APPENDIX 7

Western Approach AQMA air quality assessment, Southampton

Baseline study to support LEZ feasibility assessment & Development of Mitigation Measures

Report for Southampton City Council

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Executive summary

Southampton City 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. According to the EC Directive on Air Quality (2008/50/EC) It is mandatory for the UK government to comply with the annual average limit value for nitrogen dioxide (NO_2) by 2010. Local Authorities have a role to play in achieving such air quality standards and must work `in pursuit' of the standard. Where Member States exceed the air quality limit values, the European Commission may commence infringement proceedings and impose a fine. The Localism Act (2011) enables such fines to be cascaded to local authorities.

The Council declared an AQMA to cover the Western Approach because measured concentrations of nitrogen dioxide exceeded the air quality limit value of 40 µg m^{-3} as an annual mean. The designated area runs from Redbridge Road to the west through Millbrook Road and Mountbatten Way through to the Paynes Road slip at the eastern edge of the boundary. 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.

Concentrations in Southampton can be compared with other similar cities by examining monitoring data from the national monitoring network, which include sites that are representative of the wider city rather than pollution hotspots. In 2012 annual average concentrations of NO_2 in Southampton were 32 µg m^{-3}, whereas concentrations in Oxford were 62 µg m^{-3}; Reading 25 µg m^{-3}; Portsmouth 21 µg m^{-3};and Brighton 16 µg m^{-3}.

The Council has worked to improve air quality since 2008 when its Air Quality Action Plan was adopted. This Action Plan set out 45 measures which the Council has been implementing to improve air quality. Recent examples of measures being implemented include the real time bus priority system and the "My Journey" programme to assist passengers to plan their journey which both aim to improve the uptake of public transport and change travel behaviour over the long term.To address the poor air quality along the Western Approach the Council undertook a feasibility study for the implementation of a Low Emission Zone. This involved characterising the baseline air quality situation so that any interventions could be implemented as part of a wider scheme that is not specific to the Western Approach. This part of Southampton has a large effect from the port operations, but also from road traffic.

The results of the assessment suggest that the spatial variation in contributions from the road, rail and port sectors are significant. The west of the AQMA is primarily affected by road sources, of which the car and HGV fleets are significant contributors. In the centre of the AQMA around Millbrook Road the port is a large NOx contributor, indeed it is as large a source of NOx as road traffic at some locations. To the east of the AQMA road sources are again the most important source group, with cars and buses being the largest two contributors within the fleet.

Management of NOx along the Western Approach would therefore sensibly target road vehicles and congestion around the M271 junction. There is a significant flow of HGVs serving the port accessing from that junction so their contribution is quite large on the western side of the AQMA. Further east management of port emissions would seem sensible as this source is as significant as local roads around Millbrook Road. Indeed, the Port Authority is examining ways to reduce emissions and is currently considering options to reduce emissions from their Straddle Carriers. However, the most significant source of emissions from the Port are from ships hotelling and to most effectively improve air quality this source of emission needs to be tackled. To the east of the modelled area areas of high concentration are more associated with congestion at junctions so perhaps traffic management options could be explored along Millbrook Road into Mountbatten Way. Options to reduce emissions in the Western Approach and across Southampton are considered within this study including the feasibility of implementing a Low Emissions Zone (LEZ).

The Do Minimum scenario (with no further local interventions and not taking account of traffic growth) indicates that the national air quality objective is likely to be met around 2019 based on national fleet improvements. To bring this compliance date forward the following LEZ scenarios were considered:

- All HGV to be Euro V compliant
- All HGV to be Euro VI compliant

In addition to these LEZ scenarios, consideration was given to the emissions reduction from the introduction of Euro VI/6 into the vehicle fleet. As previous Euro standards have not delivered in the real world as was expected from test bed emissions monitoring, it was deemed prudent to assess the following improvements from Euro VI/6

- Euro Standard achieving 25% of the predicted benefit
- Euro Standard achieving 50% of the predicted benefit
- Euro Standard achieving 75% of the predicted benefit

An economic analysis of the LEZ options for the Western Approach indicated that in all scenarios monetary costs outweighed the predicted benefits, which included the health benefits. An LEZ based on the Euro V standard brought compliance forward by one year but the costs outweighed the benefits by £200,000 (2014 NPV) across a 10 year scheme. An LEZ based on Euro VI standard would be more effective bringing forward compliance to the year of implementation, which for this initial assessment was deemed to be 2014. However the costs of the scheme outweighed the benefits by £1.9m, and implementing a scheme swiftly would not be practicable. Also, if Euro VI achieved 50% of the predicted benefit the year of compliance is estimated at 2017, with costs outweighing the benefits by £2m.

It should be noted that the abatement costs outlined in this study would not necessarily fall to Southampton City Council- no distinction is made in government guidance as to where costs of abatement should be apportioned. As the abatement scenarios we have looked at would mainly involve private vehicles, it is likely that most of the cost burden would be felt by vehicle owners faced either with replacing their vehicles or paying to enter a LEZ. That said, there would be an implementation cost (e.g. cost of road traffic cameras) and enforcement cost to the Council of any LEZ scheme, and some financial gain from penalty notices. We have made no attempt to ascertain where these costs/gains would ultimately fall as this would necessarily involve detailed LEZ planning with well understood infrastructure requirements which is not available at this time. Should the Council wish to pursue this as a measure to improve air quality, detailed LEZ planning would form part of a further study. This would involve detailed traffic modelling to ascertain the best locations for entry into the LEZ, the impact of traffic displacement on surrounding areas of the proposed LEZ and how economic development would be impacted within the City. Importantly, it would need to focus on the preparation of a detailed cost model and apportion where those costs would fall.

In the meantime, the Council is undertaking to develop a Low Emission Strategy which would cover the whole city and use existing policy levers where possible to reduce emissions.

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1 Introduction

1.1 Background

Southampton City Council has participated in the local authority air quality review and assessment process since 1998 as required by the Environment Act 1995. The Council has currently declared 11 Air Quality Management Areas (AQMAs) for nitrogen dioxide (NO_2):

- • AQMA 1 - Bevois Valley Road
- • AQMA 2 - Bitterne Road West
- • AQMA 3 - Winchester Road
- • AQMA 4 - Town Quay
- • AQMA 5 - Millbrook Rd & Redbridge Rd
- • AQMA 6 - Romsey Road
- • AQMA 7 - (has now been merged with AQMA 5)
- • AQMA 8 - Commercial Road
- • AQMA 9 - Burgess Road
- • AQMA 10 - New Road
- • AQMA 11 - Victoria Road

1.1.1 Air Quality and Health

The effect that poor air quality has on human health is widely reported and the mechanisms that affect mortality and morbidity are becoming clearer. Elevated concentrations of NO_2 are known to cause constriction of the bronchioles, sensitivity to allergens and trigger asthma, however, it is still unclear about the effect that NO_2 has on morbidity[1].

While Southampton City Council has not declared AQMAs for PM_{10} exceedences, our understanding of the effect that fine particulates ($PM_{2.5}$) have on health is increasing. There is strong correlation between fine particulate concentrations and cardiovascular and respiratory diseases, such as strokes and heart disease[2]. Defra has stated that the evidence suggests that there is no "safe" limit for exposure to $PM_{2.5}$, and that this type of man-made pollution cuts the average life expectancy of people living in the UK by seven to eight months[3]. Public Health England have published data showing that 6.3% of deaths in Southampton are attributable to $PM_{2.5}$ exposure – the national average being 5.6%[4]. The Department of Occupational and Environmental Medicine at the University of Southampton believe that further study is needed to establish that there are important health risks from levels of exposure below current exposure limits. They state that “this is because the differences in risk that are observed may have been a long-term effect of exposures in the past when levels of pollution were higher."[5]

In 2012, the World Health Organisation (WHO/IARC) designated diesel exhaust fumes as carcinogenic[6], increasing the risk of both lung and bladder cancer.

[1] http://www.comeap.org.uk/air/pollutants/106-health-effects-of-nitrogen-dioxide
[2] http://www.comeap.org.uk/air/pollutants/97-health-effects-of-particles
[3] Air Pollution: Action in a Changing Climate, Defra, 2010
[4] http://www.phoutcomes.info/public-health-outcomes-framework#gid/1000043/pat/6/ati/101/page/3/par/E12000008/are/E06000045
[5] http://www.bbc.co.uk/news/health-25827304
[6] http://www.bmj.com/content/344/bmj.e4174

1.1.2 Western Approach AQMA

This study is concerned with AQMA 5 which runs from Redbridge Road to the west through Millbrook Road and Mountbatten Way through to the junction with West Quay Road at the eastern edge of the boundary. A map showing the AQMA boundary is shown in Figures 1.1a to c. The stretch of road under consideration here is commonly named the "Western Approach" which is mainly formed by the A33 dual carriageway.

Figure 1.1a Location of Western Approach AQMA, Southampton

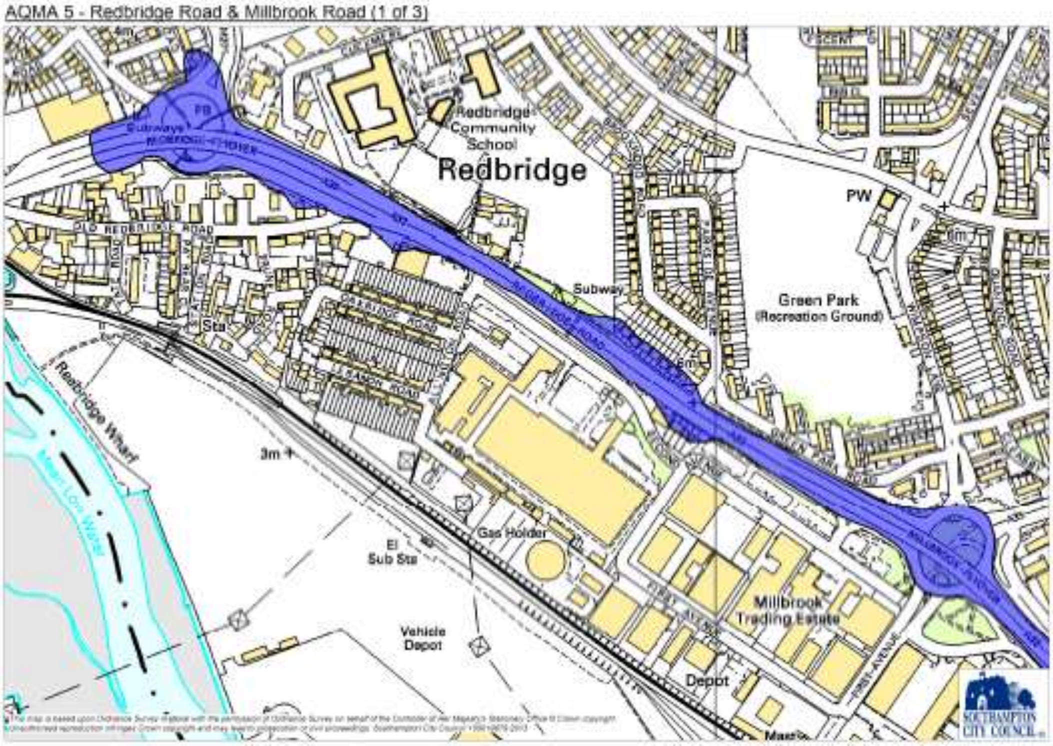
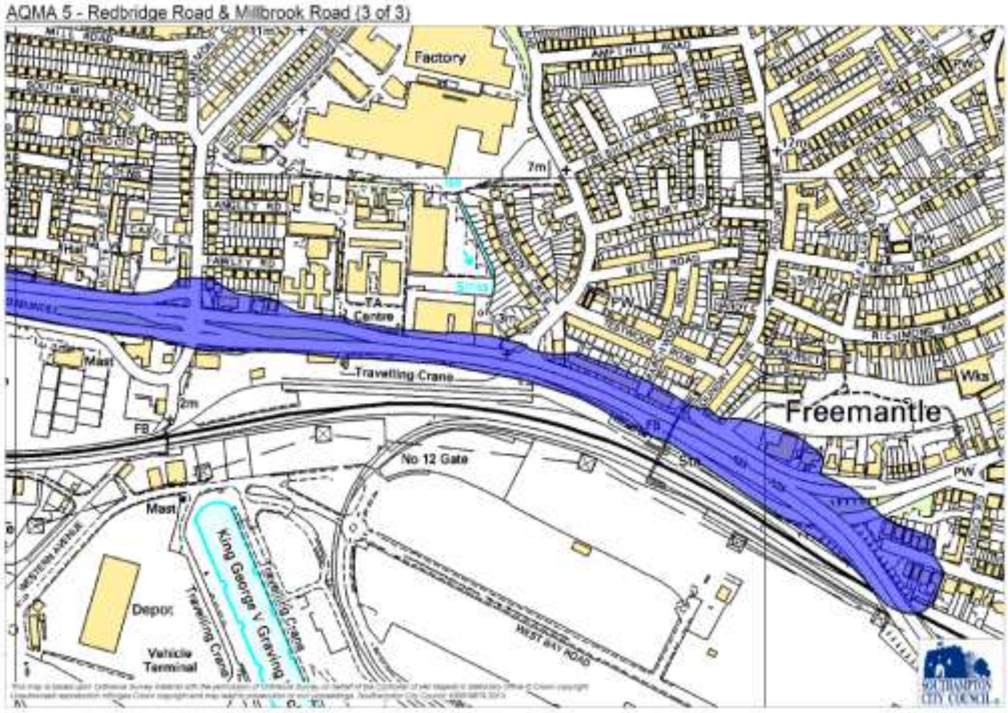


Figure 1.1b Location of Western Approach AQMA, Southampton

Figure 1.1c Location of Western Approach AQMA, Southampton



1.1.3 Southampton City Council Air Quality Action Plan

Southampton adopted its Air Quality Action Plan[7] in 2008 and this was updated in 2009. Recently, the Council has been selected[8] as having the potential to benefit from a Low Emission Zone based on all buses and HGVs meeting Euro IV standards for both NOx and PM_{10} on locally controlled roads. The air quality action plan describes a series of actions to improve air quality within the AQMAs and across the whole city. The AQMAs were declared based on measured concentrations exceeding the national objective for nitrogen dioxide (NO_2), principally due to emissions from road transport.

Progress on the implementation of the plan is described in progress reports (most recently the 2011 air quality action plan progress report[9]). Recognising the contribution of road traffic emissions, the air quality action plan has been integrated into the Local Transport Plan[10] (LTP3) which includes several policies which can aid air quality management. The status of each measure is reported as red/amber /green with a high, medium and low impact in air quality for each measure. The 2011 air quality action plan progress report reported that some outcomes show a broader picture of progress towards cleaner air. However, despite efforts to implement measures in the action plan since 2008, trends in NO_2 data, for both Redbridge School and Millbrook Road (and indeed other monitoring locations in Southampton) have been fairly stable. This is a trend which is commonplace throughout the UK and research has demonstrated it is related to the failure of the Euro vehicle standards to deliver the expected emission reductions in real world driving conditions.

There is however some evidence of a downward trend in some of the NO_2 measurements along the Western Approach from 2007 to 2011 but there are still measured exceedances of the annual mean objective locally. Many urban authorities in the UK have long standing

[7] https://www.southampton.gov.uk/Images/Air%20QUality%20Action%20Plan%202009_tcm46-258022.pdf

[8] http://uk-air.defra.gov.uk/library/no2ten/documents/110609_Technical_report_FINAL.pdf

[9] Available here: http://www.southampton.gov.uk/Images/progress%20report%202011%20Nov%202011%20for%202010%20data%20(2)_tcm46-314418.pdf

[10] Available here : https://www.southampton.gov.uk/s-environment/transportplanning/localtransportplan3/

exceedances of the annual mean NO_2 objective so the results of SCCs monitoring are in line with a trend which is commonplace throughout the UK.

In 2013/14, Southampton CC secured £60,000 of Defra Air Quality Grant funding to develop a Low Emission Strategy (LES) for the City. The LES, to be developed over a 2 year period from 2014 to 2016, will review the policies and measures within the Local Transport Plan[4] (LTP3) and build on this study to develop an appropriate strategy to reduce road transport and port emissions. This is discussed further in Section 4.

1.1.4 This study

This air quality study is focussed specifically on the potential for a Low Emission Zone that might address the NO_2 exceedances that have been measured along the Western Approach in 2011. The first step in this process was to robustly characterise the baseline air quality situation in the city. . This part of Southampton has a large effect from the port operations, but also from road traffic. Therefore a key outcome of this study is to apportion those sources before testing any potential abatement scenarios.

We have undertaken this analysis based primarily on dispersion modelling of NOx emissions from roads, local railways, and the Port of Southampton. In general terms the approach taken was to first characterise the NOx emissions from each source group. Emissions were then modelled NOx dispersion separately in two dispersion models (ADMS and ADMS Roads) and apply an appropriate background NOx background to determine 2011 based NO_2 concentrations across the model domain.

LEZ scenarios were also tested as part of this work along the Western Approach As HGVs were estimated to significantly add to the total NOx pollution levels the following scenarios were considered:

- All HGV to be Euro V compliant
- All HGV to be Euro VI compliant

In addition to these LEZ scenarios, consideration was given to the emissions reduction from the introduction of Euro VI/6 into the vehicle fleet. As previous Euro standards have not delivered in the real world as was expected from test bed emissions monitoring, it was deemed prudent to assess the following improvements from Euro VI/6

- Euro Standard achieving 25% of the predicted benefit
- Euro Standard achieving 50% of the predicted benefit
- Euro Standard achieving 75% of the predicted benefit

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The consideration of an LEZ was supplemented by other measures which may also help to reduce emissions in the Western Approach and throughout the City.. These mitigating measures and progress towards their implementation are discussed in Section 3, and could be included within the development of a Low Emission Strategy for Southampton.

Mitigation measures considered by Southampton CC can be found in Appendix 4.

2 Air quality at the Western Approach

2.1 NO_2 Monitoring data

Southampton City Council measures nitrogen dioxide concentrations at a network of diffusion tube sites throughout Southampton. Nitrogen dioxide is also measured by continuous automatic monitor at five locations of which two are within the modelling domain for this study.

Figure 2.1 shows the locations of diffusion tube and automatic monitors in or close to the AQMA. The limit value for nitrogen dioxide set in the EC Air Quality Directive and Regulations in England and Wales is 40 µg m^{-3}. Table 2.1 shows the concentrations measured at these locations for 2008-2011.

The NO_2 annual mean concentration exceeded the limit value in 2011 at several of the measurement sites in the area of the AQMA, highlighted in bold in Table 2.1. The highest concentrations in 2011 were measured at the M271 diffusion tube site and the Redbridge School and Millbrook automatic sites.

Figure 2.1: Location of monitoring sites in the Redbridge Road/Millbrook Road AQMA

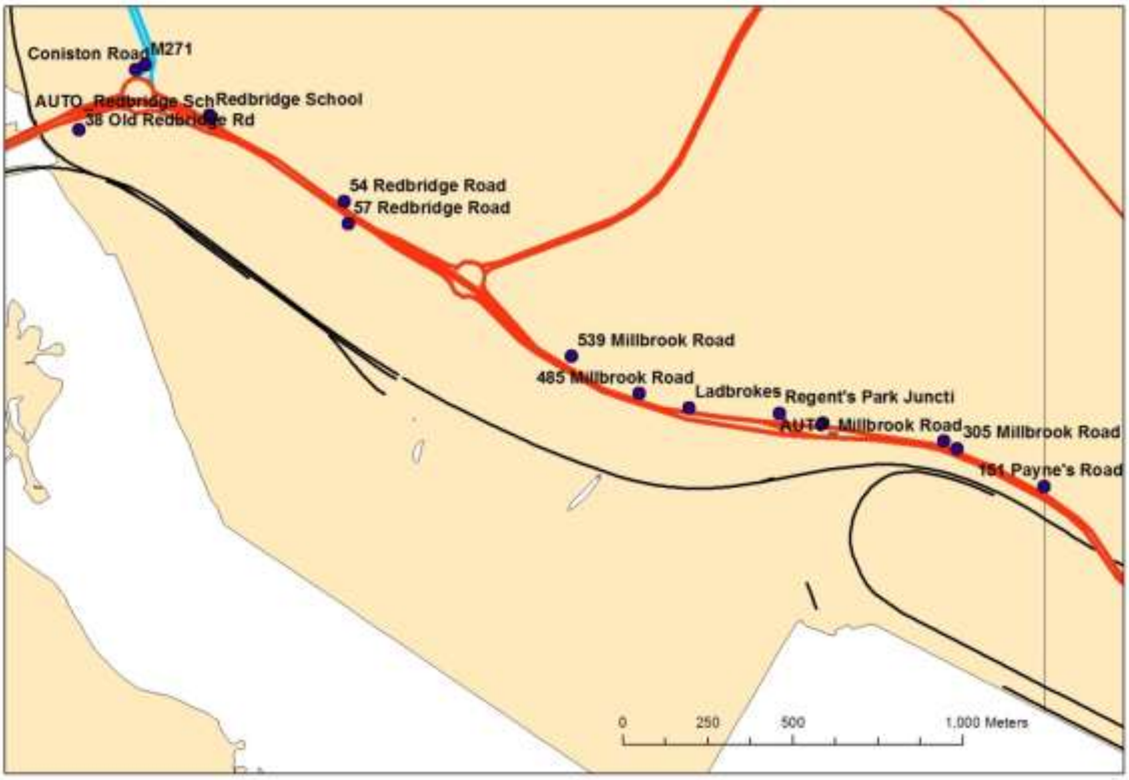


Table 2.1: Summary of the results of NO_2 diffusion tube monitoring in the AQMA

Location	Data Capture, 2011	Annual mean concentration, µg m^{-3}

		2008	2009	2010	2011
M271	75%	**59.1**	**51.0**	**-**	**54.1**
Coniston Road	66%	35.5	34.4	-	37.7
38 Old Redbridge Rd	33%	35.7	36.3	37.3	33.6
Redbridge School	100%	**46.9**	**45.8**	**41.6**	**42.1**
AUTO_Redbridge School	86%	**44.3**	**39.9**	**41.0**	**47.5**
54 Redbridge Road	83%	-	**41.3**	**42.8**	39.8
57 Redbridge Road	100%	-	**41.5**	**42.7**	39.8
539 Millbrook Road	91%	**40.1**	35.4	32.1	32.9
485 Millbrook Road	100%	38.4	37.4	32.0	33.3
Ladbrokes	91%	**46.1**	**43.2**	**40.6**	39.8
Regent's Park Junction	83%	**45.5**	**41.7**	38.3	42.0
367A Millbrook Road	91%	**46.1**	**48.7**	**41.6**	**45.1**
AUTO_Millbrook Road	99%	**51.9**	**50.0**	**51.5**	**48.7**
305 Millbrook Road	100%	**41.7**	**43.0**	**42.3**	39.7
151 Payne's Road	100%	-	33.8	33.5	33.0

NO_2 concentrations at the monitoring sites will be affected to varying degrees by contributions from local traffic and the port. It is thought that the sites around Millbrook Road are affected to a larger degree by NOx emissions from the port. Sites further east and west are expected to be mainly affected by road traffic emissions due to the increased distance from the most NOx intensive port activities (see Section 3). Apportioning the contribution from the sources at the different locations will allow effective targeting of interventions in any Low Emission Strategy that may follow for the city.

The 2011 NO_2 results have been used to verify the outputs of the air dispersion modelling study which is described below.

2.2 Road source dispersion modelling

We have conducted an air dispersion modelling analysis of NO_2 concentrations around the Western Approach. The results of this work can be used to understand the air pollution climate in the area given the relative contributions of the local road network and the Port of Southampton. Our approach follows the methodological recommendations of LAQM.TG(09).

Annual mean concentrations of NO_2 from roadways during 2011 have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.1).

The model was verified by comparing the modelled predictions of road NO_x with local monitoring results. The available roadside measurements within the study area were used to verify the annual mean road NOx model predictions.

Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the local measurements.

A surface roughness of 1.5 m was used in the modelling to represent a large urban area in the model domain. A limit for the Monin-Obukhov length of 30 m was applied.

The source-oriented grid option was used in ADMS-Roads; this option provides finer resolution of predicted pollutant concentrations along the roadside, with a wider grid spaced at approximately 20 metres being used to represent concentrations further away from the road across the wider study area. The predicted concentrations were interpolated to derive values between the grid points using the Spatial Analyst tool in the GIS software ArcMap 10. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping.

A time varying emissions file based on an analysis of diurnality in the traffic data was used in the model to account for daily variations in traffic flow. This was derived from the 24hr traffic counts provided by SCC for Redbridge Road and Millbrook Road.

The model domain is shown in Figure 2.2 below; roads modelled are shown in blue. All roads included in the model were treated as two way flows. The Redbridge and Millbrook flyovers were modelled at heights representative of the difference between them and the closest roadside receptors.

2.2.1 Validation of ADMS-Roads

Validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications; this is usually conducted by the model developer.

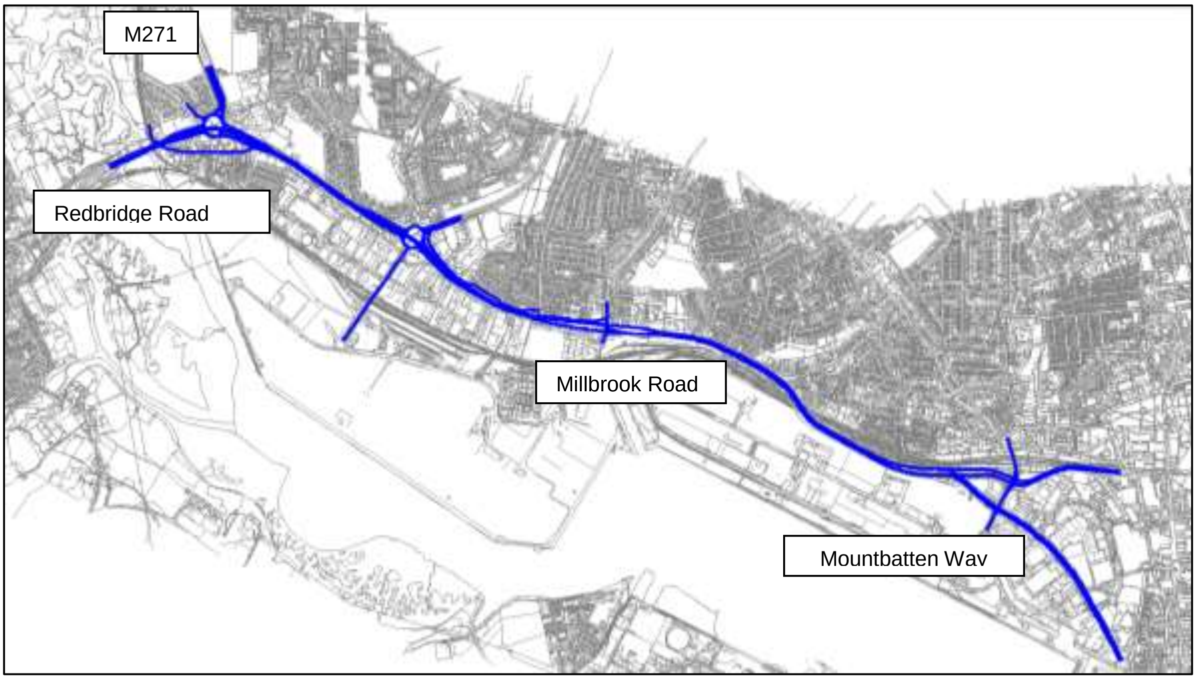
CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and Defra.

2.2.2 Mapping

Ordnance Survey based GIS data of the model domain and a road centreline GIS dataset were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined in ArcMap.

Southampton City Council provided OS Mastermap data to support the assessment. All OS Mastermap maps in this document are reproduced from Ordnance Survey material with permission of Her Majesty's Stationery Office © Crown Copyright and database right 2013. All rights reserved. Ordnance Survey License number LA 100019679 2013.

Figure 2.2: Model domain and roads included (in blue) in emissions and ADMS Roads dispersion calculations



2.2.3 Road traffic data

Real time traffic count data collected by Southampton City Council and Hampshire County Council in 2011 were used for the assessment to characterise traffic flows and fleet splits in the area; this included annual counts with 1-hr resolution for the roads being modelled.

Speed data was supplied by the Economy, Transport and Environment Department at Hampshire County Council from their Strat-e-gis dataset. The Strat-e-gis data provides high temporal resolution speed data that represents the speed on a link by link basis across the day. The use of this data removes the need for assumption as to how traffic speed is affected near junctions and other obstacles. Each link has an average speed for the time interval specified- in this instance 7 to 9am, 9am to 4pm, 4 to 6pm, and 10pm to 6am. Each link also has the number of GPS observations from which the average for the year is derived; this allows weighting of the daily average speed by the number of observations. In practice the weighted average speed is normally around the same as the measured speed for the 9am to 4pm interval.

An example of how the Strat-e-gis data was processed is provided in Table 2.2 below- this example is from the Redbridge Road area to the west of the model domain where the traffic is reasonably free flowing.

All vehicle fleets except buses were assumed to be the same as those defined in the EfT which uses fleet splits for England provided by the DfT. The bus fleet was defined in more detail as information was provided by local operators.

Table 2.2: Excerpt of Strat-e-gis data for Redbridge Road

Road	Speed (kph) 7am to 9am	No. of Obs	Speed (kph) 9am to 4pm	No. of Obs	Speed (kph) 4pm to 6pm	No. of Obs	Speed (kph) 10pm to 6am	No. of Obs	Speed (kph) Total Obs	Weighted Speed (kph)
Redbridge Causeway from A36 Junction_1	46.73	2877	61.98	7901	61.8	2685	75.78	718	14181	60
Redbridge Causeway from A36 Junction_2	51.90	2907	59.86	7923	59.37	2698	71.63	721	14249	59
Redbridge Causeway from A36 Junction_3	64.73	1311	70.81	4220	73.53	1614	74.28	443	7588	71
Redbridge Causeway from A36 Junction_4	59.19	1313	68.65	4233	71.87	1615	69.87	442	7603	68
Redbridge Causeway from A36 Junction_5	59.89	1310	69.63	4227	74.08	1617	74.41	441	7595	69
No. of Obs= number of GPS observations										

The Strat-e-gis data was also very useful for delineating areas of the road network that are congested with resulting low average speeds. In general speeds near junctions were much lower as would be expected, with some junctions having weighted average speeds in the order of 10 to 15 kph.

All roads were split into 50m links within the ADMS Roads model yielding over 300 individual road sources in the model domain. Each was assigned a bespoke AADT flow, speed and fleet composition.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics a degree of uncertainty is introduced into the modelling.

Road traffic in the Western Approach area has a diurnal variation in flow which is, as would be expected for a dual carriageway serving a major city, quite tidal in nature. During the morning most traffic is flowing East to access the city, with the opposite being true in the afternoon.

The weekend diurnal profile is less associated with commuting and appears to be more associated with shopping and leisure based trips, so the peak period is later in the day. There is still something of a tidal effect at the weekend as before but it is less pronounced. Figures 2.3 and 2.4 show the diurnal traffic profile derived for the A33 West and Eastbound, and by weekday and weekend (the same phenomena is observed at both the Redbridge Road and Millbrook Road ends of the A33). All other roads in the domain were modelled using a combined diurnal profile.

Figure 2.3: Diurnal traffic profile- Redbridge Road Eastbound (1=total daily traffic flow)

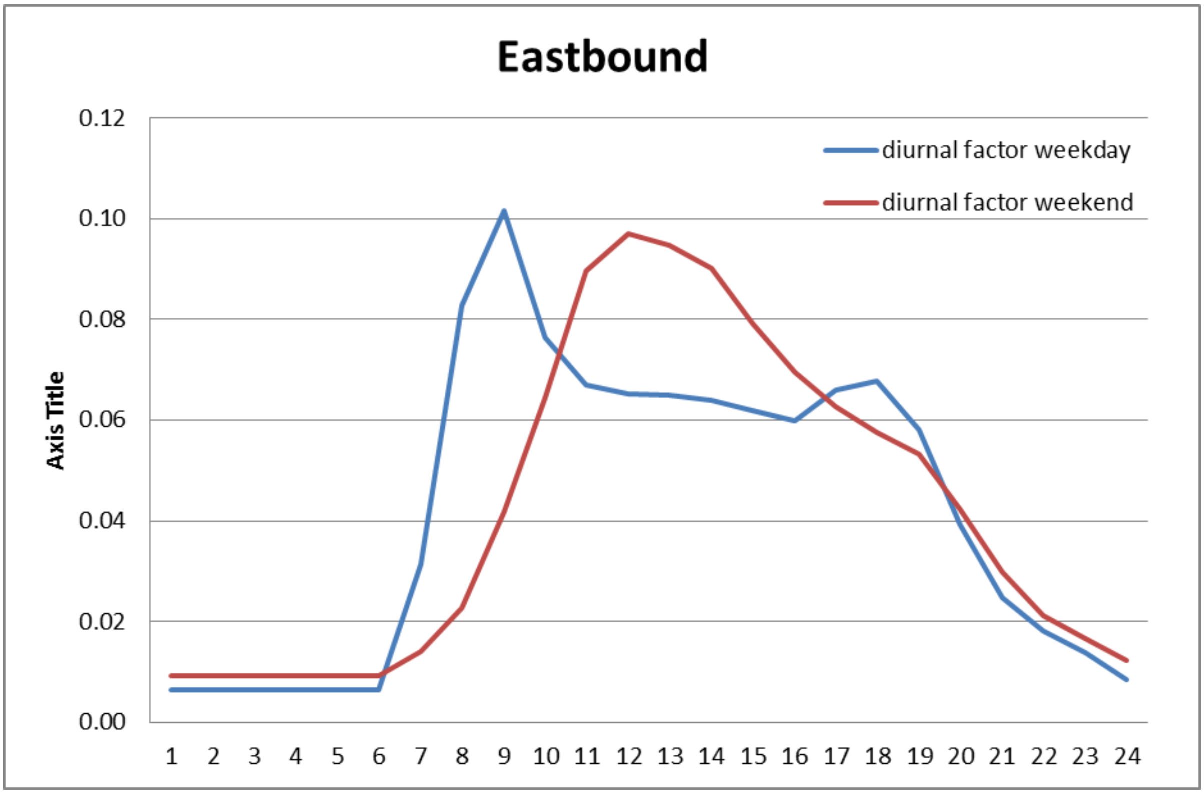
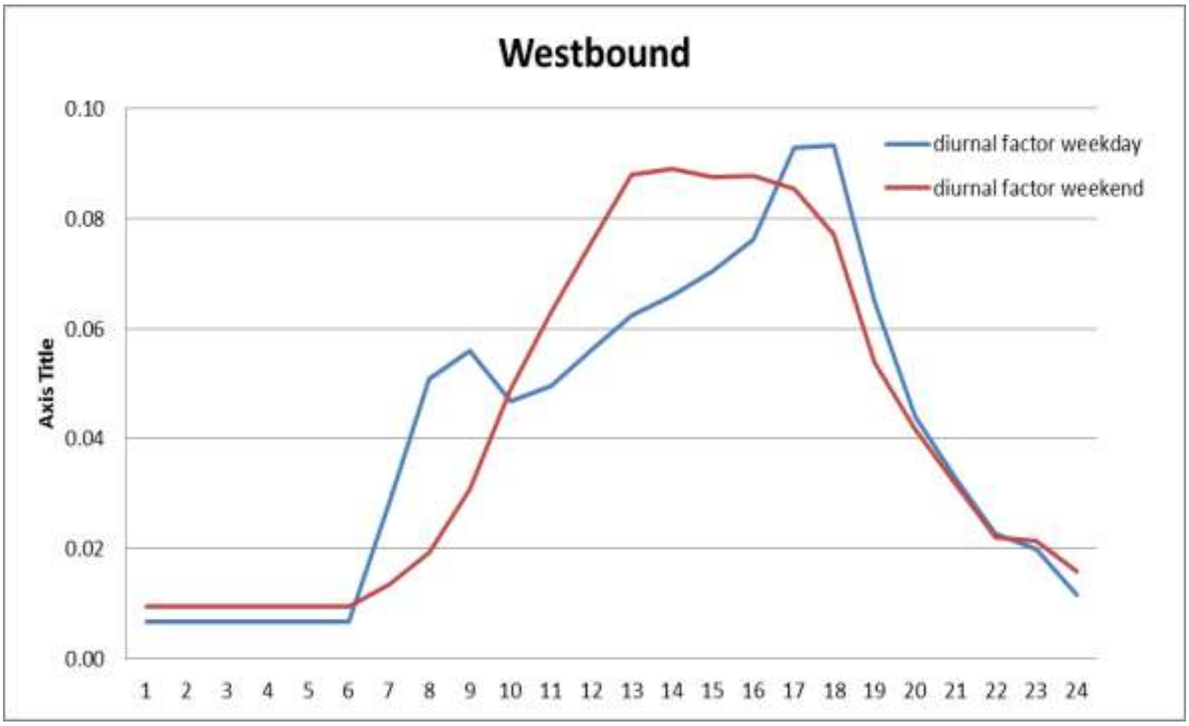


Figure 2.4: Diurnal traffic profile- Redbridge Road Westbound (1=total daily traffic flow)



2.2.4 Road traffic emissions factors

The most recent version of the Emissions Factors Toolkit[11] (EFT V5.2c Jan 2013) release) was used in this assessment to calculate pollutant emissions factors for each road link modelled. The calculated emission factors were then imported in to the ADMS-Roads model.

[11] http://laqm1.defra.gov.uk/documents/tools/EFT_Version_4_2.zip

Parameters such as traffic volume, speed and fleet composition are entered into the EfT, and an emissions factor in grams of NOx/kilometre/second is generated for input into the dispersion model. In the latest version of the EfT, NOx emissions factors previously based on DFT/TRL functions have been replaced by factors from COPERT 4 v8.1. These emissions factors were published in May 2011 through the European Environment Agency and are widely used for the purpose of calculating emissions from road traffic in Europe.

The latest version of the EFT also includes addition of road abrasion emission factors for particulate matter; and changes to composition of the vehicle fleet in terms of the proportion of vehicle km travelled by each Euro standard, technology mix, vehicle size and vehicle category.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will reduce as newer vehicles are introduced. Any inaccuracy in the emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

All Strat-e-gis data was used in the EfT as received and following the weighting procedure described.

The EFT has also been used for this study to test the implementation of an idealised set of scenarios based around uptake of Euro 6 and Euro VI vehicles in Southampton.

Example EfT inputs and outputs are provided in Appendices 2 and 3.

2.2.5 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2011 from the Southampton Airport site was obtained from a third party supplier and used for the modelling assessment. The meteorological measurement site has good data quality for the period of interest though cloud cover data had to be taken from another site some 80km away (Gatwick Airport). Cloud cover is relatively regional so the conditions measured at Gatwick will be representative of those in Southampton for that parameter.

2.2.6 Background concentrations

Background NOx concentrations for a dispersion modelling study can be accessed from either local monitoring data conducted at a background site or from the Defra background maps[12]. The Defra background maps are the outputs of a national scale dispersion model provided at a 1km x 1km resolution and are therefore subject to a degree of uncertainty.

We consulted with Southampton City Council on the treatment of background and it was agreed that using the mapped background values was appropriate for this assessment. In the context of an area that is affected by both road and other transport sources it is important that these can be screened out of the background concentrations used. The Defra NOx mapping is sectorised so we were able to remove the contributions of the roads and the port from the background so that these could be discretely modelled thereby avoiding double counting.

When the contributions of the local roads and shipping based sources were removed from the background grid squares covering the model domain this resulted in a uniform background NOx concentration of 20.1μg.m^{-3} which was applied in the modelling. The background data derived from the Defra maps is shown in Table 2.3 below. For the purposes of this study, and since these source groups will be modelled explicitly, we have used the “Total minus other + industry + A Roads + Rail” as shown in the table.

Table 2.3: Summary of NOx background values around the Western Approach (μg.m^{-3})

x	y	Total NOx 2001	Total minus "other"	Total minus "other+A roads"	Total minus "other + industry"	Total minus "Other + industry	Total minus "Other + industry +

[12] Defra (2012) http://laqm1.defra.gov.uk/review/tools/background.php (accessed September 2012)

						+ A Roads"	A Roads + Rail"
437500	113500	41.8	32.6	20.1	31.4	18.9	**17.9**
438500	113500	41.3	31.9	22.1	30.6	20.8	**19.9**
439500	113500	47.9	31.4	27.2	27.7	23.4	**22.5**
440500	113500	43.7	30.8	26.8	28.5	24.5	**23.6**
441500	113500	40.8	29.2	25.3	27.0	23.0	**22.0**
438500	112500	37.7	24.4	19.4	22.9	17.9	**15.4**
439500	112500	59.9	28.1	21.4	26.3	19.6	**17.6**
440500	112500	51.6	32.1	24.2	30.0	22.0	**20.8**
441500	112500	52.7	35.1	29.2	32.1	26.3	**24.8**
440500	111500	64.2	25.1	22.4	21.5	18.8	**16.3**
441500	111500	72.7	32.0	26.4	28.7	23.2	**19.8**
Mean		50.4	30.2	24.0	27.9	21.7	**20.1**

2.2.7 Treatment of modelled NOx road contribution

It is necessary to convert the modelled NOx concentrations to NO_2 for comparison with the relevant objectives.

The Defra NOx/NO_2 model[13] was used to calculate NO_2 concentrations from the NOx concentrations predicted by ADMS-Roads. The model requires input of the background NOx, the modelled road contribution and accounts for the proportion of NOx released as primary NO_2. For the Southampton area in 2011 with the “All other UK urban Traffic” option in the model, the NOx/NO_2 model estimates that 22% of road NOx is released as primary NO_2.

2.2.8 Road model verification

The results of the roadway dispersion modelling have been verified by comparing with the available local measurements. As roads are not the only important source of NOx in the modelled area we must also include the contribution from other local sources in the verification exercise. Hence, the verification procedure is described in a later section.

2.3 Air dispersion modelling of other transport sources

Emission sources within the Port of Southampton contribute to pollutant concentrations on the Western Approach road. This section provides details of how the contribution from the port to roadside pollutant concentrations was estimated. It considers the contribution from:

- Manoeuvring and hotelling of container ships in the dredged channel
- Manoeuvring and hotelling of cruise ships in the dredged channel
- Manoeuvring and hotelling of other cargo ships, including vehicle import/export, in the dredged channel
- Straddle carriers used for container handling operations
- Container transfers from/to lorries
- Container lorry emissions in the port area
- Vehicle delivery lorries in port area
- Rail terminals
- Mainline railway

[13] Defra (2012) NOx NO_2 Calculator v3.2 released September 2012; Available at http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html

Figure 2.5 shows the location of these sources of emission.

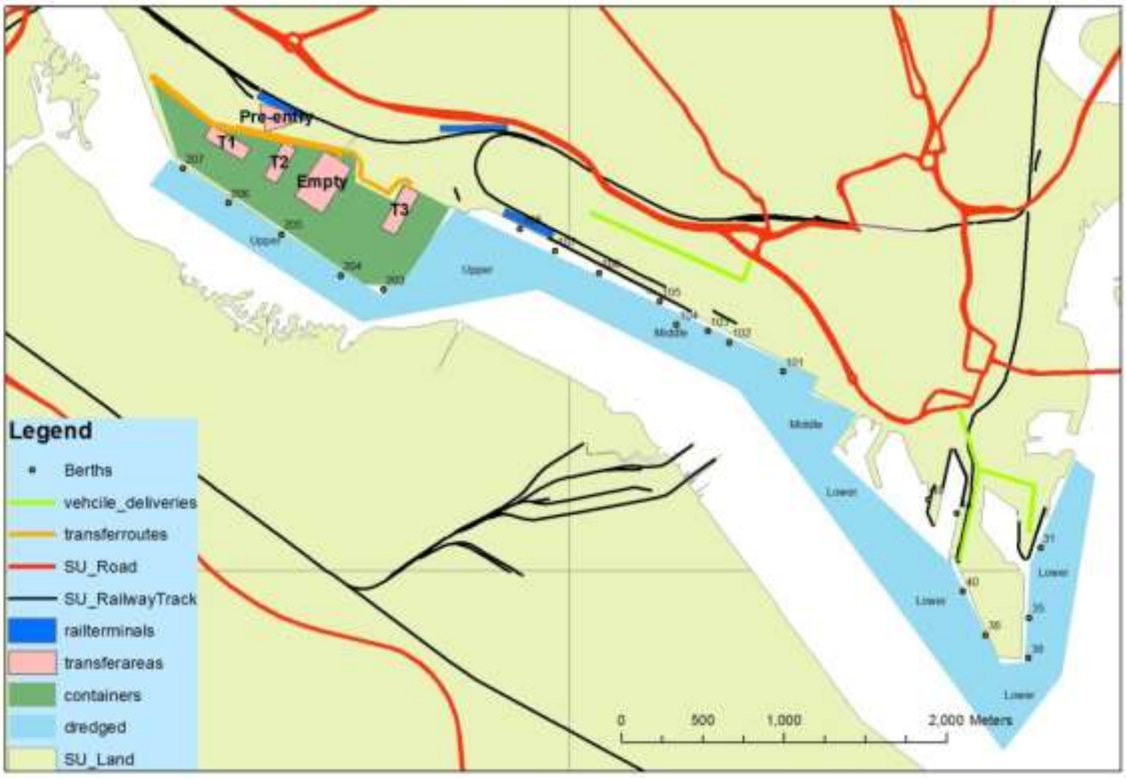
This section describes how the emissions were estimated and how dispersion models were used to predict the concentrations at relevant locations.

Two dispersion models were used for this assessment:

- The ADMS5 dispersion model is widely used to model industrial point, area and volume sources. ADMS 5 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by the boundary layer depth, and the Monin-Obukhov length. ADMS 5 has an in-built meteorological pre-processor that allows flexible input meteorological data both standard and more specialist.

- LADSUrban The air quality impact from port roads and railways was assessed using our proprietary urban model (LADS Urban). This model provides a tool for calculating atmospheric dispersion using a 10 m x 10 m x 3 m volume-source kernel derived from ADMS5 to represent elements of the specified road links. The volume source depth takes account of the initial mixing caused by the turbulence induced by the vehicles. The LADSUrban tool calculates the emissions for each road link using the emissions factors published by the Department for Transport in 2012. It calculates the annual emissions for each road link taking into account the annual average daily traffic flow, the proportion of vehicles in each vehicle category and the vehicle speed. The emission factors for heavy goods vehicles, buses and coaches for oxides of nitrogen have been updated in line with the COPERT IV emission factors. The tool takes account of the age of the vehicle fleet based on national statistics.

Figure 2.5 Location of Port of Southampton emission sources



2.3.1 Container ships

The emissions from container ships were estimated using the methods described in the EMEP/EEA air pollutant emission inventory guidebook, 2009. The total deadweight tonnage of container ships entering the Port of Southampton in 2011 was 49.9 million DWT (Department for Transport Port Statistics Table 0603). There were 252 ships of less than 20,000 DWT and 525 of more than 20,000 DWT (Department for Transport Port Statistics Table 0601). The smaller ships are feeder ships: the Vega Stockholm (8306 DWT) is typical and has been assumed to be representative. The estimates of the emissions from larger ships assume a representative deadweight tonnage of 91,219 DWT. The gross tonnage of the container ships was estimated as 0.96 times the deadweight tonnage, based on an analysis of a sample of container ships entering the Port of Southampton. The main engine power rating was then estimated using an empirical formula relating the size of the main engines to the gross tonnage, taken from the EEA guidebook.

Table 2.4 lists the assumptions made about the operation of the main and auxiliary engines during manoeuvring and hotelling in port and the emission factors used, based on the recommendations in the EEA guidebook. Table 2.4 also shows the calculated annual emissions from manoeuvring and hotelling the container ships.

The ADMS5 dispersion model was used to predict ground level concentrations. Meteorological conditions were represented by hourly sequential wind speed, wind direction and cloud cover data from Southampton Airport, for 2011.

The manoeuvring emissions were represented in the model as a 45 m deep volume source, covering the upper part of the dredged channel shown in Fig. 2.5.

The hotelling emissions were represented as point sources located at berths 204, 205, 206 and 207, shown in Fig. 2.5. A quarter of the total emission was allocated to each of the berths. Ships less than 20,000 DWT were assumed to discharge through 1 m diameter stacks at a height 30 m above ground level with a discharge velocity of 2 m s^{-1} and a discharge temperature of 180°C. Ships more than 20,000 DWT were assumed to discharge through 3 m stacks at a height of 45 m above ground level.

Table 2.4 Container ship emissions

	< 20000 dwt	>20000 dwt	Total
Number	252	525	
Typical dwt	8306	91061	
Annual dwt	2.09 million	47.8million	49.9 million
Ratio GT/DWT	0.9598	0.9598	
GT	7972	87400.	
Main engines, kW	6032	48663.	
Ratio Auxiliary/main	0.25	0.25	
Auxiliary engines, kW	1508	12166	
Manoeuvring time, hrs	1	1	
Fraction load Main	0.2	0.2	
Fraction time operating	1	1	
Fraction load Auxiliary	0.5	0.5	
Fraction time operating	1	1	
NOx Emission factor main , g/kWH	14	14	
NOx Emission factor aux	14.2	14.2	
Manoeuvring NOx emissions, tonne per year	6.95	116.9	
Average emission rate NOx, g s^{-1}	0.221	3.71	
PM Emission factor main , g/kWH	2.4	2.4	
PM Emission factor aux	0.3	0.3	
Manoeuvring PM emissions, tonne per year s^{-1}	0.786	13.2	
Average emission rate PM, g s^{-1}	0.025	0.419	
Hotelling time, hrs	14	24	
Fraction load main engine	0.2	0.2	
Fraction time operating	0.05	0.05	
Fraction load auxiliary	0.4	0.4	
Fraction time operating	1	1	
NOx Emission factor main , g/kWH	13.1	13.1	
NOx Emission factor aux	13.5	13.5	
NOx Hotelling emissions, tonnes per year	31.5	908.1	
Average NOx emission rate, g s^{-1}	1.00	28.8	
PM Emission factor main , g/kWH	0.3	0.3	
PM Emission factor aux	0.3	0.3	
PM Hotelling emissions, tonnes per year	0.703	20.2	
Average PM emission rate, g s^{-1}	0.022	0.642	

2.3.2 Cruise ships

The emissions from cruise ships were estimated using the methods described in the EMEP/EEA air pollutant emission inventory guidebook, 2009. The cruise ships use five cruise terminals: Ocean Terminal, City Terminal, Mayflower Terminal, QE II Terminal and Southampton 104 Terminal. These correspond to berths 49, 101, 106, 38/39 and 104 respectively shown in Fig. 2.5. The ships using each of the terminals were identified from the Port of Southampton Cruise Ship Schedule for 2013. The main engine power for each ship was estimated from its gross tonnage using an empirical formula for passenger ships relating the size of the main engines to the gross tonnage, taken from the EEA guidebook. The emissions for each ship were then calculated assuming the operational duty and emission factors shown in Table 2.5, which are based on the EEA guidance.

The annual emission for each terminal was calculated as the sum of the emissions from ships using each terminal. Table A.2 lists the assumptions made about the operation of the main and auxiliary engines during manoeuvring and hotelling in port and the emission factors used, based on the recommendations in the EEA guidebook. Table 2.5 also shows the calculated annual emissions from manoeuvring and hotelling the cruise ships.

The manoeuvring emissions were represented in the ADMS5 dispersion model as a 45 m deep volume source, covering the part of the dredged channel shown in Fig. 2.5. Emissions from ships using the Mayflower, Southampton104, and City Terminals were allocated to the middle part of the dredged channel shown in Fig. 2.5. Emissions from ships using the QE II and Ocean Terminals were allocated to the lower part of the dredged channel.

The hotelling emissions were represented as point sources located at each of the terminal berths.. Cruise ships were assumed to discharge through 2.8 m diameter stacks at a height 45 m above ground level with a discharge velocity of 2 m s^{-1} and a discharge temperature of 180^{o}C.

Table 2.5 Operating pattern for cruise ships

	Manoeuvring	Hotelling
Time, hrs	1	14
Fraction load maximum continuous rating	0.2	0.2
Fraction time operating	1	0.05
Fraction load auxiliary engine continuous rating	0.5	0.4
Fraction time operating	1	1
Ratio Auxilary/Main	0.16	0.16
NOx Emission factor main engine, g/kWh	14	13.1
NOx Emission factor auxiliary engines	14.2	13.5
PM Emission factor main engine, g/kWh	2.4	0.3
PM Emission factor auxiliary engines	0.3	0.3
Total NOx emission, tonnes per year	82.0	290.1
Total PM emission, tonnes per year	10.5	6.47

2.3.2.1 Vehicle carriers, Ro-Ro and general cargo ships

Vehicle carriers and Ro-Ro ships, for the import and export of vehicles, make up the majority of the other ships using the Port of Southampton. The Port of Southampton web site provided details of expected arrivals for the period 2-6 March 2013. The web site provided details of the deadweight tonnage of each ship and the berth allocated to the ship. It was assumed that this period was representative of the types of ship using the port and the berth allocation. The gross tonnage of each ship was obtained from the marinetraffic.com website. The main engine power for each ship was estimated from its gross tonnage using an empirical formula for Ro-Ro ships relating the size of the main engines to the gross tonnage, taken from the EEA guidebook. The emissions for each ship were then calculated assuming the operational duty and emission factors shown in Table 2.6, which are based on the EEA guidance.

The total deadweight tonnage of general cargo ships using the port in 2011 was 21.9 million DWT (Department for Transport Port Statistics Table 0603). This was a factor of 72.8 times the deadweight tonnage of the ships during the sample period: the emissions were scaled using this factor.

The manoeuvring emissions were represented in the ADMS5 dispersion model as a 45 m deep volume source, covering part of the dredged channel shown in Fig. 2.5. Emissions from ships using berth numbers less than 100 were allocated to the lower part of the dredged channel shown in Fig 2.5. Emissions from ships using berth numbers 101-106 were allocated to the middle part of the dredged channel. Emissions from ships at berth numbers 107 upwards were allocated to the upper part of the dredged channel.

The hotelling emissions were represented as point sources located at each of the berths.. The emissions were assumed to discharge through stacks with heights in the range 25-45 m and diameters in the range 0.5-2 m depending on the size of the ship. A discharge velocity of 2 m s^{-1} and a discharge temperature of 180 ºC were assumed in each case.

Table 2.6: Operating pattern for Vehicle carriers, Ro-Ro and general cargo ships

Parameter	Manoeuvring	Hotelling
Time, hrs	1	15
Fraction load maximum continuous rating	0.2	0.2
Fraction time operating	1	0.05
Fraction load auxiliary engine continuous rating	0.5	0.4
Fraction time operating	1	1
Ratio Auxilary/Main	0.16	0.16
NOx Emission factor main engine, g/kWh	14	13.1
NOx Emission factor auxiliary engines	14.2	13.5
PM Emission factor main engine, g/kWh	2.4	0.3
PM Emission factor auxiliary engines	0.3	0.3
Total NOx emission, tonnes per year	81.6	309.3
Total PM emission, tonnes per year	11.0	7.26

2.3.3 Container handling operations

DP World manages the container handling operations at the Port of Southampton. Fig. 2.5 shows the location of the main area of container handling and storage operations. Electric-powered gantry cranes load the containers on and off the ships. Straddle carriers and other non-road mobile equipment are used to move the containers around the container handling area. The straddle carriers consume approximately 90% of the fuel used at the site. DP World provided details of annual fuel consumption for the non-road mobile equipment and an age breakdown of the straddle carriers. The annual emissions were calculated from the fuel consumption using the EEA/EMEP Emission Inventory guidebook Tier 2 emission factors for non-road diesel engines shown in Table 2.7.

Table 2.7: Non-road emission factors

EC Stage	Date of implementation	NOx emission factor kg/tonne	PM emission factor. Kg/tonne
Pre Stage II	Pre 2002	31.1	0.967
Stage II	January 2002	22.1	1.031
Stage IIIA	January 2006	16.4	0.957

The container handling operations were represented in the ADMS5 dispersion model as a volume source, 6 m deep covering the area shown in Fig. 2.5.

2.3.4 Container transfer areas

All HGVs arriving at the container port are required to use the Vehicle Booking System to pre-book the transfer/pickup of containers. Vehicles park up at a pre-entry park before being directed to one of three transfer areas or to the empty park area, shown in Fig. 2.5. Vehicles initially park up in the transfer areas to wait to be unloaded/loaded. They are then required to reverse into the area of crane operation before loading or unloading. The vehicles then drive away from the crane. Drivers are instructed to turn the engines off whenever possible.

DP World provided details of the number of HGVs travelling to each transfer area. The emissions were calculated assuming that HGVs ran their engines typically for 4 minutes at the Empty Park and Transfer areas and 2 minutes at the pre-entry park. The calculations assume emission rates based on Defra's Emission Factor Toolkit v 5.2 emission factors for the 2011 national fleet of articulated lorries for a speed of 11 kph:

- 166 g veh-h^{-1} NOx
- 3.03 g veh-h^{-1} $PM_{2.5}$
- 20.5 kg veh-h^{-1} CO_2

The container transfer areas were represented in the ADMS5 dispersion model as a volume source, 3 m deep covering the area shown in Fig. 2.5.

2.3.5 Container lorry movements

Container lorries travel from the A35/A33 roundabout along First Avenue to Dock Gate 20 and then into the container terminal. Container lorries travel from the container terminal entrance to the transfer areas along internal roadways within the container terminal (Fig. 2.5). It was assumed that each lorry travelled from and to the container terminal entrance each time it visited one of the transfer areas: this may overestimate the distance travelled by lorries making multiple transfers. Ricardo-AEA's LADSUrban dispersion model was used to predict the contribution to pollutant concentrations from these vehicles assuming a speed of 40 kph. Slower speeds of 10 kph were assumed on the approaches to Dock Gate 20 and the A35/A33 roundabout.

2.3.6 Vehicle import/export

Total vehicle exports through the Port of Southampton in 2011 numbered 362,000: total imports numbered 150,000 (Department for Transport Port Statistics Table 0445). For this assessment, it was conservatively assumed that all vehicles were transported by road, with 6 vehicles per road transporter lorry. It was also assumed that the imports would be carried on the return journeys so that a total of 165 transporters per day come to the port. It was then assumed that the transporters would deliver to the Western and Eastern docks in proportion to the Gross Tonnage of Ro-Ro and Motor Vehicle ships using berths in these docks. The vehicles were allocated to the vehicle delivery road links shown in Fig. 2.5. Ricardo-AEA's LADSUrban dispersion model was used to predict the contribution to pollutant concentrations from these vehicles in 2011 assuming a speed of 40 kph.

2.3.7 Rail terminals

Freightliner operates two rail terminals in the Port of Southampton. The Maritime terminal is the most westerly of the three terminals shown in Fig. 2.5. The Millbrook terminal is the middle one. DB Schenker operates the third terminal -the Herbert Walker terminal. There are 11 services per day during the week at the Maritime terminal, with 4 per day at the weekend. There are also 4 services per weekday at both the Millbrook and Herbert Walker terminals. For this assessment, it has been assumed that each service is associated with 2 hours shunting time at the terminal. The assessment assumes fuel use of 90.9 kg/h for shunting operations and emission factors of 39.9 kg $tonne^{-1}$ for NO_x and 1.0 kg $tonne^{-1}$ $PM_{2.5}$ taken from the EEA Air pollutant Emission Inventory guidebook, 2009.

The rail terminals were represented in the ADMS5 dispersion model as volume sources, 5 m deep covering the areas shown in Fig. 2.5.

2.3.8 Mainline railway

Mainline trains between Southampton and Bournemouth and between Southampton and Salisbury run parallel with the Western Approach road between the port area and the road. Table 2.8 shows the numbers of passenger trains travelling along the line per day.

The trains mostly consist of railcar units. The assessment assumes fuel consumption of 53.6 kg h^{-1}(EEA emissions inventory guidebook) and a speed of 80 kph. It assumes emission factors of 39.9 kg $tonne^{-1}$ for NO_x and 1.0 kg $tonne^{-1}$for $PM_{2.5}$ (EEA emissions inventory guidebook).

The mainline railway links were modelled as curved line sources within Ricardo-AEA's LADSUrban dispersion model.

Table 2.8: Frequency of passenger trains.

Direction	Monday-Friday	Saturday	Sunday	Weekly Total
Bournemouth - Southampton	67	61	40	436
Southampton-Bournemouth	79	77	44	516
Southampton-Salisbury	40	38	30	268
Salisbury-Southampton	40	40	32	272
Total				1492

2.3.9 Modelled contributions to NOx

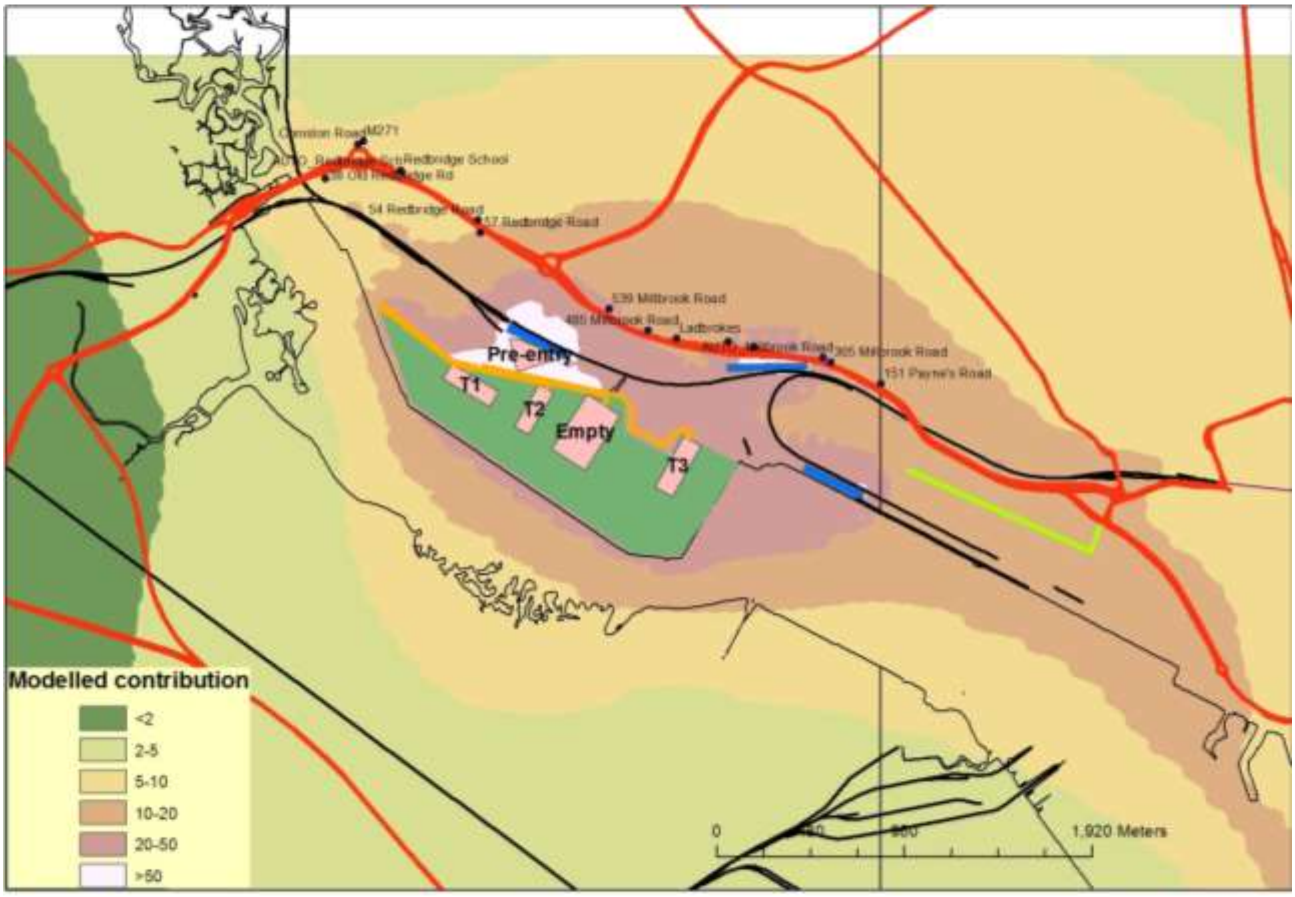
Table 2.9 shows the modelled contribution to oxides of nitrogen concentrations at the locations of diffusion tubes close to the Western Approach Road. This highlights that ships hotelling is the most significant source of emissions at the Port. . Fig. 2.6 shows a map of the modelled contribution to oxides of nitrogen concentrations.

Table 2.9: Modelled contribution to oxides of nitrogen concentrations at NO_2 monitoring sites, µg m^{-3}

Receptor name	Contribution to oxides of nitrogen concentrations, µg m^{-3}									
	Ships hotelling	Ships manoeuvring	Container handling	HGV container transfer	Rail terminals	Container lorries in container terminal	Vehicle delivery lorries	Mainline railways	Container lorries on dock road	total
M271	2.9	0.7	0.7	0.1	0.3	0.1	0.0	0.4	0.1	5.2
Coniston Road	3.0	0.7	0.7	0.1	0.2	0.1	0.0	0.4	0.1	5.2
38 Old Redbridge Rd	3.2	0.7	0.8	0.1	0.2	0.1	0.0	1.1	0.1	6.1
Redbridge School	3.1	0.8	0.9	0.1	0.4	0.1	0.0	0.4	0.1	5.9
AUTO_Redbridge School	3.1	0.8	0.9	0.1	0.4	0.1	0.0	0.4	0.1	6.0
54 Redbridge Road	3.9	1.0	1.5	0.3	0.9	0.4	0.0	0.4	0.3	8.7
57 Redbridge Road	4.1	1.1	1.7	0.3	1.1	0.5	0.0	0.5	0.4	9.6
539 Millbrook Road	7.4	1.9	3.7	0.9	4.2	0.8	0.0	0.5	0.7	20.0
485 Millbrook Road	7.7	2.3	4.1	0.7	2.0	0.8	0.0	0.6	0.3	18.4
Ladbrokes	7.7	2.4	3.9	0.6	1.5	0.6	0.0	0.6	0.2	17.5

Receptor name	Contribution to oxides of nitrogen concentrations, µg m^{-3}									
	Ships hotelling	Ships manoeuvring	Container handling	HGV container transfer	Rail terminals	Container lorries in container terminal	Vehicle delivery lorries	Mainline railways	Container lorries on dock road	total
Regent`s Park Junction	7.3	2.5	3.1	0.4	3.2	0.4	0.0	0.6	0.1	17.6
367A Millbrook Road	7.2	2.6	2.9	0.3	7.1	0.3	0.0	0.9	0.1	21.3
AUTO_Millbrook Road	6.5	2.7	2.1	0.2	5.2	0.2	0.0	1.4	0.1	18.4
151 Payne`s Road	6.2	3.2	1.5	0.1	1.4	0.1	0.0	1.6	0.0	14.2
303 Millbrook Road	6.5	2.8	2.0	0.2	3.6	0.1	0.0	1.7	0.1	16.9

Figure 2.6: Modelled contribution to oxides of nitrogen concentrations



2.4 NO_2 concentrations from all sources

2.4.1 Model verification

In order to check that the model is representing NO_2 concentrations accurately we have carried out a model verification exercise where we have checked the model predictions against the local measurements.

This is done by first back calculating the contribution of local roads to measured NOx concentrations at the measurement sites. This provides a road NOx value with which we can compare our modelled road NOx predictions from ADMS Roads. It is important to perform the back calculation in the context of contributions from other local sources. We assume the modelled concentrations from the port and railway plus the regional background value of 20.1µg.m^{-3} to account for all other sources not modelled discretely in this study are fixed- only the modelled road NOx are adjusted to account for any overall model underprediction between modelled and measured NO_2 results.

In practice there is bound to be some uncertainty in both the background NOx values in the Defra maps and the modelled port contributions. However, it is only possible in practice to verify and tune the model by adjusting the contributions of a single source, in this instance the road traffic around the Western Approach.

The model was verified and adjusted by plotting modelled road NOx against back calculated measured road NOx. We then conducted a regression analysis of the two variables and derived the slope of the line which was used as a scaling factor that was then applied to all road NOx values. Once adjusted the road NOx emissions were added to the background, port and rail concentrations, before deriving the NO_2 concentrations arising from all of these sources.

The model verification exercise yielded an adjustment factor of 1.37 which represents quite good agreement given that the road sources are assumed to carry all of the underestimation in the study. This value was used to scale all modelled road NOx predictions upwards- the regression plot is shown in Figure 2.7 below.

Figure 2.7: Modelled vs measured Road NOx (road only sources, µg.m^{-3})

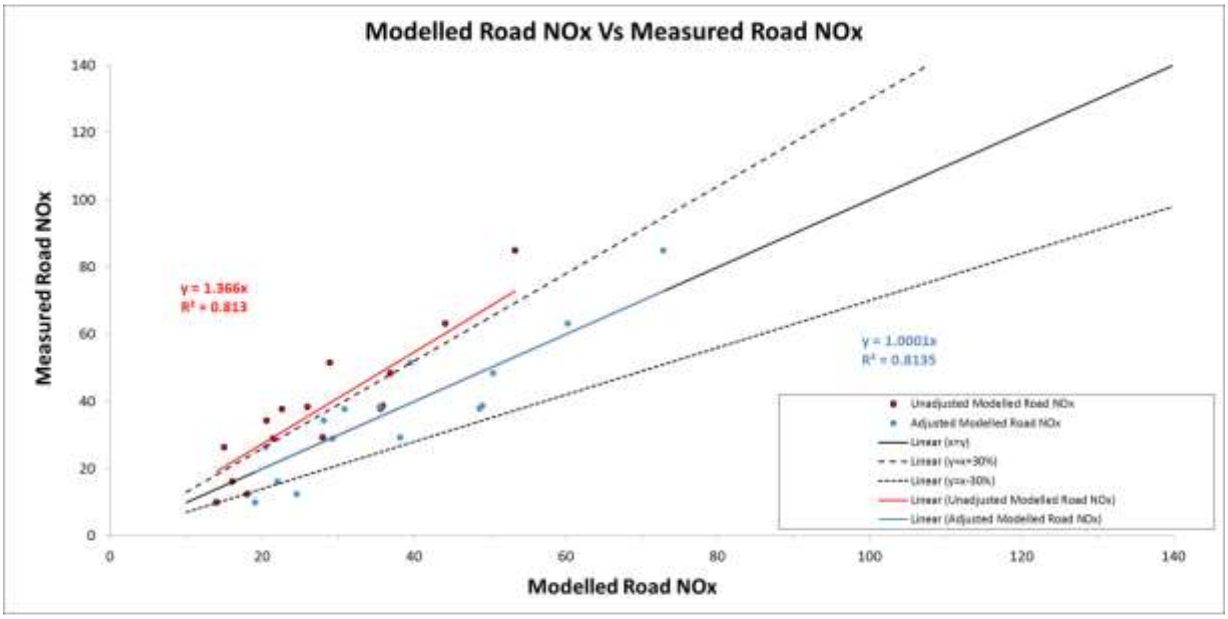


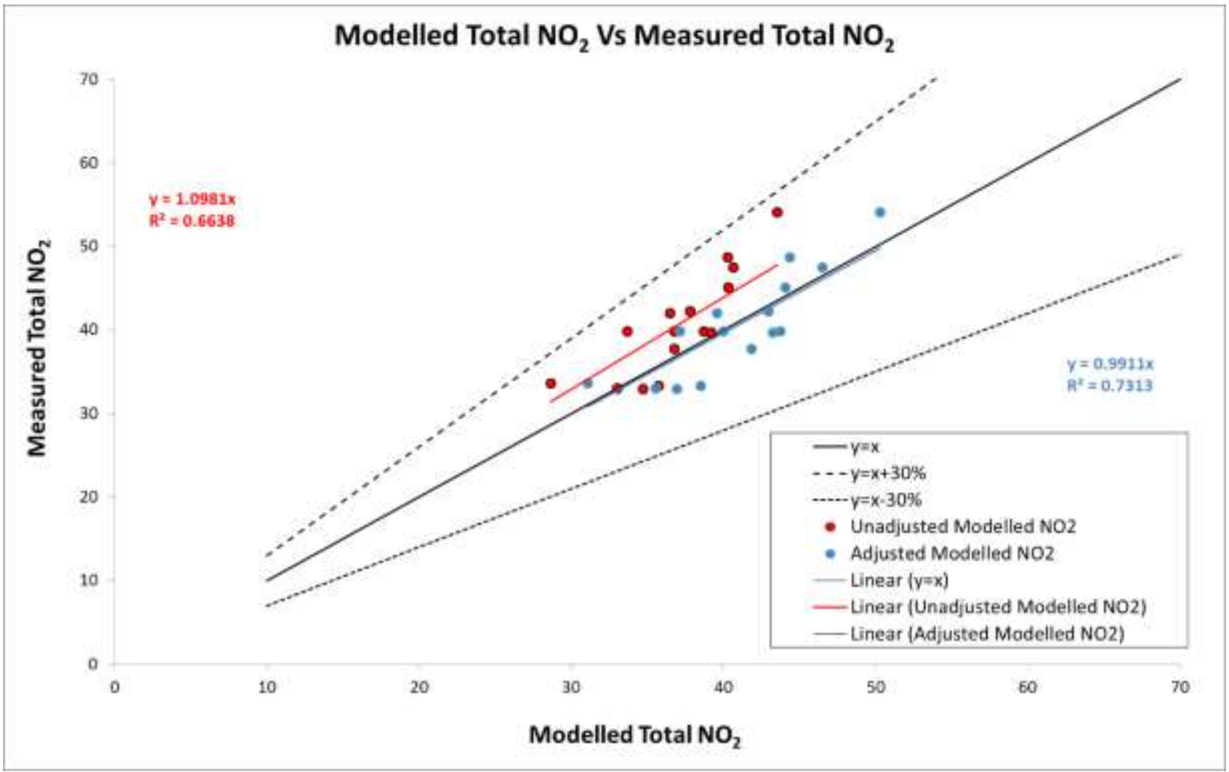
Table 2.10 and Figure 2.8 below shows the model agreement in terms of measured NO_2 vs modelled total NO_2 when all sources are summed in the model. The model underpredicted by around 10% prior to adjustment of the road NOx concentrations. After adjustment the model agrees well with the local measurements and has a Root Mean Square Error value of 3.2µg.m^{-3}. This is well within the recommended value of 4µg.m^{-3} suggested in LAQM.TG(09).

Table 2.10: Measured vs modelled concentrations of NO_2 at SCC monitoring locations (all sources, µg.m^{-3})

Location	Measured NO_2	Modelled NO_2
M271	54.1	50.3
Coniston Road	37.7	41.8
38 Old Redbridge Rd	33.6	31.1
Redbridge School	42.2	43.0
AUTO Redbridge School	47.5	46.5
54 Redbridge Road	39.8	43.7
57 Redbridge Road	39.8	37.1

Location	Measured NO_2	Modelled NO_2
539 Millbrook Road	32.9	36.9
485 Millbrook Road	33.3	38.5
Ladbrokes	39.8	40.0
Regent`s Park Junction	42.0	40.0
367A Millbrook Road	45.1	44.1
AUTO Millbrook Road	48.7	44.4
151 Payne`s Road	33.0	35.6
305 Millbrook Road	39.7	43.2
	RMSE= 3.2 µg.m^{-3}	

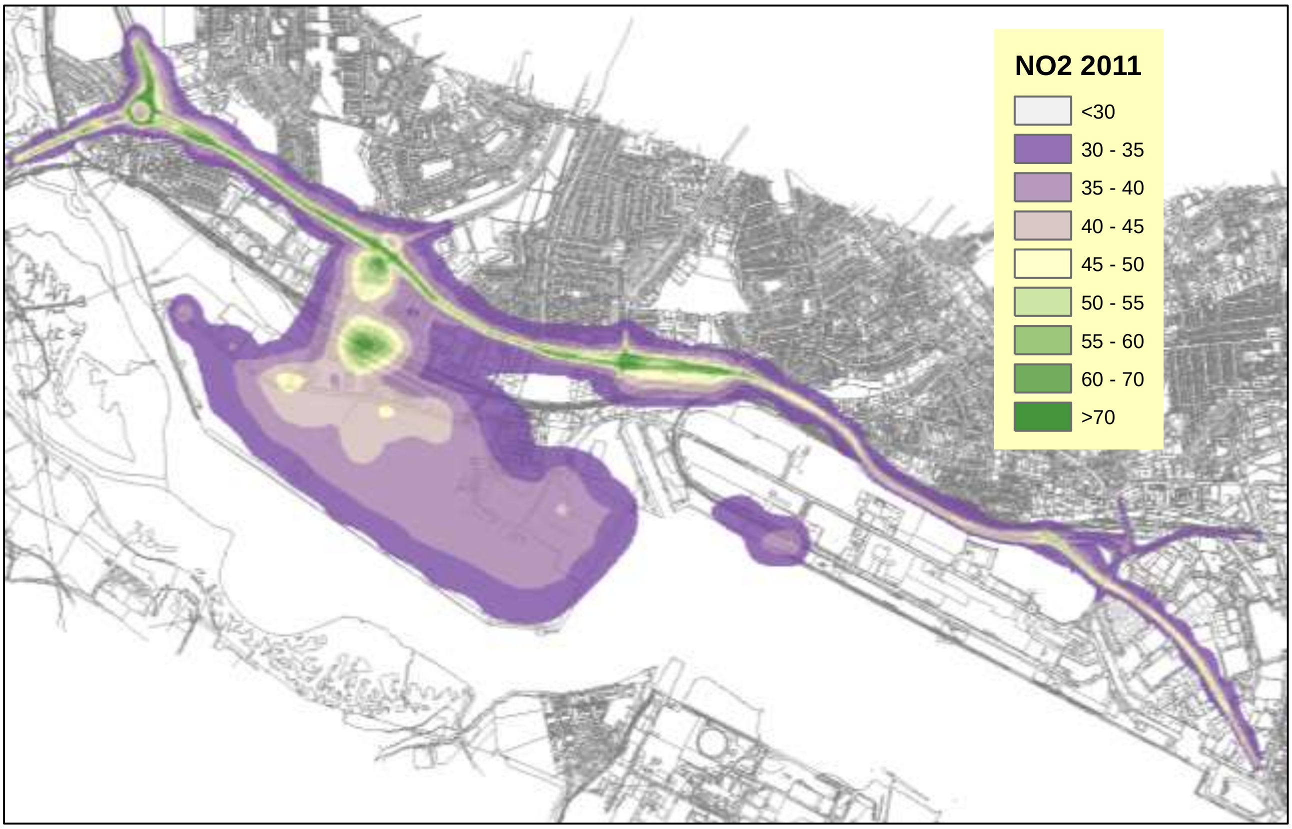
Figure 2.8 Modelled vs measured NO_2 (all sources, µg.m^{-3})



2.4.2 NO_2 dispersion plots

Once good model agreement had been established we plotted the total NO_2 concentration field across the whole model domain, yielding the plot provided in Figure 2.9 below. The plot was derived by summing the NO_2 rasters for each of the sources in the Spatial Analyst tool in ArcMap 10 at a resolution of 5m. The plot shows the influence of the road, rail and port sources included in the model on local NO_2 concentrations. We explore the relative contribution of each of these sources at SCC's measurement sites later in this report.

Figure 2.9 Total modelled NO_2 within the model domain (all sources, µg.m^{-3})



To better outline the annual mean NO_2 concentration profiles along the Western Approach we have prepared contour line plots that show the 40µg.m^{-3} concentration line, along with 37 and 43 µg.m^{-3} to reflect the error in the model (RMSE was 3 µg.m^{-3}). As before the plots show clearly the relative influence of the roadways, railway, and port emissions across the model domain. Figures 2.10 to 2.15 show NO_2 contour lines for the different parts of the modelled area.

Figure 2.10 Close up view of M271/ Redbridge Road Junction- modelled NO_2 contours (all sources, µg.m^{-3})

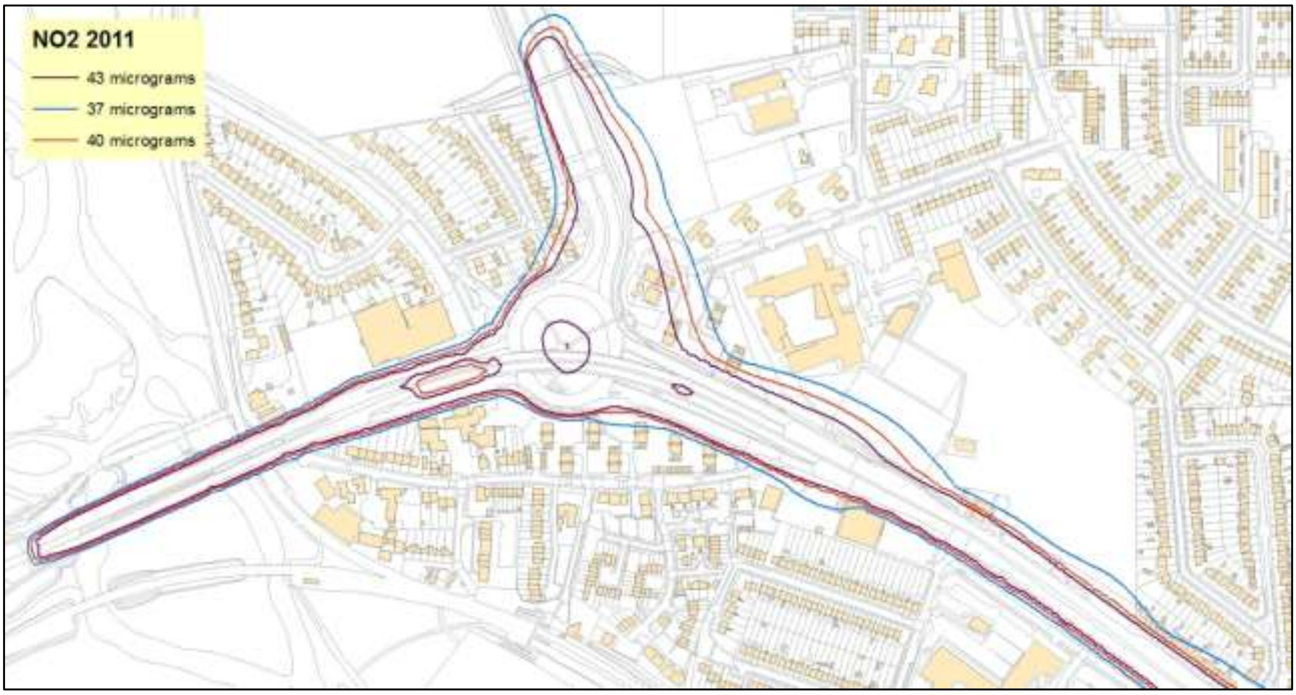


Figure 2.11 Close up view Redbridge Road - modelled NO_2 contours (all sources, µg.m^{-3})

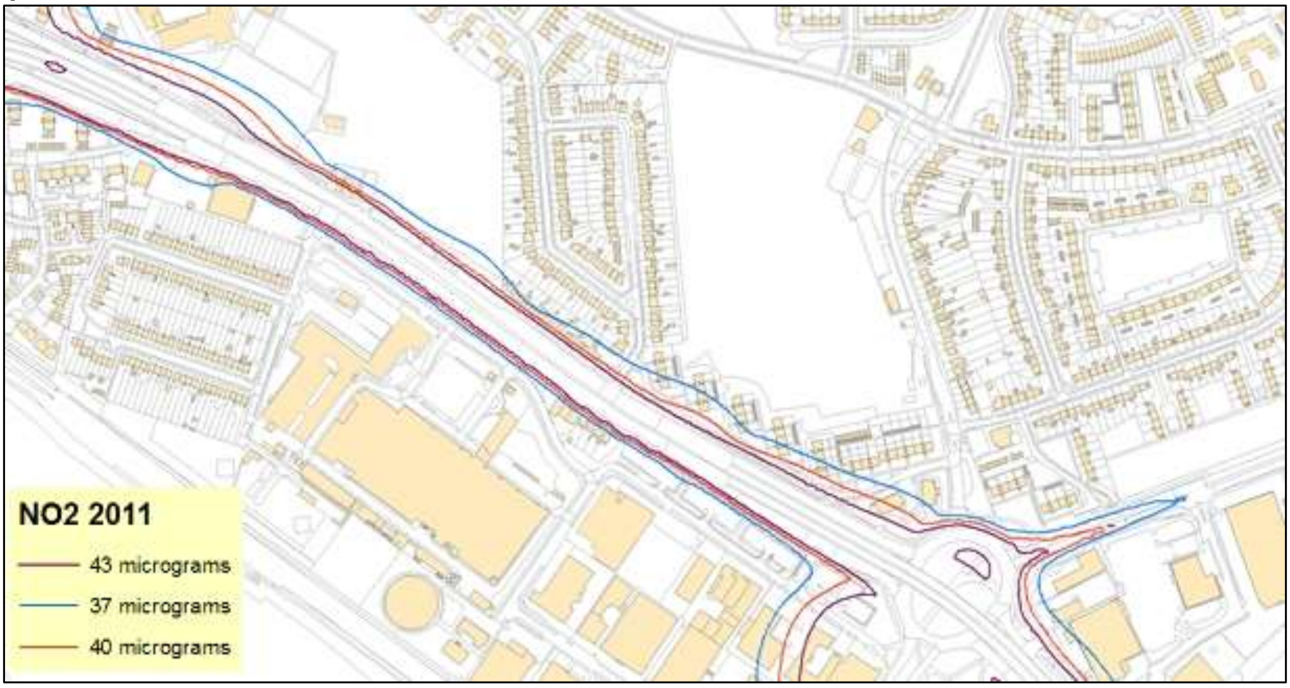


Figure 2.12 Close up view Port area and Millbrook Road- modelled NO_2 contours (all sources, µg.m^{-3})

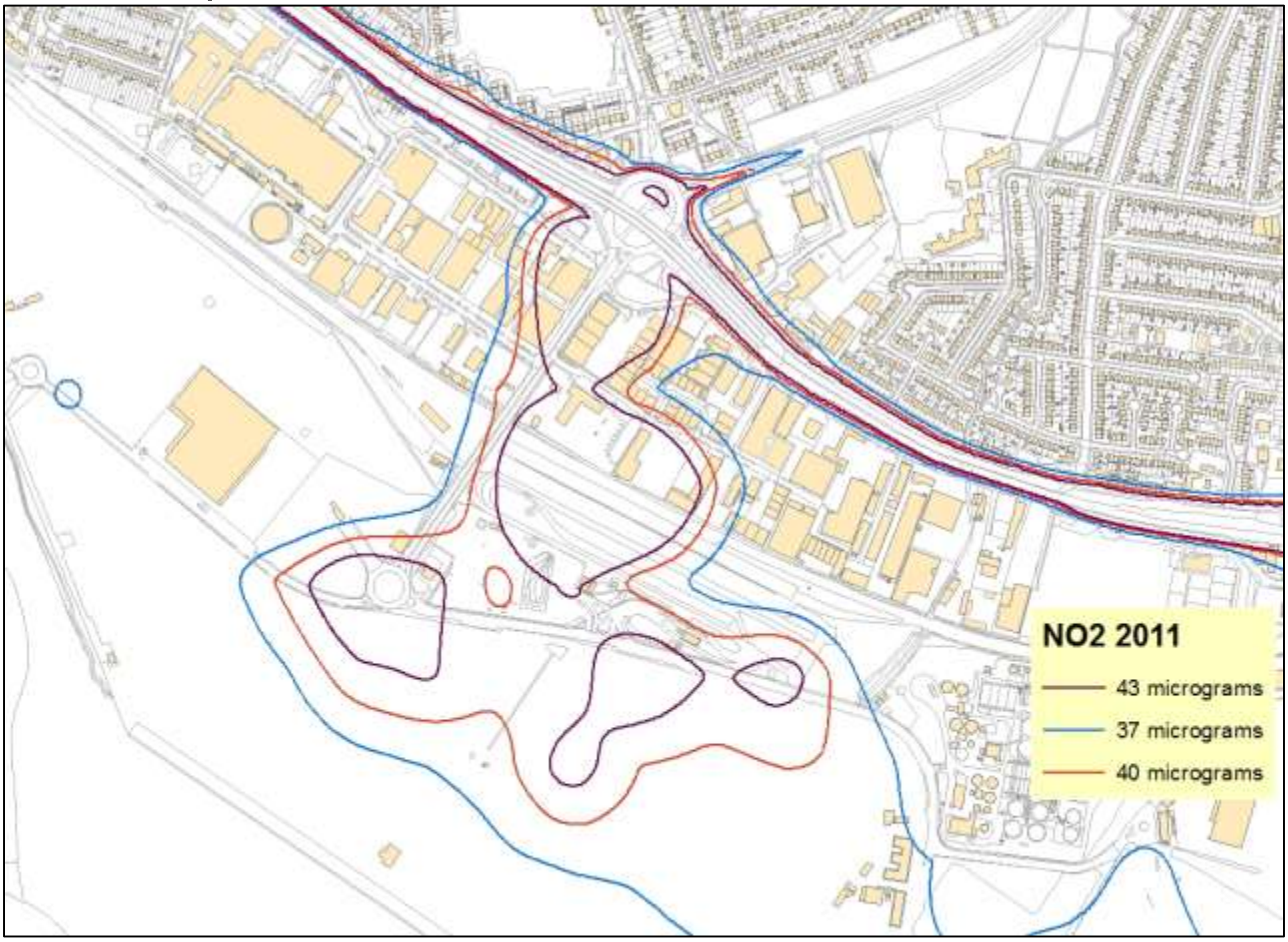


Figure 2.13 Close up view Millbrook Road near Railway- modelled NO_2 contours (all sources, µg.m^{-3})

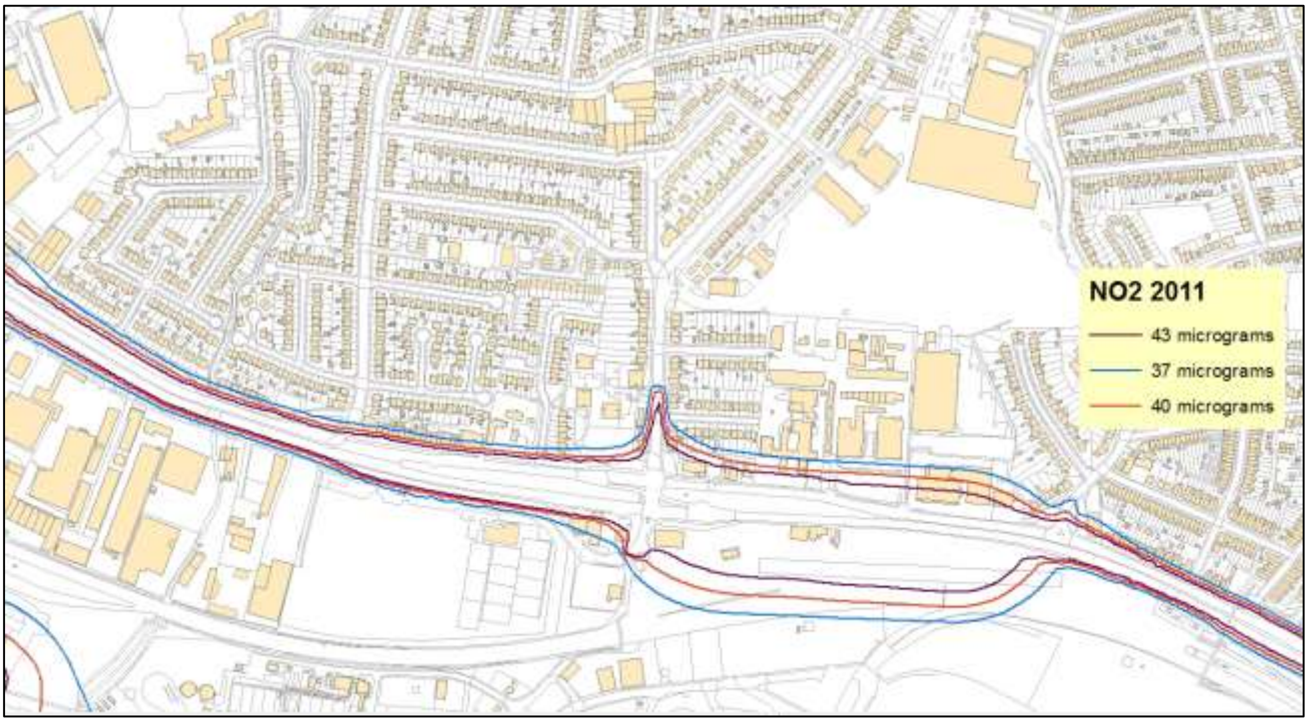
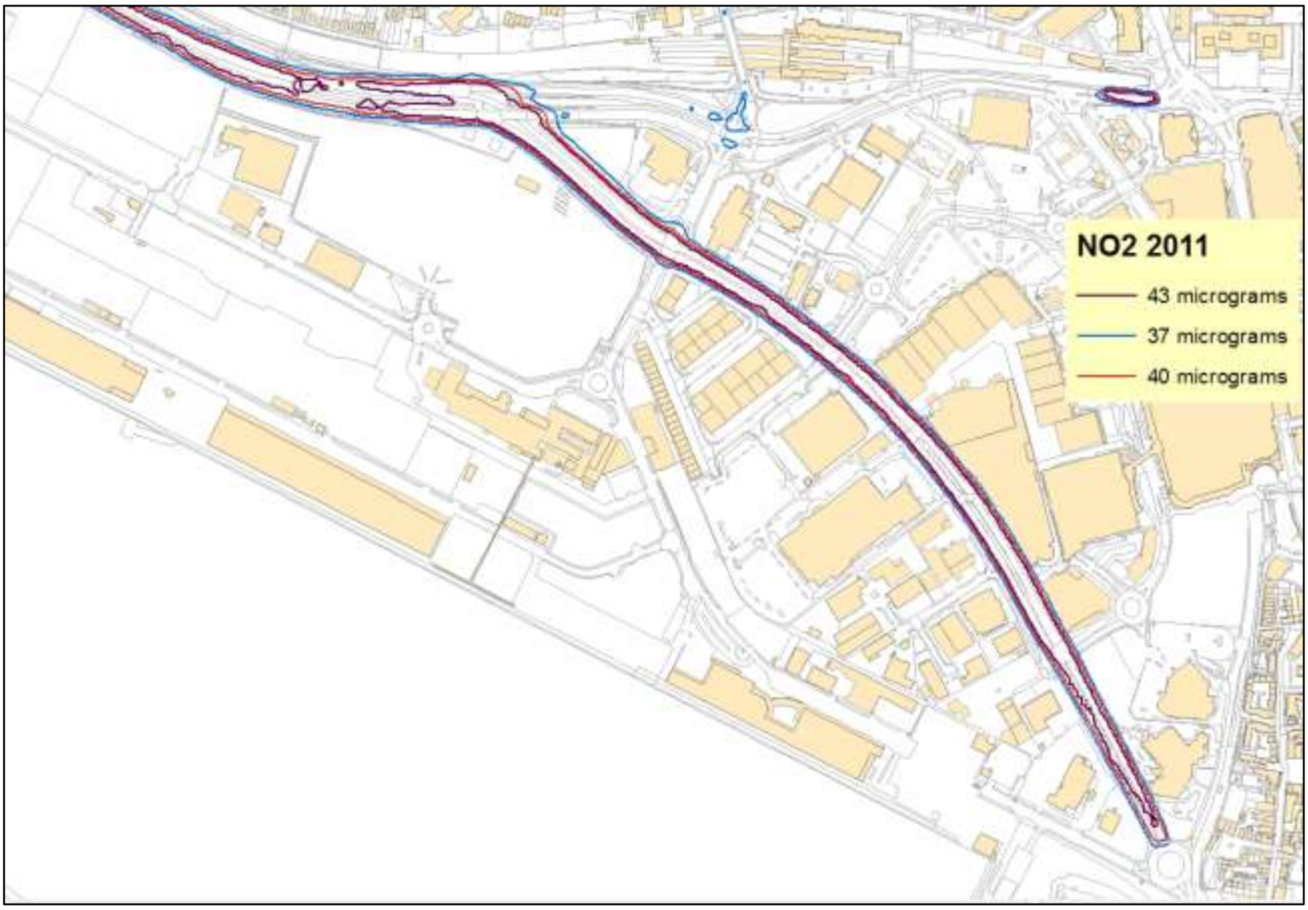


Figure 2.14 Close up view Mountbatten Way- modelled NO_2 contours (all sources, µg.m^{-3})

Figure 2.15 Close up view West Quay Rd- modelled NO_2 contours (all sources, $\mu g.m^{-3}$)



2.4.3 Source apportionment

To better understand the relative contributions from the various source types in the model domain we have carried out a source apportionment of NOx concentrations at each of the monitoring locations used in this assessment. LAQM.TG(09) recommends conducting source apportionment of NOx rather than NO_2.

The results of this in terms of microgram contributions from each location are shown in Table 2.11 below. Percentage contributions at the same locations are provided in Table 2.12. Note that the total NOx in is the product of either 1+2+3, or 1+2+4+5+6+7- this reflects the relative contributions from the different vehicle classes within the road fleet.

Table 2.11: Source apportionment of NOx at SCC monitoring locations ($\mu g.m^{-3}$)

Location	*Total Modelled NOx*	*Mapped Background NOx (1)*	*Port activities and rail NOx (2)*	*Road NOx (3)*	*Car NOx (4)*	*HGV NOx (5)*	*Bus NOx (6)*	*LGV NOx (7)*
M271	99.0	20.1	5.2	73.7	19.6	44.8	2.2	7.2
Coniston Road	74.1	20.1	5.2	48.7	14.6	27.1	2.1	4.9
38 Old Redbridge Rd	46.7	20.1	6.1	20.5	8.2	8.1	1.5	2.6
Redbridge School	76.9	20.1	5.9	50.9	17.5	24.5	3.3	5.6
AUTO_Redbridge Sch	86.9	20.1	6.0	60.8	20.7	29.6	3.9	6.6
54 Redbridge Road	78.1	20.1	8.7	49.4	18.0	22.8	3.0	5.6
57 Redbridge Road	60.6	20.1	9.6	30.9	11.2	14.4	1.8	3.5

Location	Total Modelled NOx	Mapped Background NOx (1)	Port activities and rail NOx (2)	Road NOx (3)	Car NOx (4)	HGV NOx (5)	Bus NOx (6)	LGV NOx (7)
539 Millbrook Road	59.1	20.1	20.0	19.1	8.5	6.1	1.5	2.9
485 Millbrook Road	63.0	20.1	18.4	24.5	11.6	6.9	2.0	3.9
Ladbrokes	67.0	20.1	17.5	29.4	13.0	9.2	2.7	4.4
Regent`s Park Junction	65.8	20.1	17.6	28.2	11.0	10.9	2.5	3.8
367A Millbrook Road	76.9	20.1	21.3	35.6	15.8	11.2	3.2	5.4
AUTO_Millbrook Road	78.0	20.1	18.4	39.5	14.2	10.1	10.4	4.8
151 Payne`s Road	56.3	20.1	14.2	22.0	10.7	5.7	1.9	3.6
303 Millbrook Road	75.6	20.1	16.9	38.6	15.7	8.9	8.6	5.4

Table 2.12 Source apportionment of NOx at SCC monitoring locations (% of total modelled NOx)

Location	Background contribution % (1)	Port and rail contribution % (2)	Road contribution % (3)	Cars % (4)	HGV % (5)	Bus % (6)	LGV % (7)
M271	20.3	5.3	74.5	19.8	45.3	2.2	7.2
Coniston Road	27.1	7.1	65.8	19.7	36.6	2.9	6.7
38 Old Redbridge Rd	43.0	13.2	43.8	17.7	17.3	3.2	5.6
Redbridge School	26.1	7.7	66.2	22.8	31.8	4.3	7.2
AUTO_Redbridge Sch	23.1	6.9	70.0	23.9	34.1	4.5	7.6
54 Redbridge Road	25.7	11.1	63.2	23.1	29.2	3.8	7.2
57 Redbridge Road	33.1	15.8	51.0	18.4	23.8	3.0	5.8
539 Millbrook Road	34.0	33.8	32.2	14.4	10.4	2.5	4.9
485 Millbrook Road	31.9	29.3	38.9	18.4	11.0	3.2	6.2
Ladbrokes	30.0	26.1	43.9	19.4	13.8	4.1	6.6
Regent`s Park Juncti	30.5	26.7	42.8	16.7	16.5	3.8	5.8
367A Millbrook Road	26.1	27.7	46.2	20.5	14.5	4.2	7.0
AUTO_Millbrook Road	25.7	23.6	50.6	18.2	12.9	13.3	6.2
151 Payne`s Road	35.6	25.3	39.1	19.0	10.2	3.5	6.5
303 Millbrook correct	26.6	22.4	51.0	20.8	11.8	11.3	7.1

As can be seen, the main source of NOx across the domain is the local road network though there is quite marked spatial variation at different locations along the road. Generally speaking the local roads are the dominant NOx source at the east and west of the model area, with the port being almost as important near the centre of the domain around Millbrook Road. This finding has implications for any abatement measures that may be planned for the area- clearly the port is an important source of NOx and any abatement in this area could deliver tangible benefits to NO_2 concentrations on Millbrook Road.

To further illustrate the spatial variation in the relative source contributions, the pie charts in Figures 2.16 to 2.18 below show the split of NOx sources at the two automatic monitoring stations at Redbridge Road and Millbrook Road, and also at the diffusion tube monitoring location at 539 Millbrook Road. Note that the port contribution also includes the railway. The further illustrate the spatial sensitivity of NOx concentrations to the main local source types, Figure 2.19 shows the contribution of each (road, port+rail, background) overlaid on a GIS plot of the area.

Figure 2.16 Redbridge Road auto site source apportionment (% of modelled NOx)

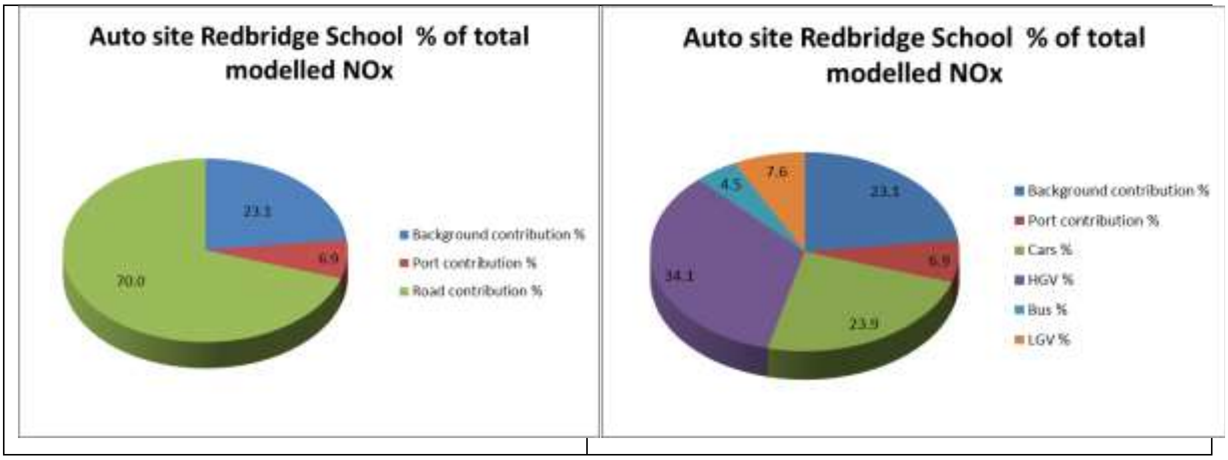


Figure 2.17 Millbrook Road auto site source apportionment (% of modelled NOx)

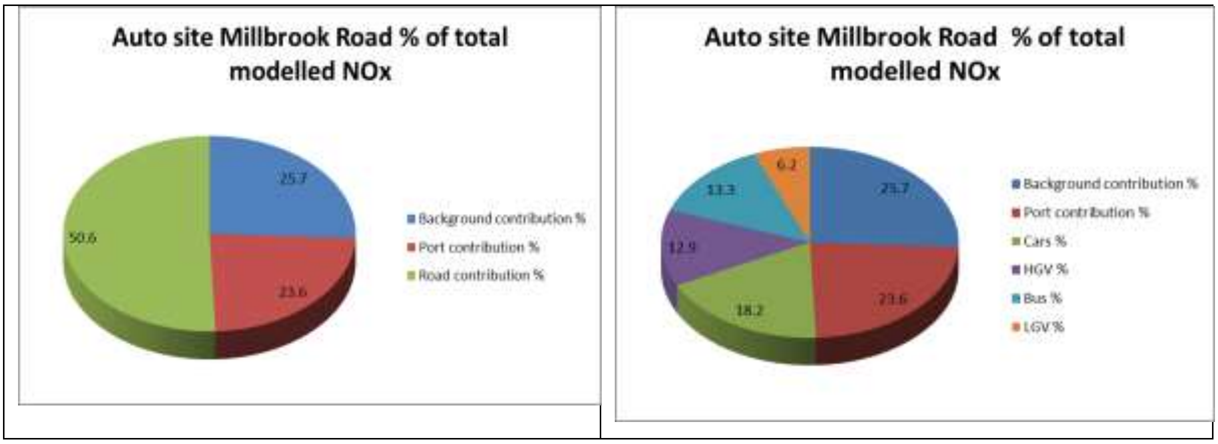


Figure 2.18 589 Millbrook Road diffusion tube site source apportionment (% of modelled NOx)

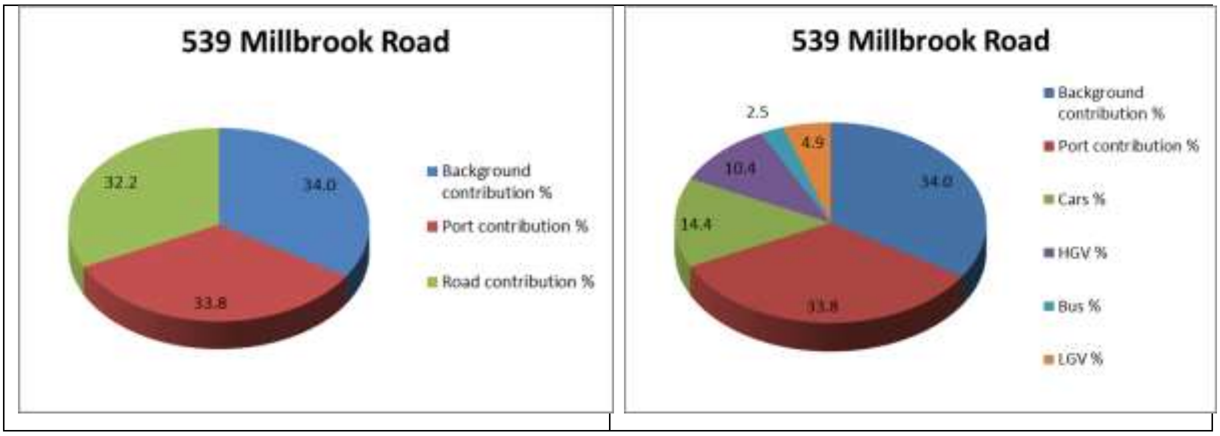
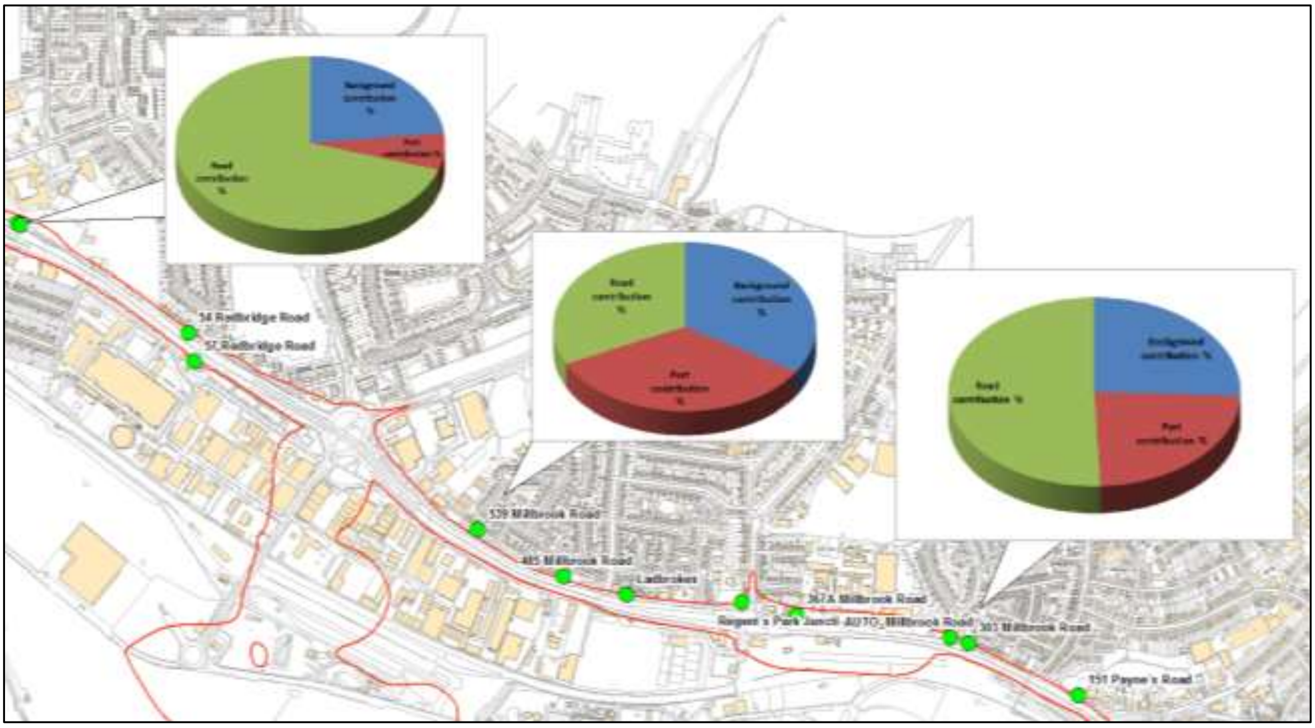


Figure 2.19 Source apportionment at West, Centre and East of Western Approach (% of modelled NOx)



2.5 Emission reduction scenario

It is our understanding that there are no feasible options for a LEZ restricted to the Western Approach area and SCC are now interested in pursuing a wider ranging Low Emissions Strategy (LES) for the whole city. Therefore we have not tested any specific LEZ scenarios as these would normally have been selected by the Council for further investigation before modelling.

However, to aid in the decision making process around the city LES we have tested the effect of uptake of Euro 6 light vehicles and Euro VI heavy vehicles in the Western Approach area based on a 2011 baseline. It is recognised that this is an idealised scenario which is in practice unlikely to occur in the short to medium term. That said this analysis provides a useful look at the future which could aid in the development of the LES as Euro 6/VI vehicles will begin entering the fleet very soon. We have started by assuming E6/EVI will deliver all of the benefits predicted by modelling emissions in the EfT- that is to say that 100% of the reduction in NOx between current fleet conditions and a fully Euro 6/fleet is assumed to be accurate. In practice it may be considered unlikely that Euro 6/VI will deliver all of these benefits and it is more likely that there will be a reduction, but perhaps not 100% of that predicted by the EfT.

To test the effect of the new fleet only delivering a proportion of the predicted benefit we have tested the effect of reducing NOx emissions by 25%, 50% and 75% of the full reduction. In this way we explore the sensitivity of local NO_2 concentrations to fleet improvement but present the results as a range rather than an absolute value. This analysis can also be interpreted as a scenario analysis whereby 25, 50, 75 and 100% of current vehicles are replaced by Euro 6 and Euro VI.

2.5.1 Emissions

The EfT allows the user to specify the Euro split of the fleet which is then used as a parameter in the emissions modelling that follows. In this instance we have simply taken the default UK fleet data that was used in the baseline modelling and applied an “all Euro 6” scenario to the light fleet, and an “all Euro VI” scenario to the heavy fleet.

We have prepared an emissions inventory for all road links in the modelling based on the 2011 fleet (about 17km of road links), and then specified the more modern fleet to test the overall effect on emissions. The results of this analysis are shown in Table 2.13 below.

Table 2.13 Road source emissions inventory, kg/yr NOx

	Total Road NOx	Total LDV NOx	Total HDV NOx
2011 NOx (kg/yr)	74306	39459	34847
2011 NOx Euro6, Euro VI (kg/yr)	14952	11154	3799
% reduction in 2011	80	72	89

As can be seen the reductions in road emissions compared to the baseline are quite large at about 80% of total road NOx emissions. Obviously the effect this would exert on NO_2 concentrations at specified locations will differ according to how important road sources are there (see source apportionment). But generally speaking and as one would expect, large reductions in road NOx are currently predicted with full uptake of Euro 6 and Euro VI vehicles.

Next we looked at the reductions associated with these scenarios on a link by link basis to assess how variable the predicted reduction is across the Western Approach. This will obviously be influenced by the fleet mix on each link but in this instance we have used an average reduction value calculated across all links which is applied at the monitoring locations to scale the modelled NO_2 concentrations. The reductions in NOx emissions associated with full uptake of Euro 6/Euro VI was between 69 to 87% across all modelled links, with a mean value of 79%.

Full uptake of Euro VI by heavy vehicles in Southampton is estimated to result in an average reduction in total road NOx of 36%. Full uptake of Euro 6 by light vehicles is estimated to result in an average road NOx reduction of 43% across the roads along the Western Approach.

2.5.2 Concentrations

We have applied these average NOx reductions (and proportions thereof) to the modelled NO_2 concentrations across the Western Approach using Defra's NOx:NO_2 model used previously. First we assume varying proportions of both heavy and light vehicles adopt Euro VI and Euro 6. Next, we apply the light vehicle specific average NOx reduction leaving the heavy vehicle NOx emissions the same, and then vice versa for Euro VI. The results of the analysis are provided in Tables 2.14 to 2.16.

Table 2.14 NO_2 concentrations assuming 25, 50, 75 and 100% of vehicles Euro 6 and Euro VI, µg.m^{-3}

Location	*NO_2 Baseline (modelled)*	*NO_2 25% Euro 6/ Euro VI*	*NO_2 50% Euro 6/ Euro VI*	*NO_2 75% Euro 6/ Euro VI*	*NO_2 100% Euro 6/ Euro VI*
M271	**50.3**	**45.6**	**40.3**	34.5	28.2
Coniston Road	**41.8**	38.2	34.3	30.2	25.8
38 Old Redbridge Rd	31.1	29.3	27.5	25.6	23.6
Redbridge School	**43.0**	39.4	35.3	31.1	26.5
AUTO_Redbridge Sch	**46.5**	**42.4**	37.8	32.8	27.5
54 Redbridge Road	**43.7**	**40.2**	36.3	32.2	27.8
57 Redbridge Road	37.1	34.6	32.0	29.3	26.5
539 Millbrook Road	36.9	35.3	33.6	32.0	30.2
485 Millbrook Road	38.5	36.4	34.4	32.2	30.0

Location	NO_2 Baseline (modelled)	NO_2 25% Euro 6/ Euro VI	NO_2 50% Euro 6/ Euro VI	NO_2 75% Euro 6/ Euro VI	NO_2 100% Euro 6/ Euro VI
Ladbrokes	40.0	37.7	35.2	32.7	30.0
Regent`s Park Junction	39.6	37.3	35.0	32.5	30.0
367A Millbrook Road	**44.1**	**41.4**	38.5	35.5	32.4
AUTO_Millbrook Road	**44.4**	**41.4**	38.2	34.9	31.5
151 Payne`s Road	35.6	33.7	31.8	29.8	27.8
303 Millbrook Road	**43.2**	**40.4**	37.3	34.1	30.7
Exceedances in **bold**					

The data above indicates that the very large NOx reductions associated with a fleet entirely comprised of Euro 6 and Euro VI vehicles are enough to achieve the NO_2 annual mean objective at all locations along the Western Approach. The analysis also suggests that if only a proportion of the benefit were achieved in practice, then this would have to be in the order of 50% of the theoretical maximum to achieve compliance (except at the M271 location where a small exceedance is still estimated for the 50% case).

Table 2.15 NO_2 concentrations assuming 25, 50, 75 and 100% of vehicles Euro 6, heavy fleet unchanged from 2011 baseline, $\mu g.m^{-3}$

Location	NO_2 baseline	NO_2 25% Euro 6	NO_2 50% Euro 6	NO_2 75% Euro 6	NO_2 100% Euro 6
M271	**50.3**	**47.9**	**45.2**	**42.3**	39.3
Coniston Road	**41.8**	39.9	37.8	35.7	33.6
38 Old Redbridge Rd	31.1	30.1	29.1	28.1	27.1
Redbridge School	**43.0**	**41.1**	39.0	36.8	34.6
AUTO_Redbridge Sch	**46.5**	**44.4**	**42.0**	39.5	36.9
54 Redbridge Road	**43.7**	**41.9**	39.9	37.8	35.6
57 Redbridge Road	37.1	35.8	34.4	33.0	31.5
539 Millbrook Road	36.9	36.0	35.1	34.3	33.3
485 Millbrook Road	38.5	37.4	36.3	35.1	34.0
Ladbrokes	40.0	38.8	37.5	36.1	34.8
Regent`s Park Junction	39.6	38.4	37.1	35.8	34.5
367A Millbrook Road	**44.1**	**42.6**	**41.1**	39.6	38.0
AUTO_Millbrook Road	**44.4**	**42.7**	**41.1**	39.4	37.6
151 Payne`s Road	35.6	34.5	33.5	32.5	31.4
303 Millbrook Road	**43.2**	**41.8**	**40.1**	38.5	36.8
Exceedances in **bold**					

The data above indicates that the NOx reductions associated with a light fleet entirely comprised of Euro 6 vehicles are enough to achieve the NO_2 annual mean objective at all locations along the Western Approach. The analysis also suggests that if only a proportion of the benefit were achieved in practice, then this would have to be in the order of 75% of the theoretical maximum to achieve compliance (except at the M271 location where an exceedance is still estimated for the 75% case).

Table 2.16 NO_2 concentrations with 25, 50, 75 and 100% of heavy vehicles Euro VI, light fleet unchanged from 2011 baseline, µg.m^{-3}

Location	*NO_2 baseline*	*NO_2 25% Euro VI*	*NO_2 50% Euro VI*	*NO_2 75% Euro VI*	***NO2 100% Euro VI***
M271	**50.3**	**48.3**	**46.1**	**43.7**	**41.3**
Coniston Road	**41.8**	**40.2**	38.5	36.8	35.0
38 Old Redbridge Rd	31.1	30.3	29.5	28.6	27.8
Redbridge School	**43.0**	**41.4**	39.7	37.9	36.1
AUTO_Redbridge Sch	**46.5**	**44.8**	**42.8**	**40.7**	38.6
54 Redbridge Road	**43.7**	**42.2**	**40.5**	38.8	37.0
57 Redbridge Road	37.1	36.0	34.8	33.7	32.5
539 Millbrook Road	36.9	36.2	35.4	34.7	33.9
485 Millbrook Road	38.5	37.6	36.6	35.7	34.7
Ladbrokes	40.0	39.0	37.9	36.8	35.7
Regent`s Park Junction	39.6	38.6	37.5	36.5	35.4
367A Millbrook Road	**44.1**	**42.9**	**41.6**	**40.3**	39.0
AUTO_Millbrook Road	**44.4**	**43.0**	**41.6**	**40.2**	38.8
151 Payne`s Road	35.6	34.7	33.8	33.0	32.1
303 Millbrook Road	**43.2**	**42.0**	**40.7**	39.3	37.9
Exceedances in **bold**					

The data above indicates that the NOx reductions associated with a heavy fleet entirely comprised of Euro VI vehicles are enough to achieve the NO_2 annual mean objective at all locations along the Western Approach except at the M271 location. The analysis also suggests that if only a proportion of the benefit were achieved in practice, then this would have to be in the order of 75% of the theoretical maximum to approach compliance at most locations (except at the M271 location where a reasonably large exceedance is still estimated for the 75% case).

As would be expected, the results of this analysis suggest that Euro 6 and Euro VI uptake should result in reduced NO_2 concentrations compared with the 2011 baseline. The scenario which assumes both sectors will adopt the modern Euro standards is estimated to deliver achievement of the NO_2 annual mean objective at all locations along the Western Approach at around 50% uptake (on a 2011 baseline). On the other hand if the light and heavy sectors are treated separately, much larger uptake rates are required (about 75% of light vehicles would need to be Euro 6, and >75% of heavy vehicles would need to be Euro VI to deliver compliance.

Of course it should be borne in mind that LEZ schemes typically do not target private cars, so it is far more practical to consider a scheme which targets only the heavy fleet (trucks and buses). We have taken the LEZ analysis further in the next section and subjected the broad options to economic assessment.

3 Economic assessment

Whilst so far the emissions reduction scenarios modelled for the Western Approach in Southampton are quite broad and are unlikely to happen in the short to medium term, it is useful to perform an economic assessment of the potential air quality changes associated with them nonetheless.

Again we suggest that whilst the analysis will be “blue sky” in nature, it will help gauge the financial effort required to abate NOx from road traffic around the Western Approach. It should be noted that the unit abatement costs we describe would not necessarily fall to Southampton City Council- no distinction is made in government guidance as to where costs of abatement should be apportioned. As the abatement scenarios we have looked at would mainly involve private vehicles, it is likely that most of the cost burden would be felt by vehicle owners faced either with replacing their vehicles or paying to enter a LEZ. That said, there would be an enforcement cost to the Council of any LEZ scheme, and some financial gain from penalty notices. We have made no attempt to ascertain where these costs/gains would ultimately fall as this would necessarily involve detailed LEZ planning with well understood infrastructure requirements which is not available at this time.

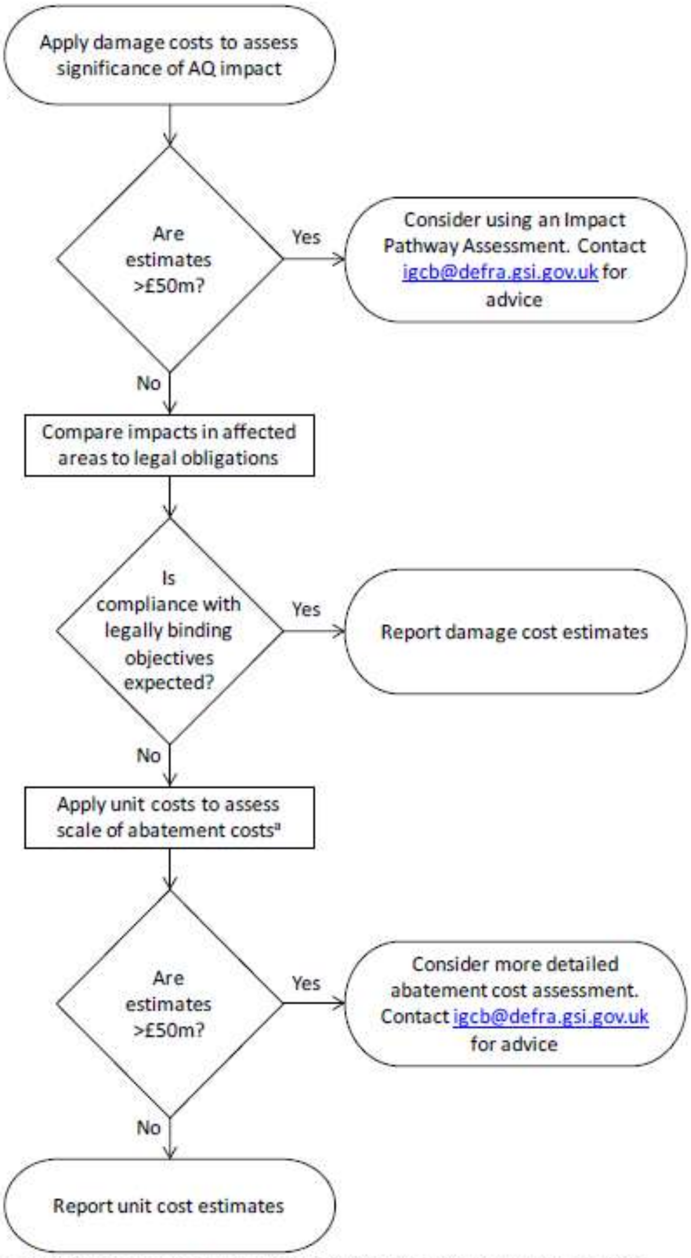
However it is possible to estimate the economic implications of a scheme to reduce emissions by following Defra guidance. The UK Government provides the Green Book guidance[14] for assessing proposals that lead to changes in UK air pollution and Defra have published methodological notes to assist air quality practitioners in the process[15].

When total air quality impacts are estimated to be less than £50 million (in present value terms) it is recommended that damage costs are used as the basis for appraising a scheme. In addition, when the scheme being assessed is expected to change its compliance status through a scheme it is expected that the cost of abatement is calculated.

Figure 3.1 below shows the HM Treasury staged process that should be followed when performing economic assessment of an air quality scheme.

Figure 3.1- Overview of air quality valuation methodologies (source ref 16)

[14] HM Treasury, Valuing impacts on air quality: May 2013 Supplementary Green Book guidance
[15] Defra, Air Quality Damage Cost Guidance, February 2011



[a] Only emissions that occur above the legal obligation should be valued using unit costs. Emissions below this level should be valued using damage costs.

3.1.1 Damage and abatement costs

Damage costs are the cost of the damage from pollution levels to health and the environment (e.g.includes monetisation of mortality and hospital admissions). Abatement costs are the cost of the abatement needed to reduce the pollution levels to below legistiive standards (i.e. to achieve compliance with standards). Defra's Interdepartmental Group on Costs and Benefits (IGCB) provides advice relating to the quantification and valuation of local environmental impacts[16]. The Group has recommended different methodologies for valuing changes in air quality, depending on the circumstances. The Group recommends the abatement cost approach where pollutant concentrations exceed legally binding obligations. Annual mean nitrogen dioxide concentrations exceed the EU limit value of 40 µg m^{-3} at several monitoring sites along the Western Approach and so this approach is appropriate.

[16] Department for Environment, Food and Rural Affairs. Abatement cost guidance for valuing changes in air quality May 2013

The EU has the option to impose fines on the UK if legally binding obligations, such as the air quality limit value for NO_2, are not met and so remedial actions are needed to restore compliance. Consequently measures, such as Low Emission Schemes that reduce the need for further remedial action can limit financial liabilities. The abatement cost approach recognises this, and values any improvements in air quality, where concentrations exceed limit values, as the cost saved by avoiding other compliance activity.

The IGCB developed a four stage methodology for the abatement cost approach:

1. Estimate the likely scale of the impact on emissions by applying damage costs to the change in emissions. The IGCB have developed a Damage Cost Calculator for this purpose.
2. Identify whether there is expected to be any impact on compliance with legally-binding obligations.
3. Estimate the value of the change in air quality using unit abatement costs, which provide an indicative marginal cost per tonne of emission based on the average marginal abatement technology. This provides an easy to use indicative estimate of the abatement impact.
4. Where a measure is likely to have a significant impact on compliance (suggested as a value greater than £50m) then more detailed analysis may be justified.

In this section of the report we apply the damage cost approach for the following scenarios to estimate the damage costs savings associated with each measure.

1) All HGVs and buses using the Western Approach are Euro V or better from 2014 to 2024
2) All HGVs and buses using the Western Approach are Euro VI from 2014 to 2024

These schemes have not been explored in any detail by SCC so this analysis is presented for illustrative purposes only; the intention is to provide a first estimate of potential costs and benefits associated with a LEZ scheme for NOx/NO_2 in the area.

Air pollution has a number of important impacts on human health, as well as on the natural and built environments. The IGCB provides guidance[17] on the assessing the value for the impacts of exposure to air pollution on health – both chronic mortality effects (which consider the loss of life years due to air pollution) and morbidity effects (which consider changes in the number of hospital admissions for respiratory or cardiovascular illness) – in addition to damage to buildings (through building soiling) and impacts on materials. The IGCB has developed a Damage Cost Calculator[18] to calculate the damage costs from proposed policies.

The IGCB Damage Cost Calculator was used to estimate the damage costs saved compared with the baseline for each of the emissions scenarios. The Damage Cost Calculator requires the user to provide the following inputs:

- The first year of your policy which may or may not be the first year where emissions change. This is also important as a different base year has a different level of damage cost associated with it. For this assessment, the base year was assumed to be 2014, so that all damage costs are expressed at 2014 prices.
- The number of years of the policy appraisal. For this assessment the policy was appraised over the period 2014-2024. The dates chosen are relatively arbitrary mainly because the types of vehicle that would be the focus of a LEZ scheme will enter the fleet anyway in the coming years. In practice the LEZ would act as an accelerator to uptake of cleaner, more modern heavy vehicles so the biggest damage cost savings would be reasonably be expected to occur in the first few years of any scheme.
- Data on annual emission changes (in tonnes, by each pollutant)

[17] https://www.gov.uk/air-quality-economic-analysis#damage-costs-approach

[18] uk-air.defra.gov.uk/.../1102150857_110211_igcb-damage-cost-c4192alculator.xls

3.2 Emissions data

The emissions of pollutants from road links in the Air Quality Management Area for 2011 were first calculated for the dispersion modelling study in previous chapters, and then again for 2014 for the economic assessment. The emissions calculations were carried out using Defra's Emission Factor Toolkit[19]. Additional emissions calculations for 2014-2024 were carried out for this study assuming that traffic flows will not change over this period.

The Emission Factor Toolkit calculated the emissions of oxides of nitrogen (as nitrogen dioxide), carbon dioxide and particulate matter PM_{10} for each road link within the specified area. As before, the emission calculation takes account of the annual average daily vehicle flows, average vehicle speeds, traffic composition (petrol cars, diesel cars, light goods vehicles, heavy goods vehicles, buses and coaches) and the emissions abatement (e.g. Euro class) levels within each vehicle category.

Table 3.1 shows the calculated annual emissions of oxides of nitrogen, PM_{10} and carbon dioxide for the modelled area of the Western Approach.

Table 3.1: Calculated emissions for baseline and two LEZ options

Scenario	Year	NO_x, kg y^{-1}	PM_{10}, kg y^{-1}	CO_2, tonnes y^{-1}
Base 2011	2011	74306	5587	23569
Do min	2014	58086	4941	22633
	2015	51703	4762	22294
	2016	45312	4606	21910
	2017	39715	4473	21555
	2018	35115	4359	21239
	2019	31439	4267	20969
	2020	28443	4192	20739
	2021	26041	4133	20546
	2022	24122	4091	20385
	2023	22577	4060	20254
	2024	21371	4038	20151
All heavy vehicles Euro V	2014	55306	4833	22650
	2015	49786	4689	22286
	2016	44003	4557	21905
	2017	38809	4440	21552
	2018	34513	4438	21237
	2019	31045	4254	20968
	2020	28195	4184	20739
	2021	25893	4129	20546
	2022	24019	4087	20385
	2023	22382	4057	20254
	2024	21324	4038	20151
All heavy vehicles Euro VI	2014	38140	4670	22650
	2015	36253	4655	22288
	2016	33711	4460	21905
	2017	31262	4369	21552

[19] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft

Scenario	Year	NO_x, kg y^{-1}	PM_{10}, kg y^{-1}	CO_2, tonnes y^{-1}
	2018	29093	4288	21237
	2019	27187	4218	20968
	2020	25495	416	20739
	2021	24031	4113	20546
	2022	22750	4076	20385
	2023	21652	4051	20254
	2024	20741	4034	20151

3.2.1 Damage cost calculations

Table 3.2 shows the damage costs saved calculated for the Euro V and Euro VI options compared with the Do-minimum case for the assessment period 2014-2024.

Separate damage cost savings are shown relating to the changes in emissions of oxides of nitrogen, particulate matter, PM_{10} and carbon dioxide. The table also shows the total damage cost saved for each scenario, the estimated range (based on the high and low estimates of the health impact of particulate emissions) and high and low sensitivity estimates. The estimates for damage costs associated with particulate matter were calculated for the "Urban Big" area category in the Defra guidance.

There is no appreciable reduction in CO_2 emissions on the Western Approach with either measure. In the Euro V case the biggest contribution to damage costs saved is from the reduction in PM_{10}. When Euro VI vehicles are assumed the contributions from reduced NOx and PM_{10} are similar.

Table 3.2: Damage cost saving calculated

Area	Pollutant	Central estimate, £(2014)	Range, £		Sensitivity range, £	
			Lower	Upper	Lower	Upper
All heavy vehicles Euro V	NO_x	9010	7015	10228	1761	20395
	PM_{10}	30194	23618	34278	4003	77798
	CO_2	0	0	0	0	0
	Total	39204	30633	44507	5765	98194
All heavy vehicles Euro VI	NO_x	76532	59444	86678	14926	172832
	PM_{10}	78179	61150	88752	10517	201433
	CO_2	0	0	0	0	0
	Total	154711	120594	175430	25444	374266

4 Compliance implications of LEZ options

4.1 Introduction

In this section we estimate the road NOx emission reductions required to achieve the EU limit values and compare the required reduction with the reduction expected from the Euro V and Euro VI options versus the Do minimum scenario. This analysis feeds into the later analysis of scheme costs and benefits.

4.2 Projections of nitrogen dioxide concentrations

Projections of concentrations at monitoring sites M271, Auto Redbridge and Auto Millbrook were made for years beyond 2014 based on the 2011 measured concentrations using an emissions rollback method based on Defra's NO_x to NO_2 converter. The highest concentrations have been measured and modelled at these sites.

Defra's NO_x to NO_2 converter allows the user to predict annual mean nitrogen dioxide concentrations given:

- Background oxides of nitrogen concentration
- Primary nitrogen dioxide factor for vehicle mix
- Estimates of regional background ozone and oxides of nitrogen concentrations
- Road contribution to oxides of nitrogen concentrations

The converter also provides a tool to estimate the contribution to oxides of nitrogen concentrations from roads from nitrogen dioxide concentrations.

The NO_x to NO_2 converter includes a database of regional background concentrations selectable on the basis of the year and the local authority. Background oxides of nitrogen concentrations were previously determined for 2011 for each diffusion tube site from Defra's background maps. This was combined with the ADMS modelled concentrations for the railway and port described previously.

The primary nitrogen dioxide factor in Southampton was assumed to be similar to that in urban areas throughout the UK and so the default value provided by the NO_x to NO_2 converter for urban areas was used.

The road contribution to oxides of nitrogen concentrations was calculated from the modelled concentrations at the monitoring sites for 2014 for the Do minimum case using the tool provided by the NO_x to NO_2 converter. The road contribution for future years was then calculated by scaling the 2014 road contribution in proportion to the emission rates for the appropriate years for both the Do min and LEZ options.

The NO_x to NO_2 converter was then used to calculate the projected concentrations at each measurement site taking into account the changes in the road contribution to oxides of nitrogen concentrations, and primary nitrogen dioxide factors. Background values have been assumed to remain the same throughout, partly to reflect potential uncertainty in the port activities in future which are an important contributor to background NOx along the Western Approach. This conservative approach can also account for some of the potential growth in HGV traffic as well.

Table 4.1 shows the projected nitrogen dioxide concentrations for the Do Minimum case for the years 2014-2024. The projections indicate that nitrogen dioxide concentrations at the most affected sites in Southampton will fall to the limit value of 40 µg m^{-3} around 2020 for the Do minimum scenario. It should be noted however that this assumption does not include any growth in port activities including HGVs or railways- the reduction in concentrations is derived entirely from reductions in road traffic emissions calculated during the emissions modelling we have undertaken.

Table 4.1: Projected nitrogen dioxide concentrations, µg m^{-3}

Site	2011	2014	2016	2018	2020	2022	2024
M271	54	49	44	39	35	33	31
Auto Redbridge Road	48	43	39	35	32	30	28
Auto Millbrook Road	49	45	42	39	36	35	34

The projected concentrations are estimated to fall below the limit value at all the diffusion tube sites around 2018 to 2020. Of course this prediction relies entirely on engine technologies delivering the predicted emission reductions inherent in the emissions factors.

The site with the slowest reduction in annual mean NO_2 with time is thought to be Millbrook Road, which reflects the port contribution which has not been scaled in this analysis. The automatic site is immediately next to a busy bus stop and is directly across the road from where the train engines idle at the Millbrook Railfreight terminal. The number of trains at the terminal is due to be reduced by half soon[20] so it would be expected that the contribution from rail to drop (its contribution is actually quite small anyway at less than 5 ug.m^3 of NOx at 539 Millbrook Road in 2011), though of course the operators could upscale their activities just as easily in future. Some reductions in the concentration at the Automatic monitor at Millbrook will probably come from updating of the current fleet of buses but it is impossible to predict the trajectory of any improvements with any certainty at present.

However, it should be noted that this analysis does not take account of the traffic growth projections at the Port which are expected to be in the region of 20-30% with time though again, the trajectory for this is unknown at present and could be the focus of additional work in future. Clearly if there was a 30% increase in HGV emissions in and around the port it would have sizeable implications for the emissions reductions predicted here and the compliance issues SCC face at present. HGVs represent over 30% of NOx emissions on the West side of the AQMA so growth of a few tens of percent could be significant.

Also, this analysis assumes that all emissions reductions associated with newer fleets will be delivered in practice so these predictions should be treated with a degree of caution. The Do min may be an underprediction (of annual mean NO_2) and the impact of the scenarios may be similarly overestimated but it is impossible to estimate this with any certainty. Therefore, it is also possible that it will be after 2018 when compliance with the air quality regulations is achieved.

4.3 Required emission reductions from Do Minimum scenario

The reduction in oxides of nitrogen annual emissions from the road network required to achieve compliance at the worst case locations should be calculated so that the costs of abating these emissions can be estimated.

In this instance, based on the projected 2014 concentrations at the three monitoring locations above, a reduction of 24% of road NOx emissions would be sufficient to achieve the limit values in 2014. By 2015 and 2016 a reduction in road NOx emissions of 20 and 16% would be enough to achieve the limit values, and in 2018 no further reductions are required though the two automatic sites only achieve the limit value by less than 2%. Therefore any growth in port or local HGV activity could mean further exceedances past 2018.

[20] Personal communication (email) from Andy Worrall of Freightliner to John Abbott Ricardo-AEA, 22nd March 2013

To estimate the required change in emissions of road NOx we simply take the headline NOx emissions value of 58 tonnes in 2014 (see Table 2.17), and calculate the tonnage of the required percentage reduction to achieve the annual mean NO_2 limit value. In 2014 this analysis suggests that we require about 24% less road NOx which equates to 14 tonnes.

In 2015 we require a reduction in road NOx of around 11 tonnes.

In 2016 we require 16% reduction on a headline figure of 45 tonnes of road NOx, giving a reduction of 7 tonnes.

In 2017 we require a reduction in road NOx of 5% overall which equates to about 4 tonnes.

No further reductions are required in 2018.

Since the locations with the highest annual mean NO_2 cannot be treated in isolation from the rest of the road network, we will use the headline percentage reduction requirements at the worst case locations to estimate the cost of abatement for the whole of the Western Approach.

5 Unit abatement costs

5.1 Choice of unit abatement costs

Defra developed estimates of the unit costs for emission abatement using a marginal abatement cost curve (MACC) to estimate the potential supply of abatement at a national scale. The MACC reflects the abatement potential and cost for a range of different abatement technologies. Wider impacts on society are incorporated, including: impacts on other pollutants; energy and fuel impacts, and health impacts (damage costs). The abatement represented by the national average compliance gap is compared against the MACC to estimate an indicative unit cost of abatement. It is only indicative because both the gap and the abatement potential from different technologies will vary between areas.

The unit cost is provided in terms of the marginal cost of emissions, usually measured in £/tonne. Table 5.1 below shows the menu of abatement costs which have been derived from the NO_x MACC. These are derived from the full package of measures that would mitigate the typical compliance gap, assessed for the year 2015. It is an extract from the complete MACC. The measures shown include those which may represent the marginal technology once all cheaper options have been exhausted.

Defra's guidance recommends that the appraiser should decide which value is most appropriate for a particular case. If there is no clear rationale to use a particular measure the recommended default value is £29,150. The default value has been used in this analysis. Marginal abatement costs are considered to remain constant over time in real terms. Given the relatively short timescales over which the abatement cost technique is expected to be used it was considered unnecessary to investigate how the costs might change through time.

Sensitivity analysis is recommended to reflect the uncertainty in the abatement costs, using both a higher and lower abatement cost technology selected from Table 9. The selection of these technologies is for the judgement of the analyst. If the default value of £29,150 is used then it is suggested that a range of £28,000 - £73,000 is appropriate, derived from the rounded values of the abatement technologies on either side of the default value in Table 5.1.

Table 5.1: Marginal abatement costs of national measures to reduce oxides of nitrogen emissions

Sector	Sub sector	Baseline Technology	Abatement Measure	Marginal Abatement Cost (£/Tonne of NOx) 2015
RT	HGV	Euro II	SCR	5099
RT	HGV	Euro III	SCR	5380
RT	Buses	Euro II	SCR	6251
RT	Buses	Euro I	Hybrid	6500
RT	Buses	Euro I	SCR	6625
RT	Buses	Euro III	SCR	7257
RT	Buses	Euro II	Hybrid	7462
RT	HGV	Euro IV	SCR	8053
RT	Buses	Euro III	Hybrid	9423
RT	Buses	Euro IV	SCR	11889
RT	Buses	Euro I	Electric	14669
RT	Buses	Euro II	Electric	14872
RT	Buses	Euro III	Electric	17352
RT	Articulated HGV	New Euro V	Euro VI	17743
RT	Buses	Euro IV	Hybrid	18391
Commercial	Buildings		Boiler replacement	19332
RT	Buses	New Euro V	Euro VI	24852
RT	Rigid HGV	New Euro V	Euro VI	28374
RT	**Buses**	**Euro IV**	**Electric**	**29150**
RT	Buses	Euro V	Hydrogen	72932
RT	Diesel LGV - class 1	New Euro 5 class I	Euro 6	79323
RT	Diesel LGV	Euro 1	Electric	100665
RT	Diesel LGV	Euro 2	Electric	111619
RT	Petrol cars	Euro 1	Electric	112030
RT	Diesel cars	Euro 1	Electric	135949
RT	Diesel LGV - class 2	New Euro 5 class II	Euro 6	144124
RT	Diesel LGV - class 3	New Euro 5 class III	Euro 6	144124
RT	Diesel cars	Euro 2	Electric	156046
RT	Diesel LGV	Euro 5	Electric	240484
RT	Diesel LGV	Euro 3	Electric	262466
RT	Petrol cars	Euro 2	Electric	280450
RT	Diesel cars	Euro 3	Electric	304593

RT=Road Transport

5.2 Cost of emissions reductions

Defra guidance recommends that abatement costs are used for valuing emissions that exceed legally binding obligations, in this case the EU limit value for nitrogen dioxide. Damage costs should be used to value the part of the change that maintains compliance.

Table 5.2 shows the emissions reductions resulting from the Do Minimum case, as well as the estimated emissions reductions from the Do Minimum case required to achieve the EU Limit value of 40 µg m^{-3}.

Table 5.2: Eligible emissions reductions

	2014	2015	2016	2017	2018
Do minimum (tonnes road NOx/yr)	58	52	45	40	35
Required reduction (tonnes road NOx/yr)	14	11	7	4	0
Abatement cost (£)	408100	320650	204050	116600	0

Therefore we can see that the road NOx reduction in emissions required compared with the Do min starts at 14 tonnes in 2014, and drops to zero in 2018 which reflects the natural fleet improvements which should occur without intervention. Since it is unlikely that a LEZ scenario which targets vehicle technologies would be able to deliver such a precise reduction we prefer to use the total reductions associated with each measure as the basis of the analysis. For example this means the unit abatement costs provided below for the Euro VI (assuming they deliver 100% of expected emissions reductions) are something of an overestimate as the reductions achieved are bigger than those needed for compliance. This could be thought of as a safety factor as the difference between what's required from 2014 to 2018 at least is not very different.

Table 5.3 shows the total benefit of the scheme, calculated as the sum of abatement costs and the damage costs saved. We have used the central value for the unit abatement costs for this analysis. The use of the lower unit cost (£28,000) would not significantly affect the outcome. The use of the higher unit abatement cost (£73,000) would of course have an effect, making the ratio of costs against benefits even more severe.

Table 5.3 Net present value calculations- Euro V scenario

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Do minimum NOx	58086	51703	45312	39715	35115	31439	28443	26041	24122	22577	21371
Do min compliance with limit value?	N	N	N	N	N	Y	Y	Y	Y	Y	Y
Euro V scenario (NOx, t/yr)	55306	49786	44003	38809	34513	31045	28195	25893	24019	22382	21324
NOx saving (t/yr)	3	2	1	1	1	0	0	0	0	0	0
Required saving (NOx, t/yr)	14	11	7	4	0	0	0	0	0	0	0
Compliance with limit value?	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
Abatement cost of full measure	£81,037	£55,881	£38,157	£26,410	£17,548	£11,485	£7,229	£4,314	£3,002	£5,684	£1,370
Total unit abatement cost	£252,118	The total summed unit costs for an LEZ scheme of Euro V in the heavy fleet are greater than the damage costs avoided between 2014 and 2024. Even where the high estimate for damage costs saved is used, the scheme cost outweighs the benefits by >£200k We estimate that compliance is reached around 2019 without the scheme, and in 2018 with the scheme.									
Damage costs avoided (central)	£39,204										
2014 Net present value (central)	-£212,914										
Damage costs avoided (low)	£30,633										
2014 Net present value (low)	-£221,485										
Damage costs avoided (high)	£44,507										
2014 Net present value (high)	-£207,611										

Table 5.4 Net present value calculations- Euro VI scenario, assume 100% benefit

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Do minimum NOx	58086	51703	45312	39715	35115	31439	28443	26041	24122	22577	21371
Do min compliance with limit value?	N	N	N	N	N	Y	Y	Y	Y	Y	Y
Euro VI scenario (NOx, t/yr)	38140	36253	33711	31262	29093	27187	25495	24031	22750	21652	20741
NOx saving (t/yr)	20	15	12	8	6	4	3	2	1	1	1
Required saving (NOx, t/yr)	14	11	7	4	0	0	0	0	0	0	0
Compliance with limit value?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Abatement cost of full measure	£581,426	£450,368	£338,169	£246,405	£175,541	£123,946	£85,934	£58,592	£39,994	£26,964	£18,365
Total unit abatement cost	£2,145,702	The total summed unit costs for an LEZ scheme of Euro VI in the heavy fleet are greater than the damage costs avoided between 2014 and 2024. Even where the high estimate for damage costs saved is used, the scheme cost outweighs the benefits by >£1.9m The scheme does bring forward compliance to 2014 from 2019 but relies on Euro VI delivering 100% of the NOx reduction benefits predicted.									
Damage costs avoided (central)	£154,711										
2014 Net present value (central)	-£1,990,991										
Damage costs avoided (low)	£120,594										
2014 Net present value (low)	-£2,025,108										
Damage costs avoided (high)	£175,430										
2014 Net present value (high)	-£1,970,272										

Table 5.5 Net present value calculations- Euro VI scenario, assume 50% emissions benefit

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Do minimum NOx	58086	51703	45312	39715	35115	31439	28443	26041	24122	22577	21371
Do min compliance with limit value?	N	N	N	N	N	Y	Y	Y	Y	Y	Y
Euro V scenario (NOx, t/yr)	48113	43978	39512	35489	32104	29313	26969	25036	23436	22115	21056
NOx saving (t/yr)	10	8	6	4	3	2	1	1	1	0	0
Required saving (NOx, t/yr)	14	11	7	4	0	0	0	0	0	0	0
Compliance with limit value?	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Abatement cost of full measure	£290,713	£225,184	£169,085	£123,202	£87,771	£61,973	£42,967	£29,296	£19,997	£13,482	£9,182
Total unit abatement cost	£2,145,702	The total summed unit costs for an LEZ scheme of Euro VI in the heavy fleet are greater than the damage costs avoided between 2014 and 2024. Even where the high estimate for damage costs saved is used, the scheme cost outweighs the benefits by >£2m The scheme does bring forward compliance to 2017 from 2019 assuming Euro VI delivers 50% of the NOx reduction benefits predicted. The costs of implementing the measure would reasonably be expected to be the same whether the technology shift delivers all of the predicted emissions reduction or not.									
Damage costs avoided (central)	£77,356										
2014 Net present value (central)	-£2,068,347										
Damage costs avoided (low)	£60,297										
2014 Net present value (low)	-£2,085,405										
Damage costs avoided (high)	£87,715										
2014 Net present value (high)	-£2,057,987										

5.3 Significance of the impact on compliance

The abatement cost guidance for valuing changes in air quality recommends that more detailed analysis is required if the net present value of the air quality impacts valued using unit costs is greater than £50m. The calculated damage costs saved are considerably less than £50 m and so no further detailed analysis is required.

5.4 Conclusions of the economic assessment of LEZ

As can be seen from the analysis presented above, the costs associated with a scheme based around Euro V as a minimum emission standard for heavy vehicles on the Western approach far outweigh the benefits. The scheme has predicted damage costs savings of about £40k, and costs of more than £200k. The date of compliance is virtually unchanged by adopting Euro V at this point in time, and the technology will penetrate the fleet in the next few years anyway so any benefits would be fleeting.

The analysis for the Euro VI case suggests much greater emissions benefits, with a fairly large influence on the date of compliance- essentially if all heavy traffic were Euro VI now compliance with the NO_2 limit value would be expected in 2014. The magnitude of the emissions reductions which could arise from such a scheme are similar to what is needed at the worst case locations along the Western Approach. That said it may not be appropriate to assume that 100% of the NOx reduction benefits that Euro VI is predicted to deliver will occur in practice so this forecasts should be treated with caution. In any case, the economic analysis suggests that (even with full emissions reductions assumed) costs will far outweigh benefits by around £2m across a 10yr scheme. As a sensitivity test, and to further supplement the analysis carried out in a previous section, we have estimated the economic case for a Euro VI LEZ where the technology shift does not deliver the whole emissions reduction benefit. Our analysis suggests that the compliance date could be brought forward by a few years to 2017 from 2019 in the base case. The case for Euro VI only delivering 50% of its expected NOx reductions has an impact on the costs versus benefits but the magnitude of the difference against the 100% NOx benefit scheme is not significant. This is because the large costs greatly outweigh the small benefits so a step change in the damage costs savings is insignificant in the context of scheme costs greater than £2m. The cost of the scheme is greater than the benefits from damage cost savings by £2m as before. We have no reason to expect that costs associated with an engine technology shift that fails to deliver would be any different to the case where we assume they will deliver all that is expected.

We consider that there is no reasonable variation in the analysis that could yield greater damage cost reduction benefits than overall costs.

6 Road Transport & Port Emissions Mitigation Measures

6.1 Consideration of Emission Reductions

The air quality modelling of the Western Approaches shows that emissions of NOx from road transport, and at key locations, those from Port activities, play a significant role in causing exceedences of the NO_2 annual mean objective. The source characterisation of emissions along the Western Approaches varies - while HGV and passengers car emissions are significant towards the Western extremities, Port emissions (including those from the Freightliner Terminal) become predominant at 539 Millbrook Road, then all vehicle types, including buses and LGVs, and Port emissions contribute to exceedences towards the City end of the Western Approaches.

It is relevant to highlight that the study modelling provides an update to the data provided in the Southampton Air Quality Action Plan – A Breathe of Fresh Air (2008). Current modelling uses updated emission factors which show that passenger vehicles, particularly diesel, have a greater contribution to NO_2 levels than was previously identified.

As part of the study, mitigation measures that have the potential to reduce emissions affecting the Western Approaches have been discussed with both Southampton CC Officers and external stakeholders, including Port Operators (DP World, AB Ports), Southampton University, bus operators (Go-Ahead, First Group) and logistics concerns (Meachers Global, Road Haulage Association). The range of low emission measures considered can be seen in Appendix 4.

Several measures were discounted at an early stage. Such measures and associated reasoning included:

Low Emission Zone (Western Approaches), including camera enforcement

- To be effective and proportional, all vehicle types would need to be included within scheme, causing significant vehicle re-routing, particularly at peak times
- Potential to affect viability of Port
- Performance of Euro Standards would make the setting of LEZ criteria problematic
- The cost of enforcement considered excessive
- Alternative measures could achieve emission reductions as effectively as a LEZ with co-ordinated implementation and at significantly less cost

Dedicated HGV Lane from M271 to First Avenue, Dock Gate 20 (access to Container Port)

- Schemes to provide a dedicated HGV lane have been considered previously
- Re-allocation of current road space would cause significant congestion at peak times
- Land constraints prevent road widening to accommodate an extra lane

The following section discusses further mitigation measures considered by both internal and external stakeholders and progress to date with implementation

6.2 Mitigation & Low Emission Strategy (LES) Development (2014-2016)

Based on the findings of the modelling undertaken, Southampton CC have focussed on developing initiatives capable of reducing emissions affecting the Western Approaches and build on these activities through the development of an overarching Low Emission Strategy (LES) for the City that will seek to optimise municipal policies and strengthen partnership working that will target cost-effective, road transport emission reductions across Southampton.

Southampton Council was awarded £60,000 through the Defra Air Quality Grant 2013/14 to develop an LES over the 2014-2016 period. The LES development will involve partnership working and will cover the following areas:

- Review of air quality and emission data for Southampton
- Review of health data and awareness in partnership with Public Health and University of Southampton
- Develop technical guidance to consider air quality through the planning & development control process
- Develop measures to support emission reductions through procurement practices, including Southampton CC Fleet
- Develop a bus emission strategy
- Develop a freight emission strategy
- Develop measures to accelerate the deployment of low emission vehicle infrastructure
- Support measures to increase modal shift and the accelerate the uptake of low/ultra low/clean passenger vehicle technologies and fuels

The LES will build on the following initiatives in development:

6.2.1 Sustainable Distribution Centre

Southampton CC have tendered for a warehousing and logistics provider to run what will be branded as a Sustainable Distribution Centre (SDC) offering freight consolidation and comprehensive warehousing from their premises to Southampton and the surrounding areas. The project is part funded through DfT Local Sustainable Transport Funding (LSTF) and the SDC will streamline deliveries from the South East region and UK into Southampton or one of the other locations. The SDC can reduce congestion by consolidating loads for the 'last mile' of the journey. Evidence from the Bristol Consolidation Centre and others has shown that freight transport traffic into the city centre can be reduced by up to 75% for those participating in the scheme. The optimal site will in the vicinity of the M27 or lower M3 – a western location could help to reduce vehicle numbers on the Western Approach. It is estimated that the SDC could initially reduce 100 vehicle movements into the City on a daily basis.

The aim of the project is to help Southampton and the surrounding areas become more sustainable, both economically and environmentally. In light of the Western Approaches Study, the SDC tender specification refers to the objectives of reducing the carbon footprint and level of NOx emissions in the areas served by the SDC and Improving air quality in the areas that the SDC serves, for example by operating, now or at some point in the future if required by SCC, specific types of low emission vehicle.

The project, due to commence in 2014, will be evaluated for environmental benefits by the University of Southampton

6.2.2 Port Operations

The initial study findings have been discussed with Port Operators (DP World and AB Ports) and the following initiatives are being considered:

Converting Straddle Carriers to Dual Fuel (gas/diesel) – the study highlights the contribution that the emissions from the straddle carriers (container Port) has on ambient NO_2 concentrations and discussions have taken place regarding the potential use of gas (methane) as part of Port operations. DP World has approved a $75,000 feasibility study to look at the feasibility of converting the straddle carriers to run on gas and diesel as a duel fuel. The location of medium pressure gas pipelines in the vicinity of the Port can be seen in the map provided in Appendix 6. The study will assess the emission benefits associated with converting the straddle carriers.

Container Port Vehicle Booking System – all commercial vehicles accessing the Container Port are subject to a pre-booking system. DP World will look at working with clients to raise awareness over vehicle emissions and look at the potential for introducing emission standards as part of the booking system

Low Emission Vehicles – both Port operators will continue to evaluate the potential for using low emission vehicles in the course of Port operations

6.2.3 Southampton CC Fleet Management

Based on 2012/13 data, Southampton CC operate a fleet of 489 municipal vehicles with the main depot based at Central Avenue, off the Millbrook roundabout. As part of the study, the fleet has been divided into 5 vehicle classes (not including specialist vehicles such as street sweepers and mobile libraries) and data analysed to look at energy costs and environmental impacts (including damage costs for CO_2, NO_x & PM) of the fleet compared with alternative vehicle technologies such as diesel electric-hybrid, electric and gas (methane) vehicle technologies. The analysis allowed the comparison of whole life costs (WLC) – a procurement consideration that forms part of the approach required by the Cleaner Road Transport Vehicle Regulations 2011.

The table below shows the basic fleet model:

Vehicle class	Number of vehicles	Average yearly mileage	Average mpg	Total fuel use
Car derived vans, cars and pickups	51	9,235	45.6	47,492
Smaller vans and tippers, 1-2.7t	106	4,193	30.9	66,239
Larger vans, minibuses and tippers, 2.8-3.5t	263	5,014	24.5	247,143
7.5t vans and tippers	12	15,159	19.9	42,114
RCVs (18-26t)	33	7,500	2.9	387,481
Totals	465			790,469

Analysis of the WLC for each of the 5 vehicle classes can be found in Appendix 5.

The assessment showed that alternative vehicle technologies, particularly in the heavier vehicle classes, could be cost-competitive with diesel vehicles, based on WLC, including gas/biomethane technologies. In addition to the emission reduction potential for NOx and particulate matter, gas/biomethane vehicle technologies also offered potential CO_2 savings.

Discussions with Southampton CC Fleet Management indicate interest in pursuing gas/biomethane vehicle technologies, however, the main barrier is the cost of providing refuelling infrastructure. Partnership approaches could be pursued (CF DP World Duel Fuel Feasibility Study). Gasrec, who provide a liquefied methane/biomethane (85/15%) fuel for transport has stated that they are to develop a public access fuelling station in Southampton, which could have potential use for the Southampton CC Fleet.

6.2.4 Bus Operations and Funding

While bus emissions are not significant along most of the Western Approaches, discussions with operators Go-Ahead (Bluestar) and First Group have indicated a willingness to look at emission standards and operational factors as part of the LES development.

DfT Clean Bus Technology Fund (CBTF) – Southampton CC, with assistance from the study team, made a successful application to the DfT Clean Bus Technology Fund 2013/14, securing £632,700 (from a total fund of £5m) to retro-fit 37 Euro III buses with a Williams Gyrodrive (flywheel) system. The funding application referenced the development of the Southampton LES and the benefits that the application would have on air quality in the City. While the Gyrodrive system will principally help reduce CO2 emissions (circa 30% reduction), it will also help reduce emissions of NOx and PM.

Potential emission reductions of 19.6% per bus could be achieved with respect to NOx which could result in overall bus emission reductions of 7.6% in some AQMAs.

Bluestar and Unilink, who have agreed to fit the systems, are also contributing 50% of the costs and suggest that they may retro-fit their entire Southampton bus fleets, creating a centre of excellence in the City

6.2.5 Southampton CC Planning Policy

Southampton is currently experiencing widespread development, with the potential to both increase vehicle numbers and emissions. Discussions have taken place with Southampton CC Planning Officers, with agreement to strengthen provisions for considering air quality through the development of technical guidance.

The National Planning Policy Framework (NPPF) states that air quality is relevant to planning and policies should help pursue the achievement of European Limit Values. While air quality is referenced within the Core Strategy (2010), City Centre Action Plan (2013) and Sustainable Construction SPD, the main focus of environmental consideration centres on climate change and CO_2 reduction, however, policies to promote transport measures, including walking, cycling and the acceleration in uptake of low emission vehicles, form key policies within the planning strategies.

Developing technical guidance to consider air quality and emissions is provided as a commitment within the Air Quality Action Plan – A Breath of Fresh Air (2008) and will be developed as part of the Southampton LES development

7 Conclusions

This assessment has looked at NO_2 concentrations along the Western Approach AQMA in Southampton for a 2011 base year. The study has confirmed that there are still measured and modelled exceedances of the NO_2 annual mean limit value in the AQMA and that the declaration is still required. That said, concentrations do appear to be reducing somewhat on analysis of the NO_2 trend data available to this work.

To enable us to understand the relative contribution to local NOx and NO_2 concentrations, we have used dispersion models to assess road, port and rail sources separately. The results of the assessment suggest that the spatial variation in contributions from each sector is significant. The west of the AQMA is primarily affected by road sources, of which the car and HGV fleets are significant contributors. In the centre of the AQMA around Millbrook Road the port is a large NOx contributor, indeed it is as large a source of NOx as road traffic at some locations. To the east of the AQMA road sources are again the most important source group, with cars and buses being the largest two contributors within the fleet.

Management of NOx along the Western Approach would therefore sensibly target road vehicles and congestion around the M271 junction. There is a significant flow of HGVs serving the port accessing from that junction so their contribution is quite large on the western side of the AQMA. Further east management of port emissions would seem sensible as this source is as significant as local roads around Millbrook Road. To the east of the modelled area areas of high concentration are more associated with congestion at junctions so perhaps traffic management options could be explored along Millbrook Road into Mountbatten Way.

The impact of implementing a LEZ along the Western Approach was estimated for the following scenarios:

- Do Minimum
- All HGV to be Euro V compliant
- All HGV to be Euro VI compliant

In addition to these LEZ scenarios, consideration was given to the emissions reduction from the introduction of Euro VI/6 into the vehicle fleet. As previous Euro standards have not delivered in the real world as was expected from test bed emissions monitoring, it was deemed prudent to assess the following improvements from Euro VI/6

- Euro Standard achieving 25% of the predicted benefit
- Euro Standard achieving 50% of the predicted benefit
- Euro Standard achieving 75% of the predicted benefit

It was concluded that with a Do Minimum scenario, where fleet replenishment was as market rates, the year of compliance of the annual average NO_2 objective is projected to be 2019. If an LEZ was implemented along the Western Approach at a Euro V standard for HGVs then this year of compliance would be brought forward by one year to 2018. However, the economic assessment which includes the monetary value for the improvement in public health through lower pollution levels, concludes that the costs of the scheme would outweigh the benefits by £200,000. Similarly, a Euro VI LEZ for HGVs would bring the compliance date forward to the year of implementation, which for this study was assumed to be 2014. However the costs outweigh the benefits by £1.9m, and the practicalities of implementing a scheme so swiftly would raise difficulties. In addition, should the Euro VI only deliver 50% of its expected emission reduction the compliance year would be 2017, with costs outweighing the benefits by some £2m.

It would appear prudent that Southampton City Council should continue to explore other options for local NOx reductions and not rely solely on future emission standards which may or may not deliver. The large contributions from the port activities also mean that waiting for better Euro standards in the road fleet may not deliver full compliance with the NO_2 limit values at all locations.

As part of the study, progress has been made in engaging with stakeholders and identifying initiatives that will both help reduce emissions along the Western Approaches and across the City. These initiatives will be developed further as part of the Southampton Low Emission Strategy.

Appendices

Appendix 1: Wind rose for Southampton Airport

Appendix 2: Sample of emissions factor toolkit input

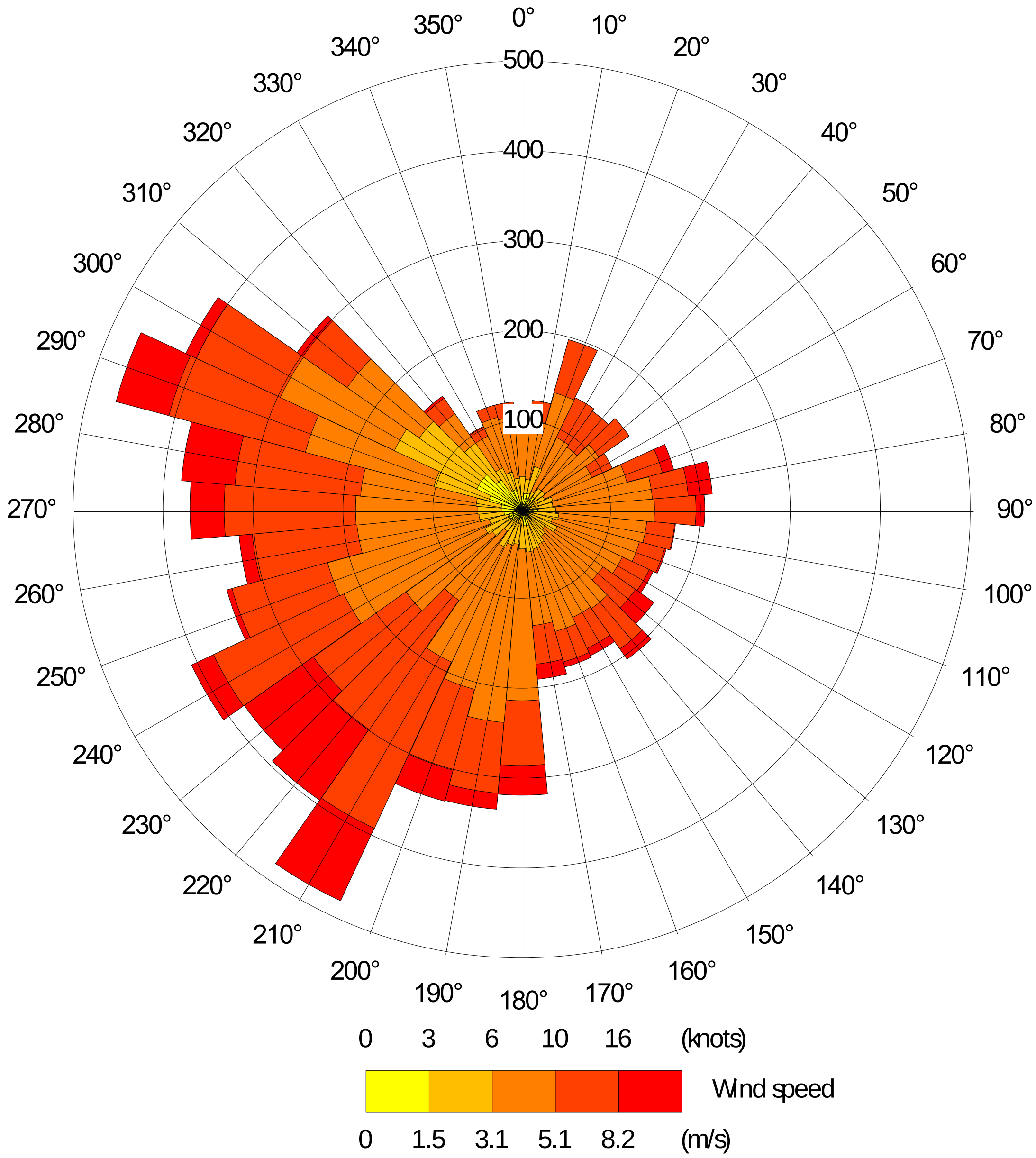
Appendix 3: Sample of emissions factor toolkit output

Appendix 4: Potential Low Emission Strategy Measures for Western Approach, Southampton

Appendix 5: Southampton City Council – Fleet Model and Whole Life Costs

Appendix 6: Compressed Natural Gas (CNG) Pipelines (Medium Pressure) in Port Area

Appendix 1- Wind Rose- Southampton Airport, 2011



Appendix 2- Sample of emission Factor toolkit inputs

Select Pollutants

- [x] NOx
- [ ] NOx(TRL)
- [x] PM10
- [ ] Carbon Dioxide
- [x] PM2.5
- [ ] Hydrocarbons

Select Outputs

- [x] Air Quality Modelling (g/km/s)
- [x] Emissions Rates (g/km)
- [x] Annual Link Emissions

Additional Outputs

- [x] Breakdown by Vehicle
- [ ] Source Apportionment
- [x] PM by Source

Advanced Options

- [x] Euro Compositions
- [ ] Alternative Technologies
- [ ] Output % Contributions from Euro Classes

Click the button to:

Run EFT

Clear Input Data

Please Select from the Following Options:

Area	England (not London)
Year	2011
Traffic Format	Detailed Option 2

Select 'Basic Split' or 'Detailed Option 1 to 3' above

Export Outputs

- [x] Save Output to New Workbook

File Name: Eft results with trafficmaster average speeds

SourceID	Road Type	Traffic Flow	% Car	% Taxi (black cab)	% LGV	% Rigid HGV	% Artic HGV	% Bus and Coach	% Motorcycle	Speed(kph)
a3057_1	Urban (not London)	10882	77.4	0.0	19.7	1.3	0.3	0.1	1.1	22
a3057_2	Urban (not London)	10882	77.4	0.0	19.7	1.3	0.3	0.1	1.1	22
a3057_3	Urban (not London)	5441	77.4	0.0	19.7	1.3	0.3	0.1	1.1	22
a3057_4	Urban (not London)	5441	77.4	0.0	19.7	1.3	0.3	0.1	1.1	22
a3057_5	Urban (not London)	3956	77.4	0.0	19.7	1.3	0.3	0.1	1.1	33
a3057_6	Urban (not London)	3956	77.4	0.0	19.7	1.3	0.3	0.1	1.1	33
a3057_7	Urban (not London)	7912	77.4	0.0	19.7	1.3	0.3	0.1	1.1	33
a3057_8	Urban (not London)	7912	77.4	0.0	19.7	1.3	0.3	0.1	1.1	33
a33_1	Urban (not London)	13421	85.0	0.0	9.0	2.1	2.4	0.5	0.9	17
a33_10	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	32
a33_11	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	32
a33_12	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	27
a33_13	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	27
a33_14	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	27
a33_15	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	27
a33_16	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	18
a33_17	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	18
a33_18	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	18
a33_19	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	18
a33_2	Urban (not London)	13421	85.0	0.0	9.0	2.1	2.4	0.5	0.9	17
a33_20	Urban (not London)	13892	85.9	0.0	9.1	1.6	1.9	0.4	1.1	18

Appendix 3- Sample of emission Factor toolkit outputs (NOx)

Source_Name	Pollutant_Nam	All Vehicle (g/km/	All LDV (g/km/	All HDV (g/km/	Petrol Cars (g/km/	Diesel Cars (g/km/	Taxi (g/km/	Petrol LGV (g/km/	Diesel LGV (g/km/	Rigid HGV (g/km/	Artic HGV (g/km/	Buses/Coaches (g/km/	Motorcycles (g/km/
a3057_1	NOx	0.081	0.064	0.016	0.011	0.028	0.000	0.000	0.024	0.011	0.004	0.001	0.000
a3057_2	NOx	0.081	0.064	0.016	0.011	0.028	0.000	0.000	0.024	0.011	0.004	0.001	0.000
a3057_3	NOx	0.040	0.032	0.008	0.006	0.014	0.000	0.000	0.012	0.005	0.002	0.001	0.000
a3057_4	NOx	0.040	0.032	0.008	0.006	0.014	0.000	0.000	0.012	0.005	0.002	0.001	0.000
a3057_5	NOx	0.025	0.020	0.004	0.004	0.008	0.000	0.000	0.008	0.003	0.001	0.000	0.000
a3057_6	NOx	0.025	0.020	0.004	0.004	0.008	0.000	0.000	0.008	0.003	0.001	0.000	0.000
a3057_7	NOx	0.049	0.040	0.009	0.008	0.017	0.000	0.000	0.015	0.006	0.002	0.001	0.000
a3057_8	NOx	0.049	0.040	0.009	0.008	0.017	0.000	0.000	0.015	0.006	0.002	0.001	0.000
a33_1	NOx	0.153	0.073	0.080	0.016	0.042	0.000	0.000	0.015	0.026	0.045	0.009	0.000
a33_10	NOx	0.102	0.061	0.041	0.015	0.033	0.000	0.000	0.012	0.013	0.023	0.005	0.000
a33_11	NOx	0.102	0.061	0.041	0.015	0.033	0.000	0.000	0.012	0.013	0.023	0.005	0.000
a33_12	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_13	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_14	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_15	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_16	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_17	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_18	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_19	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_2	NOx	0.153	0.073	0.080	0.016	0.042	0.000	0.000	0.015	0.026	0.045	0.009	0.000
a33_20	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_21	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_22	NOx	0.137	0.075	0.062	0.017	0.043	0.000	0.000	0.015	0.019	0.035	0.007	0.000
a33_23	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_24	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_25	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_26	NOx	0.112	0.065	0.047	0.015	0.036	0.000	0.000	0.013	0.015	0.026	0.006	0.000
a33_27	NOx	0.126	0.064	0.063	0.015	0.036	0.000	0.000	0.013	0.020	0.035	0.007	0.000
a33_28	NOx	0.126	0.064	0.063	0.015	0.036	0.000	0.000	0.013	0.020	0.035	0.007	0.000
a33_29	NOx	0.126	0.064	0.063	0.015	0.036	0.000	0.000	0.013	0.020	0.035	0.007	0.000
a33_3	NOx	0.153	0.073	0.080	0.016	0.042	0.000	0.000	0.015	0.026	0.045	0.009	0.000
a33_30	NOx	0.126	0.064	0.063	0.015	0.036	0.000	0.000	0.013	0.020	0.035	0.007	0.000
a33_31	NOx	0.126	0.064	0.063	0.015	0.036	0.000	0.000	0.013	0.020	0.035	0.007	0.000
a33_32	NOx	0.125	0.073	0.052	0.017	0.040	0.000	0.000	0.015	0.017	0.029	0.006	0.000
a33_33	NOx	0.125	0.073	0.052	0.017	0.040	0.000	0.000	0.015	0.017	0.029	0.006	0.000
a33_34	NOx	0.125	0.073	0.052	0.017	0.040	0.000	0.000	0.015	0.017	0.029	0.006	0.000
a33_35	NOx	0.125	0.073	0.052	0.017	0.040	0.000	0.000	0.015	0.017	0.029	0.006	0.000
a33_36	NOx	0.125	0.073	0.052	0.017	0.040	0.000	0.000	0.015	0.017	0.029	0.006	0.000
a33_37	NOx	0.130	0.075	0.055	0.018	0.042	0.000	0.000	0.015	0.018	0.031	0.007	0.000
a33_38	NOx	0.130	0.075	0.055	0.018	0.042	0.000	0.000	0.015	0.018	0.031	0.007	0.000
a33_39	NOx	0.130	0.075	0.055	0.018	0.042	0.000	0.000	0.015	0.018	0.031	0.007	0.000
a33_4	NOx	0.153	0.073	0.080	0.016	0.042	0.000	0.000	0.015	0.026	0.045	0.009	0.000
a33_40	NOx	0.130	0.075	0.055	0.018	0.042	0.000	0.000	0.015	0.018	0.031	0.007	0.000
a33_41	NOx	0.153	0.084	0.069	0.019	0.048	0.000	0.000	0.017	0.022	0.039	0.008	0.000
a33_42	NOx	0.153	0.084	0.069	0.019	0.048	0.000	0.000	0.017	0.022	0.039	0.008	0.000

Appendix 4 : Potential Low Emission Strategy Measures for Western Approach, Southampton

Measures are colour coded in relation to the following four categories:

Promoting low emission vehicles – measures that can support or accelerate fleet transformation through the accelerated uptake of low or zero emission vehicles

Improving efficiency – measures that can improve the way that vehicles are used, or people and goods moved, in order to reduce emissions

Managing demand – mainly measures around modal shift, but also those that can help to reduce overall transport activity

Barrier Mechanisms – improving separation from highway or using barrier mechanisms to reduce exposure

Specific Western Approach LES Measures		
Measure	**Mechanism**	**Notes**
Low Emission/Environmental/Clear Zone: • **Emission criteria for vehicles accessing A33/Western Esplanade, including HGVs/LGVs/Buses/Cars** • **Emission criteria for HGVs travelling eastwards beyond Dock Gate 20/Millbrook Roundabout**	RTRO / HGV routing signs	• Would need to consider national fleet emission profile 2016/2018 • Would need to be focussed on Euro 6/VI • HGVs/cars main contributors, buses/LGVs also to be considered • Vehicle displacement /re-routing considerations • ANPR/manual enforcement • Implementation and scheme management costs • Learnings from London/Oxford/Norwich/poss West Mids
HGV Priority Lane from end M27 to Dock Gate 20/Millbrook Roundabout	RTRO/Additional road lane constructed	Would ease congestion, however, several plans looked at and difficult to reallocate road space
Low Emission Lanes – Bus/HGV/LGV priority lanes for low emission vehicles	RTRO	• Bus service level relatively low, therefore, opportunity to encourage accelerated emission improvement in HGV/LGV/car sectors

		• Could increase congestion/re-routing • Should be aimed at Euro 6/VI
EcoPass System – access charging related to emission standards	RTRO	• Similar to Milan scheme • Scheme acceptability and re-routing considerations • ANPR/manual enforcement • Implementation and scheme management costs
Low Emission Port Development	Public Private Partnership	Port contribution to background levels significant • Further investigation required as to main port sources • Could develop public private initiative • Could provide competitive advantage for port • Consideration of gas infrastructure to support emission reduction activity
Car Share Lane	RTRO	• M606/M62 scheme considered successful • M4 scheme removed • Can increase congestion on remaining restricted road space • Enforcement considerations
Sustainable Freight Consolidation Centre	LSTF	Successful £400k LSTF bid. Currently undergoing tender process. Meachers Global identified as a possible site/bidder. Could remove 100 vehicle deliveries per day to Council/Unis/NHS in first phase. Potential to expand scheme
Low Emission Enterprise Zone/Emission related Business Rates incentive	Business Rates / Planning Policy	Commercial zones to West of City and those accessed by Western Approach could be incentivised through business rates to reduce vehicle emissions/introduce infrastructure for LEVs
Area specific low emission land-use planning measures	Planning Policy/AQAP	Adoption of mitigation based approach to counter cumulative impacts of developments to West of City • Discourage use of high emission vehicles

		• Include provision for low emission vehicle re-charging/refuelling infrastructure • Incentivise uptake of low emission vehicle/specify low emission fleets • Require public sector travel passes for employees • Damage cost approach to achieving site acceptability • CIL and Section 106 considerations • Secure enhanced travel planning measures • Timing to coincide with wider policy update • Introduced through AQAP update • Cf West Mids, Bradford, West Yorks, Sussex
Focussed Public & Private Sector Travel Planning	Public Private Partnership Southampton Travel Plan / AQAP / Grey Fleet Policy	Monitored schemes can reduce vehicle activity up to 30% (cf. Pfizer) • Consider public & private sector targeted home working /delayed start & finish times • Incentives for modal shift • Grey fleet incentives for LEVs
Focussed Freight Accreditation Scheme	LTP / Public Private Partnership	Could compliment Low Emission Enterprise Zones. • FORS • EcoStars • Major benefits if tied into procurement
Smarter Choices - Public Information/Signage on vehicle emissions/Information Portal	LTP/LSTF	• Ongoing activity to facilitate modal shift and LEV take up • Public information campaign
Enhanced Cycle Lane	LTP/LSTF/Cycling ambition/Sustrans	• Consideration of super-cycle highway and associated infrastructure/incentives • Road space allocation considerations • Elevated highway consideration
Park & Ride / Park & Cycle	LTP/LSTF	• Potential to increase modal shift • Suitable site considerations • Potential for introducing Low Emission Buses

SCC Fleet Management	Council Policy / AQAP	Fleet based at Dock Gate 20, with over 400 vehicles, therefore, potential to influence emissions marginally – demonstration of LEVs/leadership considerations. Fleet currently at mainly Euro 5. Currently looking at WLC and possibility of looking at gas vehicle infrastructure with private sector
Alternative Fuel Infrastructure	Public Private Partnership NPPF / AQAP	(See above) • Potential to build on DfT Strategy to Switch HGVs to Gas (due end 2013) • Low Carbon Truck Demonstration • Build on regional capability • Consideration of gas as part of Green Port
Phasing / Gating / Speed Limit Management	LTP	To be discussed
Vegetation barriers	Maintenance contracts	Studies indicate that vegetation barriers can help trap particles but have little effect (poss increase) on reducing NO2
	Southampton Wide LES Measures	
Low Emission Parking	AQAP / NPPF / Work Place Parking Levy	Public and private sector initiatives • NCP annual pass reduction for CO2 • Priority parking/loading bays • Differentiated work place parking levy • Signage
Bus Emission Strategy	Voluntary agreement SQBP, Quality Contracts, AQAP, LTP, Green Bus Fund/Clean Bus Tec Fund	Discussions with GoAhead and First indicate willingness for voluntary Euro III standard city wide (GoAhead more than First). Bus operators may only go beyond BAU if City policy introduced ie through SQBP. • Consideration of emission standards on key routes • Consideration of re-engine/retro fit (DfT Clean Bus Tech Fund) • Consideration of low emission buses (Green Bus Fund or business case for gas)
Freight Emission Strategy	FQP/LTP	Voluntary standard possible but not high enough

		• Focus on infrastructure • Work with City centre businesses / CSR agenda • Promote consolidation centre
Low Emission Land-Use Planning Policies	Planning Policy/NPPF/AQAP	See before - focussed LE Land-use Planning
Taxi Emission Strategy	LTP/AQAP/ Licensing	• Taxi emissions to be assessed • Potential to influence emissions through licensing • Priority ranks for LEVs • Incentives through public sector contracts • Infrastructure for LEVs
Public Sector Procurement • **SCC Fleet Procurement** • **Public sector vehicle emission consideration in award criteria** • **Local sourcing**		Opportunities to cost effectively reduce vehicle emissions of both vehicles purchase and those delivering to City. • Cleaner Road Transport Vehicle Regs 2011 • Govt Buying Standards for Transport • Local sourcing can help local economy – focussed on CO2
Promote shared modes: • **City/development led car clubs** • **Cycle/e-cycle hire schemes**	LTP/LSTF/Sustrans	Ongoing activity.
Smarter Choices	LTP/LSTF	Ongoing activity
Eco Driving	LSTF/LTP/FQP/BQP/FORS/EcoStars /SAFED	Programmes targeted at: • Public • Freight (linked to FQP) • Buses • Taxis

Appendix 5 Southampton City Council – Fleet Model and Whole Life Costs

A simplified model of the Southampton City Council fleet has been created, based on vehicle fuelling data supplied for the 2012-13 year (the latest full year of data). The fleet has a total of 489 vehicles, subdivided into 50 classes. These have been simplified into five classes for the purposes of the model, with a few specialist vehicles such as skip lifters, street sweepers and mobile libraries omitted.

Fuelling data for a sample of vehicles in each class was checked for errors and then analysed in detail. The result was an estimate of the average yearly mileage and mpg for each simplified vehicle class. These estimates were multiplied up by the number of vehicles in each class, and the resulting approximation of total fuel use compared against the original data as a 'sense check'.

For four of the five model vehicle classes, the modelled fuel use was close to the actual data. However, in the case of the RCVs the model predicted fuel use far lower than recorded. The reason for this is unclear, as there are a large number of missing odometer readings in the RCV data, and relatively few vehicles overall. However, compared to other local authority fleets, the mpg figures in the model seemed appropriate, so the yearly mileage was increased until the model gave a similar overall fuel use to that recorded.

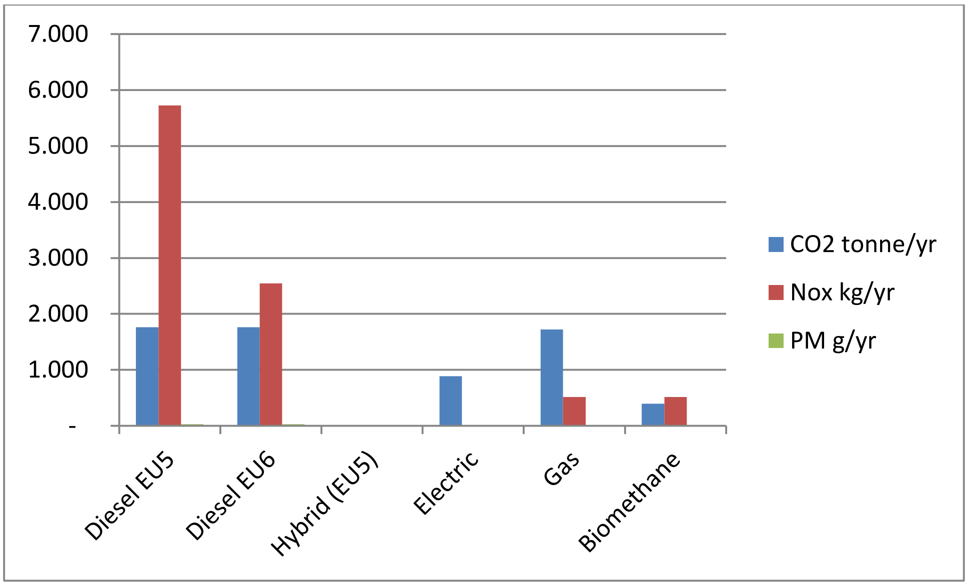
The table below shows the final fleet model:

Vehicle class	Number of vehicles	Average yearly mileage	Average mpg	Total fuel use
Car derived vans, cars and pickups	51	9,235	45.6	47,492
Smaller vans and tippers, 1-2.7t	106	4,193	30.9	66,239
Larger vans, minibuses and tippers, 2.8-3.5t	263	5,014	24.5	247,143
7.5t vans and tippers	12	15,159	19.9	42,114
RCVs (18-26t)	33	7,500	2.9	387,481
Totals	465			790,469

Based on the model figures, estimates were made of the emissions of CO_2, NO_x and particulates from each vehicle class, assuming they are Euro 5/V diesel vehicles. Then estimates were made of the energy use and emissions of alternative hybrid, electric and/or gas vehicles in each class (where such alternatives exist). Differences in purchase price and running cost were also estimated.

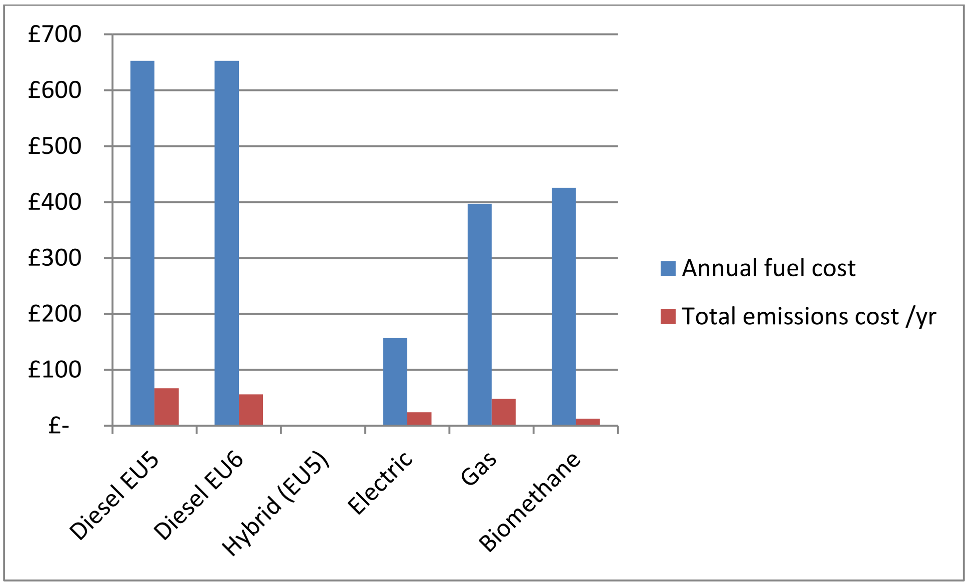
Car-derived vans, cars and pickups

There are around 51 vehicles of these types within the SCC fleet, accounting for about 6% of fuel use as modelled. Using data based on the VW Caddy and Renault Kangoo (which are available in gas and electric variants respectively) the chart below shows the differences in emissions for different drivetrains. (Note that there is no hybrid car-derived van suitable for comparison on the UK market.)



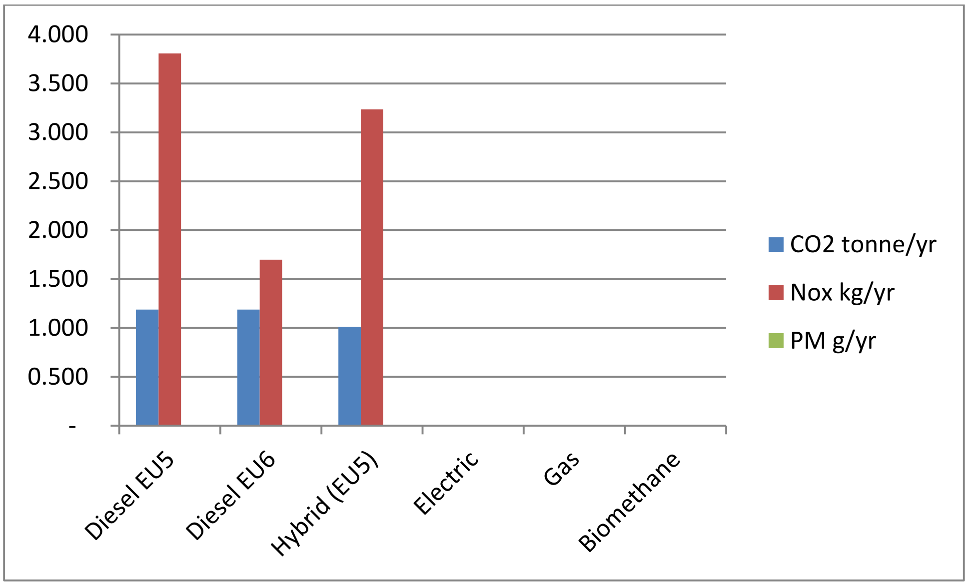
The gas version of the Caddy costs around £640 more than its diesel equivalent. If used in Southampton's fleet, it would save an average of £274 per year if run on grid gas, and £281 per year on biomethane, at current diesel/gas prices[21]. The electric Kangoo costs around £10,000 more than its diesel counterpart[22], and would save an average of £539 per year on fuel and emissions.

[21] This is the combined saving on fuel and emissions costs as worked out using the EU Cleaner Vehicles Directive methodology. It assumes a 5p/kg premium on biomethane, and does not include any allowance for additional gas refuelling infrastructure.
[22] Including the lease of the battery for five years.

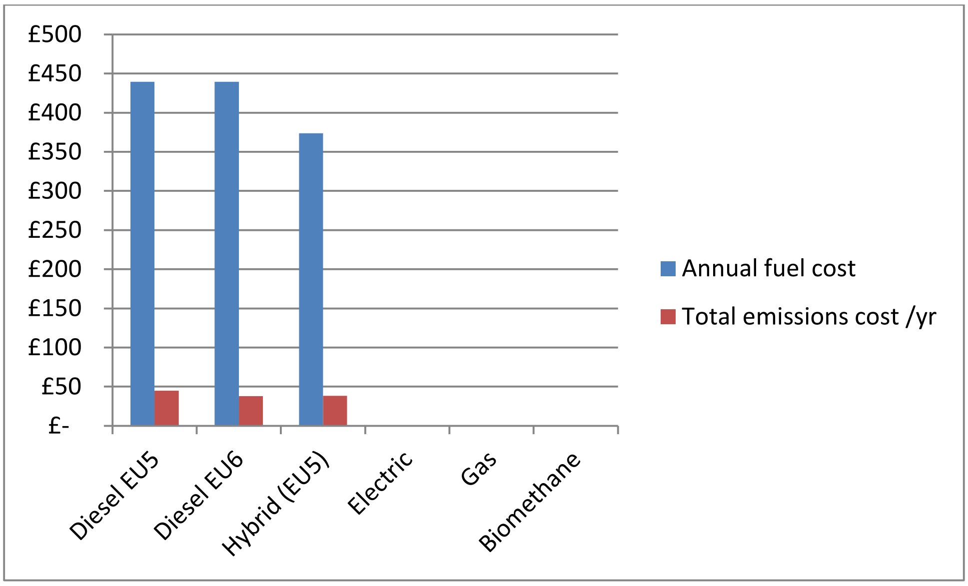


'Smaller' vans, (between 1 and 2.7t GVW)

There are around 106 vehicles of these types within the SCC fleet, accounting for about 8% of fuel use as modelled. Using data based on the Ford Transit and the Ashwoods Transit hybrid conversion, the chart below shows the differences in emissions for different drivetrains. (Note that there are currently no electric or gas vans suitable for comparison on the UK market, although Nissan will soon launch a 1t electric van based on the Leaf drivetrain, and Vauxhall are gauging interest in a range of smaller gas vehicles.)

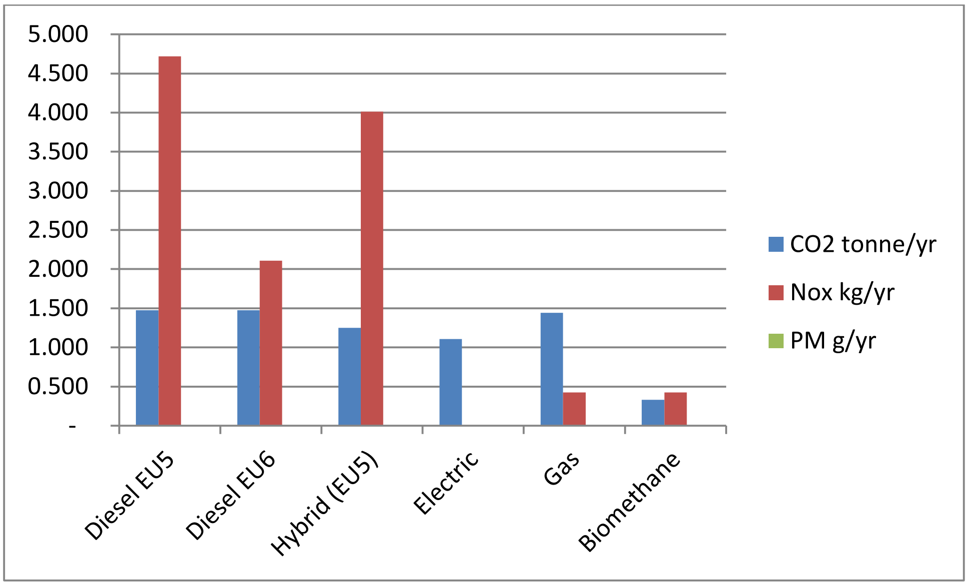


The Ashwoods Transit would save an average of £73 per year in fuel and emissions costs if used in Southampton's fleet, at current diesel prices. The exact additional cost over a standard transit is hard to estimate due to the wide range of deals available on a vehicle as popular as the Transit, but public sector fleets can still claim a grant of £3,430 per van from the DfT for the hybrid, which Ashwoods claim covers all of the additional cost.

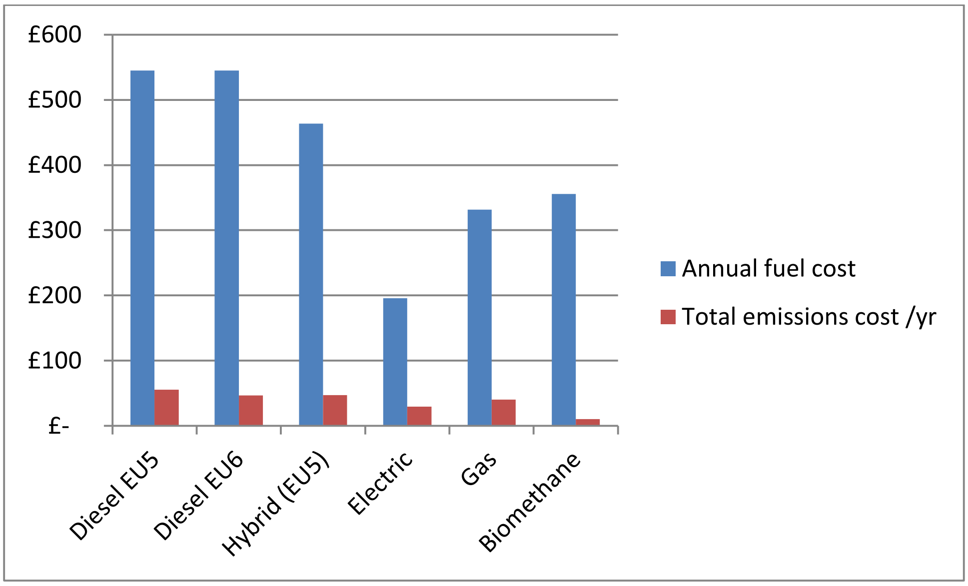


'Larger' vans, minibuses and tippers, 2.8-3.5t GVW

These are by far the most numerous type of vehicle in the SCC fleet, numbering 263 and accounting for about 31% of fuel use as modelled. Using data based on the Ford Transit, the Ashwoods Transit hybrid conversion, the Smith Edison (electric van based on a Transit chassis) and the Mercedes Sprinter NGT (the gas variant), the chart below shows the differences in emissions for different drivetrains.

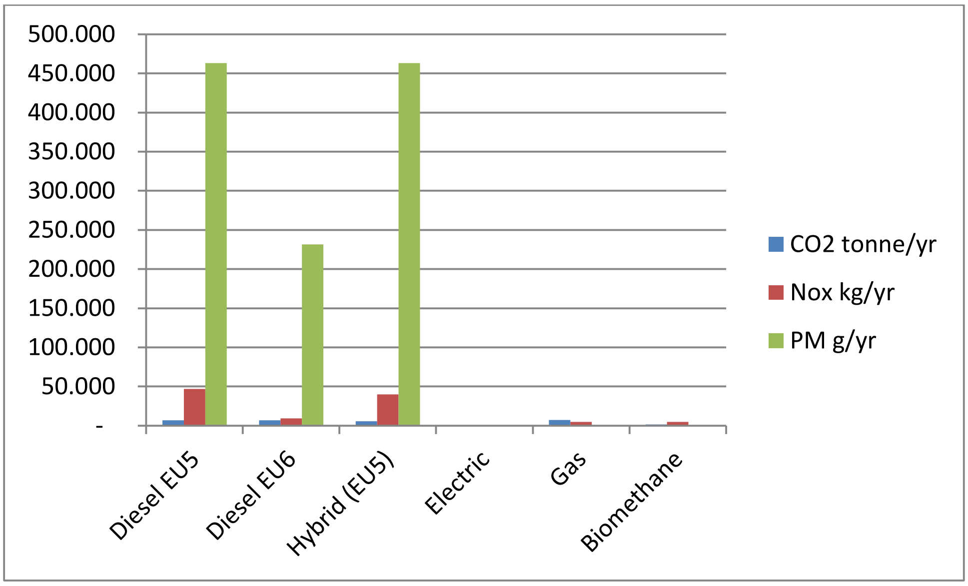


The Ashwoods Transit would save an average of £90 per year on fuel and emissions costs if used in Southampton's fleet in this larger size, at a small additional cost after claiming government funding (see above). The Smith Edison would save £375 per year, but costs £49,566 after subtracting the £8,000 it attracts in government funding. The Sprinter NGT would save £229 per year on grid gas, and £259 on biomethane, and costs £4,000 more than an equivalent diesel Sprinter.



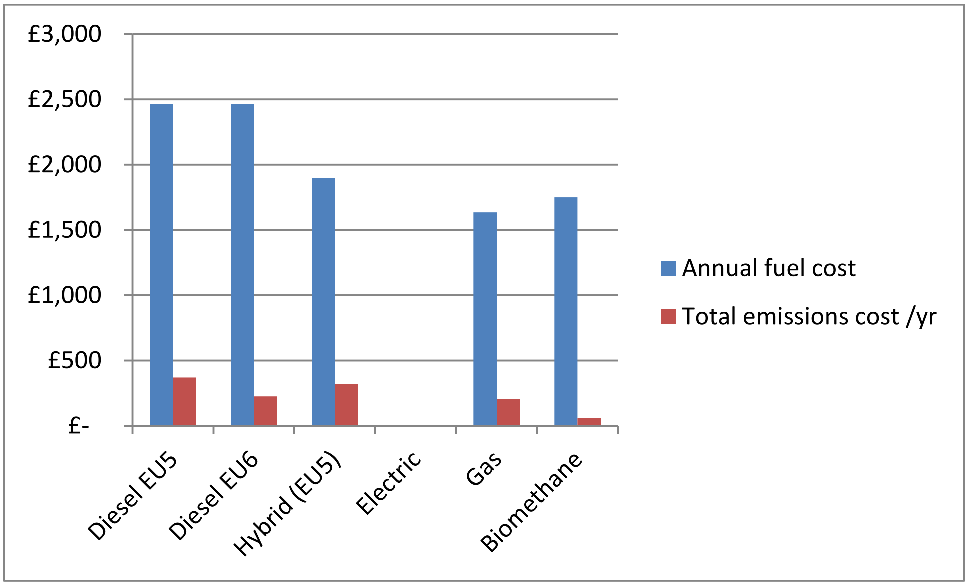
7.5t vans and tippers

There are only 12 vehicles of this size in the fleet as modelled, and they account for just 5% of fuel used. Using data based on the Iveco Eurocargo in diesel and gas versions, and the Fuso Cantor hybrid, the chart below shows the differences in emissions for different drivetrains. Note that there is an electric truck available at this weight, the Smith Newton, but there is no data available on its energy consumption and it costs £78,400.



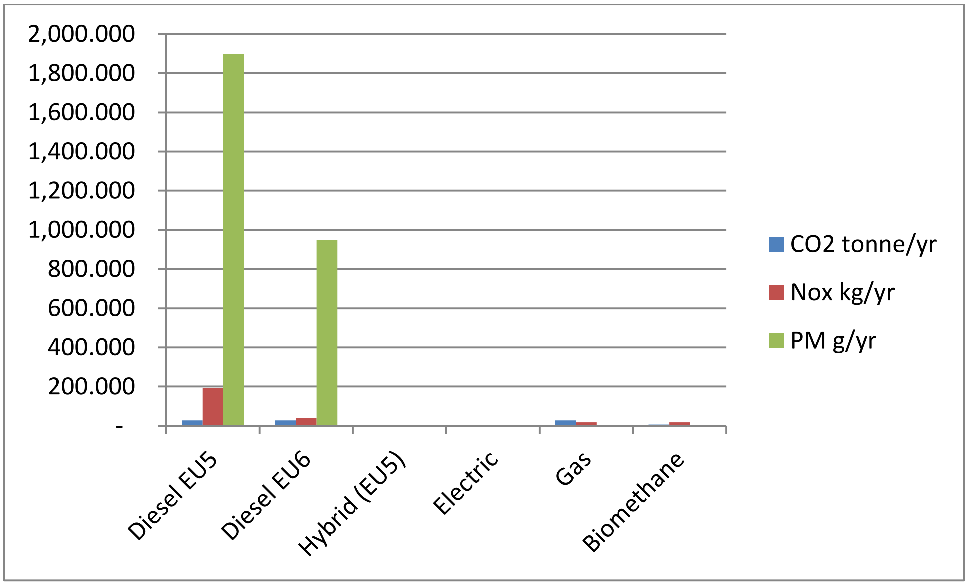
In the graph above, the units have been kept the same as the previous graphs to illustrate the large jump in particulate emissions when moving to heavier vehicles.

The Fuso Cantor hybrid is £7,200 more than its diesel counterpart, and would save around £617 per year on fuel and emissions costs in the Southampton fleet. The Eurocargo gas model would save an estimated £991 per year on grid gas, and £1,022 per year on biomethane [still awaiting price data].



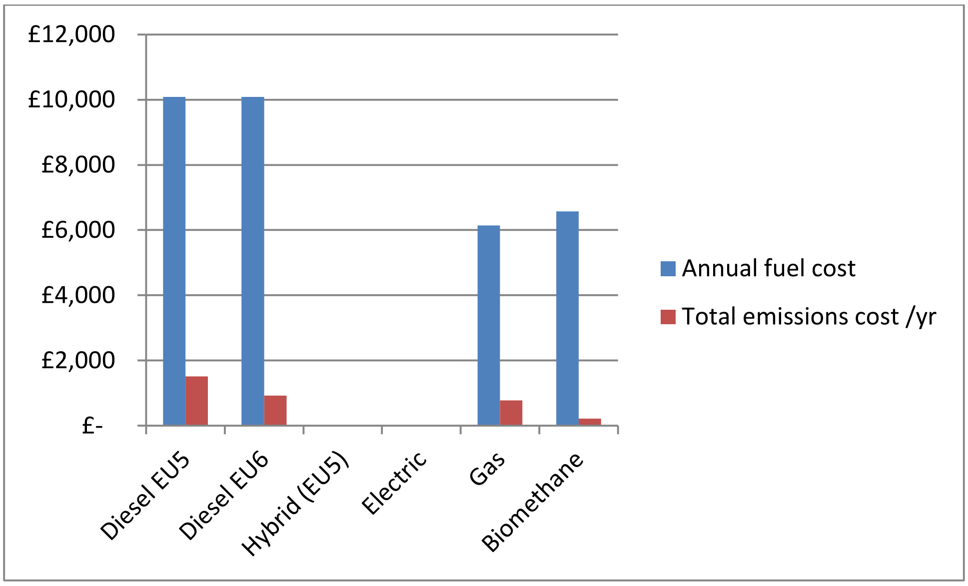
Refuse Collection Vehicles (18-26t)

There are only 33 of these vehicles in the Southampton fleet, but at an average of just 2.9 mpg they account for 49% of the total fuel used. Using data for the Mercedes-Benz Econic and Econic NGT (gas variant) the chart below shows the differences in emissions for different drivetrains. (Note that an attempt was made to get data for the Volvo hybrid RCV, but this was unavailable)

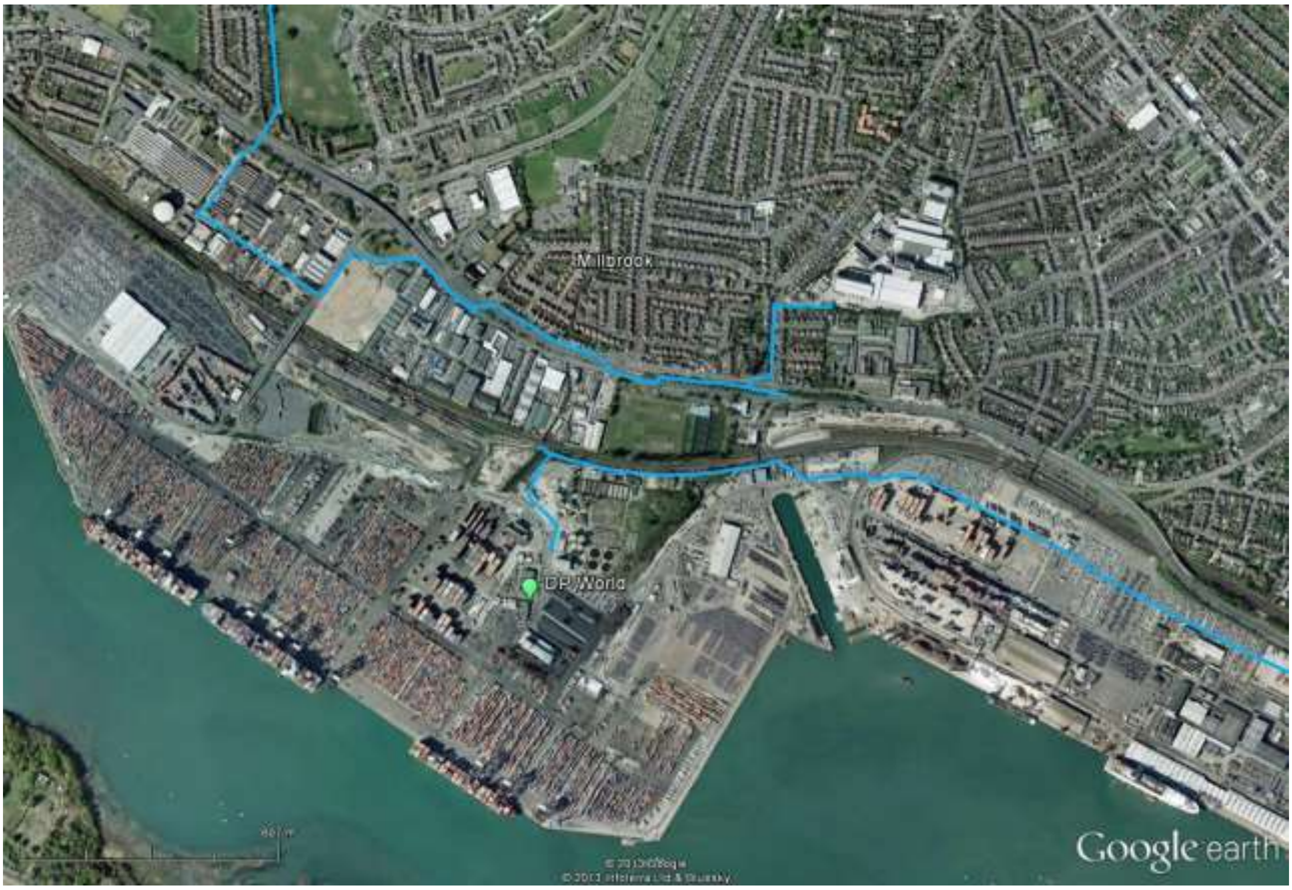


In the graph above, the units have been kept the same as the previous graphs to illustrate the large jump in particulate emissions when moving to heavier vehicles.

The Econic NGT costs around £25,000 more than its diesel equivalent, and would save in the region of £4,682 per year in fuel and emissions costs if run on grid gas, or £4,796 if run on biomethane.



Appendix 6: Compressed Natural Gas (CNG) Pipelines in Port Area



[Not to scale. For indicative purposes only. Image supplied courtesy of CNG Services Ltd]

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