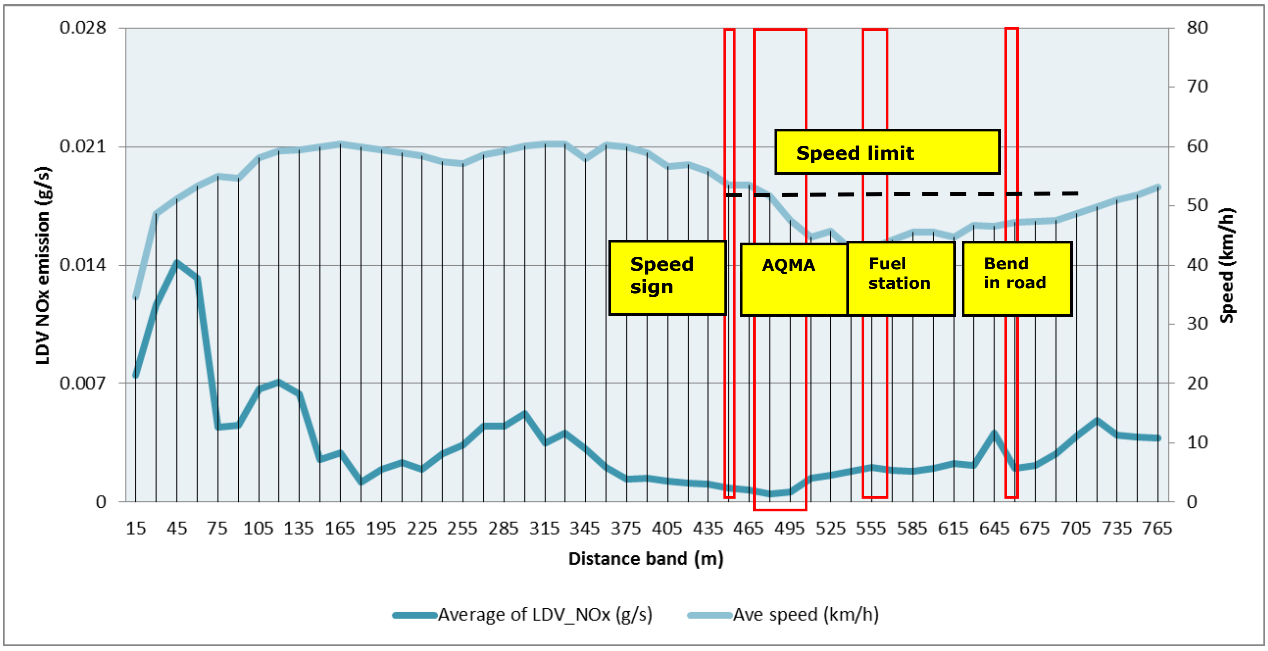

Figure 17: LDV emissions and average speed profile across the drive cycle, typical driving (AM period), northbound.

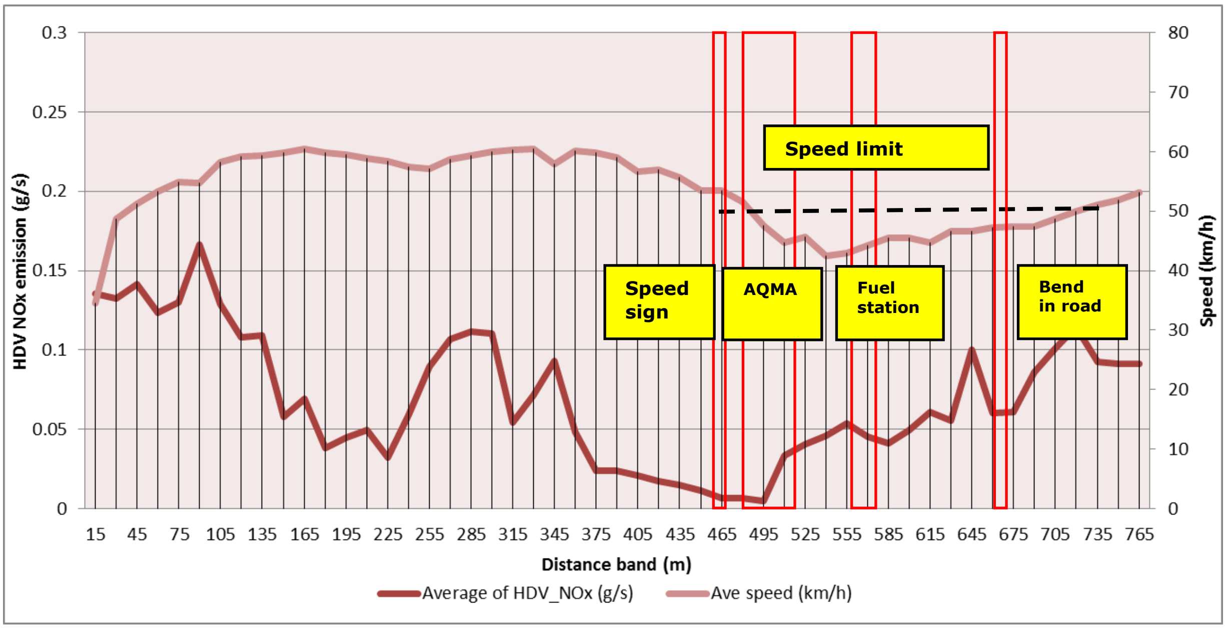

Figure 18: HDV emissions and average speed profile across the drive cycle, typical driving (AM period), northbound

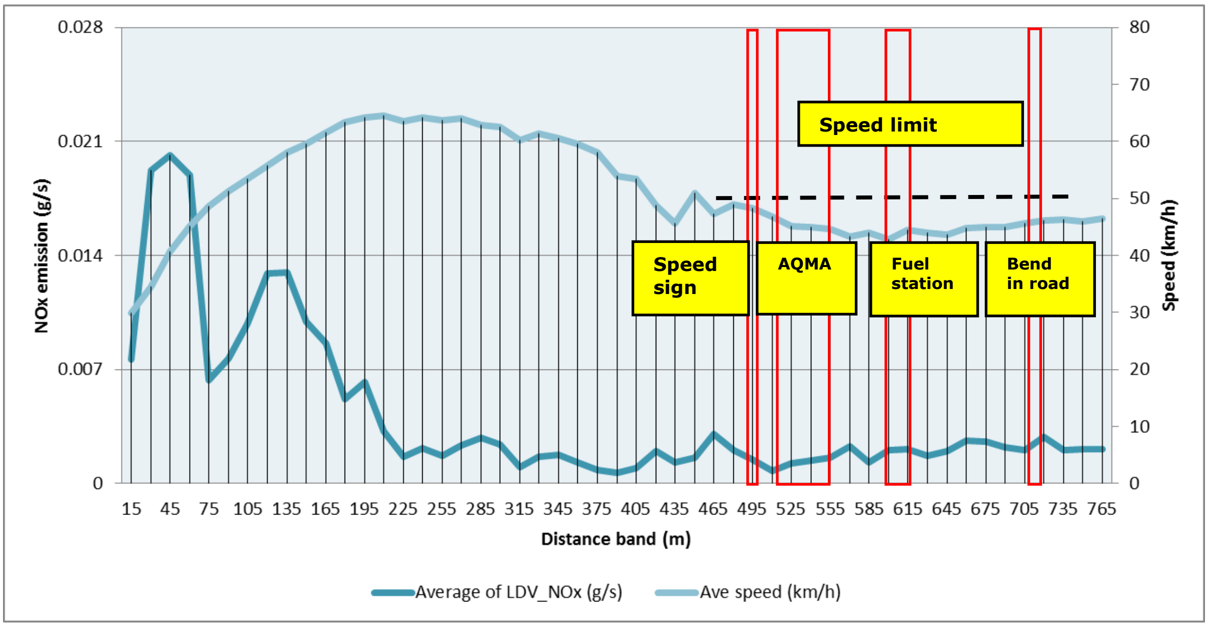

Figure 19: LDV emissions and average speed profile across the drive cycle, typical driving (PM period), northbound.

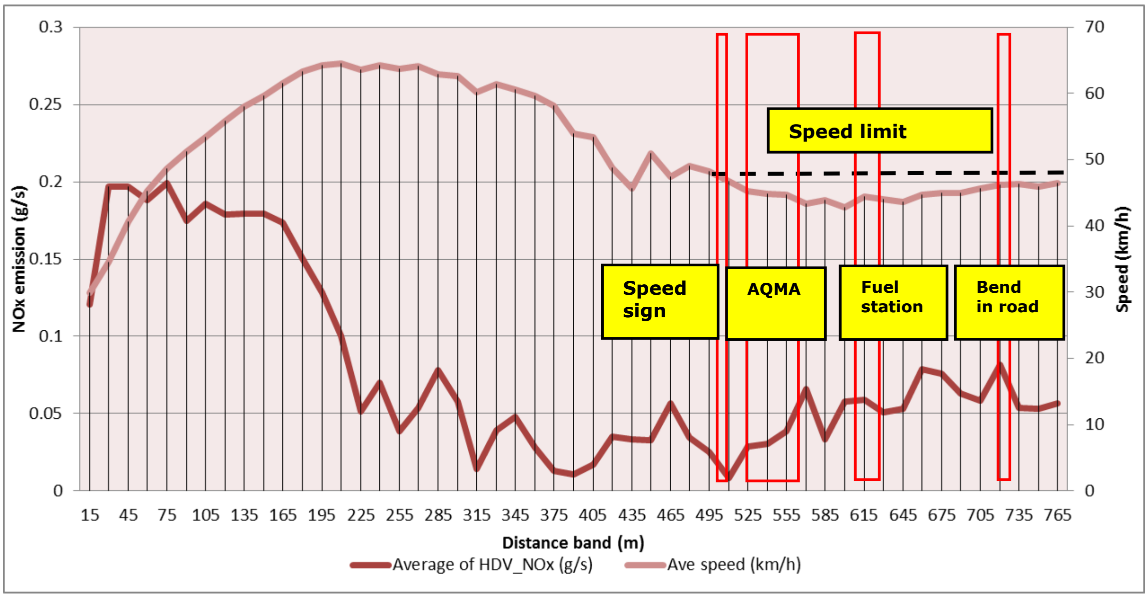

Figure 20: HDV emissions and average speed profile across the drive cycle, typical driving (PM period), northbound.

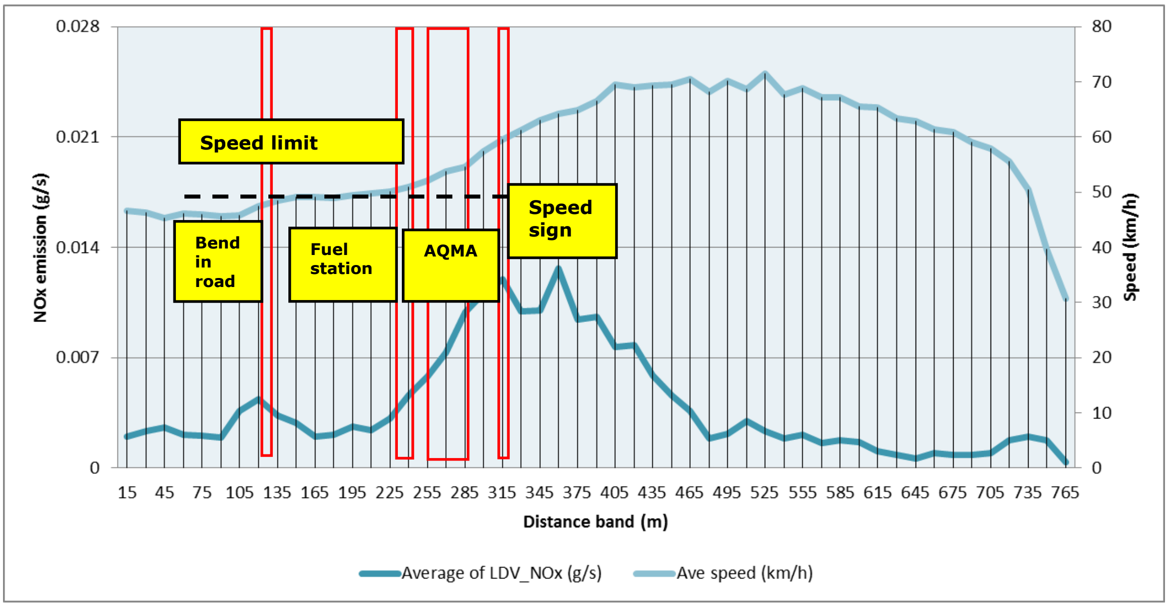

Figure 21: LDV emissions and average speed profile across the drive cycle, typical driving (AM period), southbound.

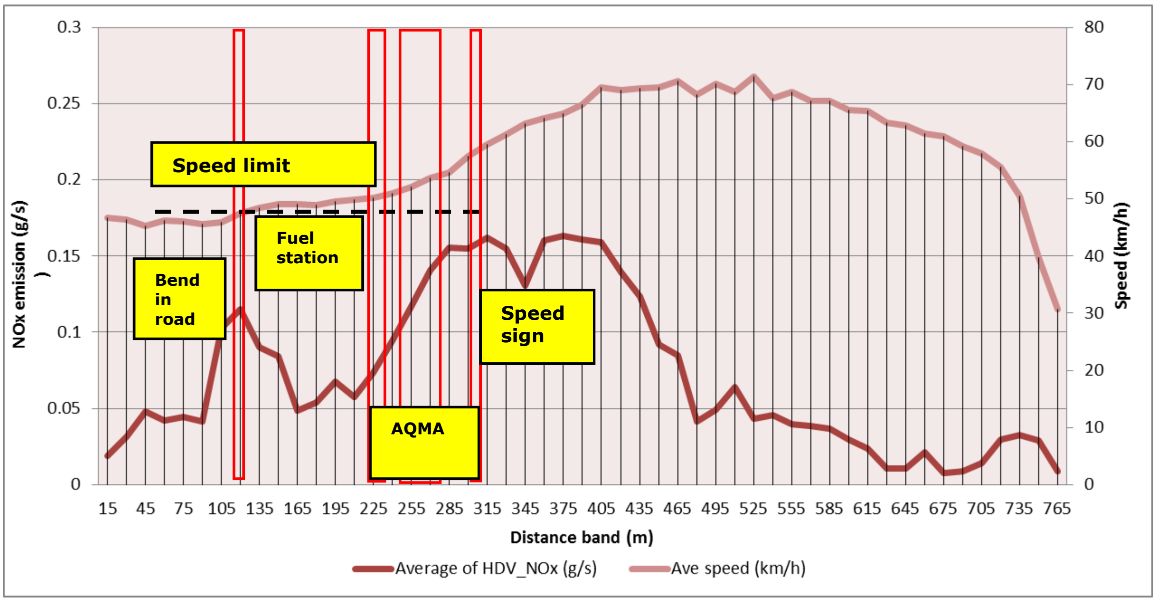

Figure 22: HDV emissions and average speed profile across the drive cycle, typical driving (AM period), southbound.

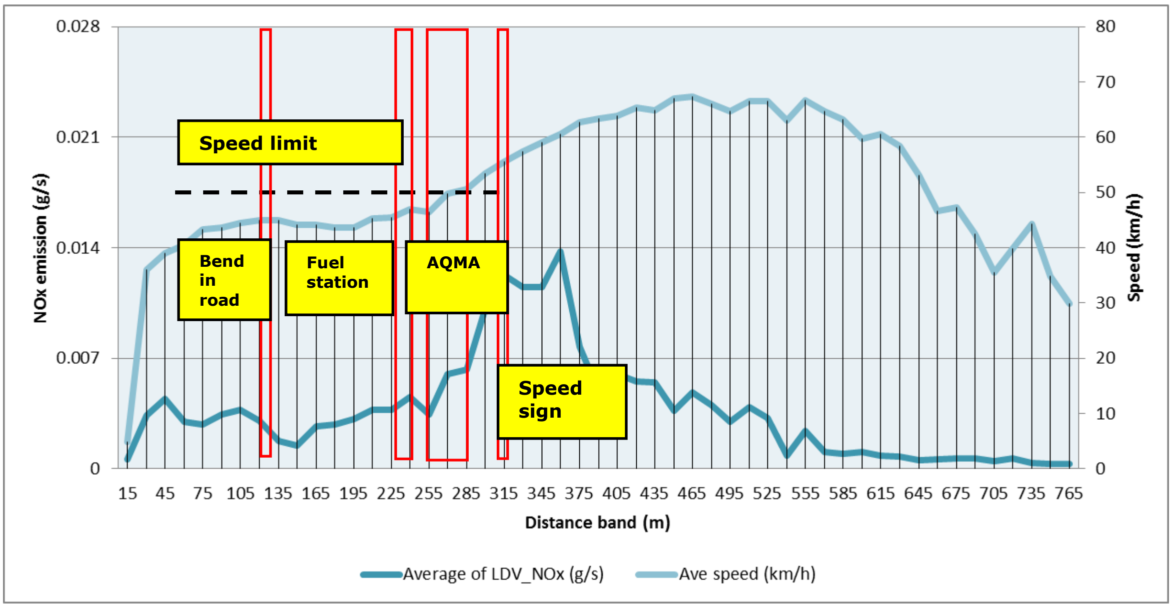

Figure 23: LDV emissions and average speed profile across the drive cycle, typical driving (PM period), southbound.

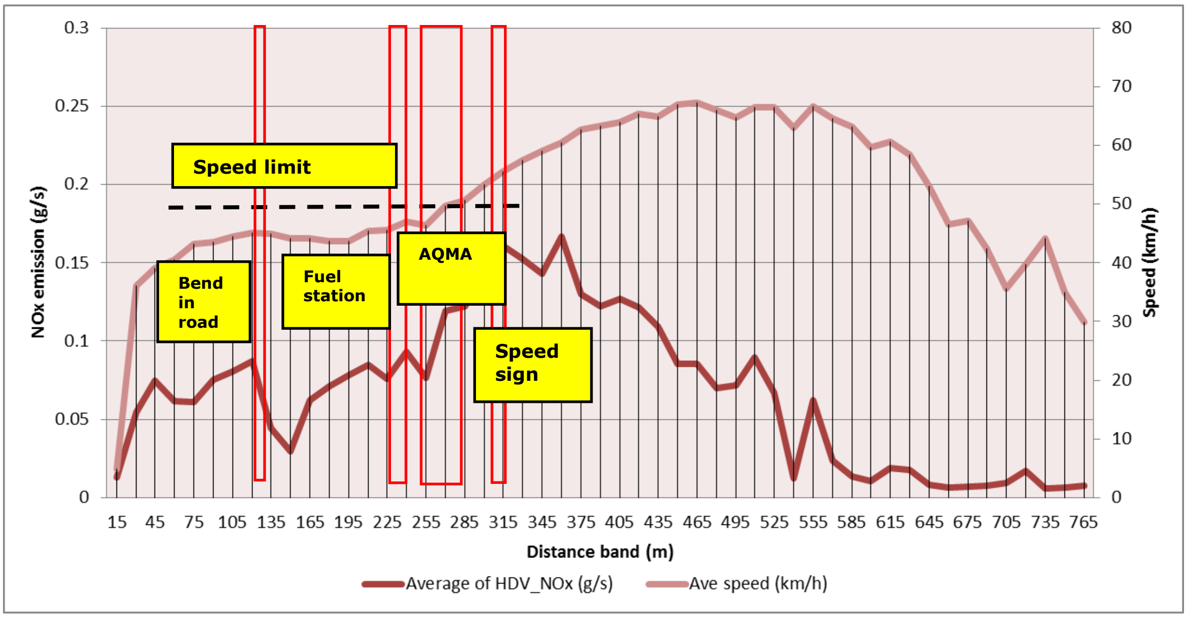

Figure 24: HDV emissions and average speed profile across the drive cycle, typical driving (PM period), southbound.