RICARDO-AEA

Farnham Traffic Management and Low Emission Feasibility Study

Air quality impacts

Waverley BOROUGH COUNCIL

Report for Waverley Borough Council

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Executive summary

Waverley Borough Council has a responsibility under Part IV of the Environment Act 1995 to monitor and identify sources of air pollution within its area. In particular, the Council considers where people are living and where air quality standards are not being met. Where these standards are not being met the local authority must designate an Air Quality Management Area (AQMA) and produce an Air Quality Action Plan to tackle the pollution identified in these areas.

Waverley Borough Council declared an AQMA to cover much of Farnham Town Centre because measured concentrations of nitrogen dioxide exceeded the air quality limit value of 40 µg m^{-3} as an annual mean. Fig. 1 shows the boundaries of the AQMA. The designated area incorporates all parts of The Borough; parts of East Street and South Street; The Woolmead; Union Street; Downing Street; and part of West Street. The boundaries incorporate a wider area than simply where concentrations exceeded the limit so that a holistic approach to tackle air quality issues can be taken.

Waverley Borough Council prepared an Air Quality Action Plan (AQAP) in July 2008. The main objective of this project was to assess the effectiveness of existing and proposed traffic management options included in Waverley's AQAP, to determine which would deliver satisfactory reductions in emissions to produce lower concentrations of nitrogen dioxide and attain the Nitrogen dioxide (NO_2) Limits Value by 2015. In addition, the project evaluated the implementation and acceptability of further low emission measures including heavy goods vehicle (HGV) or other vehicle restrictions and 20 mph speed limits.

The highest concentrations in Farnham town centre, up to 68 µg m^{-3} in 2010, occur on The Borough. These are predicted to decrease to 56 µg m^{-3} by 2015 as the result of changes in the vehicle fleet. The planned development in the town would increase the concentrations to 58 µg m^{-3}. The nitrogen dioxide concentrations are thus expected to remain substantially above the objective of 40 µg m^{-3}. In 2015 we estimate that a 46% reduction in emissions would be required without the planned development to meet the objective.

The AQAP noted changes to the traffic circulation in the town centre, including partial pedestrianization of The Borough east of Castle Street. The analysis indicates that removing all non-bus traffic from The Borough would reduce concentrations to levels well below the objective. The analysis indicates that limiting closure to non-bus traffic for a few hours a week would not be sufficient to achieve the air quality objective, or even if weekly traffic flows were half the base case levels.

Diesel cars provide a substantial part of the emissions of oxides of nitrogen emissions in the Farnham AQMA. They emit substantially more oxides of nitrogen than the equivalent petrol car. Furthermore, they emit substantially higher proportion of the oxides of nitrogen directly as nitrogen dioxide. The analysis indicates that restricting access for diesel cars, for example by restricting access to town centre car parks, would substantially reduce roadside concentrations so that the air quality objective could be achieved - particularly if accompanied by changes to traffic circulation.

The AQAP envisaged a range of measures designed to reduce congestion, including:

- the enforcement of on-street parking restrictions
- the introduction of further rear servicing arrangements for shops
- improved car park access and information
- improved pedestrian access to promote the use of the St James and Riverside car parks (Park and Stride)
- street enhancement with wider pavements and servicing bays

Reducing congestion in the town centre would have some benefit in reducing nitrogen dioxide concentrations but the reduction would not be sufficient to achieve the air quality objective from these measures alone.

The analysis indicates that other measures such as reducing access for heavy goods vehicles, a low emission zone for buses and goods vehicles or imposing a 20 mph speed limit would have little impact on nitrogen dioxide concentrations.

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1 Outline of brief

The main objective of this project is to assess the effectiveness of existing and proposed traffic management options included in Waverley District Council's Air Quality Action Plan (AQAP), to determine which would deliver satisfactory reductions in emissions to produce lower concentrations of nitrogen dioxide and attain the air quality standards by 2015.

To fulfil the above objective, Waverley Borough Council requested a project to facilitate the management of air quality in Farnham be undertaken by appointed consultants. The project outline was submitted to Defra for Air Quality Grant funding and was awarded funds following the acceptance of a detailed project plan.

The aim of this project is to conduct a feasibility and emission reduction study with traffic management strategies proposed for Farnham, in order to achieve compliance of UK Air Quality standards within Farnham AQMA. These standards are set for the protection of human health.

To fulfil these aims and objectives the project contained the following work packages:

Work package 1:
Assessment of proposed traffic management options and low emission options

During the preparation and implementation of the Council's air quality action plan discussions have taken place with stakeholders, particularly Surrey County Council to examine a number of traffic management scenarios which have the potential to lower emissions and improve air quality in Farnham. Previous work has indicated that Heavy Goods Vehicles have a large influence on emissions, although their number is low compared to Light Goods Vehicles and passenger cars. It is also known that emissions from congested traffic is higher compared to traffic moving at a steady speed. This work package should commence with meetings with relevant stakeholders to ascertain the most appropriate scenarios to quantify the emission benefit if implemented. However, at this stage this should include the consideration of the following scenarios:

1. The implementation and acceptability of further low emission measures including HGV or other vehicle restrictions
2. Putting in place a 20 mph speed limit
3. Measures to reduce congestion e.g. evaluation of interactive LED "no-idling" and information signs
4. Traffic management measures, including discouraging A31 bypass traffic from entering the town centre
5. Restricting HGVs for access only

Work Package 2: Feasibility study

This work package outlines the programme of work carried out throughout the second phase of the project.

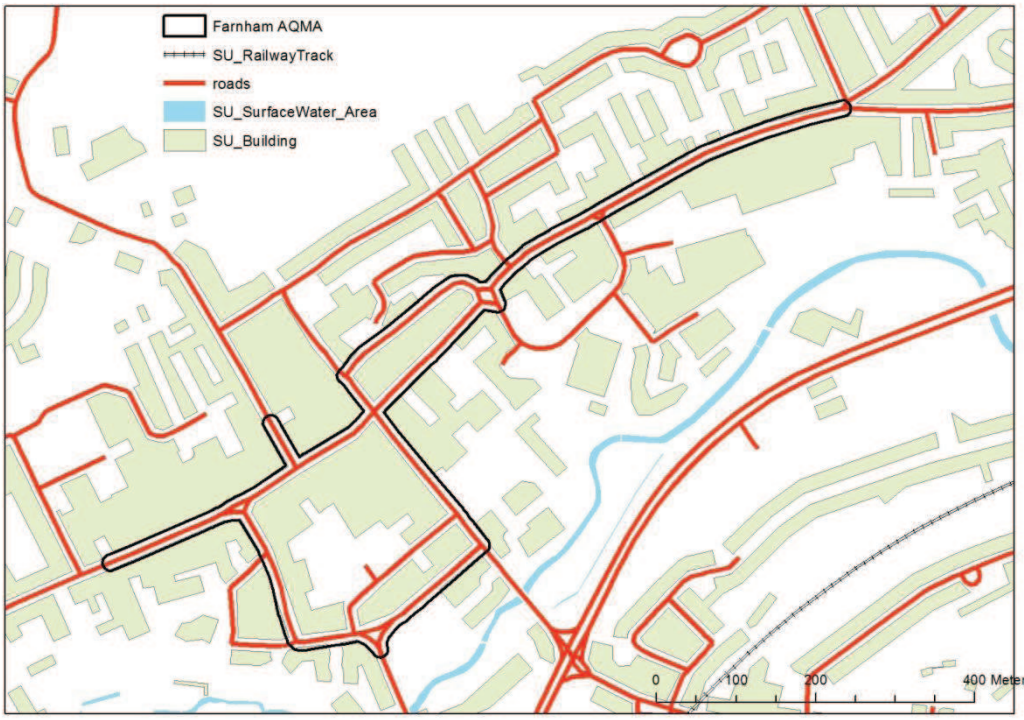
In order to target funding and effort in the best possible way quantified measures will be assessed in terms of feasibility, acceptability and cost effectiveness. This should include the prioritisation of emission reduction options to be presented in this, the final report.

2 Introduction

Waverley Borough Council has a responsibility under Part IV of the Environment Act 1995 to monitor and identify sources of air pollution within its area. Where air quality standards, which are set for the protection of human health, are not being met the local authority must designate an Air Quality Management Area (AQMA) and produce an Air Quality Action Plan to tackle the pollution identified in these areas.

Waverley Borough Council declared 3 such areas, including an AQMA to cover much of Farnham Town Centre because measured concentrations of nitrogen dioxide exceeded the air quality standard of 40 µg m^{-3} as an annual mean. Fig. 1 shows the boundaries of the AQMA. The AQMA was further reviewed in 2007 and the designated area incorporates all parts of The Borough; parts of East Street and South Street; The Woolmead; Union Street; Downing Street; and part of West Street. The boundaries incorporate a wider area than simply where concentrations exceeded the limit so that a holistic approach to tackle air quality issues can be taken.

Fig. 1: Farnham Air Quality Management Area



The main source of pollution in the AQMA is road vehicles and therefore measures to reduce road vehicles need to be considered to improve the quality of the air in Farnham. Emissions

from heavy goods vehicles and buses are significantly higher than from passenger cars, although the numbers of cars outweigh the number of HGVs in most urban roads.

Traffic movement and congestion have been of concern in Farnham for some years. Surrey County Council commissioned the consultancy Scott Wilson to review traffic management, and this work was published in a report "Farnham Review of Movement Studies and Major Schemes" in 2003. The aim of the review was to identify measures that would form the basis of a town centre transport strategy for Farnham. The report took into account national, regional and local policies including the Surrey Local Transport Plan objectives to:

- Tackle congestion
- Increase accessibility to key services
- Improve road safety and security
- Enhance environment and quality of life
- Improve management and maintenance of the road network

Using these policy criteria, the report outlined three town centre strategies (1, 2a and 2b) with each strategy building on the measures included in the previous package. Strategy 1 would provide visual improvements to the footways, the establishment of a streetscape design or style that reinforces the local character of the town. It would include pedestrian crossing improvements, bus service facilities, routes and facilities for cyclists, disabled parking and consideration of rear servicing. Strategy 2a would address problems relating to narrow footways, particularly vehicle related pedestrian accidents, and problems caused through illegal parking by reducing the streetscape available to vehicular traffic in the main shopping streets; the widening of footways; and the provision of on-street loading areas for service vehicles. Strategy 2b is the combination of both 1 and 2a. Key measures included are:

- Improvements in access and parking for cyclists
- Changes in delivery patterns through the introduction of rear servicing arrangements for shops and dedicated on-street parking bays for delivery vehicles
- Variable message signs indicating car park availability
- Town centre junction improvements
- A park and stride scheme that would encourage use of an edge of town car park particularly for people parking all day at Farnham

The most sweeping package "Strategy 2b" included all of these elements plus some changes to the circulation of traffic in the town centre as follows:

- Semi-pedestrianization of East Street with cars and lorries diverted along Woolmead road, which would become a two-way street;
- Two-way flow on the western part of The Borough, with a right turn permitted from Castle Street;
- Two-way traffic on Union Street and South Street
- Part-time pedestrianization of The Borough, initially from 11:00 to 15:00 on Saturdays.

The strategy took into account proposed traffic improvements suggested by Crest Nicholson Sainsbury's as part of the proposed redevelopment of land in East Street.

Waverley Borough Council prepared an Air Quality Action Plan in July 2008. The Air Quality Action plan noted the scope of strategy 2b in principle as offering the greatest potential for improving air quality in the Farnham AQMA. However there were some local concerns that the scheme would simply add to congestion and air quality problems or shift them to locations elsewhere in the town.

The aim of this project is to conduct a feasibility and emission reduction study with traffic management strategies proposed for Farnham, in order to achieve compliance with UK Air Quality Objectives (AQOs) within Farnham AQMA.

3 Traffic management scenarios

3.1 Introduction

This section considers the potential reduction in the emissions of oxides of nitrogen from road links in the Farnham AQMA that might be achieved as the result of various low Emission Schemes. The schemes considered are:

- Changes in traffic circulation corresponding to Strategy 2b of the Farnham Review of Movement Studies and Major Schemes
- Measures to reduce congestion
- Limiting speeds to 20 mph or less
- Reduction in heavy goods vehicle access
- Restrictions on access for other vehicle types

3.2 Changes in traffic circulation

Moving some traffic away from the pollution hotspots is clearly one way of improving air quality in the most polluted of Farnham's streets. However, care needs to be taken when implementing such measures as pollution displacement can result, where air quality improvement in one street leads to an air quality issue in another. As a traffic circulation scheme has been considered to improve traffic movement throughout Farnham, data are available to consider the air quality impact of such a scheme.

As noted in the AQAP, strategy 2b of the Farnham Review of Movement Studies and Major Schemes included the following changes to the circulation of traffic in the town centre:

- Semi-pedestrianization of East Street with cars and lorries diverted along Woolmead Road, which would become a two-way street
- Two-way flow on the western part of The Borough, with a right turn permitted from Castle Street
- Two-way traffic on Union Street and South Street
- Part-time pedestrianization of The Borough, initially from 11:00 to 15:00 on Saturdays

The strategy itself took into account proposed traffic improvements suggested by Crest Nicholson Sainsbury's as part of the proposed redevelopment of land in East Street. Surrey County Council have also carried out indicative modelling of the traffic flows for various scenarios using the Farnham Microsimulation Model 2010[1], including proposals from the Farnham Society. However, none of the scenarios modelled corresponds exactly with the Strategy 2b scenario, but are used as a `best fit'. In particular, further detailed design of the junctions in the town would be required before robust predictions of the effects of circulation changes on congestion can be made. Nevertheless, the simulations carried out to date can provide an indication of the potential redistribution of traffic arising from circulation changes and are thus useful here for the assessment of potential impacts on air quality. The output from this study will then provide support for further detailed design work if the measures can be shown to improve air quality. Surrey County Council provided model outputs for a scenario that included the following changes to traffic circulation that could be implemented following the planned development in East Street:

[1] A computer model used to predict traffic movements based on traffic counts in 2010 in Farnham

- Semi-pedestrianization of East Street with cars and lorries diverted along Woolmead road, which would become a two-way street
- Two-way flow on the western part of The Borough, with a right turn permitted from Castle Street
- Two-way traffic on Union Street and South Street
- Pedestrianization of The Borough

The output from the Farnham Microsimulation Model for this scenario was used for air quality modelling. It was assumed that the proportion of the traffic in each vehicle category was unchanged from the base case. It was also assumed the same distribution of vehicle speeds.

Table 1 shows the Annual Average Daily Traffic (AADT) flows for the key road links for the revised traffic circulation compared with the base case. Clearly, the traffic flows are reduced on most of the road links. There are two main reasons for this. Firstly, the closure of The Borough to through traffic substantially reduces demand. Secondly, the junction design has not been optimised in the Microsimulation model. The current proposals within Strategy 2b include only part-time pedestrianization of The Borough and in practice junction design would be optimised before implementation of the strategy: both of these factors are expected to increase total traffic flows above the modelled values. Nevertheless, these traffic estimates have been used to assess the potential for improvement from the proposed changes to traffic circulation.

Table 1: Traffic flows

Link	Direction	AADT Flows			
		2010	2015	2015 with future planned developments	2015 Revised traffic circulation
The Borough, west of Castle Street	WE	12567	12712	13830	8841*
South St, north of East Street development	NS	13035	13185	13663	11384*
South St, south of East Street development	NS	14862	15032	15032	11756*
Union Road	EW	12173	12313	12817	9692*
Downing Street	SN	9875	9989	10025	4075
Bear Lane Woolmead Road-The Borough	SN	7965	8057	14255*	11414*
Woolmead Road	WE	7340	7424	14238*	11806*
East St, South St - Dogflud Way	EW	8395	8492	155	70
East St, Woolmead Road-Dogflud Way	WE	10653	10775	11391	8714
East St, Dogflud Way-Hale Road	EW	7152	7234	7654	7454
East St, Dogflud Way-Hale Road	WE	3411	3450	3870	1832
Dogflud Way, east of planned development	EW	9902	10015	10565	11386
Dogflud Way, west of planned development	SN	11374	11505	11677	12322
Hale Road	WE	5628	5693	5858	4683
Hale Road	EW	5338	5399	5564	6145
Guildford Road	WE	3796	3840	4069	3343
Guildford Road	EW	2493	2521	2751	2303
South St, south of Union Road	SN	2144	2169	2264	4201
South St, south of Union Road	NS	5207	5267	5362	4984
The Borough Castle St-South St	WE	15076	15249	15663	111
West St, west of Downing St	EW	4778	4833	4883	5513
West St, west of Downing St	WE	9351	9458	9508	3987

*2-way

3.3 Measures to reduce congestion

Emissions from traffic increase as speed reduces and therefore congested conditions give rise to poorer air quality. Measures to reduce congestion were consequently considered in this project. The Farnham Review of Movement Studies and Major Schemes proposed a set of measures that together would reduce congestion in the town centre. These include:

- the enforcement of on-street parking restrictions
- the introduction of further rear servicing arrangements for shops
- improved car park access and information
- improved pedestrian access to promote the use of the St James and Riverside car parks (Park and Stride)
- street enhancement with wider pavements and servicing bays

Other measures that could be used to reduce congestion include “gating” in which traffic is held behind traffic lights outside the town centre until the roads are clear.

The effect of these measures on traffic volumes and speeds has not been investigated and so it was not possible to consider the effects of individual measures on emissions. Instead, the potential for emissions reduction by comparing the base case with the situation where traffic flows without delay through the town centre, have been considered. The CJAMS-Strat-e-gis night-time[2] vehicle speed distribution (20:00-06:00) to represent free-flowing traffic has been used. However, this may be an optimistic approach as night time traffic speeds will not be subject to high pedestrian flows and crossings that will be prevalent in the town centre, which is a limitation to the approach adopted.

3.4 20 mph speed limit

The introduction of 20 mph speed limits have been shown to reduce road accidents and casualties, increase walking and cycling and are welcomed by local residential communities[3]. Emissions from a smooth drive cycle are lower compared to those where there is fast acceleration and deceleration. A 20 mph restriction is more likely to encourage better driver behaviour, and hence lower emissions. Therefore the effect of limiting vehicle speeds in Farnham Town Centre to 20 mph has been investigated. The calculation of emission factors for the base case used a range of percentile vehicle speeds corresponding to the speed distribution derived from the CJAMS-Strat-e-gis data. For this scenario, the percentile vehicle speeds were replaced by 20 mph where they exceeded this limit.

3.5 Articulated lorry ban

Larger articulated lorries have higher emissions than smaller HGVs and Light Goods Vehicles. The introduction of an articulated lorry ban has the potential to remove the most polluting vehicles and therefore was included in the project scenarios. The manual count data[4] provided information on the proportion of Heavy Goods Vehicles classes OGV1 and OGV2 in the traffic on each road link[5]. A significant proportion of the OGV1 category services the shops and offices in the town centre and it is not likely that this traffic can be substantially reduced. The OGV2 category vehicles (articulated lorries and large rigid lorries) are less likely to be used to service the shops and it is assumed that a significant proportion of this vehicle category is through traffic. The calculated emissions from road links in the town centre AQMA for this scenario assume that OGV2 vehicles are prevented from travelling through the town centre.

3.6 Low emission zone for buses and goods vehicles

The emissions of oxides of nitrogen from vehicles are regulated under various European Directives. The regulations become increasingly stringent for newer vehicles. Vehicles meeting specific emissions regulations are classified according to “Euro” class.

Consideration has been given to the potential reduction in emissions if access to the AQMA were restricted so that the vehicle classes met the following standards in 2015:

- Rigid HGVs : Euro V or better
- Articulated HGVs: Euro V or better
- Buses: Euro V or better
- Diesel LGV: Euro 5 or better
- Restrictions on parking diesel cars

[2] An online system that allows users to interactively map and analyse journey time data

[3] http://www.bristol.gov.uk/sites/default/files/documents/transport_and_streets/managing_roads_and_traffic_schemes/20mphMonitoringReport6_3_12.pdf

[4] Traffic counts completed by human observers during a specified period

[5] See Table A1 in Appendix 1. OGV1 includes 2 and 3 axle rigid lorries; OGV2 includes 4 axle rigid lorries and 3-6 axle articulated lorries

3.7 Restrictions on diesel cars

Diesel cars emit substantially more oxides of nitrogen than modern petrol cars, which are fitted with catalysts to reduce pollutant emissions. Diesel cars also emit a higher proportion of their emissions as nitrogen dioxide than petrol cars. Restricting access to the town centre for diesel cars, for example by restricting access to car parks, has the potential to reduce emissions. The proportion of NO_2 concentration due to diesel cars at various locations in Farnham can be compared to that due to other vehicle types in figure 2.

Much of the traffic in the town centre is travelling to and from the town car parks. Access to the Waggon Yard, Central and South Street car parks is obtained via the South Street/ Union Road/ Downing Street/ The Borough one way system in the centre of town: access to the Maltings, Upper Hart, Lower Hart, East Street, Dogflud, St James and Riverside car parks can be obtained without driving through the town centre. One way of discouraging diesel car drivers from driving through the one way system would be to restrict access to the car parks in the centre of the town. The potential effect on emissions of restricting access for diesel cars from the Waggon Yard, Central and South Street car parks has been considered. Petrol cars have been substituted for diesel cars on the South Street/ Union Road/ Downing Street/ The Borough one way system.

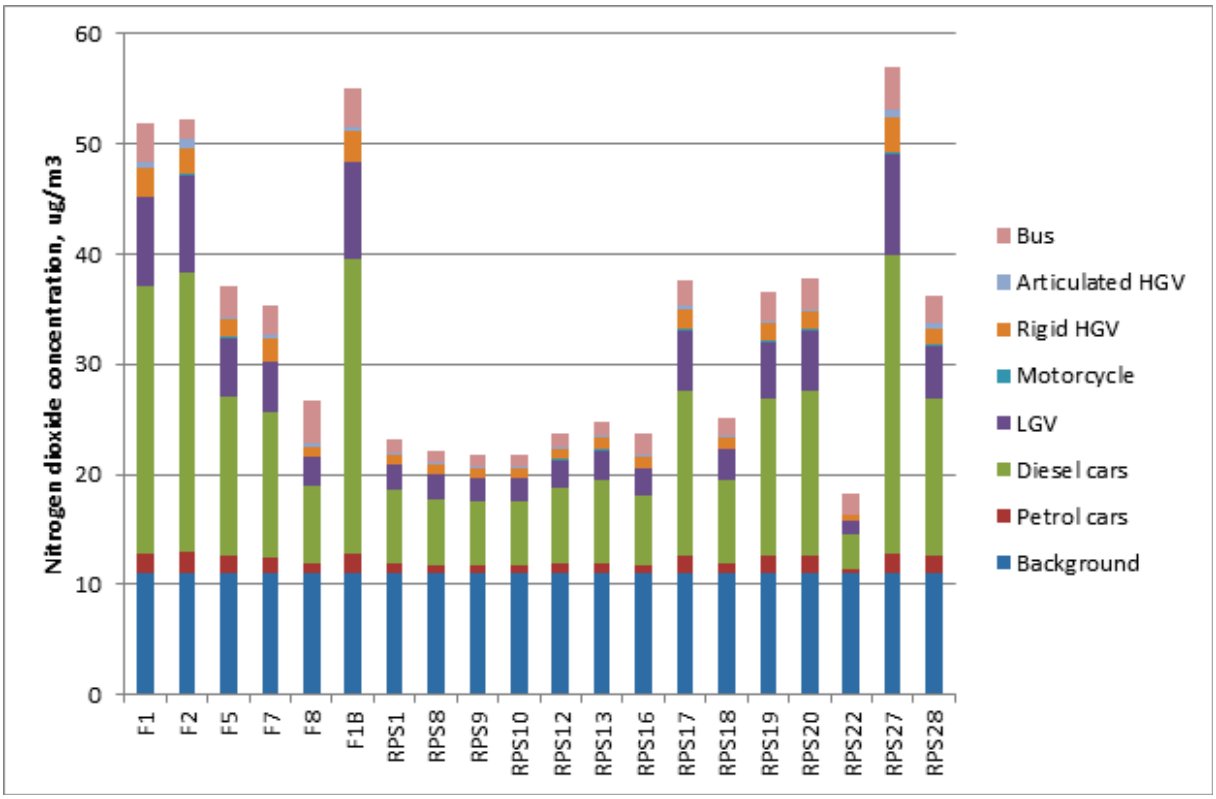


Fig 2: Source apportionment of NO_2 at selected receptors for 2015 with planned development. The location of the selected receptors are given in Fig 3.

3.8 Summary of scheme scenarios

Table 2: Summary of low emission scheme scenarios

Scheme	Components	Justification	Year modelled
Future planned developments	Planned developments would result in changes to traffic flows and patterns. Approximately 239 residential units are proposed with a total of 425 car parking spaces on the site together with improvements to the existing highway network off site. East Street, between South Street and Dogflud Way would be pedestrianized, and traffic, other than buses, would be diverted onto Bear Lane and Woolmead Road. Chapter 10 of the Environmental Statement for the planned development provided estimates of the additional traffic generated by the development on each road link. These flows were added to the 2015 traffic flows to provide estimates of the total flows with the development.	Planning Permission approved	2015
Changes in traffic circulation	a. Semi-pedestrianization of East Street with cars and lorries diverted along Woolmead road, which would become a two-way street; b. Two-way flow on the western part of The Borough, with a right turn permitted from Castle Street; c. Two-way traffic on Union Street and South Street d. Pedestrianization of The Borough e. Part time pedestrianistion of The Borough resulting in 10% reduction in non-bus traffic in The Borough f. Part time pedestrianistion of The Borough resulting in 50% reduction in non-bus traffic in The Borough Summary: 3 model runs are 1) (a+b+c+d) 2) (a+b+c+e) 3) (a+b+c+f)	Surrey County Council have provided traffic modelled data for this scheme, based on their Farnham Review of Movement Studies and Major Schemes	2015
Measures to reduce congestion	Assume free flowing traffic conditions to be potentially achieved by identified measures	Measures have been identified to reduce congestion by the County Council in their Farnham	2015

Scheme	Components	Justification	Year modelled
		Review of Movement Studies and Major Schemes	
Introduction of 20 mph speed limit on all town centre road links in Farnham[6]	All traffic will travel at 20 mph	Encourages good driving behaviour, which leads to lower emissions, reduces accidents	2015
Articulated Lorry Ban	All Articulated lorries banned from town centre AQMA roads[7]	Articulated lorries have high emissions	2015
Low Emission Zone (LEZ)	LEZ for buses and HGVs have to meet Euro V standards in AQMA roads	Older HGVs have higher emissions compared to new vehicles	2015
Diesel car access restriction (LEZ)	Restrict access to diesel cars to the town centre Waggon Yard, Central and South Street car parks. Petrol cars are substituted for diesel cars on the South Street/ Union Road/ Downing Street/ The Borough one way system.	Diesel vehicles have higher NOx emissions compared to their petrol counterparts	2015

[6] As set out in this study – see table 1
[7] As set out in this study – see table 1

4 Effects on air quality

4.1 Introduction

This Section presents the results of predicted air quality levels for emissions reduction scenarios set out in Section 3. The model performance is given in Appendix 2.

4.2 Changes in traffic circulation

Fig. 3 shows the predicted nitrogen dioxide concentrations for 2015 throughout the AQMA corresponding to the scenario with the following changes to traffic circulation:

- The modelled concentrations for 2015 are less than the objective of 40 µg m^{-3} throughout most of the AQMA except for small areas on West Street, The Borough, South Street and Union Road.
- The largest differences in concentrations resulting from the modelled changes in traffic circulation are expected on The Borough as the result of its pedestrianization. Strategy 2b relates to part-time pedestrianization of The Borough, initially from 11:00 to 15:00 on Saturdays. As the exact impact of the part time pedestrianization on non-bus traffic in The Borough is not known as yet, both a 10% reduction in non-bus traffic and a 50% reduction in non-bus traffic in The Borough as a result of this measure have been estimated in terms of air quality impacts. Table 3 shows that a 50% reduction in non-bus traffic on The Borough is not sufficient to meet the air quality objective.

4.3 Restrictions on diesel cars

Table 3 shows the effects of restricting diesel car access to the town centre for the 2015 with planned developments base case and for the case with changes to traffic circulation. As this measure is to restrict access to town centre car parks, analysis is focused on the South St./ Union Road/ Downing St./ The Borough one way system. In each case, restricting diesel car access to the town centre reduces the concentrations below the air quality objective.

4.4 Other measures

Table A3 and A4 in the Appendix of this report provides estimates of the reduction in emissions resulting from other measures:

- Measures to reduce congestion
- Limiting speeds to 20 mph or less
- Reduction in heavy goods vehicle access
- Low emission zone for buses and goods vehicles

The estimated nitrogen dioxide concentrations at relevant receptor points (for scenarios based on the 2015 with planned developments base case) are given in Table 4. The other measures produce relatively small changes in the estimated concentrations: none of which is sufficient to reduce concentrations in The Borough to below the air quality objective.

As shown in Table 5 the predicted concentrations with the traffic recirculation with full pedestrianization of The Borough are all less than the air quality objective at the modelled receptor locations. Concentration levels in between these receptor locations are shown to be exceeding the objective level in small areas on West Street, The Borough, South Street and Union Road (Fig. 2).

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Fig. 3: Modelled nitrogen dioxide concentrations, 2015 with changes to traffic circulation

Table 3: Predicted nitrogen dioxide concentrations for 2015 scenarios with changes in circulation and diesel car restrictions.

Location	Receptor	Concentration, µg m-3					
		2015 with planned development	Changes in circulation (A)	10 % Changes in circulation	50 % Changes in circulation	2015 baseline+Diesel car restrictions	A+Diesel car restrictions
The Borough	F1	53.3	20.0	50.5	38.3	34.6	17.8
Junction Downing Street/West Street/The Borough	F2	52.2	39.5	51.0	46.1	32.3	25.8
East Street, east of Dogflud Way	F5	36.8	32.7	36.4	34.7		
Junction South Street/Union Road	F7	35.3	36.8	35.5	36.1	24.8	26.1
Junction East Street/Bear Lane	F8	26.9	21.6	26.3	24.3	21.2	17.7
The Borough	F1B	58.5	21.2	55.4	41.9	37.0	18.9
Downing Street	RPS1	22.8	18.5	22.4	20.7	17.4	15.2
Woolmead Road	RPS8	21.8	20.0	21.6	20.9		
Woolmead Road	RPS9	21.5	19.8	21.4	20.6		
Woolmead Road	RPS10	21.5	19.8	21.4	20.6		
Union Street	RPS12	23.1	20.8	22.8	21.9	17.6	16.4
Union Street	RPS13	24.4	22.1	24.2	23.3	18.4	17.2
Junction East Street/Woolmead Road	RPS16	23.3	21.5	23.1	22.4		
East Street Woolmead Road-Dogflud Way	RPS17	37.2	32.4	36.7	34.9		
Junction East Street/ Dogflud Way	RPS18	24.7	22.9	24.5	23.8		
East Street, east of Dogflud Way	RPS19	36.4	32.4	36.0	34.4		
East Street, east of Dogflud Way	RPS20	37.7	33.4	37.3	35.6		
East Street South Street-Woolmead Road	RPS22	18.3	16.2	18.1	17.3		
The Borough	RPS27	58.8	21.4	55.7	42.2	37.3	19.0
Downing Street	RPS28	36.3	23.9	35.1	30.3	24.9	18.2

Table 4: Predicted nitrogen dioxide concentrations for 2015 scenarios including other measures

Location	Receptor	Concentration, µg m^{-3}				
		2015 with planned developments	No articulated lorries	20 mph limit	Reduced congestion	Low emission zone
The Borough	F1	53.3	53.3	54.3	46.4	49.9
Junction Downing Street/West Street/The Borough	F2	52.2	50.8	53.7	46.5	48.0
East Street, east of Dogflud Way	F5	36.8	36.8	38.0	33.0	34.3
Junction South Street/Union Street	F7	35.3	35.3	37.6	33.1	33.1
Junction East Street/Bear Lane	F8	26.9	26.9	28.0	27.4	25.1
The Borough	F1B	58.5	58.5	59.8	50.9	54.7
Downing Street	RPS1	22.8	22.8	23.4	20.5	21.7
Woolmead Road	RPS8	21.8	21.8	23.3	22.3	20.8
Woolmead Road	RPS9	21.5	21.5	22.9	22.0	20.5
Woolmead Road	RPS10	21.5	21.5	22.9	22.0	20.5
Union Street	RPS12	23.1	23.1	24.3	21.9	21.9
Union Street	RPS13	24.4	24.4	25.8	23.1	23.1
Junction East Street/Woolmead Road	RPS16	23.3	23.3	25.0	23.9	22.2
East Street Woolmead Road-Dogflud Way	RPS17	37.2	35.9	38.4	34.6	34.6
Junction East Street/ Dogflud Way	RPS18	24.7	24.7	25.4	22.5	23.3
East Street, east of Dogflud Way	RPS19	36.4	36.4	37.6	32.7	33.9
East Street, east of Dogflud Way	RPS20	37.7	37.7	39.0	33.8	35.1
East Street South Street-Woolmead Road	RPS22	18.3	18.3	18.3	15.4	15.4
The Borough	RPS27	58.8	58.8	60.1	51.2	55.0
Downing Street	RPS28	36.3	36.3	54.3	31.8	34.0

Table 5: Predicted nitrogen dioxide concentrations for 2015 scenarios with changes to circulation including other measures

Location	Receptor	Concentration, µg m^{-3}				
		Changes in circulation (A)	A+No articulated lorries	A+20 mph limit	A+Reduced congestion	A+Low emission zone
The Borough	F1	20.0	20.0	20.0	17.1	17.1
Junction Downing Street/West Street/The Borough	F2	39.5	38.0	41.1	34.9	36.5
East Street, east of Dogflud Way	F5	32.7	31.4	33.9	28.7	28.7
Junction South Street/Union Street	F7	36.8	36.8	40.0	35.2	35.2
Junction East Street/Bear Lane	F8	21.6	21.6	22.6	22.1	20.6
The Borough	F1B	21.2	21.2	21.2	17.9	17.9
Downing Street	RPS1	18.5	18.5	18.5	16.7	17.6
Woolmead Road	RPS8	20.0	19.5	20.9	20.0	19.0
Woolmead Road	RPS9	19.8	19.3	20.7	19.8	18.8
Woolmead Road	RPS10	19.8	19.3	20.7	19.8	18.8
Union Street	RPS12	20.8	20.8	22.1	20.1	20.1
Union Street	RPS13	22.1	22.1	23.6	21.3	21.3
Junction East Street/Woolmead Road	RPS16	21.5	20.9	22.6	21.5	20.4
East Street Woolmead Road-Dogflud Way	RPS17	32.4	32.4	35.3	31.0	31.0
Junction East Street/ Dogflud Way	RPS18	22.9	22.2	23.7	20.6	20.6
East Street, east of Dogflud Way	RPS19	32.4	31.1	33.7	28.5	28.5
East Street, east of Dogflud Way	RPS20	33.4	32.1	34.7	29.3	29.3
East Street South Street-Woolmead Road	RPS22	16.2	16.2	16.2	13.6	13.6
The Borough	RPS27	21.4	21.4	21.4	18.1	18.1
Downing Street	RPS28	23.9	23.9	23.9	20.8	22.4

5 Feasibility

Measures to improve air quality will only have a real impact if the implementation of these can be completed successfully. The feasible implementation of the measures examined here requires a full detailed study. The issues to be considered in such a full feasibility study are outlined, for information only, below. It therefore follows that a study on the feasibility of implementation is a crucial next stage in the decision making process to improve air quality in Farnham.

The success of each proposed measure is correlated to cost effectiveness which includes the following aspects:

1. The ***effectiveness*** of measures for improving air quality - judged in terms of pollutant concentration improvement and, to eliminate the impact of meteorological factors, in terms of emissions reduction;
2. The **utility** of the measures and their ***ease of implementation*** (logistical effectiveness); and finally
3. The ***resource requirements*** to implement the measures and, where available, **cost data**.

The most effective measures considered in the highest polluted hotspot (The Borough) are ranked in Table 6.

Banning articulated lorries did not improve air quality in The Borough and introducing a 20 mph speed limit worsened air quality throughout most of the town. On this basis neither of these measures should be considered further in terms of their feasibility. The only measures to meet the air quality objective level were the changes in circulation and restricting diesel vehicles.

Table 6: Priority of measures in terms of pollution reduction effectiveness

Scheme	Priority	Comment	Recommendation
Changes in traffic circulation including full pedestrianization of The Borough	First	This measure gives overall low concentrations but at some junctions levels are only just below the objective level	To undertake further analysis and in conjunction with other measures
Restrict access to diesel cars from town centre car parks	Second	This measure also gives widespread low pollution levels but again concentrations of NO_2 are only just below the objective level in The Borough	To undertake further analysis and in conjunction with other measures
Reduced congestion	Third	High pollution levels remain in The Borough	No, but is effective with recirculation and diesel restriction schemes
Low emission zone	Fourth	High pollution levels remain in The Borough	No, but is effective with recirculation and diesel restriction schemes
Articulate lorry ban	Fifth	High pollution levels remain in The Borough	No, but is effective with recirculation and diesel restriction schemes
20 mph speed limit	Sixth	High pollution levels remain in The Borough	No

Ease of implementation: the characteristics of these aspects of feasibility are:

Applicability: a measure should contribute towards the strategic objectives of improving air quality and have the capacity to address non compliances (e.g. could it reduce Particulate Matter (PM) if PM exceedence is the problem?)

Appropriateness: effective measures are either balanced or of overall benefit in both environmental and economic terms

Attractiveness: (acceptability to the public) - competent authorities should have prepared an environmental and economic case for the measure, and associated public information, in sufficient detail that the effectiveness of the measure and its health and other benefits can be seen to justify any costs of the measure

Affordability: appropriate budgets need to be available for the measures to be implemented

Achievability: key implementation issues including enforcement powers and other practical considerations are understood and in place. To assess ease of implementation information on “time scale”, “spatial scale”, “type of measure”, “is the measure regulatory?”, “source sector(s) affected” should be considered.

Consideration of the measures in Farnham in terms of ease of implementation should be given in a detailed feasibility study to proceed from the current work. An outline of such consideration includes:

1. **Changes in traffic circulation**. The traffic modelling undertaken to assess the air quality impact of proposed changes in circulation was done at a screening level[8]. In doing so, the analysis makes assumptions about how the traffic will behave, which may not be achieved fully in practice. It is assumed that detailed design of junctions will ensure that congestion in the town centre will not increase and current vehicle speeds will be maintained on each link. Also, that the reduction in congestion achieved by the detailed design of junctions will not encourage more traffic to use the roads. Lastly, it is assumed that The Borough, between Castle Street and South Street is pedestrianized at all times. The net effect of these assumptions is that the expected reduction in emissions may not be achieved fully in practice. Our analysis thus provides an optimistic estimate of the potential improvements associated with the changes in traffic circulation. Before any decision making can be completed, more detailed traffic modelling is required to investigate whether a traffic management recirculation design can produce traffic flow efficiencies across the town road network. Following this the air quality improvements in such a design need to be re-assessed.

   This option has merit in terms of public acceptability as it should ease congestion around the town; pedestrianized shopping streets also tend to be more attractive to shoppers, easing movement across the area with increased safety. However, the feasibility study must consider impact on local businesses and the provision of adequate nearby car parking or park and ride/stride.

2. **Restricting diesel vehicles**. This measure is relatively unknown in the UK as the impact of diesel vehicles in comparison with petrol has only recently been recognised. The public image of diesel vehicles is that they are more fuel efficient and have lower carbon emissions and therefore are better for climate change. While this is accurate, they have significantly higher NOx emissions. Recent data suggest that diesel accounts for 51% of new car sales.

   One method of discouraging diesel cars from travelling into the heart of the town centre is a car park cost strategy, whereby car parks in the centre charge a high cost for a parking space occupied by a diesel car than compared to a petrol car. Car park spaces on the proximity of the town, however, would cost much less for diesel cars thereby indirectly influencing driver behaviour.

   It is typical for this type of scheme to be assessed using a parking choice logit model with the S-Paramics model. This would, however, require specific information regarding parking charges. Given this, a crude assessment of the viability of a diesel car park cost strategy will be undertaken instead. The appraisal will make the following assumptions:

   - 15% of diesel cars parking in the town centre will be replaced with petrol cars.
   - 5% of diesel cars parking in the town centre will be replaced with electric or hybrid cars.
   - 80% of the remaining diesel cars parked at Castle Street on-street, Central, South Street (Sainsbury's), Lower Hart (Waitrose) and Waggon Yard car parks in the base model would relocate to a cheaper alternative of Upper Hart, Dogflud, St James,

[8] An approximate analysis

Riverside 1, or Riverside 2, based on proximity of the origin and destination to the trip and length of stay.

This basic assessment will help to determine if this option could achieve the required reduction in emissions and therefore whether to invest in further work to progress the scheme.

3. **Reduced congestion**. This option has been assumed to be implemented in a generic manner which, when one considers the feasibility of it, needs to be examined in detail. The manner in which this could be implemented includes the following:
    - the enforcement of on-street parking restrictions
    - the introduction of further rear servicing arrangements for shops
    - improved car park access and information
    - improved pedestrian access to promote the use of the St James and Riverside car parks (Park and Stride)
    - street enhancement with wider pavements and servicing bays.
    - "gating" in which traffic is held behind traffic lights outside the town centre until the roads are clear.

    We have assumed that these measures would be sufficient to maintain free flowing traffic. Further traffic modelling would be required to determine the most likely impact of such measures on traffic and whether these would remove sufficient trips into the town to impact the overall traffic speed. "Gating" has been used in many towns to improve traffic flows, but care is required to not just displace the location of high pollution.

4. **Low emission zone**. Such zones are in operation in London, Oxford and Norwich. In London older HGV and vans are restricted from entering the zone, otherwise a penalty fine is given. In Oxford and Norwich, the LEZ applies to buses along certain high pollution routes. These are implemented via a Traffic Regulation Order with prior detailed negotiations having been undertaken with the major bus operators. A bus LEZ is much simpler to put in place and to enforce than the London wide scheme. There is certainly merit in examining the improvement of the bus fleet in Farnham. Whether this be by LEZ, bus quality partnership or bus contract renewals requires consideration from the bus operators and regulators. As HGVs other than buses do not comprise a large proportion of the fleet, a London style LEZ does not appear appropriate or applicable to Farnham.

Resource requirements: issues to be considered in the full feasibility study are outlined below for information purposes:

- Who/which organisation is responsible for initiating the measure, for delegating actions to others and for terminating the actions
- What the actions are that need to be taken to reduce emissions or to provide information and recommendations
- When the actions will be initiated or terminated (for example when measured or forecast concentrations exceed information or alert values)
- Where the measures will be applied; and
- Why the measures are needed (e.g. to provide the public with information; to reduce emissions, etc.).

In terms of Farnham, changes in traffic circulation and measures to reduce congestion would require examination of the following aspects which would be done in the full feasibility study:

- Legal works
- Detailed design
- System specification
- Certification / identification approach
- Funding strategy
- Preparation of public consultation/marketing plan
- Decision to proceed (break-point)
- Marketing and information campaign
- Construction procurement
- Construction period with management of traffic
- New system operation

The costs of each of the above stages need to be developed and budgets secured.

For a LEZ the following costs and benefits should be considered:

- Costs
  - Expenditure for compliance, including automated number plate recognition, signage, administration (including issuing penalty charge notices), creation and management of database and links to DVLA, vehicle retrofit, vehicle replacement
  - Who pays?
  - Effects of additional costs on economic activity and employment
  - Costs absorbed by vehicle owners
  - Costs passed onto customers

When considering costs of the proposed measures it is recommended that the benefits are monetised - including the health damage costs using the procedures set out in Defra's Inter-governmental group on costs and benefits. In this manner the benefits to the local population's health, as a result of such measures to improve air quality, can be compared on the same level.

6 Recommendations:

1. Of the measures considered, it has been demonstrated that the changes in traffic circulation deliver the best air quality outcome across the town. Assumptions have been made in this study and it is recommended that detailed traffic modelling of this measure is undertaken to provide a better insight to the likely impact of such a proposal. However, this alone may not meet the annual average NO_2 objective in all locations and we therefore recommend that it should be considered in conjunction with congestion reducing measures to ensure compliance and best local health protection.

2. The updated traffic modelled data should be reviewed to ascertain if it is likely that this will deliver the air quality objectives. If not, further consideration should be given to additional congestion reduction measures. The air quality impact of this should be re-examined in light of the updated traffic model.

3. An economic and health impact assessment should be undertaken to examine the feasibility of such measures.

4. Restricting diesel vehicles going into Farnham also delivers significant air quality benefit. While this is not a well established measure, it does focus on those responsible for the higher sources of emission that leads to the air pollution i.e. diesel vehicles. Consideration should be given to raising awareness of this issue locally and whether realistic steps can be put in place to reduce the polluting effects of diesel vehicles in Farnham

Appendix 1 – Emission Results

Baseline 2010 air quality and 2015 with planned development

This section shows traffic data and modelled concentrations across Farnham in 2010 and in 2015 with planned development.

Surrey County Council provided modelled traffic flows for each 1-way road link for the weekday afternoon peak hour from the Farnham Microsimulation Model 2010. The model has been verified by comparison with automatic and manual count and journey time data throughout Farnham.

Surrey County Council also provided factors to scale the afternoon peak hour flows to provide estimates of annual average daily traffic flows. The Council provided separate factors for the A31 (12.15) and for the town centre (10.627) derived from automatic count data.

Surrey County Council provided classified 12-hour manual count data for various roads throughout Farnham for the following vehicle types:

- Cars
- Light goods vehicles
- Rigid goods vehicles (OGV1)
- Articulated goods vehicles (OGV2)
- Buses and coaches
- Motorcycles

The data provided the basis for estimating the percentage of the total flows on each road link in each of the vehicle categories.

The County Council also provided CJAMS Strat-e-gis data of the vehicle speeds on each road link. The data provided included the length and the average and standard deviation of transit time for each road link for specific time periods throughout the day based on the analysis of GPS data from suitable equipped vehicles. The data was provided as ESRI shape files linked to the OS Integrated Transport Network road centrelines. We combined this data to provide estimates of the daily average speed and the daily 95^{th}, 85^{th}…….5^{th} percentile speeds on each road link assuming that the distribution of vehicle speeds was lognormal.

We identified 133 CJAMS-Strat-e-gis 1-way road links in or near the Farnham AQMA, including sections of the A31 (Fig.3). We then allocated the annual average daily traffic flows and percentages of each vehicle category to each road link.

The Farnham Microsimulation Model provides estimates of traffic flows on each road link for 2010. We used the Department for Transport's TEMPRO v6.2 tool to provide a National Traffic Model adjusted growth factor from 2010 to 2015 of 1.0115 for Farnham[9].

The planned development, assuming it proceeds as proposed at the current time, would result in changes to traffic flows and patterns. Approximately 239 residential units and 425 car parking spaces are proposed on the site together with improvements to the existing highway network off site. East Street, between South Street and Dogflud Way would be pedestrianized, and traffic, other than buses, would be diverted onto Bear Lane and Woolmead Road. Chapter 10 of the Environmental Statement for the planned development provided estimates of the additional traffic generated by the development on each road link. We added these flows to the 2015 traffic flows to provide estimates of the total flows with the development.

[9] Origin/Destination, car driver, all purposes, urban, average day, principal roads

Table A1 provides a summary of the traffic flows for road links in the AQMA.

Table A1: Traffic flows

Link	Direction	AADT Flows			Percentage of traffic in vehicle category						Average speed, kph
		2010	2015	2015 with planned development	cars	LGV	motorcycles	OGV1	OGV2	Buses	
The Borough, west of Castle Street	WE	12567	12712	13830	85.5	10.7	0.7	1.6	0.3	1.3	22
South St, north of planned development	NS	13035	13185	13663	86.0	10.3	0.7	1.5	0.2	1.3	36
South St, south of planned development	NS	14862	15032	15032	86.0	10.3	0.7	1.5	0.2	1.3	31
Union Road	EW	12173	12313	12817	86.6	10.0	0.8	1.3	0.1	1.2	50
Downing Street	SN	9875	9989	10025	85.9	10.4	0.7	1.2	0.3	1.4	38
Bear Lane Woolmead Road-The Borough	SN	7965	8057	14255*	84.4	11.4	0.9	1.3	0.2	1.8	43
Woolmead Road	WE	7340	7424	14238*	85.5	10.7	0.7	1.6	0.3	1.3	51
East St, South St - Dogflud Way	EW	8395	8492	155	85.3	10.7	0.9	1.2	0.1	1.8	32
East St, Woolmead Road-Dogflud Way	WE	10653	10775	11391	85.5	10.7	0.7	1.6	0.3	1.3	59
East St, Dogflud Way-Hale Road	EW	7152	7234	7654	85.3	10.7	0.9	1.2	0.1	1.8	50
East St, Dogflud Way-Hale Road	WE	3411	3450	3870	85.5	10.7	0.7	1.6	0.3	1.3	40
Dogflud Way, east of planned development	EW	9902	10015	10565	85.3	10.7	0.9	1.2	0.1	1.8	54
Dogflud Way, west of planned development	SN	11374	11505	11677	85.5	10.7	0.7	1.6	0.3	1.3	44
Hale Road	WE	5628	5693	5858	85.5	10.7	0.7	1.6	0.3	1.3	52
Hale Road	EW	5338	5399	5564	85.3	10.7	0.9	1.2	0.1	1.8	45
Guildford Road	WE	3796	3840	4069	85.5	10.7	0.7	1.6	0.3	1.3	58
Guildford Road	EW	2493	2521	2751	85.3	10.7	0.9	1.2	0.1	1.8	52
South St, south of Union Road	SN	2144	2169	2264	82.6	11.1	0.5	2.4	0.3	3.1	45
South St, south of Union Road	NS	5207	5267	5362	86.0	10.3	0.7	1.5	0.2	1.3	28
The Borough Castle St-South St	WE	15076	15249	15663	85.6	10.6	0.8	1.3	0.5	1.1	34
West St, west of Downing St	EW	4778	4833	4883	86.5	10.8	0.6	1.1	0.3	0.7	41
West St, west of Downing St	WE	9351	9458	9508	85.8	11.1	0.8	1.4	0.6	0.5	33

* 2-way flow

Fig. A1 shows the modelled concentrations for 2010 at locations near roads throughout the AQMA. The modelled concentrations exceed the objective on The Borough, Castle Street, South Street, Union Road, Downing Street, West Street and East Street.

Fig. A2 shows the modelled concentrations for 2015 with planned development. The concentrations are lower than for 2010 but remain above the objective on parts of The Borough, Castle Street, South Street, Union Road, Downing Street, West Street and East Street.

The highest modelled concentrations occur on The Borough. Trial and error use of the NO_x to NO_2 converter indicates that a 46% reduction in traffic emissions would be required to reduce the modelled concentrations in 2015 at receptors F1B/RPS27 to the objective of 40 µg m^{-3}.

Fig. A1: Modelled nitrogen dioxide concentrations, 2010

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Fig. A2: Modelled nitrogen dioxide concentrations, 2015 with development

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Table A2: Modelled nitrogen dioxide concentrations at selected receptor locations

Receptor	Location	Concentration, µg m^{-3}		
		2010	2015	2015 planned development
F1	The Borough	58.0	51.1	53.3
F2	Junction Downing Street/West Street/The Borough	59.0	52.0	52.2
F5	East Street, east of Dogflud Way	42.1	35.4	36.8
F7	Junction South Street/Union Street	42.0	34.9	35.3
F8	Junction East Street/Bear Lane	42.0	35.6	26.9
F1B	The Borough	62.8	56.0	58.5
RPS1	Downing Street	27.8	22.7	22.8
RPS8	Woolmead Road	23.4	19.0	21.8
RPS9	Woolmead Road	23.2	18.8	21.5
RPS10	Woolmead Road	23.2	18.8	21.5
RPS12	Union Street	27.9	22.8	23.1
RPS13	Union Street	29.5	24.2	24.4
RPS16	Junction East Street/Woolmead Road	30.0	24.6	23.3
RPS17	East Street Woolmead Road-Dogflud Way	43.1	36.1	37.2
RPS18	Junction East Street/ Dogflud Way	29.7	24.3	24.7
RPS19	East Street, east of Dogflud Way	41.8	35.1	36.4
RPS20	East Street, east of Dogflud Way	43.0	36.2	37.7
RPS22	East Street South Street-Woolmead Road	29.8	24.4	18.3
RPS27	The Borough	63.3	56.3	58.8
RPS28	Downing Street	42.9	36.2	36.3

Without changes to circulation of traffic

Table A2 shows the calculated emissions for a range of scenarios without the changes to traffic circulation proposed under Strategy 2b of the Farnham Review of Movement Studies and Major Schemes. Each of the scenarios is derived from the 2015 base case with planned development.

Table A2 shows that restricting access to articulated lorries has very little effect on emissions in the AQMA: this is because articulated lorries make up a very small part of the traffic in Farnham town centre. This measure would therefore not be effective in reducing nitrogen dioxide concentrations in the town centre AQMA.

The Table shows that imposing a 20 mph speed limit will increase emissions of oxides of nitrogen slightly. This measure would therefore not be effective in reducing nitrogen dioxide concentrations in the town centre AQMA.

Measures to reduce congestion in the town centre have the potential to reduce emissions slightly. The annual emissions in the town centre shown in Table 3 are 11% lower under this scenario.

The Low Emission Zone restrictions on Heavy Goods vehicles, Light goods vehicles and buses have the potential to reduce emissions slightly. The annual emissions in the town centre shown in Table are 9% lower under this scenario.

Discouraging diesel cars from using the central one-way system, for example by restricting access to car parks has the greatest potential for reducing emissions on these roads. Predicted emissions on the roads affected under this scenario are 40% lower.

With changes to circulation of traffic

Table A3 shows the calculated emissions for a range of scenarios with the changes to traffic circulation indicative of those proposed under Strategy 2b of the Farnham Review of Movement Studies and Major Schemes. The Table also shows the emissions for the '2015 with development baseline' for comparison. Each of the other scenarios is derived from the 2015 case with the proposed changes to traffic circulation.

Table A3 indicates that the proposed changes to traffic circulation would have a substantial effect on the emissions from nearly all of the road links in the AQMA as the result of the reductions in traffic flows. Emissions in the AQMA are predicted to be 30% lower with the changes in place: predicted emissions from traffic on the eastern section of The Borough are 90% lower. However, the analysis has made the following assumptions about how the traffic will behave: these may not be achieved fully in practice. It is assumed that:

1. detailed design of junctions will ensure that congestion in the town centre will not increase and current vehicle speeds will be maintained on each link.
2. the reduction in congestion achieved by the detailed design of junctions will not encourage more traffic to use the roads.
3. The Borough, between Castle Street and South Street is pedestrianized at all times.

The net effect of these assumptions is that the expected reduction in emissions may not be achieved fully in practice. Our analysis thus provides an optimistic estimate of the potential improvements associated with the changes in traffic circulation.

Table A3 shows that restricting access to articulated lorries has very little effect on emissions in the AQMA: this is because articulated lorries make up a very small part of the traffic in Farnham town centre. This measure would therefore not be effective in reducing nitrogen dioxide concentrations in the town centre AQMA.

The Table shows that imposing a 20 mph speed limit will increase emissions of oxides of nitrogen slightly. This measure would therefore not be effective in reducing nitrogen dioxide concentrations in the town centre AQMA.

Measures to reduce congestion in the town centre have the potential to reduce emissions slightly. The annual emissions in the town centre shown in Table A3 are 10% lower under this scenario.

The Low Emission Zone restrictions on Heavy Goods Vehicles, Light Goods Vehicles and buses have the potential to reduce emissions slightly. The annual emissions in the town centre shown in Table A34 are 10% lower under this scenario.

Discouraging diesel cars from using the central one-way system, for example by restricting access to car parks has the greatest potential for reducing emissions on these roads. Predicted emissions on the roads affected under this scenario are approximately 40% lower. This measure is directed at a small number of roads on the one way system in the town centre and consequently emissions reductions are only calculated for these roads.

Table A3: Annual emissions of oxides of nitrogen from key road links in the AQMA for scenarios without changes in traffic circulation

Road link	Direction	Emission rate, tonnes/km/year					
		2015 with planned development	No articulated lorries	20 mph limit	Reduced congestion	Low emission zone	Diesel car restrictions
The Borough, west of Castle Street	WE	2.9	2.8	3.0	2.6	2.6	1.7
South St, north of planned development	NS	2.5	2.4	2.6	2.0	2.2	1.5
South St, south of planned development	NS	3.1	3.0	3.2	2.7	2.7	1.8
Union Road	EW	1.9	1.9	2.1	1.7	1.7	1.1
Downing Street	SN	2.0	2.0	2.1	1.6	1.8	1.2
Bear Lane Woolmead Road-The Borough	2-way	2.5	2.5	2.7	2.6	2.2	
Woolmead Road	2-way	2.1	2.1	2.4	2.2	1.9	
East St, South St - Dogflud Way	EW	0.5	0.5	0.5	0.3	0.3	
East St, Woolmead Road-Dogflud Way	WE	1.8	1.7	1.9	1.6	1.6	
East St, Dogflud Way-Hale Road	EW	1.2	1.2	1.3	1.0	1.1	
East St, Dogflud Way-Hale Road	WE	0.6	0.6	0.6	0.5	0.5	
Dogflud Way, east of planned development	EW	2.0	2.0	2.2	1.9	1.8	
Dogflud Way, west of planned development	SN	2.1	2.0	2.2	1.7	1.8	
Hale Road	WE	0.8	0.8	0.9	0.8	0.8	
Hale Road	EW	1.4	1.4	1.5	0.9	1.2	
Guildford Road	WE	0.6	0.6	0.7	0.6	0.6	
Guildford Road	EW	0.7	0.7	0.7	0.5	0.6	
South St, south of Union Road	SN	0.4	0.4	0.5	0.4	0.4	
South St, south of Union Road	NS	1.0	1.0	1.0	0.8	0.9	
The Borough Castle St-South St	WE	3.0	3.0	3.1	2.4	2.7	1.8
West St, west of Downing St	EW	0.8	0.8	0.8	0.7	0.7	
West St, west of Downing St	WE	1.6	1.5	1.7	1.3	1.4	
AQMA total, tonnes/year		4.4	4.4	4.8	3.9	4.0	

Table A4: Annual emissions of oxides of nitrogen from key road links in the AQMA for scenarios with changes in traffic circulation

Road link	Direction	Emission rate, tonnes/km/year						
		2015 with planned development (baseline)	Changes in circulation (A)	A+No articulated lorries	A+20 mph limit	A+Reduced congestion	A+Low emission zone	A+Diesel car restrictions
The Borough, west of Castle Street	2-way	2.9	1.6	1.6	1.7	1.5	1.5	1.0
South St, north of planned development	2-way	2.5	2.1	2.0	2.2	1.7	1.8	1.2
South St, south of planned development	2-way	3.1	2.4	2.4	2.5	2.1	2.1	1.4
Union Road	2-way	1.9	1.4	1.4	1.6	1.3	1.3	0.8
Downing Street	SN	2.0	0.8	0.8	0.8	0.6	0.7	0.5
Bear Lane Woolmead Road-The Borough	2-way	2.5	2.0	2.0	2.2	2.1	1.8	
Woolmead Road	2-way	2.1	1.8	1.7	2.0	1.8	1.6	
East St, South St - Dogflud Way	EW	0.5	0.2	0.2	0.2	0.1	0.1	
East St, Woolmead Road-Dogflud Way	WE	1.8	1.3	1.3	1.5	1.2	1.2	
East St, Dogflud Way-Hale Road	EW	1.2	1.2	1.1	1.3	1.0	1.0	
East St, Dogflud Way-Hale Road	WE	0.6	0.3	0.3	0.3	0.2	0.2	
Dogflud Way, east of planned development	EW	2.0	2.0	2.0	2.1	1.9	1.8	
Dogflud Way, west of planned development	SN	2.1	2.2	2.1	2.3	1.8	2.0	
Hale Road	WE	0.8	0.7	0.7	0.8	0.6	0.6	
Hale Road	EW	1.4	1.6	1.6	1.6	1.0	1.4	
Guildford Road	WE	0.6	0.5	0.5	0.6	0.5	0.5	
Guildford Road	EW	0.7	0.6	0.6	0.6	0.4	0.5	
South St, south of Union Road	SN	0.4	0.8	0.8	0.9	0.8	0.7	
South St, south of Union Road	NS	1.0	0.9	0.9	1.0	0.7	0.8	
The Borough Castle St-South St	WE	3.0	0.3	0.3	0.3	0.2	0.2	0.3
West St, west of Downing St	EW	0.8	0.9	0.9	1.0	0.8	0.8	
West St, west of Downing St	WE	1.6	0.7	0.6	0.7	0.5	0.6	
AQMA total, tonnes/year		4.4	3.0	3.0	3.3	2.7	2.7	

Appendix 2: Adjustment of dispersion model

This Appendix provides details of the adjustments made to the ADMS-Roads model output to provide the best agreement between the modelled concentrations and the concentrations measured at diffusion tube sites in the Farnham AQMA in 2010. The method follows Technical Guidance LAQM.TG(09).

Table A5 shows the monitored concentrations at the monitoring site and the assumed background concentrations of oxides of nitrogen and nitrogen dioxide. An estimate of total oxides of nitrogen concentrations was derived from the measured nitrogen dioxide concentrations using the NOx to NO2 converter from Defra's air quality website. Fig.A3 shows the monitored road contribution to oxides of nitrogen concentrations plotted against the modelled values. The monitored contribution is 1.695 times greater than the modelled value. The modelled contributions were therefore adjusted by this factor.

Table A5: Comparison of unadjusted modelled and measured road contributions to oxide of nitrogen concentrations, µg m^{-3}

Site ID	Monitored total NO_2	Monitored total NOx	Background NO_2	Background NOx	Monitored road contribution NOx (total – background)	Modelled road contribution, NOx
1	57.5	140.63	13.42	18.43	122.2	73.3
1B	67.9	182.93	13.42	18.43	164.5	84.6
2	54.9	130.93	13.42	18.43	112.5	75.2
5	42.3	88.43	13.42	18.43	70	41.0
7	39.5	80.13	13.42	18.43	61.7	40.7
8	40.2	82.23	13.42	18.43	63.8	40.9

Fig. A3: Comparison of unadjusted modelled and measured road contributions to oxide of nitrogen concentrations

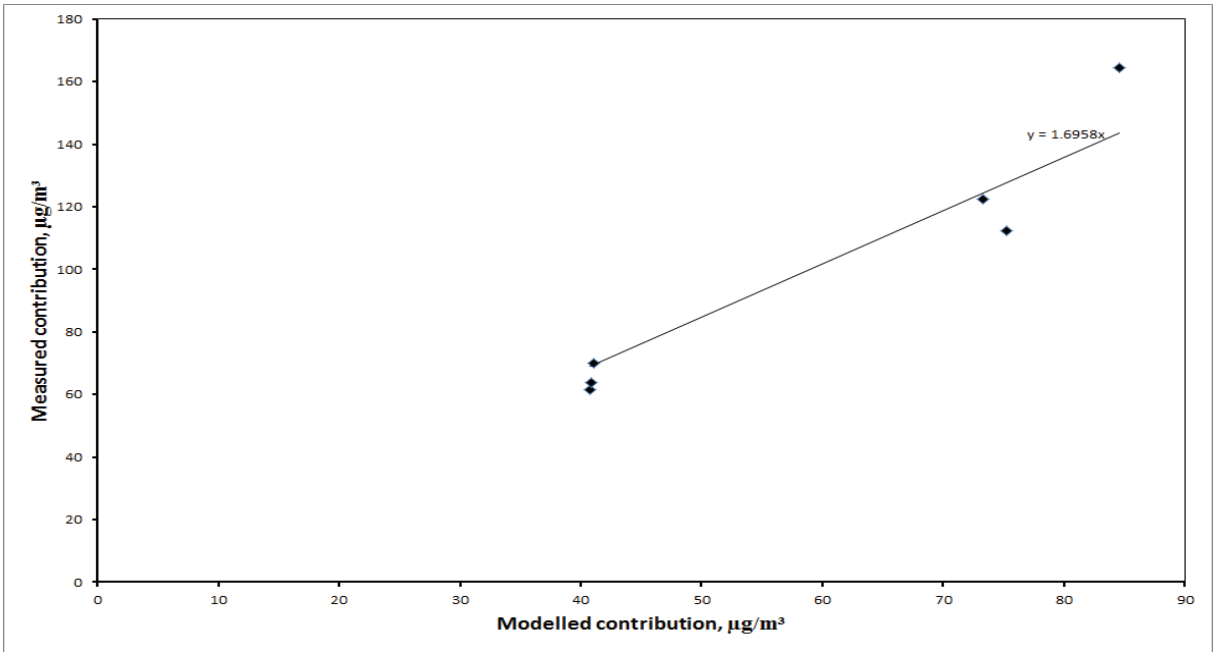
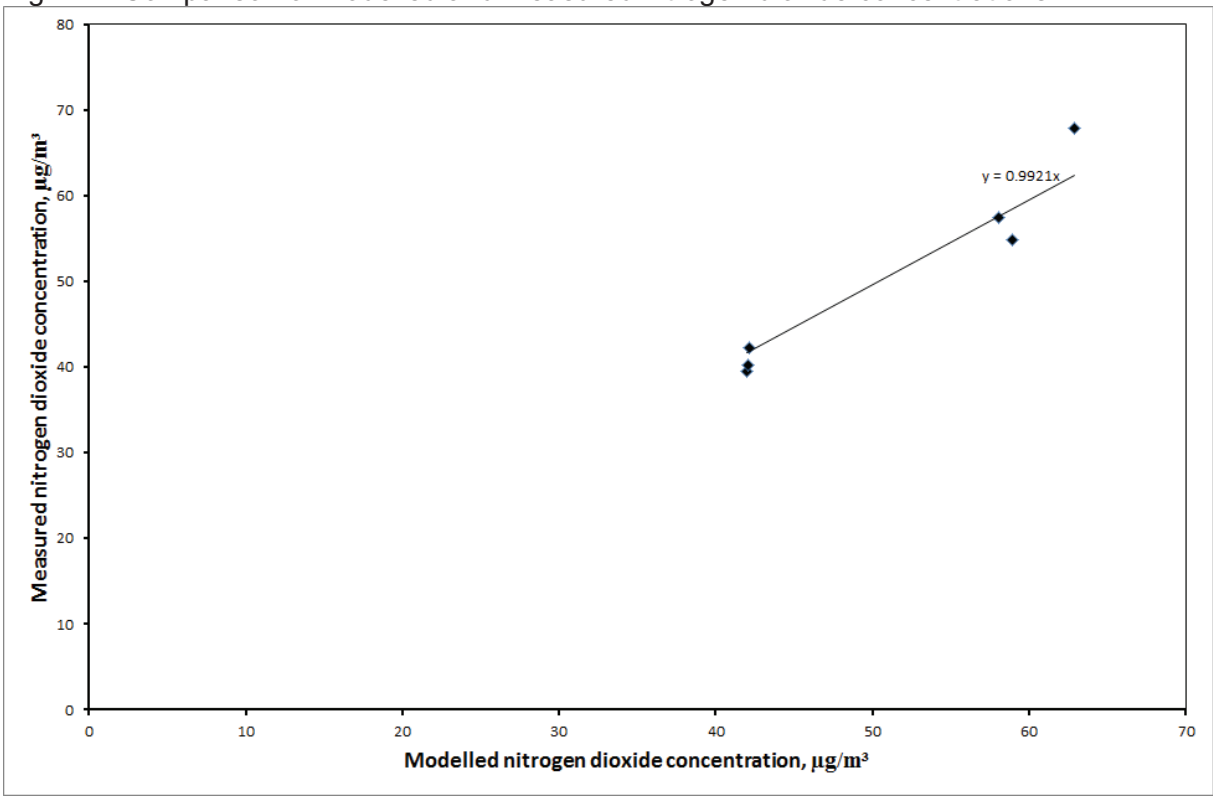


Table A6 shows the adjusted oxides of nitrogen concentrations. The NOx to NO2 converter then provided the adjusted modelled nitrogen dioxide concentration values shown in Table A6. Table A6 compares the modelled and measured nitrogen dioxide concentrations. The differences in concentrations are less than 10% of the monitored concentrations. Fig. A4 shows the monitored nitrogen dioxide concentration plotted against the modelled values.

Table A6: Comparison of modelled and measured nitrogen dioxide concentrations, µg m^{-3}

Site ID	Adjusted Modelled road contribution, NOx	Adjusted modelled total NOX (incl. background NOX)	Modelled total NO2	Monitored total NO_2	% Difference [(modelled - monitored)/ monitored] x100
1	124.4	142.8	58.1	57.5	1
1B	143.5	161.9	62.9	67.9	-7
2	127.6	146.0	58.9	54.9	7
5	69.6	88.0	42.1	42.3	0
7	69.1	87.5	42.0	39.5	6
8	69.3	87.8	42.1	40.2	5

Fig. A4: Comparison of modelled and measured nitrogen dioxide concentrations



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