Environment Act 1995 Part IV

Local Air Quality Management

# Further assessment of air quality
## Riverside Road, Norwich

NORWICH
City Council

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# Executive Summary

Local authorities are required to review and assess the air quality in their areas following a prescribed timetable to determine whether the air quality objectives are likely to be met. Where the likelihood of exceedences of air quality objectives has been identified in areas of significant public exposure, an Air Quality Management Area (AQMA) should have been declared, followed by a further assessment, and the formulation of an action plan to work toward eliminating exceedences.

This modelling study, in consultation with the most recent monitoring and meteorological data for the area, suggests that the current AQMA boundary is sufficient to encompass the areas around Riverside Road which were shown to be exceeding the $NO_2$ annual mean objective in the previous Detailed Assessment. It is estimated that approximately 11 properties lie within the exceedence areas, equating to an exposed population of around 26.

It is estimated that ambient Road-NOx reductions of around 46% are required in the AQMA to achieve compliance with the annual mean $NO_2$ objective.

Projection of the worst case receptor concentrations to future years using the LAQM.TG(09) methodology indicates that $NO_2$ concentrations could be in compliance with the objective in the AQMA by 2012 though we would recommend treating this prediction with some caution.

The source apportionment exercise has found that the main contribution across the model domain is from moving traffic, although queuing vehicles are also an important source of NOx, particularly near the junction at the south end of Riverside Road. This would indicate that the air quality action plan that follows should be broadly aimed at reducing vehicle flows of both heavy and light vehicles, and easing congestion in the area.

The mitigation scenario assessments carried out for this report included reductions in bus flows and improvement in average speed near the congested junction. When this was modelled and compared to the 2009 baseline situation, the scenarios on their own were found to reduce concentrations of $NO_2$ in most areas of the domain, though not sufficiently to remove all exceedences of the annual mean objective. If the bus reduction/ flow enhancement measures could be delivered in tandem there is potential for the objective to be achieved reasonably quickly.

**In light of this further assessment, NCC should retain the existing AQMA at Riverside Road, Norwich. NCC should now also proceed towards preparing an air quality action plan for the area concerned.**

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# 1. Introduction

## 1.1 National Air Quality Strategy

All local authorities (LAs) are obliged to review and assess air quality under the Environment Act 1995. A requirement of the Act was that the UK Government prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The AQS was published in January 2000 with a revised version published in July 2007.

Within the AQS, national air quality objectives are set out and LAs are required to review and assess air quality against these objectives. Table 1-1 lists the objectives included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM) with dates to they should be achieved.

**Table 1-1 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management.**

| National Air Quality Objectives | | | |
|---|---|---|---|
| **Pollutant** | **Air Quality Objective** | | **Date to be achieved by** |
| | **Concentration** | **Measured as** | |
| **Benzene**<br>All authorities | 16.25 $\mu g.m^{-3}$ | running annual mean | 31.12.2003 |
| Authorities in England and Wales only | 5 $\mu g.m^{-3}$ | annual mean | 31.12.2010 |
| Authorities in Scotland and Northern Ireland only | 3.25 $\mu g.m^{-3}$ | running annual mean | 31.12.2010 |
| **1,3-Butadiene** | 2.25 $\mu g.m^{-3}$ | running annual mean | 31.12.2003 |
| **Carbon monoxide**<br>Authorities in England, Wales and Northern Ireland only | 10.0 $mg.m^{-3}$ | maximum daily running 8-hour mean | 31.12.2003 |
| Authorities in Scotland only | 10.0 $mg.m^{-3}$ | running 8-hour mean | 31.12.2003 |
| **Lead** | 0.5 $\mu g.m^{-3}$<br>0.25 $\mu g.m^{-3}$ | annual mean<br>annual mean | 31.12.2004<br>31.12.2008 |
| **Nitrogen dioxide** | 200 $\mu g.m^{-3}$ not to be exceeded more than 18 times a year<br>40 $\mu g.m^{-3}$ | 1 hour mean<br>annual mean | 31.12.2005<br>31.12.2005 |
| **Particles ($PM_{10}$) (gravimetric)**[a]<br>All authorities | 50 $\mu g.m^{-3}$ not to be exceeded more than 35 times a year<br>40 $\mu g\ m^{-3}$ | 24 hour mean<br>annual mean | 31.12.2004<br>31.12.2004 |
| Authorities in Scotland only[b] | 50 $\mu g.m^{-3}$ not to be exceeded more than 7 times a year<br>18 $\mu g.m^{-3}$ | 24 hour mean<br>annual mean | 31.12.2010<br>31.12.2010 |
| **Sulphur dioxide** | 350 $\mu g.m^{-3}$ not to be exceeded more than 24 times a year<br>125 $\mu g.m^{-3}$ not to be exceeded more than 3 times a year<br>266 $\mu g.m^{-3}$ not to be exceeded more than 35 times a year | 1 hour mean<br>24 hour mean<br>15 minute mean | 31.12.2004<br>31.12.2004<br>31.12.2005 |

a. Measured using the European gravimetric transfer sampler or equivalent.
b. These 2010 Air Quality Objectives for $PM_{10}$ apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

## 1.2 Purpose of the Further Assessment

This study is a Further Assessment, which aims to confirm the findings of the Detailed Assessment, apportion sources of NOx (and therefore $NO_2$), estimate the level of NOx reduction required to achieve the $NO_2$ objective, and test selected abatement scenarios to help inform an Air Quality Action Plan (AQAP).

## 1.3 Locations where the Air Quality Objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be regularly present and are likely be exposed over the averaging period of the objective. Table 1-2 summarises examples of where air quality objectives for $NO_2$ should and should not apply.

**Table 1-2 Examples of where the $NO_2$ Air Quality Objectives should and should not apply**

| Examples of where the Air Quality Objectives should/should not apply | | | |
|---|---|---|---|
| **Averaging Period** | **Pollutants** | **Objectives *should* apply at …** | **Objectives should *not* generally apply at …** |
| Annual mean | NO2 | All locations where members of the public might be regularly exposed.<br>Building façades of residential properties, schools, hospitals, care homes etc. | Building facades of offices or other places of work where members of the public do not have regular access.<br>Hotels, unless people live their as their permanent residence.<br>Gardens of residential properties.<br>Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term |
| 1 hour mean | NO2 | All locations where the annual mean and 24 and 8-hour mean objectives apply.<br>Kerbside sites (e.g. pavements of busy shopping streets).<br>Those parts of car parks and railway stations etc. which are not fully enclosed.<br>Any outdoor locations to which the public might reasonably be expected to have access. | Kerbside sites where the public would not be expected to have regular access. |

## 1.4 Overview of the approach taken

The general approach taken to this further assessment was to:

- Collect and interpret data from previous review and assessment reports
- Collect and analyse all available traffic data, air quality monitoring data and background concentration data for use in the models
- Identify potential hotspots where it is likely that the AQS objectives would not be met
- Model $NO_2$ concentrations surrounding these hotspots
- Produced contour plots of the modelled pollutant concentrations
- Recommend whether Norwich should retain, revoke or amend the Riverside Road Air Quality Management Area (AQMA)
- Test proposed mitigation scenarios to inform air quality improvement interventions.

The methodologies outlined in Technical Guidance LAQM.TG(09)[1] were used throughout this further assessment.

## 1.5 Conclusions of previous reports for $NO_2$

A summary of recent review and assessment reports relevant to the Riverside Road AQMA is provided below.

[1] Local Air Quality Management Technical Guidance LAQM.TG(09), Defra, 2009

- **2004, 2005 and 2007 Progress Reports-** all concluded that no further action was required in respect of $NO_2$.

- **2004 and 2006 Updating and Screening Assessments-** both concluded that a Detailed Assessment was not required for $NO_2$.

- **2008 Detailed Assessment-** As part of this Detailed Assessment air dispersion modelling was carried out for NCC covering the following locations:

    - Grapes Hill;
    - King Street;
    - Riverside Road;
    - Magdalen Street; and
    - Boundary Road.

  Modelling and measured results for Riverside Road predicted exceedences of the $NO_2$ annual mean objectives at locations with relevant exposure. It was therefore recommended that NCC declare an AQMA in this area. This Riverside Road AQMA was declared in December 2009.

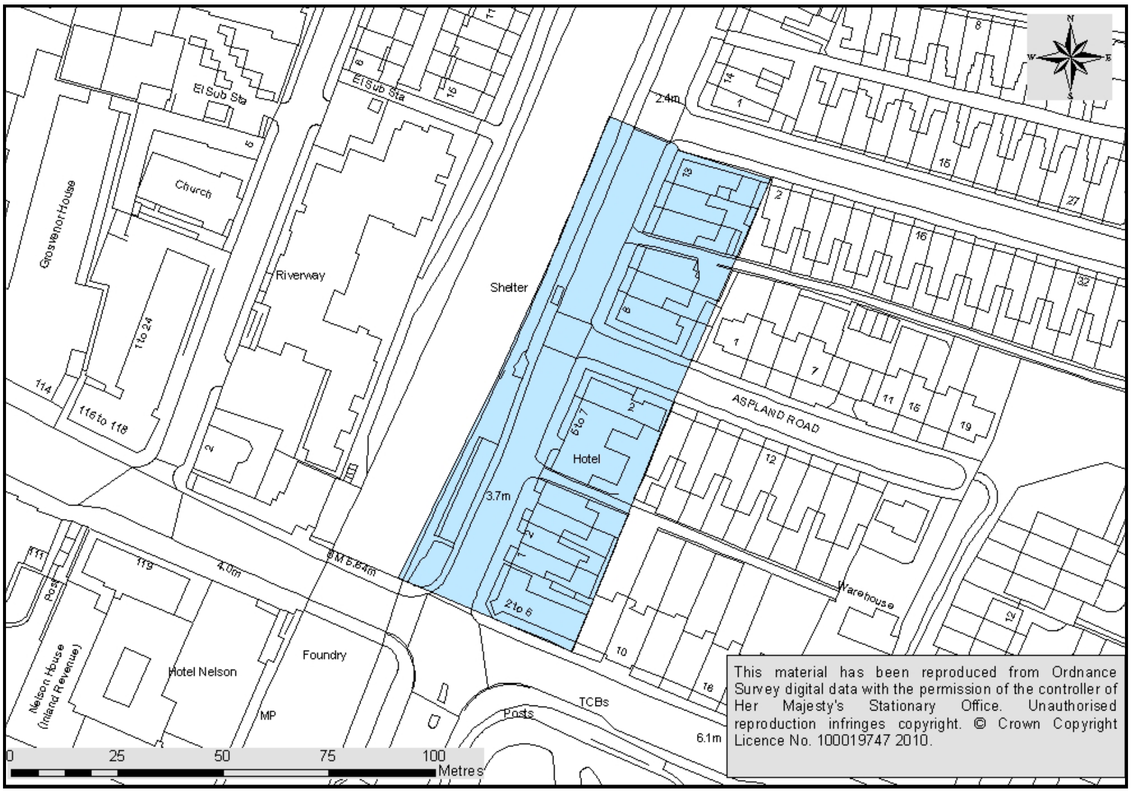
- **2009 Updating and Screening Assessment-** This assessment concluded that a Detailed Assessment was not required for $NO_2$.

The 2008 Detailed Assessment concluded that an AQMA was necessary at Riverside Road, and this Further Assessment is the next stage in the review and assessment process for the area.

# 2. AQMA Location

In December 2009 NCC declared an AQMA for the area encompassing a small number of properties along Riverside Rd in Norwich. The AQMA boundary is shown in Figure 2.1 below. This further assessment is concerned with an area larger than the AQMA boundary, extending to the north along Riverside Road. This allows the findings of the detailed assessment to be checked in light of new evidence, and also to assess the appropriateness of the AQMA boundary shown below.

**Figure 2.1 Norwich Riverside Road AQMA**



# 3. Information used to support this assessment

## 3.1 Maps

NCC provided OS Landline data of the model domain and a road centreline layer. This enabled accurate road widths and the distance of the housing to the kerb to be determined in the GIS system.



## 3.2 Road traffic data

### 3.2.1 Average flow, speed and fleet split

Daily traffic flow data and percentage of different vehicle classes derived from a traffic count study carried out in Riverside Road in March 2009 were provided by Norfolk County Council. The traffic count point (grid ref 623871, 308537) is near the centre of the AQMA so provides confidence that the traffic data used are appropriate for the assessment. The traffic counts were split according to the direction of flow as well as by lane- which allowed entry of discreet lanes in ADMS-Roads, each with their own AADT and fleet split. In addition Norfolk County Council provided estimates of speed at the Riverside Rd/Thorpe Rd/Prince of Wales Rd Junction and a diagram denoting the length of queues on Riverside Rd. Appendix 1 summarises the traffic flow data used.

### 3.2.2 Emissions factors

The most recent version of the Emissions Factors Toolkit[1] (EfT V4.1) was used in this assessment and the factors derived were used in the ADMS-Roads model in preference to the quite outdated emission factors in the model. Parameters such as traffic volume, speed and fleet composition are entered into the EfT, and an emissions factor in grams of NOx/second/kilometre is generated for input into the dispersion model. The version of the EfT used incorporates the latest emission factors published in 2009 by Department for Transport.

## 3.3 Ambient monitoring

### 3.3.1 Nitrogen dioxide

$NO_2$ concentrations are monitored by diffusion tube at locations throughout Norwich although only two sites (Riverside Road, Chalk Hill Road) are within the area be modelled in this assessment. Details of the type, locations, and concentrations recorded by the diffusion tubes are given in Chapter 4.

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

# 4. Monitoring- $NO_2$

## 4.1.1 New monitoring data

NCC currently monitors $NO_2$ across the authority using passive diffusion tubes (five sites have triplicate tubes deployed), and NOx at two locations using continuous analysers- although not all of these sites are pertinent to this assessment.

Only the Riverside Road and Chalk Hill Road are within the area be modelled in this assessment. Table 4-1 lists current $NO_2$ diffusion tube monitoring sites in Norwich relevant to this assessment.

The 2009 data from the diffusion tubes at the relevant locations has been bias adjusted using the nationally calculated factor for Gradko. The bias adjustment factor was 0.99 for 2009 and is the same one used in the 2010 Progress Report recently prepared by NCC. The data capture at Chalk Hill Road was only 58% for the year because the site was commenced in June. The data has not been period mean adjusted as the ratio between the whole year and period diffusion tube data at the Riverside Road site is 0.97- therefore not adjusting the period mean at Chalk Hill can be considered slightly conservative.

A summary of relevant diffusion tube data for 2009 is presented in Table 4-1.

**Table 4-1 Diffusion tube locations in Riverside Road AQMA with raw and bias corrected data for 2009**

| Site | Type | OS x,y | Data Capture 2009 (%) | Raw Annual mean (μg $m^{-3}$) | Bias corrected annual mean (x0.99) |
|---|---|---|---|---|---|
| 3 Riverside Road | R | 623870.26,308515.77 | 100 | **54.9** | **54.4** |
| Chalk Hill Road | R | 623906.97, 308596.92 | 58 | 31.2 | 30.9 |
| Exceedences of the annual mean objective in **bold** | | | | | |
| K = Kerbside, 0-1m from the kerb of a busy road<br>R = Roadside, 1-5m from the kerb | | | | | |

## 4.1.2 QA/QC

As outlined in Technical Guidance LAQM.TG(09), it is important to have QA/QC procedures in place in order to ensure that the air quality monitoring data are reliable and credible. Good quality data should have:

- Accuracy;
- Precision;
- Traceability to national/international metrology standards; and
- Long-term consistency.

The following section outlines the QA/QC procedures for diffusion tube monitoring employed by NCC.

The Workplace Analysis Scheme for Proficiency (WASP) is an independent analytical performance-testing scheme, operated by the Health and Safety Laboratory (HSL). WASP formed a key part of the former UK NO2 Network's QA/QC, and remains an important QA/QC exercise for laboratories supplying diffusion tubes to Local Authorities for use in the context of Local Air Quality Management (LAQM). The laboratory participants analyse four spiked tubes, and report the results to HSL. HSL assign a performance score to each laboratory's result, based on their deviation from the known mass of nitrite in the analyte.

The Performance criteria were changed in April 2009, the criteria are now based upon the Rolling Performance Index (RPI) statistic and will be tightened to the following:

GOOD: Results obtained by the participating laboratory are on average within 7.5% of the assigned value. This equates to an RPI of 56.25 or less.

ACCEPTABLE: Results obtained by the participating laboratory are on average within 15% of the assigned value. This equates to an RPI of 225 or less.

UNACCEPTABLE: Results obtained by the participating laboratory differ by more than 15% of the assigned value. This equates to an RPI of greater than 225.

# 5. Modelling- $NO_2$

## 5.1 Modelling methodology

Annual mean concentrations of $NO_2$ for 2009 have been modelled within the study area using ADMS Roads (version 2.3). The model was verified and outputs were adjusted by comparing the modelled predictions for road $NO_x$ with local monitoring results. In this case, the modelled results were compared to the results gathered by the automatic analyser, and diffusion tubes. Further information on model verification is provided in Appendix 1.

Hourly sequential meteorological data for 2009 for Norwich Centre was found to be of poor quality; and so on the advice of the met data vendor the site at Marham was used (approx 50km from the study area). A surface roughness of 1m was used in the modelling to represent the urban conditions in the model domain. A limit for the Monin-Obukhov length of 30 m was applied.

The intelligent gridding option was used in ADMS-Roads which provides spatially resolved concentrations along the roadside, with a wider grid spaced at approximately 20m being used to represent concentrations further away from the road. These predictions were added to ArcGIS 9.3 and values between grid points are derived using interpolation in the Spatial Analyst tool. This allows contour concentrations to be produced and added to the base map provided by NCC.

Background concentrations of NOx were derived from the recently updated Defra maps[1]. A CSV file containing concentrations across Norwich was obtained and the appropriate grid square was selected with the appropriate concentration for the assessment.

A mapped NOx background concentration of 32.4µg.m$^{-3}$ was used in this assessment.

### 5.1.1 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 recently published Defra NOx/$NO_2$ model[2] 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 the proportion of NOx released as primary $NO_2$. For the purposes of this assessment we have assumed that 19% of NOx is released as primary $NO_2$- the value associated with the “UK Traffic” option in the model.

### 5.1.2 Validation of ADMS-Roads

In simple terms, 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.

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.

### 5.1.3 Verification of the model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. LAQM.TG(09) recommends making the adjustment to the road contribution only

[1] http://laqm1.defra.gov.uk/review/tools/background.php
[2] http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

and not the background concentration these are superimposed onto. The approach outlined in Example 2 of LAQM.TG(09) has been used, and a correction factor was calculated which was applied to all modelled data.

The model generated in this study was validated using two available monitoring sites- both of which are diffusion tubes (the Riverside Road site has triplicate tubes deployed). The comparison of monitored against modelled $NO_x$ revealed that the model under-predicted the Road NOx component when compared with the local measurements.

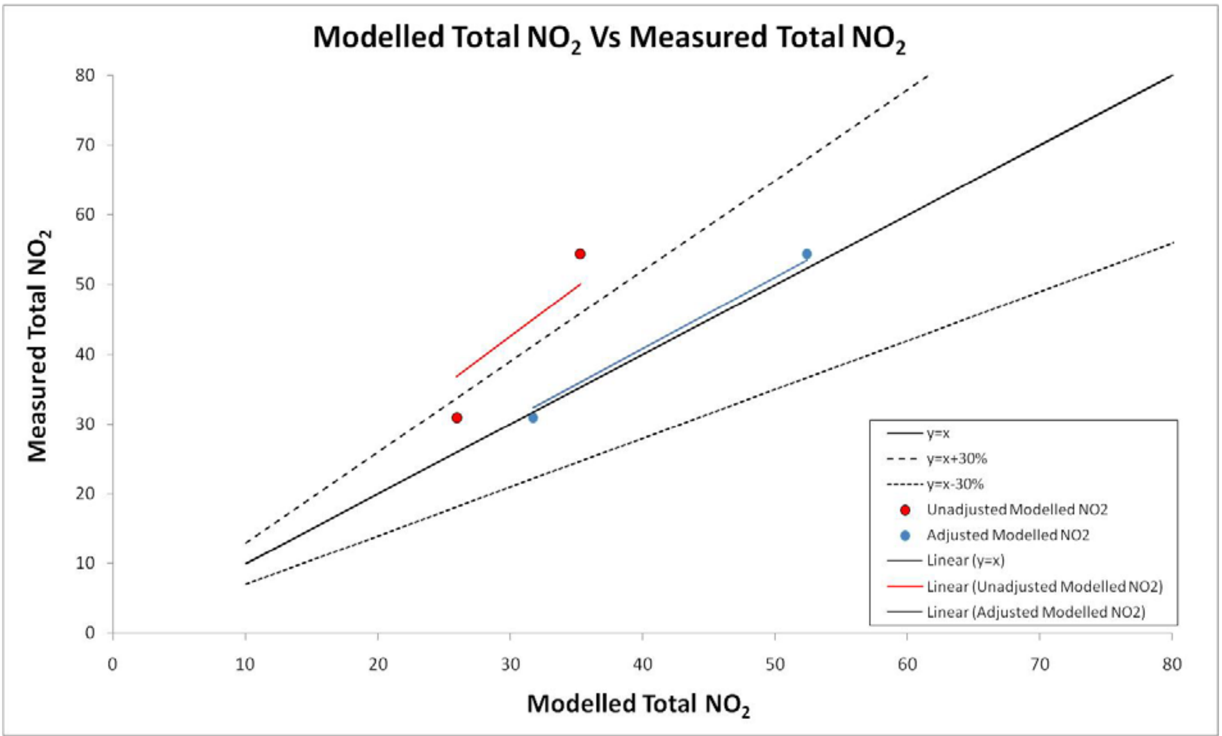
As such, the modelled Road $NO_x$ contribution required adjustment by an average factor of **2.66** to bring the predicted $NO_2$ concentrations within good agreement of those results obtained from the monitoring data. This factor was applied to all Road $NO_x$ concentrations predicted by ADMS Roads, with the final $NO_2$ model predictions being calculated using the Defra $NO_x/NO_2$ model.

After the NOx/NO2 model was run no further adjustments were made to the data. Table 5-1 and Figure 5.1 show model agreement with the $NO_2$ monitoring data after adjustment. Full model verification data is provided in Appendix 1.

**Table 5-1 Comparison of modelled/measured $NO_2$ concentrations in model domain after adjustment**

| Site | $NO_2$ Concentration, μg $m^{-3}$ | | Difference (%) |
|---|---|---|---|
| | Modelled (roadNOx component x 2.66) | Measured | |
| 3 Riverside Road | 52.4 | 54.4 | -3.7 |
| Chalk Hill Road | 31.7 | 30.9 | 2.6 |

**Figure 5.1 Comparison of modelled Vs modelled annual mean concentrations of $NO_2$ (μg $m^{-3}$)**

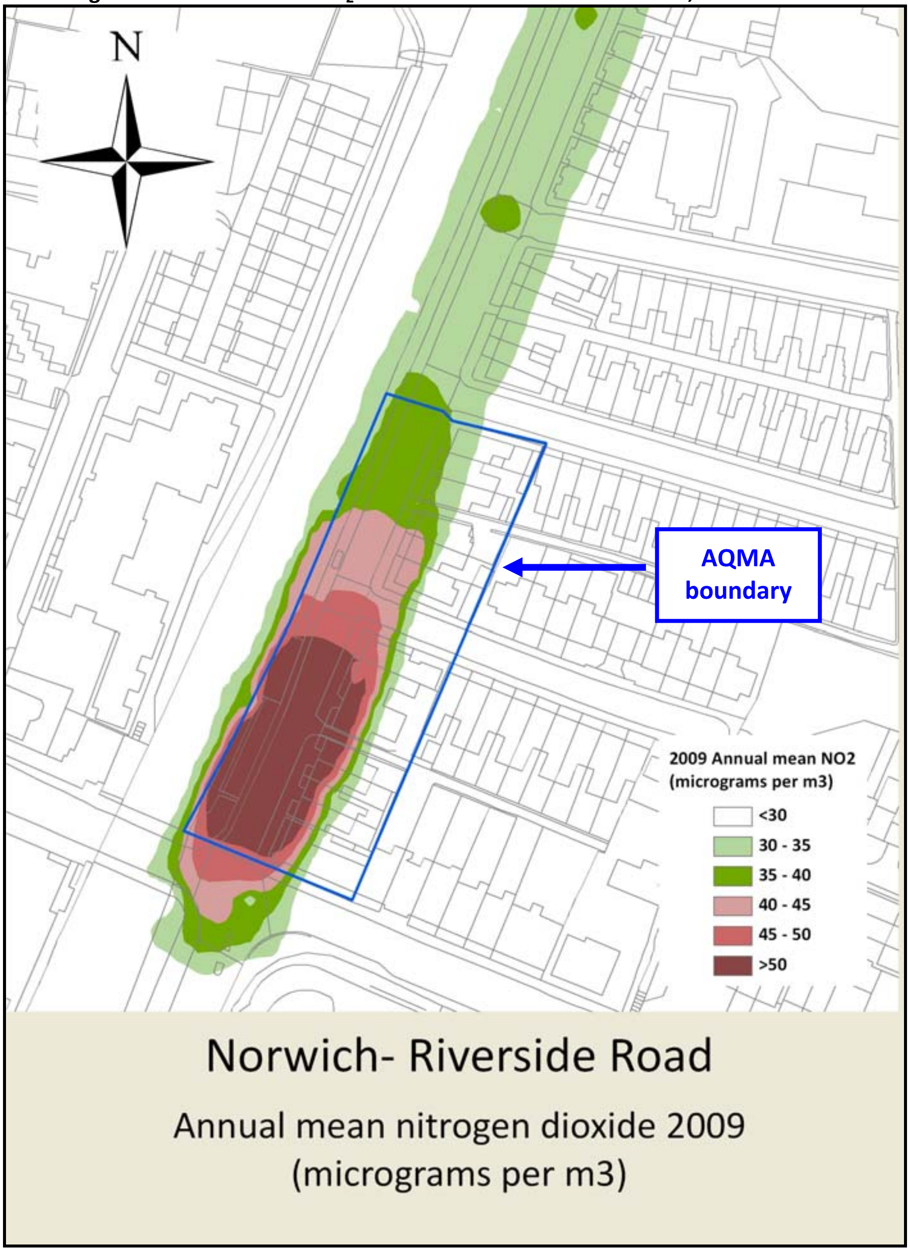



Adjusting modelling data to diffusion tubes will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The adjusted model agrees well with available local monitoring and has therefore been assessed to perform sufficiently well for use within this assessment without further adjustment.

## 5.2 Modelling Results- $NO_2$

Figure 5.2 shows a contour plot the predicted $NO_2$ annual average concentrations during 2009 at Riverside Road. As shown, it has been confirmed by the monitoring and subsequent modelling that the 40 $\mu g\ m^{-3}$ annual average objective has been exceeded in 2009 at Riverside Road in Norwich at locations with relevant exposure. The model also demonstrates that the current AQMA boundary is appropriate.

**Figure 5.2 Annual mean $NO_2$ concentrations at Riverside Road, Norwich 2009**



### 5.2.1 People exposed to exceedences of the annual mean $NO_2$ objective

Based on available information it is estimated that approximately 11 properties lie within the exceedence area on Riverside Road, equating to an exposed population of around 26 (based on census data which suggests an average occupancy per household of 2.36 in England and Wales[1]).

## 5.3 Source Apportionment

Source apportionment is the process whereby the sources of pollutants can be assessed so that the Local Authority can proceed with an action plan to attempt to address the air quality problems in the area of interest.

The source apportionment should:

- Confirm that exceedences of $NO_2$ are due to road traffic.
- Determine the extent to which different vehicle types are responsible for the emission contributions to $NO_x$ and hence $NO_2$.
- Quantify what proportion of total NOx is due to background emissions, or local emissions from busy roads in the local area. This will help determine whether local traffic management measures could have a significant impact on reducing emissions in the area of exceedence, or, whether national measures would be a suitable approach to achieving the air quality objectives.

### 5.3.1 Base case

The "Base Case" is the modelling of annual mean NOx concentrations without any measures to reduce these concentrations by NCC. In this case the "base case" is the previously calculated NOx concentrations in 2009.

The EfT was used within which emission sources were effectively switched off or on accordingly e.g. for calculating the contribution from buses all other sources were set to zero. This allowed derivation of new emission factors for the road segments which were then modelled in ADMS-Roads to obtain the contribution of each source to ambient NOx.

### 5.3.2 Locations and sources considered

The locations considered within this further assessment were taken as the diffusion tube monitoring locations currently operated by NCC within the model domain.

The following sources have been considered:

- Local background
- Regional background
- Rural background
- Moving vehicles
- Queuing vehicles
- Light duty vehicles (LDV- comprising cars, vans, motorcycles)
- Buses
- Other heavy duty vehicles (articulated and rigid HGVs)

Table 5-2 and Figure 5.3- 5.6 summarise the relevant NOx contributions from the above sources at each of the monitoring locations.

[1] http://www.statistics.gov.uk/census2001/profiles/commentaries/housing.asp

In general, measures aimed at reducing the amount of moving traffic will have a beneficial effect at the locations described above. Stationary traffic is also an important source (particularly near the junction to the South of the model domain) that should be addressed. It is likely much of the queuing relates to the roads being used beyond their capacity so measures to improve the former will benefit the latter. Also, buses and other types of heavy vehicle transiting the AQMA have quite similar impacts on local air quality.

**Table 5-2 NOx source apportionment for Chalk Hill Road and Riverside Road**

| Site | Contribution to annual mean NOx ($\mu g.m^{-3}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total NOx | Local Background | Regional Background | Rural Background | Moving traffic | Queuing Traffic | Light vehicles | Buses | Other heavy vehicles |
| Chalk Hill Road | 55.1 | 10.6 | 10.8 | 10.9 | 22.8 | 1.3 | 14.1 | 3.7 | 5.0 |
| 3 Riverside Road | 112.9 | 10.6 | 10.8 | 10.9 | 41.1 | 39.5 | 50.0 | 14.8 | 15.8 |
| | % contribution to total | | | | | | | | |
| | Total NOx | Local Background | Regional Background | Rural Background | Moving traffic | Queuing Traffic | Light vehicles | Buses | Other heavy vehicles |
| Chalk Hill Road | 100 | 19.2 | 19.6 | 19.8 | 41.4 | 2.4 | 25.6 | 6.7 | 9.1 |
| 3 Riverside Road | 100 | 9.4 | 9.6 | 9.7 | 36.4 | 35.0 | 44.3 | 13.1 | 14.0 |

**Figure 5.3 % contribution to total NOx from background and moving/queuing traffic at Chalk Hill Road**

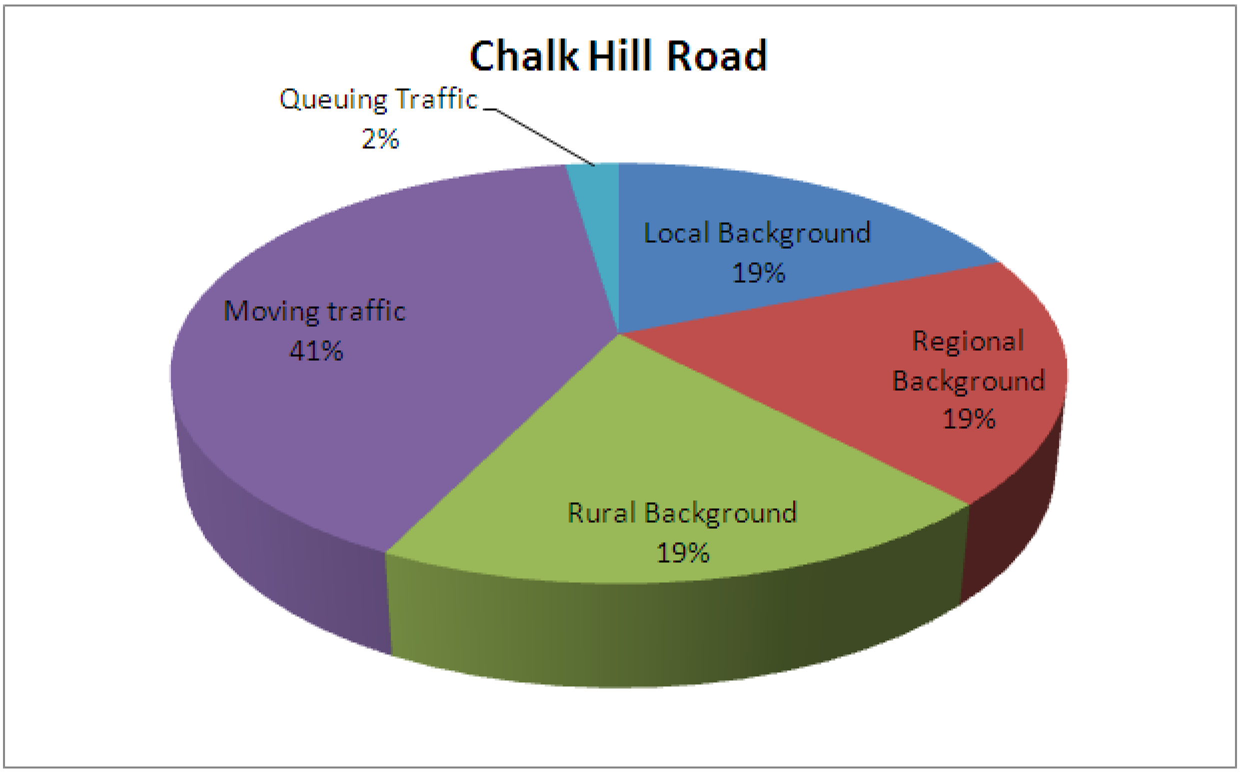


**Figure 5.4 % contribution to total NOx from background and moving/queuing traffic at Riverside Road**

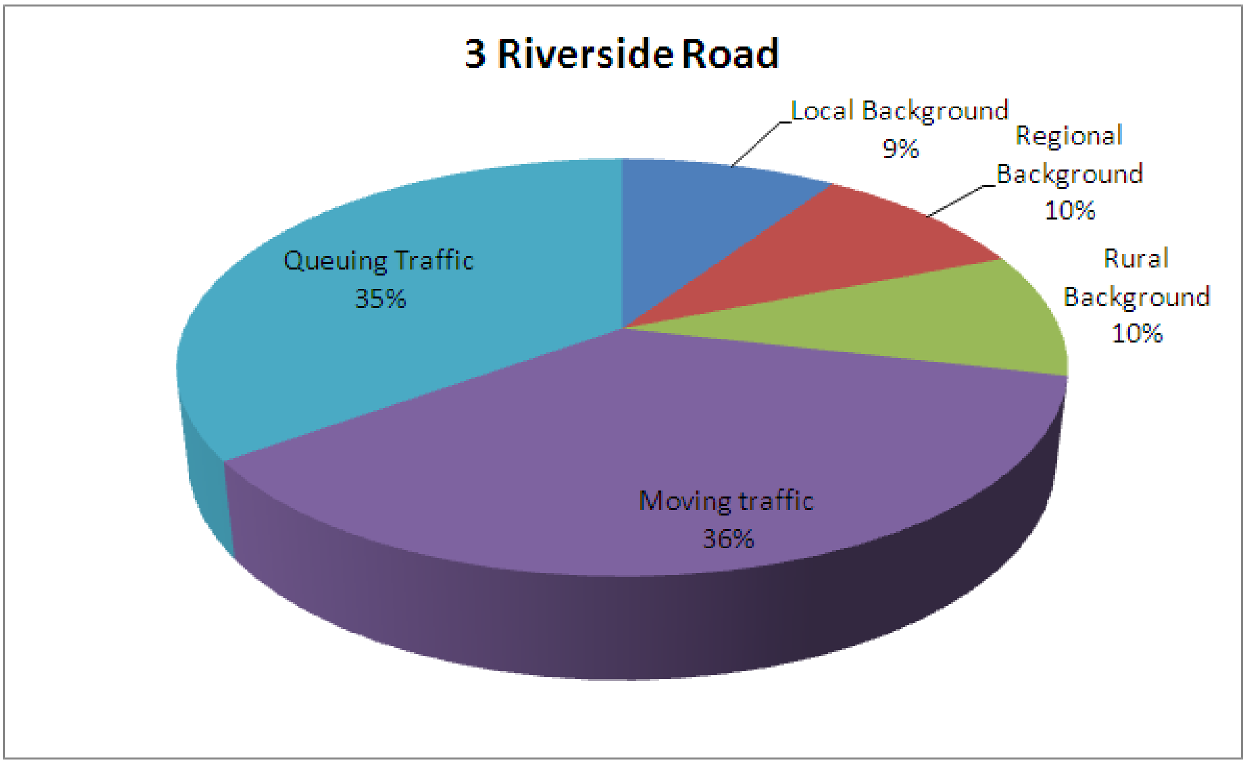



**Figure 5.5 % contribution to total NOx from background and light, bus and HGV traffic at Chalk Hill Road**

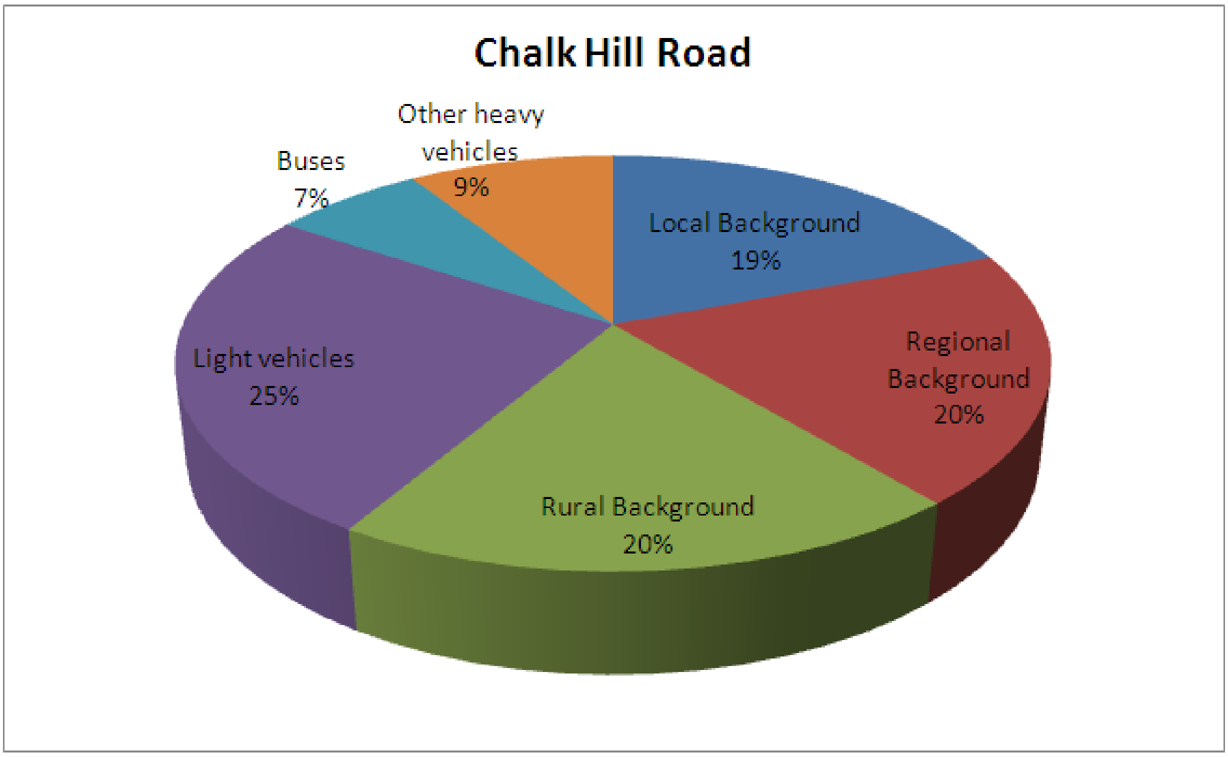
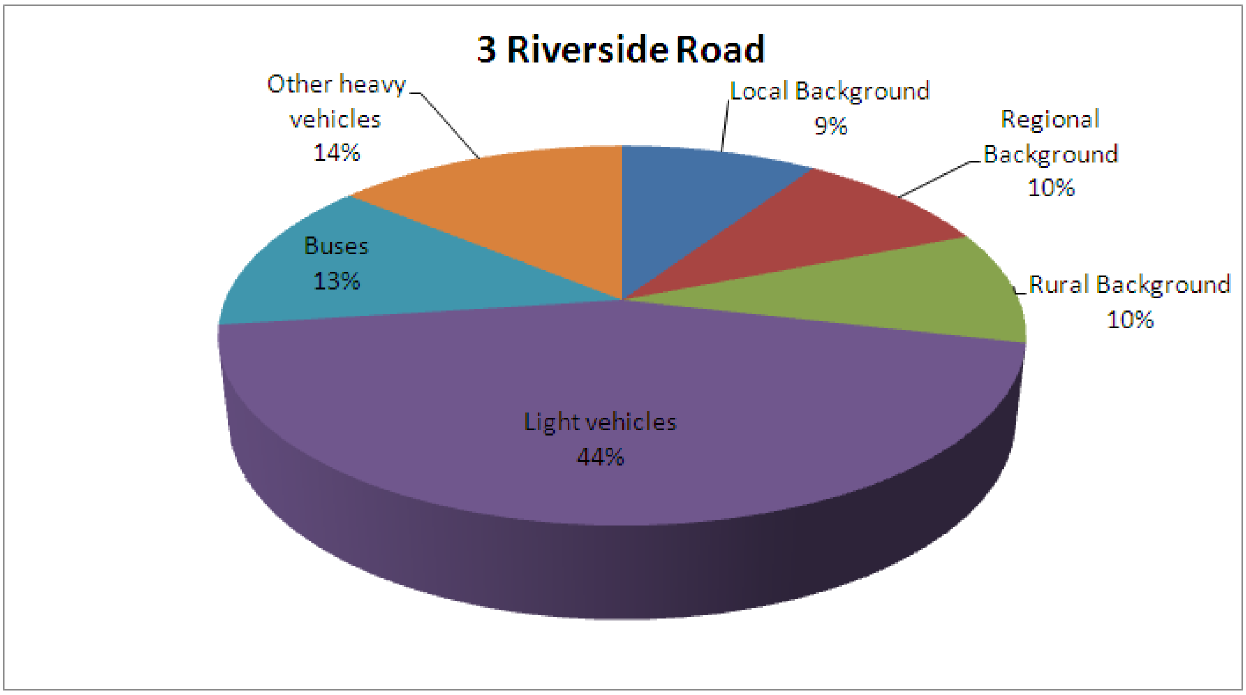


**Figure 5.6 % contribution to total NOx from background and light, bus and HGV traffic at Riverside Road**



# 6. Required reduction in ambient NOx concentrations

The required reduction in Road-NOx concentrations to attain the objectives allows the Local Authority to judge the scale of the effort required to comply with the $NO_2$ objective. For $NO_2$, the required reduction in road contribution to ambient concentrations should be expressed in terms of NOx as this is the primary emission and a non-linear relationship exists between NOx and $NO_2$ concentrations. The ambient concentrations of NOx required to achieve the annual mean objective for $NO_2$ at the locations of worst case relevant exposure have been derived using the NOx/$NO_2$ model described previously.

The largest reduction is required at 3 Riverside Road with a required Road-NOx concentration reduction of 45.8%. The required Road-NOx reductions at the relevant locations are provided in Table 6-1 below.

**Table 6-1 Reductions required in NOx concentrations to achieve the 2005 $NO_2$ annual mean objective**

| Location | Current Road-NOx ($\mu g.m^{-3}$) | Required Road-NOx ($\mu g.m^{-3}$) | Road NOx- Reduction required (%) |
|---|---|---|---|
| 3 Riverside Road | 80.6 | 43.7 | **45.8** |
| Chalk Hill Road | 22.7 | 43.7 | **0** |

# 7. Expected date of achievement of the $NO_2$ objectives

LAQM TG(09) introduced a new requirement for further assessments, namely that the Local Authority should predict the date of achievement of the air quality objectives were no mitigative action to be taken. The approach to making this prediction can either be based on modelling of future years, or by simply projecting monitoring data forward using the factors outlined in Box 2.1 of the guidance. Box 2.1 was updated in a recent LAQM FAQ and the most recent adjustment factors have been used.

**Table 7-1 Predicted $NO_2$ concentrations at 3 Riverside Road for 2009-2015 ($\mu g.m^{-3}$)**

| Year | 3 Riverside Road |
|---|---|
| 2009 | 51.9 |
| 2010 | 47.1 |
| 2011 | 42.8 |
| 2012 | **38.9** |
| 2013 | **35.3** |
| 2014 | **32.1** |
| 2015 | **29.1** |
| Compliance with $NO_2$ annual mean objective in ***bold*** | |

These predictions are **indicative** only, and take no account of local conditions such as traffic growth or contraction (perhaps resulting from planning decisions or congestion management interventions) or changes in fleet composition and should therefore be considered with care. This prediction should not be viewed as justification for not progressing fully with action plan measures as projection of $NO_2$ data to future years has, in the past proven to be subject to significant uncertainty, and projected improvements have proven to be optimistic as monitoring data has become available for direct comparison.

# 8. Mitigation Scenarios

The findings of this Further Assessment will provide additional scientific justification for the development of an air quality action plan (AQAP) in order that NCC can demonstrate that they are fulfilling their statutory duty to work towards achievement of the $NO_2$ objectives. A number of hypothetical scenarios have been proposed by Norfolk County Council in order to assess the level of intervention that would be required to meet the objectives. These have been modelled in ADMS-Roads using the same methodology but with updated traffic data to reflect the potential effect of the proposed intervention. The effect on ambient concentrations of $NO_2$ of three scenarios has been modelled at the worst-case relevant exposure locations.

## 8.1 Scenario 1- 35.5% and 15.7% Reduction in HDV vehicles

The first scenario involves removing a proportion of HDV vehicles from the right hand turning lane on the southbound end of Riverside Road. The 35.5% reduction in overall HDV corresponds with a 50% reduction in southbound buses at the section of the road approaching the junction. The section north of this had a reduction of 15.7% applied to the HDV flow.

**Table 8-1 $NO_2$ concentrations at receptors for the do-nothing and Scenario 1**

| Location | Modelled $NO_2$ 2009 *do-nothing* (µg.m$^{-3}$) | Modelled $NO_2$ 2009 *do-something* (µg.m$^{-3}$) |
|---|---|---|
| 3 Riverside Road | **51.9** | **47.4** |
| Chalk Hill Road | 32.0 | 30.4 |
| Exceedences of the annual mean $NO_2$ objective in **bold** | | |

## 8.2 Scenario 2- 71.0% and 31.4% Reduction in HDV vehicles

The second scenario involves removing a proportion of HDV vehicles from the right hand turning lane on the southbound end of Riverside Road. The 71% reduction in overall HDV corresponds with removing all southbound buses from Riverside Road. The section north of this had a reduction of 31.4% applied to the HDV flow.

**Table 8-2 $NO_2$ concentrations at receptors for the do-nothing and Scenario 2**

| Location | Modelled $NO_2$ 2009 *do-nothing* (µg.m$^{-3}$) | Modelled $NO_2$ 2009 *do-something* (µg.m$^{-3}$) |
|---|---|---|
| 3 Riverside Road | **51.9** | **45.3** |
| Chalk Hill Road | 32.0 | 30.0 |
| Exceedences of the annual mean $NO_2$ objective in **bold** | | |

## 8.3 Scenario 3- Improvement in average speed

This scenario involves raising the average speed at the most congested area near the junction to 6.8km/h, and 18.4/19.1km/h further away from the junction.

**Table 8-3 $NO_2$ concentrations at receptors for the do-nothing and Scenario 3**

| Location | Modelled $NO_2$ 2009 *do-nothing* (µg.m$^{-3}$) | Modelled $NO_2$ 2009 *do-something* (µg.m$^{-3}$) |
|---|---|---|
| 3 Riverside Road | **51.9** | **46.8** |
| Chalk Hill Road | 32.0 | 31.7 |
| Exceedences of the annual mean $NO_2$ objective in **bold** | | |

As would be expected, the scenarios above improve the likelihood of compliance with the $NO_2$ annual mean objective. If more general reductions in traffic could also be achieved, and national reductions occur as predicted then the annual mean objective for $NO_2$ could be achieved at Riverside Road within the next several years. If a combination of HDV reductions (providing $NO_2$ reductions of between about 4-6 $\mu g.m^{-3}$) and speed improvements (providing $NO_2$ reductions of around 5$\mu g.m^{-3}$) could be achieved in the short term, there is potential that the objective could be achieved much sooner.

# 9. Summary and Conclusion

In this Further Assessment concentrations of $NO_2$ have been assessed in and around the Riverside Road AQMA for 2009 using a combination of available monitoring data and a dispersion modelling exercise. The study took account of traffic conditions in the area and the latest meteorological data available.

The study has confirmed the findings of the previous detailed assessment, namely that there are exceedences of the annual mean $NO_2$ objective to the South of Riverside Road. It is estimated that approximately 11 properties lie within this exceedence area equating to an exposed population of 26.

It is estimated that ambient NOx reductions of some 48% are required in the AQMA to achieve compliance with the annual mean $NO_2$ objective.

Projection of the worst case receptor $NO_2$ concentrations to future years indicates that $NO_2$ concentrations could be in compliance with the objective in the AQMA by 2012 though we would recommend treating this prediction with some caution.

Source apportionment indicates that the primary source of emissions is derived from local moving traffic, although queuing vehicles are also particularly important near the junction. Light vehicles are thought to be the main source type although important contributions are also noted from buses and other heavy vehicles.

Modelling of the mitigation scenarios provided by the Council indicates that significant $NO_2$ reductions are achievable if any of the schemes described were to proceed. Removing all exceedences would obviously depend on the package of measures chosen but this study provides evidence that the combination of removing a proportion of buses combined with increasing the average speed of all vehicles has capability to deliver  the air quality improvements required to achieve the $NO_2$ annual mean objective.

**The monitoring and dispersion modelling demonstrate that the current AQMA boundary is appropriate and Norwich City Council should proceed with air quality action planning for the area.**

# 10. Acknowledgements

AEA are grateful for the support received by Mark Leach of Norwich City Council; and Chris Wood of Norfolk County Council in completing this assessment.

# 11. Appendix 1

## Model Verification

It is appropriate to verify the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides ($NO_x$ = NO + $NO_2$). The model has been run to predict annual mean Road$NO_x$ concentrations during 2009 at the diffusion tubes located at Riverside Road and Chalk Hill Road.

The model output of RoadNOx (the total $NO_x$ originating from road traffic) has been compared with the measured Road$NO_x$, where the measured RoadNOx contribution is calculated as the difference between the total $NO_x$ and the background $NO_x$ value. Total measured $NO_x$ for each diffusion tube was calculated from the measured $NO_2$ concentration using the 2010 version of the Defra $NO_x$/$NO_2$ model.

An adjustment factor was determined as the average of the difference between modelled Road$NO_x$ contribution and the measured Road$NO_x$ contribution, as shown in Figure A.1. **A factor of 2.66 was calculated** in this instance. This factor was then applied to the modelled Road$NO_x$ concentration for each modelled point to provide adjusted modelled Road$NO_x$ concentrations. The appropriate background concentration was added to these concentrations in order to determine the adjusted total modelled $NO_x$ concentrations. The total annual mean concentrations were then determined using the $NO_x$/$NO_2$ model.

**Figure A.1 Comparison of unadjusted Road$NO_x$ Vs Measured Road$NO_x$ and primary adjustment factor (2.34)**

| X | Y | STREET | Predicted Modelled Road NOx | Background NOx | Total Modelled NOx Prediction | Total Modelled NO2 Prediction | Total Measured NO2 | (Measured-Modelled)/Measured*100 |
|---|---|---|---|---|---|---|---|---|
| 623868 | 308517 | Riverside Road | 31.00 | 32.40 | 63.4 | 35.27 | 54.40 | -26.14 |
| 623903 | 308596 | Chalk Hill | 8.83 | 32.40 | 41.23 | 25.95 | 30.90 | -12.88 |

Derivation of primary Road NOx adjustment factor

| X | Y | STREET | Road NOx required | Total (Road + BG) NOx Required to match measured NO2 | (Measured Road NOx/Modelled Road NOx)/Measured Road NOx x 100 | Required Road NOx/ Measured Road NOx | Adjusted modelled RoadNOx | (Measured Road NOx/Adjusted Modelled Road NOx)/Measured Road NOx x 100 |
|---|---|---|---|---|---|---|---|---|
| 623868 | 308517 | Riverside Road | 89.64 | 122.04 | -65.42 | 2.89 | 82.56 | -7.90 |
| 623903 | 308596 | Chalk Hill | 20.21 | 52.61 | -58.93 | 2.43 | 22.11 | 9.38 |
| | | | | | average | 2.66 | | |

No secondary adjustment factor has not been applied to the modelled $NO_2$ data as it was not required in this instance. If applied, the secondary correction factor accounts for error introduced by converting NOx to $NO_2$ using the DEFRA NOx/$NO_2$ tool.

The results show that the model is under predicting the Road$NO_x$ contribution. This is a typical experience with this and the majority of other models, and probably arises from deriving predictions for a complex situation using what are quite simple metrics as model inputs.

# 12. Appendix 2

# Diffusion Tube Bias Adjustment

National Bias Adjustment Factor was used as there is no triplicate site in Norwich that could have been used to calculate a local Bias Adjustment Factor. National Bias Adjustment Factor of 0.99 applied to all uncorrected diffusion tube annual mean values. National Spreadsheet of Bias Adjustment Factors (v.03/10) is shown below.

**Spreadsheet Version Number: 03/10**

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies

**Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods**

**Whenever presenting adjusted data, you should state the adjustment factor used**

This spreadsheet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated in late September 2010 on the R&A website

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**Step 1:** Select the Laboratory that Analyses Your Tubes from the Drop-Down List. If a laboratory is not shown, we have no data for this laboratory.

**Step 2:** Select a Preparation Method from the Drop-Down List. If a preparation method is not shown, we have no data for this method at this laboratory.

**Step 3:** Select a Year from the Drop-Down List. If a year is not shown, we have no data[2]

**Step 4:** **Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.**

If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Review and Assessment Helpdesk 0117 328 3668 aqm-review@uwe.ac.uk.

| Analysed By[1] | Method (To undo your selection, choose (All) from the pop-up list) | Year[5] (To undo your selection, choose (All)) | Site Type | Local Authority | Length of Study (months) | Diffusion Tube Mean Conc. (Dm) (µg/m3) | Automatic Monitor Mean Conc. (Cm) (µg/m3) | Bias (B) | Tube Precision[6] | Bias Adjustment Factor (A) (Cm/Dm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Gradko | 50% TEA in Acetone | 2009 | R | Boston BC | 11 | 45 | 33 | 35.2% | G | **0.74** |
| Gradko | 50% TEA in Acetone | 2009 | R | East Hampshire DC | 12 | 27 | 25 | 8.5% | G | **0.92** |
| Gradko | 50% TEA in Acetone | 2009 | B | LB Brent | 10 | 32 | 31 | 2.7% | G | **0.97** |
| Gradko | 50% TEA in Acetone | 2009 | R | LB Richmond | 12 | 43 | 43 | -0.3% | G | **1.00** |
| Gradko | 50% TEA in Acetone | 2009 | S | LB Richmond | 12 | 27 | 28 | -2.4% | G | **1.02** |
| Gradko | 50% TEA in Acetone | 2009 | R | Reading BC | 11 | 41 | 44 | -7.8% | G | **1.09** |
| Gradko | 50% TEA in Acetone | 2009 | R | Stevenage BC | 12 | 38 | 29 | 32.0% | G | **0.76** |
| Gradko | 50% TEA in Acetone | 2009 | R | Sandwell MBC | 12 | 45 | 44 | 3.0% | G | **0.97** |
| Gradko | 50% TEA in Acetone | 2009 | UB | Sandwell MBC | 11 | 17 | 17 | -1.6% | S | **1.02** |
| Gradko | 50% TEA in Acetone | 2009 | UB | Sandwell MBC | 11 | 27 | 28 | -6.6% | G | **1.07** |
| Gradko | 50% TEA in Acetone | 2009 | R | Sandwell MBC | 12 | 38 | 40 | -3.6% | S | **1.04** |
| Gradko | 50% TEA in Acetone | 2009 | UB | Sheffield CC | 10 | 33 | 38 | -12.9% | G | **1.15** |
| Gradko | 50% TEA in Acetone | 2009 | UC | Uttlesford DC | 9 | 24 | 25 | -1.7% | G | **1.02** |
| Gradko | 50% TEA in Acetone | 2009 | R | West Berkshire Council | 12 | 45 | 54 | -15.9% | P | **1.19** |
| Gradko | 50% TEA in Acetone | 2009 | K | AEA Tech Intercomparison | 12 | 106 | 107 | -0.9% | G | **1.01** |
| Gradko | 50% TEA in Acetone | 2009 | | **Overall Factor[3] (15 studies)** | | | | | **Use** | **0.99** |

# 13. Appendix 3

# Traffic data

The following counted traffic data were used to derive emission factors for the roads of interest. Speed data is provided in the diagram provided by Norfolk County Council.

| AADT | Cycle /Motorcycle | Car | LGV | Short towing | HGV2 + Buses | HGV3 | HGV 4 | HGV 5 | HGV ART 3 | HGV ART 4 | HGV ART 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **16641** | **272** | **15113** | **709** | **70** | **385** | **46** | **23** | **10** | **3** | **3** | **6** |

The traffic data set was also split into north and southbound, and also split the southbound lane into the right turn and ahead/left turn lanes. Comparison with the combined flows reveals slight inconsistencies in the counts- for instance the northbound plus southbound AADT from the tables below do not add up to the combined total in the table below. The differences are marginal in the context of the overall flow.

Data for these is provided below.

**Northbound**

| AADT | Cycle /Motorcycle | Car | LGV | Short towing | HGV2 + Buses | HGV3 | HGV 4 | HGV 5 | HGV ART 3 | HGV ART 4 | HGV ART 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **8480** | **159** | **7771** | **276** | **46** | **197** | **10** | **10** | **2** | **2** | **2** | **5** |

**Southbound**

| AADT | Cycle /Motorcycle | Car | LGV | Short towing | HGV2 + Buses | HGV3 | HGV 4 | HGV 5 | HGV ART 3 | HGV ART 4 | HGV ART 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **8452** | **117** | **7614** | **441** | **25** | **193** | **35** | **14** | **8** | **1** | **1** | **2** |

**Southbound Right Turn**

| AADT | Cycle /Motorcycle | Car | LGV | Short towing | HGV2 + Buses | HGV3 | HGV 4 | HGV 5 | HGV ART 3 | HGV ART 4 | HGV ART 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1878** | **20** | **1684** | **61** | **9** | **83** | **8** | **11** | **2** | **2** | **0** | **0** |

**Southbound Left Turn/ Straight Ahead**

| AADT | Cycle /Motorcycle | Car | LGV | Short towing | HGV2 + Buses | HGV3 | HGV 4 | HGV 5 | HGV ART 3 | HGV ART 4 | HGV ART 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **6623** | **98** | **5974** | **382** | **16** | **112** | **27** | **3** | **7** | **1** | **1** | **1** |

# Buses

Bus flows were derived from the following timetable information provided by Norfolk County Council.

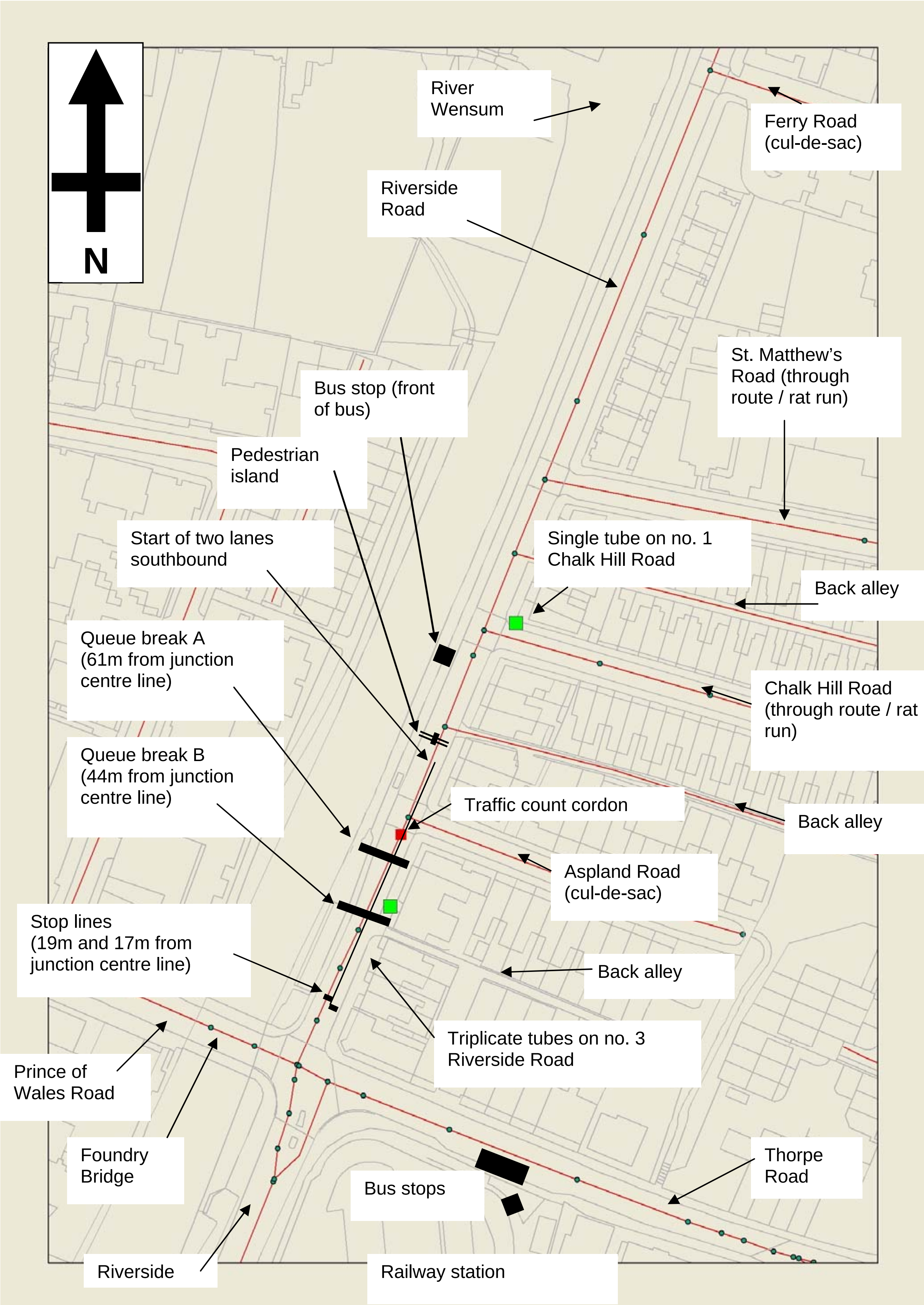
| | |
|---|---|
| 1. | Monday-Friday, 06:00-07:00, 3 buses per hour southbound, 0 northbound. |
| 2. | Monday-Friday, 07:00-08:00, 6 buses per hour southbound, 5 northbound. |
| 3. | Monday-Friday, 08:00-18:00, 8 buses per hour in each direction. |
| 4. | Monday-Friday, 18:00-19:00, 5 buses per hour southbound, 8 northbound. |
| 5. | Monday-Friday, 19:00-23:30, 2 buses per hour in each direction. |
| 6. | Saturday, 06:00-07:00, 2 buses per hour southbound, 1 northbound. |
| 7. | Saturday, 07:00-08:00, 4 buses per hour in each direction. |
| 8. | Saturday, 08:00-09:00, 5 buses per hour in each direction. |
| 9. | Saturday, 09:00-18:00, 8 buses per hour in each direction. |
| 10. | Saturday, 18:00-19:00, 4 buses per hour southbound, 7 northbound. |
| 11. | Saturday, 19:00-23:30, 2 buses per hour in each direction. |
| 12. | Sunday (& English Public Holidays, except 25th & 26th December), 08:30-23:30, 2 buses per hour in each direction. |

The bus data was input into ADMS-Roads according to the direction of travel as a daily average- which was derived as follows:

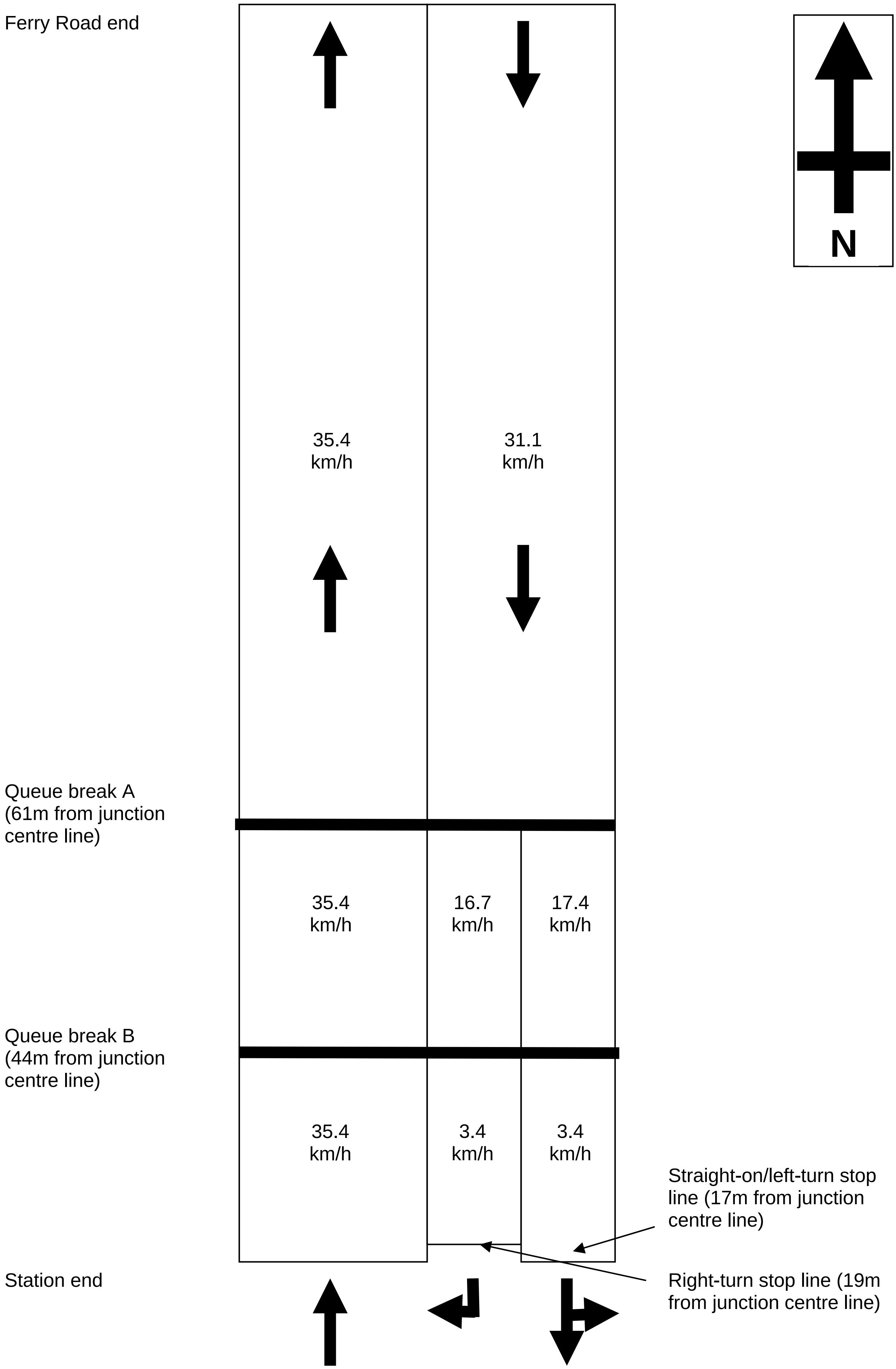
| Northbound | | | | | Southbound | | | |
|---|---|---|---|---|---|---|---|---|
| time | mon-Friday | Saturday | Sunday | | time | mon-Friday | Saturday | Sunday |
| 0-1 | 0 | 0 | 0 | | 0-1 | 0 | 0 | 0 |
| 1-2 | 0 | 0 | 0 | | 1-2 | 0 | 0 | 0 |
| 2-3 | 0 | 0 | 0 | | 2-3 | 0 | 0 | 0 |
| 3-4 | 0 | 0 | 0 | | 3-4 | 0 | 0 | 0 |
| 4-5 | 0 | 0 | 0 | | 4-5 | 0 | 0 | 0 |
| 5-6 | 0 | 0 | 0 | | 5-6 | 0 | 0 | 0 |
| 6-7 | 0 | 1 | 0 | | 6-7 | 3 | 1 | 0 |
| 7-8 | 5 | 4 | 0 | | 7-8 | 6 | 4 | 0 |
| 8-9 | 8 | 5 | 2 | | 8-9 | 8 | 5 | 2 |
| 9-10 | 8 | 8 | 2 | | 9-10 | 8 | 8 | 2 |
| 10-11 | 8 | 8 | 2 | | 10-11 | 8 | 8 | 2 |
| 11-12 | 8 | 8 | 2 | | 11-12 | 8 | 8 | 2 |
| 12-13 | 8 | 8 | 2 | | 12-13 | 8 | 8 | 2 |
| 13-14 | 8 | 8 | 2 | | 13-14 | 8 | 8 | 2 |
| 14-15 | 8 | 8 | 2 | | 14-15 | 8 | 8 | 2 |
| 15-16 | 8 | 8 | 2 | | 15-16 | 8 | 8 | 2 |
| 16-17 | 8 | 8 | 2 | | 16-17 | 8 | 8 | 2 |
| 17-18 | 8 | 8 | 2 | | 17-18 | 8 | 8 | 2 |
| 18-19 | 8 | 7 | 2 | | 18-19 | 5 | 4 | 2 |
| 19-20 | 2 | 2 | 2 | | 19-20 | 2 | 2 | 2 |
| 20-21 | 2 | 2 | 2 | | 20-21 | 2 | 2 | 2 |
| 21-22 | 2 | 2 | 2 | | 21-22 | 2 | 2 | 2 |
| 22-23 | 2 | 2 | 2 | | 22-23 | 2 | 2 | 2 |
| 23-24 | 2 | 2 | 2 | | 23-24 | 2 | 2 | 2 |
| **total** | **103** | **99** | **32** | | **total** | **104** | **96** | **32** |

As can be seen from the above, bus flows are almost equal in the north and south bound directions.

**Norwich Riverside Road AQMA Model**
**Traffic Annotation by Chris Wood, Norfolk County Council, July 2010**

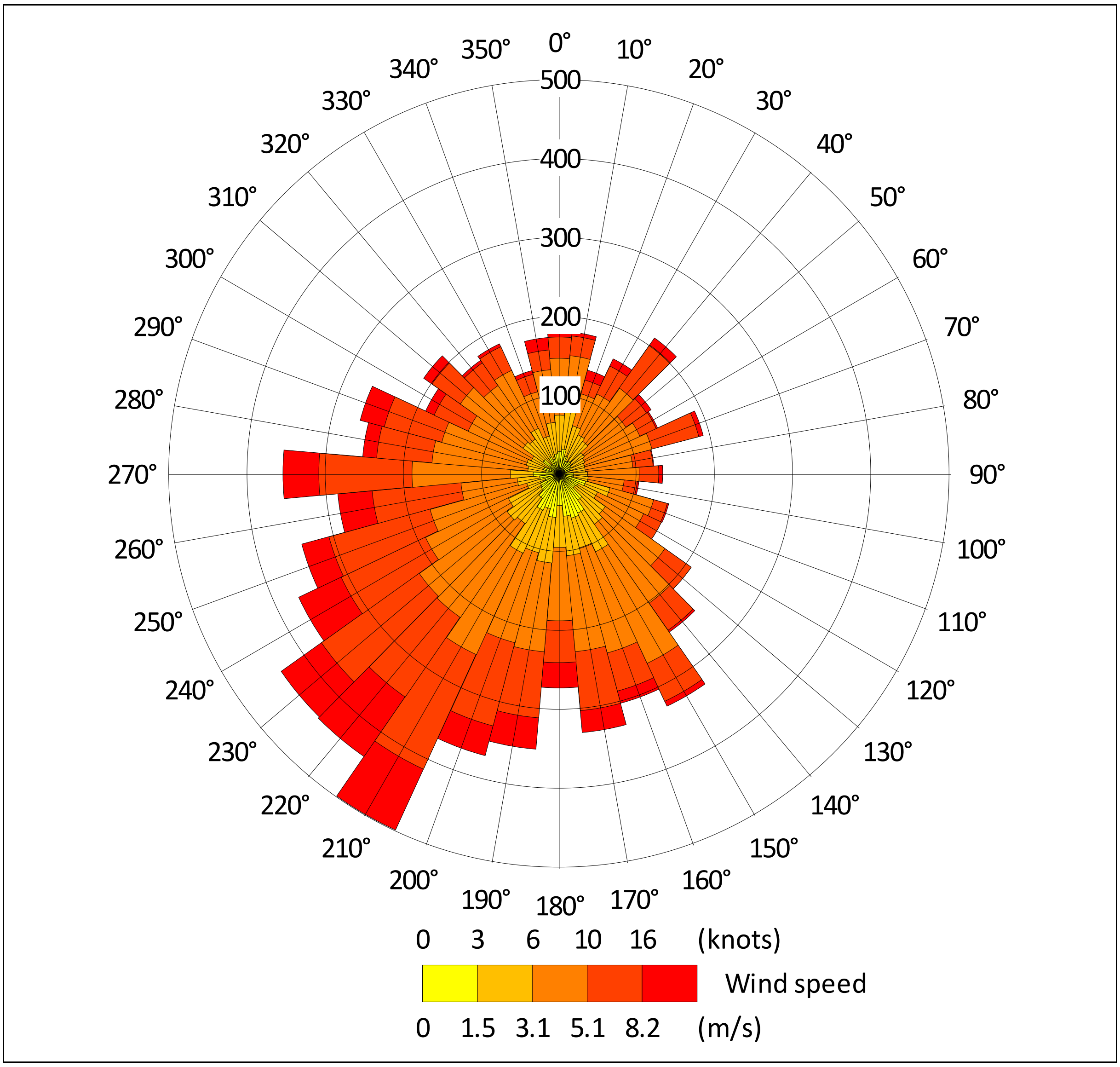


**Riverside Road AQMA – 24-hour Average Traffic Speeds**



# 14. Appendix 4

## ADMS Wind Rose for Marham 2009



M G Stephenson
Public protection manager

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