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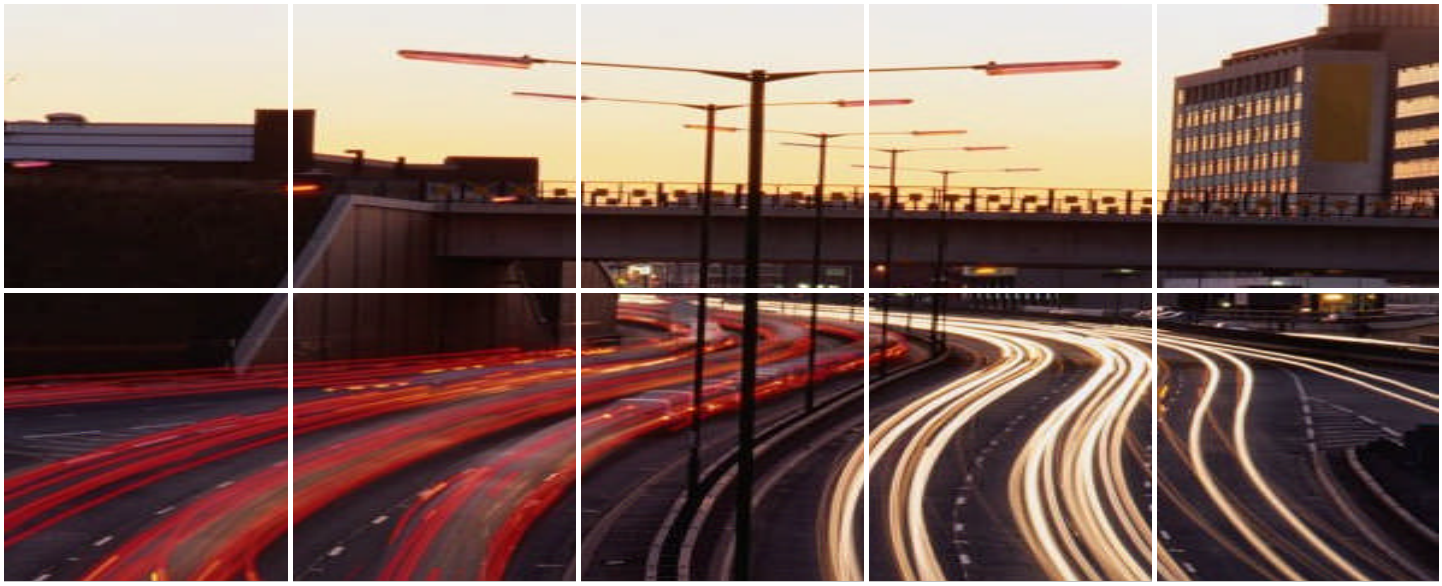

Further Assessment of Air Quality

Perth and Kinross Council

Report to Perth and Kinross Council

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Executive summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality which culminated in the Environment Act, 1995. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality standards. These and other air quality standards[1] and their objectives[2] have been enacted through the Air Quality Regulations in 1997 and 2000 and the Air Quality (Amendment) Regulations 2002. The Environment Act 1995 requires Local Authorities to undertake an air quality review. In areas where the air quality objective is not anticipated to be met, Local Authorities are required to establish Air Quality Management Areas to improve air quality.

The intention is that local authorities should only undertake a level of assessment that is proportionate to the risk of air quality objectives being exceeded. The first step in the second round of review and assessment is an Updating and Screening Assessment (USA), which is to be undertaken by all authorities. Where the USA has identified a risk that an air quality objective will be exceeded, the authority is required to undertake a detailed assessment.

The Detailed Assessment, completed in 2004 by the former netcen for Perth and Kinross Council, found that it was likely that the annual mean NO_2 objective for 2005 would be exceeded and the PM_{10} objectives for 2010 will be exceeded in areas where personal relevant exposure occurs. The report concluded that Perth and Kinross Council needed to declare an Air Quality Management Area to cover the area of exceedence in the Atholl Street/Barrack Street Junction and possibly other areas of Perth City. Subsequently the whole of the city of Perth was declared an AQMA for NO_2 and PM_{10}.

The Updating and Screening Assessment for Perth and Kinross was completed in 2006. The monitoring data and DMRB modelling indicated a number of exceedences of the annual mean objective for nitrogen dioxide at busy junctions in Perth and no exceedences of the 2004 objectives for PM_{10} in the Perth and Kinross Council area. Projections to 2010 indicated that the annual mean objective of 18μg m^{-3} for PM_{10} is unlikely to be met at a number of locations close to junctions in central Perth. All predicted and measured exceedences were inside the existing AQMA. The report concluded that Perth and Kinross Council was not required to carry out a Detailed Review and Assessment for carbon monoxide, benzene, 1,3-butadiene, lead, nitrogen dioxide, PM_{10} or sulphur dioxide.

The objective of this Further Assessment was to confirm the conclusions of the detailed assessment and to test out action planning scenarios to assess the likely impact they may have on pollutant concentrations in future years, and therefore their likely effectiveness.

The present report therefore constitutes a Further Assessment for Perth and Kinross Council. Only the impact of NO_2 and PM_{10} emissions are considered in this report. This report investigates current and potential future nitrogen dioxide and PM_{10} levels through an examination of the location and size of principal traffic emission sources, emissions modelling exercises and by reference to monitored air quality data.

Nitrogen Dioxide

It is recommended that Perth and Kinross Council retain their city wide air quality management area for NO_2, and proceed with preparation of their action plan to reduce NO_2 concentrations in this area. In summary:

[1] Refers to standards recommended by the Expert Panel on Air Quality Standards. Recommended standards are set purely with regard to scientific and medical evidence on the effects of the particular pollutants on health, at levels at which risks to public health, including vulnerable groups, are very small or regarded as negligible.

[2] Refers to objectives in the Strategy for each of the eight pollutants. The objectives provide policy targets by outlining what should be achieved in the light of the air quality standards and other relevant factors and are expressed as a given ambient concentration to be achieved within a given timescale.

NO_2 2005 Base Case
This Further Assessment has confirmed a significant risk of exceedance of the UK annual mean objective for NO_2 in 2005 in central Perth only. Both monitoring and modelling generally indicate that in 2005, for the Base Case, concentrations were above the required concentration at a maximum of 14 monitoring locations in Perth City Centre. At one monitoring location it is possible that the hourly NO_2 objective was exceeded.

NO_2 2005 with the CCTMR
This Further Assessment has confirmed a significant risk of exceedance of the UK annual mean objective for NO_2 in 2005, with the CCTMR in place, in central Perth only. Modelling generally indicates that in 2005, with the CCTMR in place, concentrations were above the required concentration at a maximum of 13 monitoring locations in Perth City Centre. At 3 monitoring locations it is possible that the hourly NO_2 objective was exceeded.

NO_2 2010
Concentrations in 2010, based on 2005 projected forward traffic data, are predicted to be lower, although the EU Limit Value for annual mean NO_2 may still be exceeded at these city centre locations in that year.

NO_2 2018
Modelling for 2018 with City Centre Management Review and Regional Bridge in place showed that again 13 monitoring locations would exceed the annual mean objective. The number of monitoring locations predicting a possible exceedance of the hourly mean is predicted to increase from 3 in 2005 with the CCTMR to 8 by 2018.

NO_2 Source Apportionment
Results for 2005 indicate that at the locations of highest predicted roadside concentrations, free-flowing traffic accounts for less than one eighth of the local NO_x and NO_2 concentrations, and of this traffic contribution, HDVs account for approximately three quarters. Queuing traffic accounts for three quarters of the local NO_x and NO_2 concentrations, and of this traffic contribution HDVs account for well over half. Total HDV traffic, both free flowing and queuing, therefore contributes to over three-fifths to the local NO_2 concentrations. Reductions in HDV queuing and congestion are therefore likely to lead to a significant reduction in roadside NO_x and NO_2.

PM_{10}
It is recommended that Perth and Kinross Council retain their city wide air quality management area for PM_{10}, and proceed with preparation of their action plan to reduce PM_{10} concentrations. Reductions in queuing and congestion, particularly aimed at HDV traffic, are needed to lead to a significant reduction in roadside PM_{10}. In summary:

PM_{10} 2005 Base Case
Both monitoring and modelling indicate that in 2005 concentrations were below the required concentrations in both the city centre and city wide AQMA.

PM_{10} 2005 with the CCTMR
Both monitoring and modelling indicate that in 2005, with the CCTMR in place, concentrations were below the required concentrations in both the city centre and city wide AQMA.

PM_{10} 2010 Base Case
This Further Assessment has however, confirmed a significant risk of exceedance of the Scottish annual mean objective for PM_{10} in Perth. For 2010 Base Case projected from the 2005 Base Case concentrations are not predicted to exceed the daily mean objective set for Scotland.

PM_{10} 2010 with the CCTMR
This Further Assessment has however, confirmed a significant risk of exceedance of the Scottish annual mean objective for PM_{10} in 2010 with the CCTMR in place in Perth. For 2010 with the CCTMR in place concentrations are not predicted to exceed the daily mean objective set for Scotland.

PM_{10} 2018 with the CCTMR
Modelling for 2018 with the CCTMR and Regional Bridge in place confirmed a significant risk of exceedance of the both the 2010 Scottish annual mean objective for PM_{10} and the 2010 daily mean objective set for Scotland.

PM_{10} Source apportionment
Results for 2005 indicate that at the location of highest predicted roadside concentrations, free-flowing traffic accounts for one tenth of the local PM_{10} concentrations, and of this traffic contribution, HDVs account for approximately half. Queuing traffic accounts for less than one fifth of the local PM_{10} concentration, and of this contribution HDVs account for over half. Total HDV traffic, for both free flowing and queuing, contributes to over one tenth to the local PM_{10} concentrations. Reductions in queuing and congestion, particularly aimed at HDV traffic, are therefore likely to lead to a significant reduction in roadside PM_{10}.

If local background is at or just below 18 $\mu g\ m^{-3}$, it will be necessary not only to reduce roadside PM_{10} but also urban background concentrations generally. To this, the city wide AQMA should remain in force and action planning should seek to reduce city wide emissions of PM_{10}.

City Centre Traffic Management Review and Regional Bridge
Conclusions on the impacts on air quality for these two measures illustrate that:

- The impacts on air quality of the CCTMR reveal little overall improvement in or difference to both NO_2 and PM_{10} concentrations for 2005.
- Modelling of 2010 concentrations both with and without the CCTMR in place for PM_{10} predicts exceedances of the 2010 PM_{10} annual mean objective for Scotland. No exceedances of the 2010 daily mean objective are expected for this year.
- Predictions of NO_2 in the 2018 with the CCTMR and Regional Bridge scenario indicate exceedances of the 2005 NO_2 annual mean objective and an increase in the number of locations, from 3 to 8, which are likely to exceed the 2005 hourly mean NO_2 objective.
- The Regional Bridge in the 2018 scenario greatly improves the PM_{10} concentrations across the whole of Perth, although, under the more stringent 2010 annual mean objective an exceedance area is predicted in the city centre.
- The Regional Bridge scenario sees a reduced re-directed flow on Perth's roads, but it is more likely that by 2018 the uptake of cleaner diesel vehicles through increasing Euro standards and the fitting of more particulate traps as standard reaps greater benefits on PM_{10} concentrations. The model also now takes into account the new NO_2: NO_x relationship, which is revealing higher concentrations than originally modelled in previous years.
- Action planning is needed that targets congestion, particularly HDVs, along the more central Perth Streets namely Atholl Street and South Street where the highest NO_2 and PM_{10} concentrations occur.

Maps reproduced within this document

Acronyms and definitions

AADTF	annual average daily traffic flow
ADMS	an atmospheric dispersion model
AQDD	Common Position on Air Quality Daughter Directives
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
CNS	central nervous system
d.f.	degrees of freedom
DEFRA	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
ERG	Environmental Research Group, Kings College, London
GIS	Geospatial Information System
kerbside	0 to 1 m from the kerb
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Strategy (now called the Air Quality Strategy)
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NPL	National Physical Laboratory
NRTF	National Road Traffic Forecast
ppb	parts per billion
r	the correlation coefficient
roadside	1 to 5 m from the kerb
SD	standard deviation
TEMPRO	A piece of software produced by the DfT used to forecast traffic flow increases
UWE	University of West of England

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Appendices

1 Introduction

1.1 PURPOSE OF THE STUDY

Following the outcome of their Detailed Assessment report of July 2004, Perth and Kinross Council commissioned AEA Energy & Environment to undertake a Further Assessment for nitrogen dioxide and PM_{10} for the Perth city wide AQMA.

The detailed assessment concluded that the 2005 UK objective for annual mean NO_2 and 2010 objectives for PM_{10} were likely to be exceeded in relevant years and that an air quality management area was required for NO_2 and PM_{10} along Atholl Street/Barrack Street junction and the junction of Main Street and County Place. A city wide AQMA has now been declared and Perth and Kinross Council are now required to proceed to a further assessment to update and confirm the conclusions of the detailed assessment, and undertake essential source apportionment work to inform their associated action planning work.

The objective of this Further Assessment is to test out action planning scenarios and assess the likely impact they may have on pollutant concentrations, and therefore their likely effectiveness.

1.2 GENERAL APPROACH TAKEN

The approach taken in this study was to:

- Collect and interpret additional data to that already used in the screening and detailed assessments, in order to support the further assessment, including more detailed traffic flow data around the areas outlined above;
- Utilise the monitoring data from the Council's monitoring campaign to assess the ambient concentrations resulting from road traffic emissions, and to validate the output of the modelling studies;
- Model the concentrations of NO_2 around the selected roads, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations.
- Undertake source apportionment work to allow action planning measures to be targeted appropriately.
- Model the potential impact of selected proposed action planning scenarios.

1.3 VERSION OF THE POLLUTANT SPECIFIC GUIDANCE USED IN THIS ASSESSMENT

This report has used the latest guidance in LAQM.TG(03), published in February 2003, and subsequent update dated January 2006.

1.4 NUMBERING OF FIGURES AND TABLES

The numbering scheme is not sequential, and the figures and tables are numbered according to the chapter and section that they relate to.

1.5 UNITS OF CONCENTRATION

The units throughout this report are presented in $\mu g\, m^{-3}$ (which is consistent with the presentation of the new AQS objectives), unless otherwise noted.

1.6 STRUCTURE OF THE REPORT

This document is a detailed Air Quality review for Perth and Kinross Council for nitrogen dioxide and PM_{10}. This chapter, Chapter 1 has summarised the need for the work and the approach to completing the study.

Chapter 2 contains details of the information used to conduct the Further Assessment for Perth and Kinross Council.

Chapter 3 introduces the latest standards and objectives for nitrogen dioxide and summarises the monitoring of NO_2 that has taken place in Perth in the area of concern.

Chapter 4 describes the results of the modelling assessment and discusses whether the UK objectives and EU limit values for nitrogen dioxide are considered likely to be exceeded in Perth in 2005 and 2010 respectively. The results of the analysis are displayed in tabular form and as contour plots. It also presents the recommendations from the assessment.

Chapter 5 introduces the latest standards and objectives for PM_{10} and summarises the monitoring of PM_{10} that has taken place in Perth in the area of concern.

Chapter 6 describes the results of the modelling assessment and discusses whether the PM_{10} objectives are considered likely to be exceeded in Perth in 2005 and 2010. The results of the analysis are displayed in tabular form and as contour plots. It also presents the recommendations from the assessment.

Chapter 7 outlines the conclusions and recommendations for both NO_2 and PM_{10} from the assessment.

1.7 GIS DATA USED

Perth and Kinross Council provided the Ordnance Survey landline data for use in this project.

1.8 EXPLANATION OF THE MODELLING OUTPUT

The contour maps generated in the modelling for this report are an indication of the predicted pollutant concentrations around the area modelled. They are not lines of absolute values and should not be considered as such. Care should also be taken, in cases where contours join up as enclosed loops. This is common, for example along a section of road. The contours may appear to circle a section of the road, rather than extend all the way along it. This is due to the input area over which the model was run being only a section of the road in question. No assumptions of pollutant concentrations can be made on locations outside of the area being modelled.

2 Information used to support this assessment

This Chapter presents the information used to support this review and assessment.

2.1 MAPS

Perth and Kinross Council provided OS Landline data of the areas in the county which needed to be modelled. This enabled accurate road widths and the distance of the housing to the kerb to be determined.

2.2 ROAD TRAFFIC DATA

Average flow, hourly fluctuations in flow, speed and fraction of HDVs.

Traffic consultants SiAS provided peak hour traffic flow data and percentage HDV for 2003 for the roads of concern. Site-specific diurnal traffic variation profile for the main roads in Perth was carried out with peak and AADT flows using the guidance given in TG.03. Following this the 2003 AADT was scaled to 2005 AADT using available SCOOT data for matching locations. 12 hours a day of queuing at selected locations in the city centre was assumed in the model runs.

Traffic Growth

Traffic flow data from 2003 was used to estimate flows up to 2010 using traffic growth factors derived from the NRTF and the TEMPRO v5 model. TEMPRO provides regional traffic growth statistics. Details of the growth factors used in the assessment to predict traffic flows in Perth are given in Appendix 1. This has been used in the 2010 scenarios for PM_{10}. For all the other scenarios, such as 2018, individual traffic data was supplied by SiAS for their associated years.

2.3 METEOROLOGICAL DATA USED IN THE DISPERSION MODELLING

Hourly sequential meteorological data for the nearest suitable meteorological station with adequate data capture, Leuchars near St. Andrews, was obtained for 2005. The meteorological data provided information on wind speed and direction and the extent of cloud cover for each hour of 2005. Other sites closer to Perth have failed to record adequate data capture levels in recent years.

2.4 AMBIENT MONITORING

Nitrogen dioxide

Nitrogen dioxide concentrations are monitored by diffusion tube at 34 roadside locations in Perth. Perth and Kinross Council also undertake automatic monitoring with triplicate co-located diffusion tubes at 2 locations. The monitoring locations are indicated in Chapter 3, Figure 3.1. Details of the type, locations, and concentrations recorded by the diffusion tubes are given in Appendix 2.

2.5 MODELLING METHODOLOGY

The air quality impact from road traffic emissions in this Further Assessment was calculated using AEA Energy & Environment's proprietary urban model. There are two parts to this model:

- ***The Local Area Dispersion System (LADS) model.*** This model was used to calculate background concentrations of oxides of nitrogen on a 1 km x 1 km grid. Estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 2004 National Atmospheric Emission Inventory disaggregated inventory, projected forward to 2005 and 2010 using factors in the **defra** Technical Guidance.

- ***The LADS-URBAN model*.** This model is a tool for calculating atmospheric dispersion using a point-source kernel. Estimates of emissions from vehicles were calculated using the latest emission factors. The dispersion kernels for the LADS-URBAN model were derived from model runs using ADMS V3.3.

This advanced two-component model is suitable for modelling road traffic emissions as defined in "Review and assessment: Selection and Use of Dispersion Models, LAQM.TG3 (00)", and in the Technical Guidance LAQM.TG(03). Information regarding the validation of this modelling approach is given in Appendix 3.

Concentrations of NO_2 from road traffic emissions were assessed using a high-resolution approach, with air quality modelled at 10 m intervals along all of the roads assessed. This high spatial resolution is recommended in LAQM.TG3 (00) and in the Technical Guidance LAQM.TG (03).

2.6 COMPUTER MODELLING

The modelling programmes used in this assessment make a number of assumptions during the calculations. These include no consideration of terrain relief, or direct consideration of buildings over the surface being modelled. Modelling of pollutant concentrations on roads can sometimes provide misleading information on produced contour maps. For example, polygons and circles on certain areas of the contour maps, e.g. roundabouts or the centres of roads, can be generated. This is not a deficiency in the model – it is an artefact of the data. As such, these additional features should be ignored and the wider context and implications of the contour maps be considered.

2.7 AIR QUALITY STRATEGY AND OBJECTIVES

Background information on the UK Air Quality Strategy, on the Local Air Quality Management regime, and on the UK air quality standards and objectives are provided in Appendix 4 and 5.

3 Nitrogen dioxide

3.1 INTRODUCTION

Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x, is road traffic, which is responsible for approximately half the emissions in Europe. NO and NO_2 concentrations are therefore greatest in urban areas where traffic is heaviest. Other important sources are power stations, heating plant and industrial processes.

Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then readily oxidised to NO_2 by reaction with ozone. Elevated levels of NO_x occur in urban environments under stable meteorological conditions, when the air mass is unable to disperse.

Nitrogen dioxide has a variety of environmental and health impacts. It is a respiratory irritant, may exacerbate asthma and possibly increase susceptibility to infections. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. In addition, nitrogen oxides have a lifetime of approximately 1-day with respect to conversion to nitric acid. This nitric acid is in turn removed from the atmosphere by direct deposition to the ground, or transfer to aqueous droplets (e.g. cloud or rainwater), thereby contributing to acid deposition.

3.2 LATEST STANDARDS AND OBJECTIVES FOR NITROGEN DIOXIDE

The National Air Quality Regulations (1997) set two provisional objectives to be achieved by 2005 for nitrogen dioxide:

- An annual average concentration of 40 $\mu g\ m^{-3}$ (21 ppb);
- A maximum hourly concentration of 286 $\mu g\ m^{-3}$ (150 ppb).

In June 1998, the Common Position on Air Quality Daughter Directives (AQDD) agreed at Environment Council included the following objectives to be achieved by 31 December 2005 for nitrogen dioxide:

- An annual average concentration of 40 $\mu g\ m^{-3}$ (21 ppb);
- 200 $\mu g\ m^{-3}$ (100 ppb) as an hourly average with a maximum of 18 exceedances in a year.

The National Air Quality Strategy was reviewed in 1999 (DETR, 1999). The Government proposed that the annual objective of 40 $\mu g\ m^{-3}$ be retained as a provisional objective and that the original hourly average be replaced with the AQDD objective. The revised Air Quality Strategy for England, Scotland, Wales and Northern Ireland (DETR, 1999; 2000) included the proposed changes. Modelling studies suggest that in general achieving the annual mean of 40 $\mu g\ m^{-3}$ is more demanding than achieving the hourly objective. If the annual mean is achieved, the modelling suggests the hourly objectives will also be achieved. Furthermore, monitoring studies suggest that the hourly objective is likely to be exceeded only in cases where the annual mean NO_2 concentration is of the order of 60 $\mu g/m^3$ or greater.

3.3 THE NATIONAL PERSPECTIVE

The main source of NO_x in the United Kingdom is road transport, which, in 2003 accounted for approximately 40% of emissions. Power generation contributed approximately 30% and domestic sources 7%. In urban areas, the proportion of local emissions due to road transport sources is larger (NAEI, 2003).

National measures are expected to produce reductions in NO_x emissions and achieve the objectives for NO_2 in many parts of the country. However, the results of the analysis set out in the National Air Quality Strategy suggest that for NO_2 a reduction in NO_x emissions over and above that achievable by national measures will be required to ensure that air quality objectives are achieved everywhere. Local authorities with major roads, or highly congested roads, which have the potential to result in elevated levels of NO_2 in relevant locations, are expected to identify a need to progress to a detailed assessment for this pollutant.

3.4 SUMMARY OF PREVIOUS AIR QUALITY REVIEW AND ASSESSMENT REPORTS

The Detailed Assessment for Perth and Kinross concluded that it was likely that the NO_2 annual mean objective for 2005 would be exceeded in areas where personal relevant exposure occurs. Specifically, the assessment found that exceedences of the 40 $\mu g\ m^{-3}$ annual mean objective for NO_2 were likely at properties close to Atholl Street and possible at properties in Barrack Street close to the junction with Atholl Street in 2005. Additionally, concentrations in Main Street in Bridgend and County Place in Perth were predicted to be lower than, but close to, the 40 $\mu g\ m^{-3}$ objective in 2005

The report concluded that Perth and Kinross Council needed to declare an Air Quality Management Area to cover the area of exceedence in the Atholl Street/Barrack Street Junction and possibly other areas of Perth City. Subsequently the whole of the city of Perth was declared an AQMA. That decision was taken to ensure that a holistic approach was adopted towards local environmental management through consideration of locations that were close to the objectives in addition to the locations of identified exceedence for these pollutants. It also helped to ensure that the Air Quality Action Plan (AQAP) would be integrated with other council policies.

The Updating and Screening Assessment concluded that Perth and Kinross Council was not required to carry out a Detailed Review and Assessment for carbon monoxide, benzene, 1,3-butadiene, lead, nitrogen dioxide, PM_{10} or sulphur dioxide.

Additional areas of exceedence of the annual mean objective for nitrogen dioxide that were not found in the Detailed Assessment were identified by the Updating and Screening Assessment within Perth City's AQMA. This vindicated the council's decision to designate the whole of Perth as an AQMA.

Monitoring data and DMRB modelling indicated a number of exceedences of the annual mean objective for nitrogen dioxide at busy junctions in Perth. All predicted and measured exceedences were inside the existing AQMA. There were no significant industrial sources of nitrogen dioxide found in the Perth and Kinross Council area. The DMRB modelling of traffic emissions indicated that in Crieff High Street the NO_2 concentrations were much lower that the concentrations measured by the diffusion tube monitors, which were close to the objective. The report recommended that more detailed traffic monitoring be carried out, so that the NO_2 concentrations could be more effectively modelled.

Figure 3.1 indicates the central area of the city wide boundary subsequently declared as an air quality management area (AQMA) in Perth City. It is this area, which is the subject of this Further Assessment.

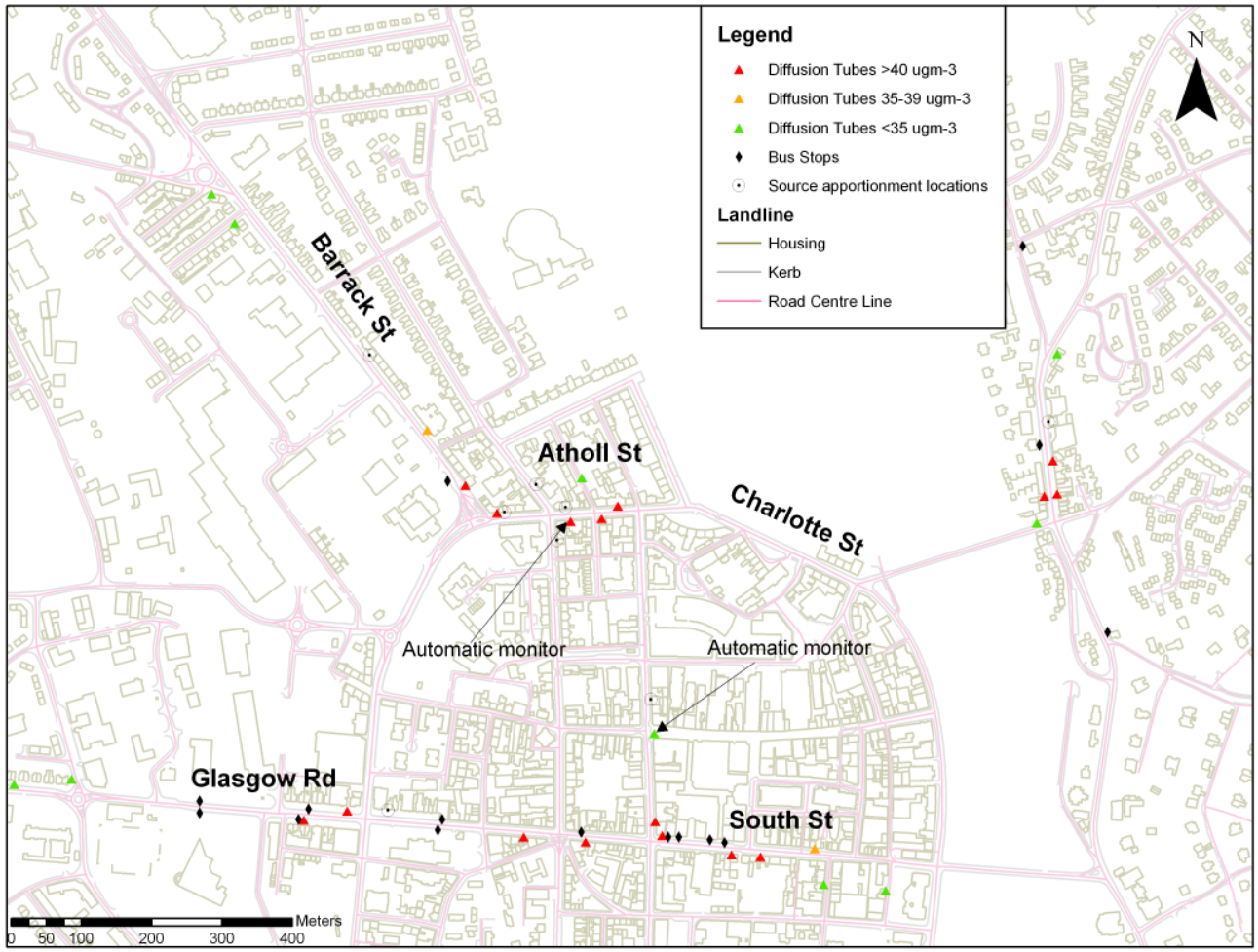

Figure 3.1 Monitoring and source apportionment locations in Perth.

3.5 PROPOSED ACTION PLANNING MEASURES

The following action plan scenarios are proposed to be implemented, all of which have been taken into account within the traffic modelling and are planned over the next 13 years, forming 3 scenarios to be modelled: 2005 Base Case, 2005 with City Centre Traffic Management Review (CCTMR) and 2018 with CCTMR and new regional bridge, the details of which are described below.

The preferred CCTMR option as advised by Perth and Kinross Council will include:

- High St (between Scott St and S. Methven St) 1 way westbound
- Murray St Taxis and Pedal Cycles only
- Charterhouse Lane one lane approach to King St and reversal of Priorities
- Traffic Calming in the New Row area

2018 Local Plan Developments with new Regional Bridge. This includes

- New River Crossing from A9 North of Inveralmond to A93 and A94
- Inveralmond Improvements
- Broxden Improvements
- Crieff Rd Improvements
- New A9 Overbridge from Crieff Rd
- Localised Junction Improvements
- CCTMR Preferred Option

3.6 MONITORING DATA

Nitrogen dioxide concentrations are monitored at 36 roadside sites within Perth by diffusion tube monitoring. 2 automatic monitors with triplicate collocated tubes are also located in Perth City Centre:

- Atholl Street (311689, 723628), 3.7m from the roadside, operating since June 2003.
- High Street (311570, 723929), 4m from the roadside, operating since October 2004.

Monitoring sites are shown in Figure 3.1. Both are roadside sites but the flows past the High Street automatic monitor are very low as it is a one-way street, and so concentrations are probably more typical of local background.

Continuous monitoring

Concentrations of NO_2, and PM_{10} are recorded using 2 continuous monitoring stations located at Atholl Street and 176 High Street Perth. Figure 3.1 shows the automatic monitoring station.

NOx analyser

An API model M200 Chemiluminescent Nitrogen Oxides analyser was used for this study. This analyser provides continuous data for concentrations of both NO_X and NO. Given that NO_X = NO + NO_2 it can be seen that concentrations of NO_2 are easily derived from this method. This analyser is typical of those employed within the Department for Environment, Food and Rural Affairs' (DEFRA) Automatic Urban and Rural Network (AURN) of national air monitoring stations.

The NO_X analyser was calibrated regularly throughout the monitoring period. Chemical scrubbers were used to provide a clean air sample, and a standard gas cylinder to provide span gas. Data from the instruments were scaled according to the instrument responses from these two point calibrations. The calibration gas cylinder used was calibrated at the **AEA** Gas Standards Calibration Laboratory (GSCL). **AEA's** GSCL holds UKAS accreditation (lab. no. 0401) for the calibration of NO, NO_2, SO_2 and CO gas mixtures. Using this cylinder to calibrate the analyser at the Perth monitoring site ensures that the data are traceable to national metrology standards.

Table 3.1 Summary of continuous nitrogen dioxide monitoring data at High Street and Atholl Street automatic monitors, Perth

High Street - Statistic	Year 2005	Estimate of Year 2010
Annual Mean NO_x (as NO_2) ($\mu g\ m^{-3}$)	63	52
Annual Mean NO_2 ($\mu g\ m^{-3}$)	28	23
Maximum Hourly mean NO_2 ($\mu g\ m^{-3}$)	149	123
Data Capture (%) NO_2	99.2%	-
Atholl Street - Statistic		
	Year 2005	Estimate of Year 2010
Annual Mean NO_x (as NO_2) ($\mu g\ m^{-3}$)	153	126
Annual Mean NO_2 ($\mu g\ m^{-3}$)	54	44
Maximum Hourly mean NO_2 ($\mu g\ m^{-3}$)	187	154
Data Capture (%) NO_2	99%	-

Nitrogen Dioxide Diffusion tubes

Diffusion tubes at 34 roadside locations in Perth measure monthly average concentrations of nitrogen dioxide. The measurement data for 2005 and for the collocation period (January 2005 to December 2005) is summarised in Table 3.2 below. Appendix 2 provides a breakdown of the raw monitoring data on a monthly basis, OS grid co-ordinates of sites, and bias adjustment factors applied to the data.

Diffusion tubes can under or over-read and if possible should be referred to the results of continuous monitoring. 2 triplicate co-location studies were undertaken at the automatic monitors in central Perth from January 2005 to December 2005. The diffusion tubes are supplied and analysed by Dundee Scientific Services using the 20% v/v TEA in water method.

Information regarding the typical bias of these tubes was sought for year 2005 from the database of co-location studies issued by UWE on behalf of DEFRA (UWE (2006)). No results were available for 2005, and only single studies were available for 2002 to 2004 and 2006.

The local bias adjustment factors calculated using results from the local collocation studies and the netcen_DifTPAB_v02 spreadsheet for Atholl Street was 1.02 and; 0.93 for the High Street automatic monitor. Adjusting the January 2005 to December 2005 diffusion tube results by 1.02, exceedances of the annual mean objective is predicted at 16 central Perth sites with 2 sites close to the objective. As the High Street automatic monitor is 4m away from the kerb on the edge of a pedestrian zone, the Atholl Street roadside automatic monitor bias adjustment was used as a more conservative approach, and the diffusion tubes were adjusted by 1.02.

It should be taken into account that diffusion tubes are spot measurements and may be very sensitive to distance from the road as concentrations change rapidly with distance from the kerbside when comparing them with modelled results.

To predict the diffusion tube concentrations in 2010 from measurements in 2005, the latest adjustment factors published in January 2006 have been applied.

Table 3.2 Nitrogen dioxide diffusion tube survey 2005 results for Perth, corrected for bias with predictions for 2010

2005 Nitrogen Dioxide Diffusion Tube Results							
X	Y	Site ID	Site Name	2005 unadjusted annual mean NO_2	Bias Adjustment Factor*	2005 adjusted annual mean NO2	2010 annual mean NO_2 estimate based on 2005 adjusted (μgm^{-3})
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	22	1.02	22	18
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	20	1.02	20	16
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	29	1.02	30	25
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	15	1.02	15	12
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	21	1.02	22	18
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	34	1.02	34	28
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	32	1.02	32	26
311059	724394	P20	2 Crieff Road Perth PH1 5RT	30	1.02	30	25
311092	724352	P45	Ballantine Place, Perth PH1 5RR	28	1.02	28	23
311190	723505	P28	28 York Place Perth PH2 8EH	**45**	1.02	**46**	38
311252	723518	P29	37 York Place Perth PH2 8EH	**40**	1.02	**40**	33
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	34	1.02	35	28
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**43**	1.02	**44**	36
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**51**	1.02	**52**	**43**
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	26	1.02	27	22
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**49**	1.02	**50**	**41**
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**53**	1.02	**54**	**45**
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	23	1.02	24	20
311591	723474	P33	216 South Street Perth PH2 8NY	39	1.02	40	33
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**52**	1.02	**53**	**44**
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**48**	1.02	**49**	**41**
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	31	1.02	32	26
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	**43**	1.02	**44**	36
311700	723483	P32	135 South St, Perth, PH2 8PA	**42**	1.02	**42**	35
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	**42**	1.02	**43**	36
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	**40**	1.02	**41**	34
311917	723465	P31	45-47 South St, Perth, PH2 8PD	34	1.02	35	29
311930	723414	P35	17 Princes St, Perth, PH2 8NG	33	1.02	33	27
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	27	1.02	28	23
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	32	1.02	33	27
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	**45**	1.02	**46**	38
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	**45**	1.02	**46**	38
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	**40**	1.02	**41**	34
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	32	1.02	32	26

Predicted exceedances of UK objective or EU Limit Value in **BOLD**
* Bias adjustment factor derived from netcen spreadsheet

Comparison of monitoring data with AQ objectives

The results of the diffusion tube monitoring both in 2005 and during the collocation study suggest that the UK annual mean objective for NO_2 in 2005 is likely to be exceeded in Perth City Centre. Predictions for 2010 suggest that the corresponding EU limit value for that year may also be exceeded at 5 of the above locations in Atholl Street and County Place.

4 Further Assessment for NO_2

This further assessment has been undertaken by means of computer dispersion modelling verified using automatic and diffusion tube monitoring. The locations at which detailed modelling was carried out are Perth City Centre focusing on Atholl Street and South Street. AQMA wide modelling was also completed.

4.1 METEOROLOGICAL DATA

Hourly sequential meteorological data for the nearest suitable meteorological station with adequate data capture; Leuchars near St. Andrews, some 29 miles northeast of Perth, was obtained for 2005. The meteorological data provided information on wind speed and direction and the extent of cloud cover for each hour of 2005.

4.2 TRAFFIC MODELLING SUMMARY

In this study, the concentrations of NO_2 at receptors close to the roads and junctions of interest have been modelled using ADMS-3.3 as a dispersion kernel model.

The roads were defined as volume sources, 3m deep, and were broken up in to a series of adjoining segments. The length of these segments was dictated by the way in which the OS LandLine data was digitised and varied from one or two metres in length (where the road rapidly changed direction) to hundreds of metres in length (where the road was essentially straight). The OS LandLine data was used to provide the co-ordinates of the centre line of the road, and the road widths. Therefore, the position of the volume sources (here the roads) were accurate to approximately a metre.

Where queuing of vehicles was reported, emissions from stationary vehicles exhausts were estimated on the basis that the engine power output and hence emissions were the same as those at a speed of 5 kph. Queuing vehicles were assumed to be 5 m apart.

4.3 SOURCES OF BACKGROUND (NON-TRAFFIC) EMISSIONS DATA

Background emissions of oxides of nitrogen (NO_x) from sources not modelled in detail have been taken from the UK National Atmospheric Emissions Inventory 2004 (www.naei.org.uk) and scaled to the year of interest where necessary following the recommended procedure in LAQM.TG(03). The contribution to emissions from the roads modelled in detail have been omitted where this would lead to double counting of the local impact of emissions.

4.4 MODEL BIAS AND VERIFICATION

Agreement between the raw model and 2 automatic monitors was generally acceptable with the model underpredicting at Atholl Street by 17% and overpredicting at the High Street by 10%; with an average underprediction of 17% across all the diffusion tube monitoring locations (Table 4.1). To improve this, a fixed offset of + 3 $\mu g/m^3$ was applied to the raw modelling results. This fixed offset was derived by the average difference between what the model predicted and the monitoring results at each of the 2 automatic monitoring locations. Figure 4.1 shows the model-monitor agreement, before (top) and following model bias correction (bottom), with Table 4.1 showing the Atholl Street automatic monitor underpredicting by 11% and the automatic monitor at the High Street overpredicting by 21% and now only underpredicting across all the other monitoring locations by 7%.

Table 4.1: Comparison of modelled and measured concentrations for 2005 (Base Case)

Monitoring Site	Type	Location	Before model bias correction			After model bias correction		
			% Error of model relative to monitor	NO_2 concentration, $\mu g\ m^{-3}$		% Error of model relative to monitor	NO_2 concentration, $\mu g\ m^{-3}$	
				Modelled	Measured		Modelled	Measured
Automatic	R	High Street	10	31	28	21	34	28
Automatic	R	Atholl Street	-17	45	54	-11	48	54

R - Roadside

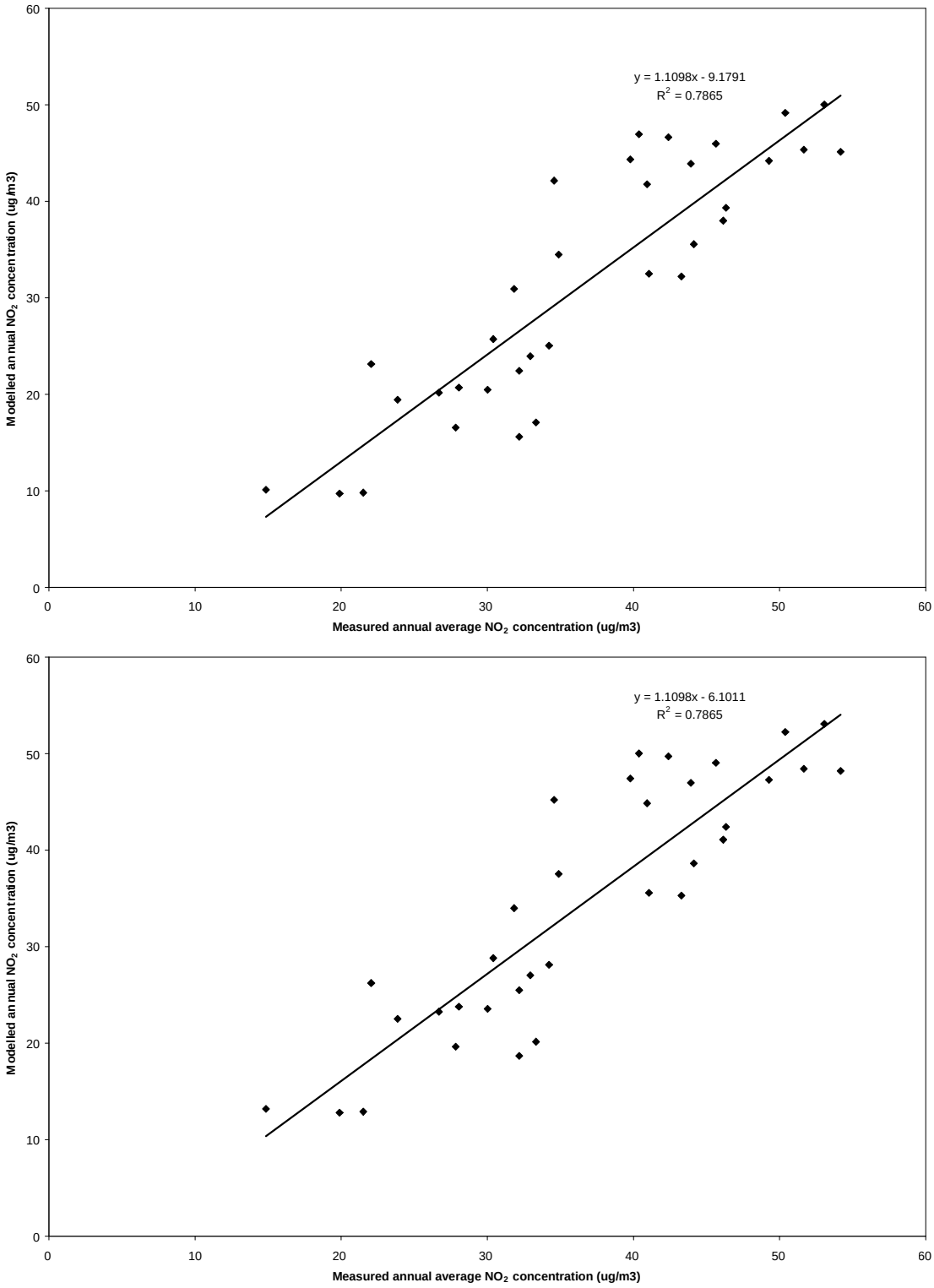

Figure 4.1:
Top: Model – Monitor Agreement for Nitrogen Dioxide before model bias correction
Bottom: Model – Monitor Agreement for Nitrogen Dioxide following model bias correction

4.5 MODEL VALIDATION

In simple terms, model validation is where the model is tested at a range of locations and is judged suitable to use for a given application. The modelling approach used in this assessment has been validated, and used in numerous AEA Energy & Environment air quality review and assessments. Statistical techniques have been used to assess the likelihood that there will be an exceedance of the air quality objectives given the modelled concentration. The validation statistics are given in Appendix 3. Confidence limits for the predicted concentrations were calculated based on the validation studies by applying statistical techniques based on Student's t distribution. The confidence limits took account of uncertainties resulting from:

- Model errors at the receptor site;
- Model errors at the reference site;
- Uncertainty resulting from year to year variations in atmospheric conditions.

The confidence limits have been used to estimate the likelihood of exceeding the objectives at locations close to the roads. The following descriptions have been assigned to levels of risk of exceeding the objectives.

It would be recommended that Perth and Kinross Council generally consider declaring an AQMA where the probability of exceedance in 2005 is greater than 50% ("Probable").

Table 4.2: Uncertainties in the modelled concentrations for NO_2.

Description	Chance of exceeding objective	Modelled annual average concentrations, µg/m^3	
		Likelihood of exceeding annual average objective	Likelihood of exceeding hourly average objective
Very unlikely	Less than 5%	<28	<38
Unlikely	5-20%	28-34	38-52
Possible	20-50%	34-40	52-67
Probable	50-80%	40-46	67-82
Likely	80-95%	46-52	82-95
Very likely	More than 95%	>52	>95

The confidence limits for the 'probable' and 'likely' annual average and hourly objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedances of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals.

A simple linear relationship can be used to predict the 99.8th hourly percentile concentration of NO_2 from the annual concentration: the 99.8th percentile is three times the annual mean at kerbside/roadside locations. Therefore, plots of the modelled annual mean NO_2 concentrations can be used to show exceedances of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedances of the hourly objective need to be adjusted so they may be used directly with the plots of annual concentration. This has been performed by simply dividing the concentrations of the confidence limits by three.

4.6 RESULTS OF MODELLING

Perth - NO_2 for 2005 Base Case

Figure 4.1 shows modelled nitrogen dioxide annual mean concentrations in the area of Perth City Centre in 2005. The model predicts that the UK annual average objective of 40 $\mu g\ m^{-3}$ for nitrogen dioxide will be exceeded at the façade of buildings at 14 city centre locations. Table 4.3 below shows the risk of exceeding the annual average objective for nitrogen dioxide at the monitoring locations in 2005. At most it is "very likely" that the annual objective will be exceeded at 1 monitoring location. The maximum concentration modelled is 53 $\mu g\ m^{-3}$ therefore; it is at most "possible" that the hourly mean objective for NO_2 will be exceeded. When compared with the monitoring results, the modelling supports the likelihood that the UK annual average objective for NO_2 was exceeded in 2005 at properties close alongside Atholl Street, Main Street, York Place, County Place, Barrack Street, Dunkeld Road and South Street. Predictions for 2010 made on the basis of projecting forward monitoring results indicate that exceedances may still remain in the city centre (see Table 3.1).

Elsewhere, outside of the city centre, it is not predicted likely that the either the NO_2 annual mean or NO_2 hourly mean objective will be exceeded.

Table 4.3 Probability of exceeding the objectives for nitrogen dioxide in 2005 in Perth.

Probability of Exceedance					
X	Y	Site ID	Site Name	Modelled 2005 NO_2 concentration (ug/m3)	Probability of exceeding NO_2 annual average objective
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	26	Very unlikely less than 5%
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	13	Very unlikely less than 5%
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	24	Very unlikely less than 5%
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	13	Very unlikely less than 5%
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	13	Very unlikely less than 5%
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	28	Very unlikely less than 5%
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	19	Very unlikely less than 5%
311059	724394	P20	2 Crieff Road Perth PH1 5RT	29	Unlikely 5-20%
311092	724352	P45	Ballantine Place, Perth PH1 5RR	24	Very unlikely less than 5%
311190	723505	P28	28 York Place Perth PH2 8EH	**49**	Likely 80-95%
311252	723518	P29	37 York Place Perth PH2 8EH	**50**	Likely 80-95%
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	**45**	Probable 50-80%
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**47**	Likely 80-95%
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**48**	Likely 80-95%
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	23	Very unlikely less than 5%
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**52**	Likely 80-95%
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**48**	Likely 80-95%
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	23	Very unlikely less than 5%
311591	723474	P33	216 South Street Perth PH2 8NY	**47**	Likely 80-95%
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**53**	Very likely More than 95%
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**47**	Likely 80-95%
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	34	Possible 20-50%
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	39	Possible 20-50%
311700	723483	P32	135 South St, Perth, PH2 8PA	**50**	Likely 80-95%
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	35	Possible 20-50%
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	36	Possible 20-50%
311917	723465	P31	45-47 South St, Perth, PH2 8PD	38	Possible 20-50%
311930	723414	P35	17 Princes St, Perth, PH2 8NG	20	Very unlikely less than 5%
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	20	Very unlikely less than 5%
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	27	Very unlikely less than 5%
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	**42**	Probable 50-80%
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	**41**	Probable 50-80%
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	**45**	Probable 50-80%
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	26	Very unlikely less than 5%

Predicted exceedances of UK objective or EU Limit Value in **BOLD**

Perth – NO_2 for 2005 with City Centre Management Review

Figure 4.2 shows modelled annual mean nitrogen dioxide concentrations in the area of Perth City Centre in 2005 with the City Centre Management Review in place. The model predicts that the UK annual average objective of 40 $\mu g\ m^{-3}$ for nitrogen dioxide will be exceeded at the façade of buildings at 13 city centre locations, one less than without the CCTMR. Table 4.4 below shows the risk of exceeding the annual average objective for nitrogen dioxide at the monitoring locations in 2005. Again, as without the CCTMR, it is at most "very likely" that the annual objective will be exceeded at 3 monitoring locations. The maximum concentration modelled is higher than for the 2005 Base Case at 54 $\mu g\ m^{-3}$ therefore; it is at most "possible" that the hourly mean objective for NO_2 will be exceeded.

Elsewhere, outside of the city centre, it is not predicted likely that the NO_2 objectives will be exceeded.

CCTMR improvements in air quality are seen in the extent of the exceedance area at the Dunkeld Road/Barrack Street junction and along Kinnoull Street; however, there are still exceedances of the annual NO_2 objective. Other areas of the city centre see increased NO_2 concentrations namely along Caledonian Road and New Row.

Table 4.4 Probability of exceeding the objectives for nitrogen dioxide in 2005 with CCTMR in Perth.

Probability of Exceedance					
X	Y	Site ID	Site Name	Modelled 2005+CCTMR NO_2 concentration (ug/m3)	Probability of exceeding NO_2 annual average objective
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	22	Very unlikely less than 5%
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	13	Very unlikely less than 5%
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	22	Very unlikely less than 5%
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	13	Very unlikely less than 5%
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	13	Very unlikely less than 5%
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	28	Very unlikely less than 5%
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	19	Very unlikely less than 5%
311059	724394	P20	2 Crieff Road Perth PH1 5RT	25	Very unlikely less than 5%
311092	724352	P45	Ballantine Place, Perth PH1 5RR	23	Very unlikely less than 5%
311190	723505	P28	28 York Place Perth PH2 8EH	**53**	Very likely More than 95%
311252	723518	P29	37 York Place Perth PH2 8EH	**52**	Very likely More than 95%
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	**46**	Probable 50-80%
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**46**	Likely 80-95%
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**48**	Likely 80-95%
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	18	Very unlikely less than 5%
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**54**	Very likely More than 95%
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**48**	Likely 80-95%
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	22	Very unlikely less than 5%
311591	723474	P33	216 South Street Perth PH2 8NY	**49**	Likely 80-95%
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**52**	Likely 80-95%
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**47**	Likely 80-95%
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	33	Unlikely 5-20%
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	39	Possible 20-50%
311700	723483	P32	135 South St, Perth, PH2 8PA	**50**	Likely 80-95%
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	35	Possible 20-50%
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	35	Possible 20-50%
311917	723465	P31	45-47 South St, Perth, PH2 8PD	37	Possible 20-50%
311930	723414	P35	17 Princes St, Perth, PH2 8NG	20	Very unlikely less than 5%
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	20	Very unlikely less than 5%
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	27	Very unlikely less than 5%
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	**41**	Probable 50-80%
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	36	Possible 20-50%
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	**45**	Probable 50-80%
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	21	Very unlikely less than 5%

Predicted exceedances of UK objective or EU Limit Value in **BOLD**

Perth – NO_2 2018 with City Centre Management Review and Regional Bridge

Figure 4.3 shows modelled annual average nitrogen dioxide concentrations in the area of Perth City Centre in 2018 with the CCTMR and Regional Bridge in place. The model predicts that the UK annual average objective of 40 $\mu g\ m^{-3}$ for nitrogen dioxide will be exceeded at the façade of buildings at 13 city centre locations, one less than without the CCTMR. Table 4.5 below shows the risk of exceeding the annual average objective for nitrogen dioxide at the monitoring locations in 2005. Again as with 2005 and 2005 with the CCTMR, it is at most "very likely" that the annual objective will be exceeded at 8 monitoring locations. The maximum concentration modelled is higher than both the 2005 Base Case and 2005 with the CCTMR, at 58 $\mu g\ m^{-3}$ therefore; it is at most "possible" that the hourly mean objective for NO_2 will be exceeded for this 2018 scenario.

Elsewhere, outside of the city centre, it is not predicted likely that the NO_2 objectives will be exceeded.

Improvements are seen in the extent of exceedance area along Main Street and Gowrie Street to the east of the city centre as West Bridge Street improves; however, there are still exceedances of the annual NO_2 objective. Other areas of the city centre see increased NO_2 concentrations namely along Caledonian Road and New Row (as with the 2005 CCTMR). The Atholl Street/Caledonian Road junction, along Atholl Street and Kinnoull Street show a widening of all the contours over the annual mean objective, which envelops more properties, increasing the exceedance area.

Table 4.5 Probability of exceeding the objectives for nitrogen dioxide in 2018 with CCTMR and Regional Bridge in Perth.

Probability of Exceedance					
X	Y	Site ID	Site Name	Modelled 2018+CCTMR+Bridge NO_2 concentration (ug/m3)	Probability of exceeding NO_2 annual average objective
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	36	Possible 20-50%
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	11	Very unlikely less than 5%
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	32	Unlikely 5-20%
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	12	Very unlikely less than 5%
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	12	Very unlikely less than 5%
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	26	Very unlikely less than 5%
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	18	Very unlikely less than 5%
311059	724394	P20	2 Crieff Road Perth PH1 5RT	32	Very unlikely less than 5%
311092	724352	P45	Ballantine Place, Perth PH1 5RR	26	Very unlikely less than 5%
311190	723505	P28	28 York Place Perth PH2 8EH	**54**	Very likely More than 95%
311252	723518	P29	37 York Place Perth PH2 8EH	**56**	Very likely More than 95%
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	**52**	Likely 80-95%
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**55**	Very likely More than 95%
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**54**	Very likely More than 95%
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	23	Very unlikely less than 5%
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**55**	Very likely More than 95%
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**53**	Very likely More than 95%
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	24	Very unlikely less than 5%
311591	723474	P33	216 South Street Perth PH2 8NY	**51**	Likely 80-95%
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**58**	Very likely More than 95%
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**52**	Likely 80-95%
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	35	Possible 20-50%
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	**41**	Probable 50-80%
311700	723483	P32	135 South St, Perth, PH2 8PA	**53**	Very likely More than 95%
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	38	Possible 20-50%
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	39	Possible 20-50%
311917	723465	P31	45-47 South St, Perth, PH2 8PD	**41**	Probable 50-80%
311930	723414	P35	17 Princes St, Perth, PH2 8NG	20	Very unlikely less than 5%
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	19	Very unlikely less than 5%
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	23	Very unlikely less than 5%
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	37	Possible 20-50%
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	33	Possible 20-50%
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	39	Possible 20-50%
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	20	Very unlikely less than 5%

Predicted exceedances of UK objective or EU Limit Value in **BOLD**

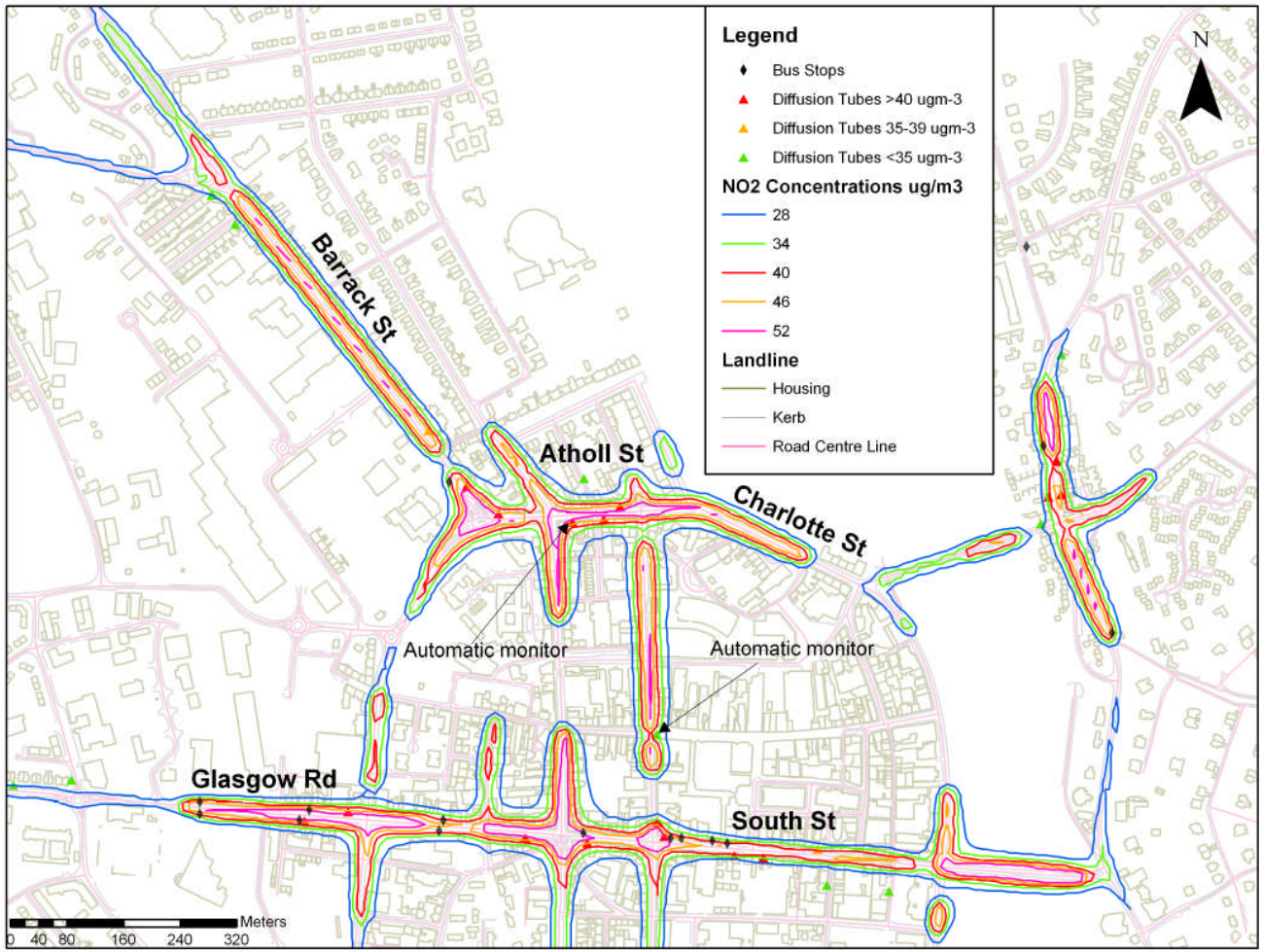

Figure 4.1 Predicted Annual Mean Nitrogen Dioxide concentrations in Perth, 2005.

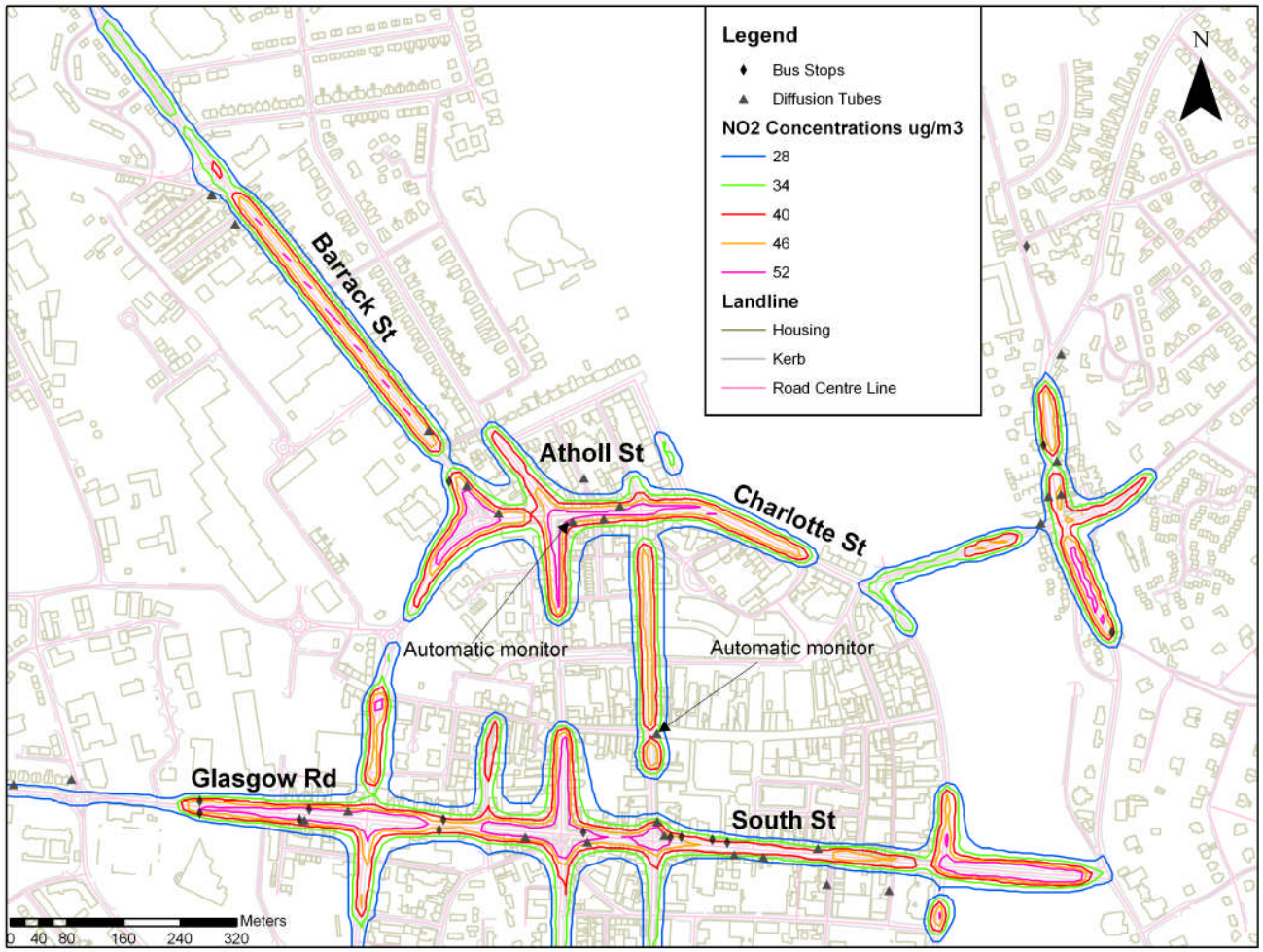

Figure 4.2 Predicted Annual Mean Nitrogen Dioxide concentrations in Perth, 2005 with City Centre Management Review.

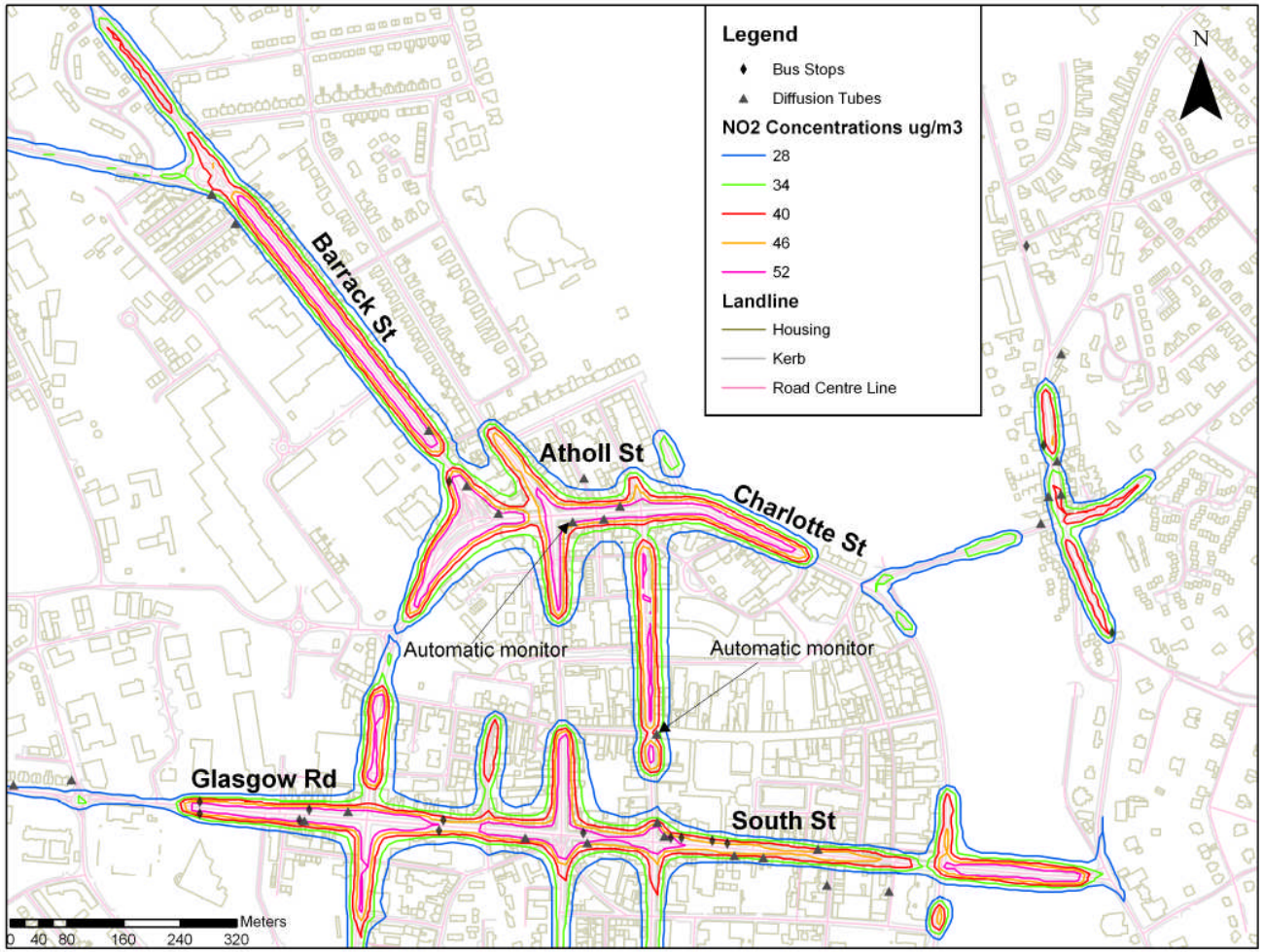

Figure 4.3 Predicted Annual Mean Nitrogen Dioxide concentrations in Perth, 2018 with City Centre Management Review and Regional Bridge.

4.7 SOURCE APPORTIONMENT OF PREDICTED EXCEEDANCES

Source apportionment is the process whereby the contributions from different sources of a pollutant are determined. In local air quality, the relevant sources could include: traffic; local background; industrial and domestic. Contributions from the different types of vehicles (for example, cars, lorries and buses) can also be considered to highlight which class of vehicle is contributing most to the emissions from traffic. Source apportionment allows the most important source or sources to be identified and options to reduce ambient concentrations of pollutants can then be considered and assessed. The concentrations have been calculated using the new traffic emission factors.

The source apportionment should:

- Confirm that exceedances of NO_2 are due to road traffic
- Determine the extent to which different vehicle types are responsible for the emission contributions to NO_2 within predicted areas of exceedance. This will allow traffic management scenarios to be modelled/tested to reduce the exceedances
- Quantify what proportion of the exceedances of NO_2 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 exceedance, or, whether national measures would be a suitable approach to achieving the air quality objectives

Receptors considered

Source apportionment has been considered at those locations in Perth where the model has predicted the highest concentration of NO_2 in 2005 at or near to a relevant receptor. These are points on the 10m x 10m receptor point grid used in the modelling, and have not been necessarily selected owing to their proximity to monitoring points. Figure 3.1 indicates the 8 locations in question:

1. Barrack Street (311284, 724165)
2. Atholl Street 1 (311476, 723942)
3. Melville Street (311521, 723981)
4. North Methven Street (311551, 723902)
5. Atholl Street 2 (311563, 7235949)
6. Main Street (312250, 724070)
7. York Place (311310, 723520)
8. Kinnoull Street (311684, 723676)

Sources of pollution considered

We have considered the effect of the following sources in this assessment at the receptor considered:

- Background concentrations used in the assessment;
- Traffic - Light Duty Vehicles on main roads in the 1 km square local area;
- Traffic - Heavy Goods Vehicles on main roads in the 1 km square local area;
- Traffic - Buses on main roads in the 1 km square local area.

It should be noted that the modelling has explicitly considered traffic on Atholl Street, York Place and Main Street in Perth. Reference in Tables 4.6 to 4.13 to 'traffic' refers to the contribution to pollutant concentrations of these traffic movements. Emissions from traffic movements on other roads in Perth and outside Perth have not been explicitly modelled. However, their contribution to pollutant concentrations in Perth is included in the modelled background concentrations. Background concentrations in Tables 4.6 to 4.13 therefore include further contributions from traffic.

There is a complex relationship between oxides of nitrogen and nitrogen dioxide concentrations. The modelling assumed that the contribution to nitrogen dioxide concentration from road traffic could be estimated by using the relationships provided in LAQM.TG(03) and the AQEG report of 2004 (AQEG(2004)): the same relationships have been applied for source apportionment calculations.

The concentrations apportioned to each source category and the fraction of the total concentrations are shown in Tables 4.6 to 4.13.

Table 4.6: Site 1, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at Barrack Street.

Barrack St (311284 724165) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Car	4.3	8.8%	13.0	9.3%
LGV	1.6	3.3%	4.9	3.5%
HGV rigid	2.8	5.7%	8.4	6.0%
HGV artic	2.0	4.1%	6.1	4.4%
Bus & Coach	2.9	6.0%	8.9	6.4%
Car (queuing)	7.1	14.7%	21.8	15.7%
LGV (queuing)	2.2	4.6%	6.8	4.9%
HGV rigid (queuing)	6.5	13.3%	19.7	14.2%
HGV artic (queuing)	4.6	9.6%	14.2	10.2%
Bus & coach (queuing)	6.6	13.6%	20.1	14.5%
Total traffic free flowing	13.5	27.9%	41.2	29.7%
Total traffic queuing	27.1	55.9%	82.5	59.5%
Total traffic	**40.6**	**84%**	**123.7**	**89%**
Background	**7.8**	**16%**	**15.0**	**11%**
Total	**48.4**	**100%**	**138.7**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.7: Site 2, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at Atholl Street 1.

Atholl St 1 (311476 723942) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Car	4.3	9.2%	12.9	9.9%
LGV	1.5	3.3%	4.6	3.6%
HGV rigid	2.8	5.9%	8.4	6.4%
HGV artic	1.9	4.2%	5.9	4.5%
Bus & Coach	3.5	7.5%	10.6	8.1%
Car (queuing)	6.5	13.9%	19.6	15.0%
LGV (queuing)	2.0	4.4%	6.1	4.7%
HGV rigid (queuing)	5.1	11.0%	15.5	11.9%
HGV artic (queuing)	3.6	7.7%	10.8	8.3%
Bus & coach (queuing)	6.4	13.8%	19.4	14.9%
Total traffic free flowing	14.0	30.1%	42.3	32.5%
Total traffic queuing	23.7	50.8%	71.5	54.9%
Total traffic	**37.7**	**81%**	**113.8**	**87%**
Background	**8.9**	**19%**	**16.3**	**13%**
Total	**46.6**	**100%**	**130.2**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.8: Site 3, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at Melville Street.

Melville St (311521 723981) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Car	0.8	1.8%	2.3	1.9%
LGV	0.3	0.6%	0.8	0.7%
HGV rigid	0.3	0.8%	1.0	0.8%
HGV artic	0.3	0.6%	0.7	0.6%
Bus & Coach	0.7	1.5%	1.9	1.6%
Car (queuing)	8.8	20.1%	25.9	21.9%
LGV (queuing)	2.5	5.8%	7.5	6.3%
HGV rigid (queuing)	5.8	13.3%	17.1	14.4%
HGV artic (queuing)	4.3	9.9%	12.8	10.8%
Bus & coach (queuing)	11.0	25.1%	32.4	27.3%
Total traffic free flowing	2.3	5.2%	6.7	5.7%
Total traffic queuing	32.5	74.3%	95.6	80.8%
Total traffic	**34.8**	**79%**	**102.4**	**86%**
Background	**9.0**	**21%**	**16.0**	**14%**
Total	**43.8**	**100%**	**118.4**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.9: Site 4, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at North Methven Street.

N Methven St (311551 723902) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Car	1.4	2.9%	4.4	3.1%
LGV	0.5	1.0%	1.6	1.1%
HGV rigid	1.5	3.0%	4.5	3.2%
HGV artic	1.1	2.1%	3.3	2.3%
Bus & Coach	1.1	2.2%	3.4	2.4%
Car (queuing)	6.9	14.1%	21.5	15.1%
LGV (queuing)	2.0	4.2%	6.4	4.5%
HGV rigid (queuing)	10.8	21.9%	33.5	23.5%
HGV artic (queuing)	7.7	15.5%	23.8	16.7%
Bus & coach (queuing)	7.7	15.6%	23.9	16.8%
Total traffic free flowing	5.5	11.2%	17.2	12.0%
Total traffic queuing	35.2	71.3%	109.1	76.5%
Total traffic	**40.7**	**83%**	**126.3**	**88%**
Background	**8.6**	**17%**	**16.4**	**12%**
Total	**49.4**	**100%**	**142.7**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.10: Site 5, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at Atholl Street 2.

Atholl St 2 (311563 723949) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Car	2.8	6.6%	8.0	7.2%
LGV	1.0	2.5%	3.0	2.7%
HGV rigid	1.0	2.3%	2.8	2.5%
HGV artic	1.6	3.8%	4.7	4.2%
Bus & Coach	2.4	5.7%	6.9	6.2%
Car (queuing)	6.4	15.2%	18.5	16.7%
LGV (queuing)	2.0	4.8%	5.8	5.2%
HGV rigid (queuing)	3.1	7.3%	8.9	8.0%
HGV artic (queuing)	5.1	12.2%	14.9	13.4%
Bus & coach (queuing)	7.4	17.7%	21.5	19.3%
Total traffic free flowing	8.7	20.9%	25.3	22.9%
Total traffic queuing	24.0	57.2%	69.5	62.7%
Total traffic	**32.7**	**78%**	**94.8**	**86%**
Background	**9.2**	**22%**	**16.0**	**14%**
Total	**41.9**	**100%**	**110.9**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.11: Site 6, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at Main Street.

Main St (312250 724070) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Car	5.3	10.7%	15.9	11.1%
LGV	2.0	4.0%	5.9	4.1%
HGV rigid	3.0	6.0%	9.0	6.3%
HGV artic	2.2	4.5%	6.8	4.7%
Bus & Coach	3.0	6.1%	9.1	6.4%
Car (queuing)	8.0	16.2%	24.2	16.9%
LGV (queuing)	2.5	5.1%	7.5	5.3%
HGV rigid (queuing)	6.3	12.8%	19.1	13.3%
HGV artic (queuing)	4.7	9.6%	14.3	9.9%
Bus & coach (queuing)	6.2	12.6%	18.8	13.1%
Total traffic free flowing	15.5	31.3%	46.7	32.6%
Total traffic queuing	27.7	56.2%	83.9	58.5%
Total traffic	**43.2**	**88%**	**130.6**	**91%**
Background	**6.1**	**12%**	**12.9**	**9%**
Total	**49.4**	**100%**	**143.4**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.12: Site 7, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at York Place.

York Place (311310 723519) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	μg m^{-3}	%	μg m^{-3}	%
Car	1.2	3.6%	3.3	4.1%
LGV	0.5	1.4%	1.3	1.6%
HGV rigid	0.9	2.7%	2.4	3.1%
HGV artic	0.5	1.6%	1.4	1.8%
Bus & Coach	1.0	3.1%	2.9	3.6%
Car (queuing)	3.9	11.6%	10.7	13.4%
LGV (queuing)	1.2	3.7%	3.4	4.2%
HGV rigid (queuing)	4.8	14.5%	13.3	16.7%
HGV artic (queuing)	2.8	8.5%	7.8	9.8%
Bus & coach (queuing)	5.4	16.1%	14.8	18.6%
Total traffic free flowing	4.1	12.3%	11.3	14.2%
Total traffic queuing	18.2	54.3%	50.0	62.6%
Total traffic	**22.3**	**67%**	**61.3**	**77%**
Background	**11.2**	**33%**	**18.5**	**23%**
Total	**33.5**	**100%**	**79.8**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 4.13: Site 8, Perth: Source apportionment of concentrations of NO_2 and NO_x in 2005 at Kinnoull Street.

Kinnoull St (311684 723676) Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	μg m^{-3}	%	μg m^{-3}	%
Car	1.0	2.1%	3.2	2.2%
LGV	0.4	0.7%	1.2	0.8%
HGV rigid	0.8	1.6%	2.4	1.7%
HGV artic	1.1	2.1%	3.4	2.3%
Bus & Coach	1.1	2.3%	3.6	2.5%
Car (queuing)	6.3	12.5%	19.6	13.4%
LGV (queuing)	1.8	3.7%	5.8	3.9%
HGV rigid (queuing)	7.6	15.2%	24.0	16.3%
HGV artic (queuing)	10.4	20.7%	32.7	22.3%
Bus & coach (queuing)	10.7	21.3%	33.6	22.9%
Total traffic free flowing	4.4	8.8%	13.8	9.4%
Total traffic queuing	36.9	73.4%	115.7	78.9%
Total traffic	**41.3**	**82%**	**129.6**	**88%**
Background	**9.0**	**18%**	**17.2**	**12%**
Total	**50.2**	**100%**	**146.7**	**100%**

Figures are rounded to the nearest 1 decimal place

From the above it may be seen that at these locations free-flowing traffic accounts for less than one eighth of the local NOx and NO_2 concentrations, and of this traffic contribution, HDVs account for approximately three quarters.

Queuing traffic accounts for three quarters of the local NO_x and NO_2 concentrations, and of this traffic contribution HDVs account for well over half.

Total HDV traffic, both free flowing and queuing, therefore contributes to over three-fifths to the local NO_2 concentrations.

4.8 CONCLUSIONS AND RECOMMENDATIONS FOR NO_2

NO_2 2005 Base Case

This Further Assessment has confirmed a significant risk of exceedance of the UK annual mean objective for NO_2 in 2005 in central Perth only. Both monitoring and modelling generally indicate that in 2005, for the Base Case, concentrations were above the required concentration at a maximum of 14 monitoring locations in Perth City Centre. At one monitoring location it is possible that the hourly NO_2 objective was exceeded.

NO_2 2005 with the CCTMR

This Further Assessment has confirmed a significant risk of exceedance of the UK annual mean objective for NO_2 in 2005, with the CCTMR in place, in central Perth only. Modelling generally indicates that in 2005, with the CCTMR in place, concentrations were above the required concentration at a maximum of 13 monitoring locations in Perth City Centre. At 3 monitoring locations it is possible that the hourly NO_2 objective was exceeded.

NO_2 2010

Concentrations in 2010, based on 2005 projected forward traffic data, are predicted to be lower, although the EU Limit Value for annual mean NO_2 may still be exceeded at these city centre locations in that year.

NO_2 2018

Modelling for 2018 with City Centre Management Review and Regional Bridge in place showed that again 13 monitoring locations would exceed the annual mean objective. The number of monitoring locations predicting a possible exceedance of the hourly mean is predicted to increase from 3 in 2005 with the CCTMR to 8 by 2018.

NO_2 Source apportionment

Results for 2005 indicate that at the locations of highest predicted roadside concentrations, free-flowing traffic accounts for less than one eighth of the local NOx and NO_2 concentrations, and of this traffic contribution, HDVs account for approximately three quarters. Queuing traffic accounts for three quarters of the local NO_x and NO_2 concentrations, and of this traffic contribution HDVs account for well over half. Total HDV traffic, both free flowing and queuing, therefore contributes to over three-fifths to the local NO_2 concentrations. Reductions in HDV queuing and congestion are therefore likely to lead to a significant reduction in roadside NOx and NO_2.

NO_2 Recommendations

It is therefore recommended that Perth and Kinross Council retain their city wide air quality management area for NO_2, and proceed with preparation of their action plan to reduce NO_2 concentrations in this area. Perth and Kinross Council should continue to monitor at this location.

5 PM_{10}

Airborne PM_{10} varies widely in its physical and chemical composition, source and particle size. Particles are often classed as either primary (those emitted directly into the atmosphere) or secondary (those formed or modified in the atmosphere from condensation and growth). PM_{10} particles (the fraction of particulates in air of very small size, <10 µm aerodynamic diameter) can potentially pose significant health risks, as they are small enough to penetrate deep into the lungs. Larger particles are not readily inhaled.

A major source of fine primary particles is combustion processes, in particular diesel combustion, where transport of hot exhaust vapour into a cooler tailpipe or stack can lead to spontaneous nucleation of "carbon" particles before emission. Secondary particles are typically formed when low volatility products are generated in the atmosphere, for example the oxidation of sulphur dioxide to sulphuric acid. The atmospheric lifetime of PM_{10} is strongly related to particle size, but may be as long as 10 days for particles of about 1 µm in diameter.

Concern about the potential health impacts of PM_{10} has increased very rapidly over recent years. Increasingly, attention has been turning towards monitoring the smaller particle fraction, $PM_{2.5}$, which is capable of penetrating deepest into the lungs, or to even smaller size fractions or total particle numbers.

5.1 LATEST STANDARDS AND OBJECTIVES FOR PM_{10}

The Air Quality Regulations, 1997 set the objective for PM_{10} particulate material of 50 µg m^{-3}, measured as the 99th percentile of the daily maximum running 24 hour mean (equivalent to 4 exceedences per year) to be achieved by 31 December 2005. The objective was based on measurements carried out using the TEOM analyser, or equivalent.

The Government published its proposals for review of the National Air Quality Strategy in early 1999 (DETR, 1999). The review presented proposals for revised and additional objectives for PM_{10}. Revised objectives for PM_{10} were proposed because:

- work carried out by the Airborne Particles Expert Group (APEG) indicated that the original objective was unrealistic;
- the Common Position agreed on the Air Quality Daughter Directive (AQDD) at Environment Council in June 1998 included different objectives for PM_{10}.

These included a 24 hour limit value of 50 µg m^{-3}, not to be exceeded more than 35 times per year and an annual limit of 40 µg m^{-3} to be achieved by 1 January 2005 (EU Stage 1 objectives). The AQDD specifies that the transfer reference method for determining compliance is to be a gravimetric[3] measuring method.

The Air Quality Strategy replaced the original objective for PM_{10} with the AQDD objectives. The current objectives to be achieved in Scotland are:

- An annual average concentration of 40 µg m^{-3} (gravimetric);
- By 2010 an annual average concentration of 18 µg m^{-3} (gravimetric);
- A 24 hour mean concentration of 50 µg m^{-3} (gravimetric) not to be exceeded more than 35 times a year in 2004, and 7 times by 2010.

5.2 THE NATIONAL PERSPECTIVE

National UK emissions of primary PM_{10} have been estimated as totalling 184,000 tonnes in 1997. Of this total, around 25% were derived from road transport sources. It should be noted that, in general, the emissions estimates for PM_{10} are less accurate than those for the other pollutants with prescribed objectives, especially for sources other than road transport.

[3] Comparison of UK monitoring data determined with TEOM instruments with the European Union Directive limit values is not straightforward since the EU limits are based on measurements of PM_{10} by other instrumental techniques which yield higher concentrations (APEG, 1999).

The Government established the Airborne Particles Expert Group (APEG) to advise on sources of PM_{10} in the UK and current and future ambient concentrations. Their conclusions were published in January 1999 (APEG, 1999). APEG concluded that a significant proportion of the current annual average PM_{10} is due to the secondary formation of particulate sulphates and nitrates, resulting from the oxidation of sulphur and nitrogen oxides. These are regional scale pollutants and the annual concentrations do not vary greatly over a scale of tens of kilometres. There are also natural or semi-natural sources such as wind-blown dust and sea salt particles. The impact of local urban sources is superimposed on this regional background. Such local sources are generally responsible for winter episodes of hourly mean concentrations of PM_{10} above 100 µg m^{-3} associated with poor dispersion. However, it is clear that many of the sources of PM_{10} are outside the control of individual local authorities and the estimation of future concentrations of PM_{10} are in part dependent on predictions of the secondary particle component.

5.3 Monitoring Data

TEOM
The particle analyser used to measure PM_{10} concentration is a Rupprecht & Patashnick (R&P) Tapered Element Oscillating Microbalance (TEOM). It provides measurements in real time which are recorded on the datalogger. The system measures PM_{10} concentration by continuously determining the particle mass deposited on a filter. The filter is attached to a hollow tapered element that vibrates at its natural frequency of oscillation. As particles collect on the filter, the frequency changes by an amount inversely proportional to the square root of the mass deposited. This analyser is typical of the type used in the AURN.

Table 5.1 shows the measured concentrations during this period. These data are provisional from 01/07/2005 and may be subject to further quality control. The results of the automatic monitoring in Perth indicate that at both roadside automatic monitors, PM_{10} concentrations recorded at these sites have met the 2004 annual mean objective of 40 µg m^{-3}. Results suggest that as regards the 2004 UK daily objective, the daily mean will not exceed 50 µg m^{-3} more than the 35 times set for the objective. By 2010, annual mean concentrations are likely to have declined to levels close to the 18 µg m^{-3} concentration for 2010 set for Scotland, and the daily mean objective for 2010 is also unlikely to be exceeded in that year.

The location of the automatic TEOM PM_{10} monitor is shown in Figure 3.1.

Automatic Monitoring

Table 5.1 shows the measured concentrations in 2005.

Table 5.1 Summary of continuous PM_{10} ratified data 2005 for High Street and Atholl Street Automatic TEOM PM_{10} Monitors

High Street - Statistic	Year 2005	Estimate of Year 2010
Annual Mean PM_{10} (µg m^{-3})	18	16
Number of Days over 50 µg m^{-3}	1	-
Data Capture (%) PM_{10}	99.2%	-

Atholl Street - Statistic	Year 2005	Estimate of Year 2010
Annual Mean PM_{10} (µg m^{-3})	25	20
Number of Days over 50 µg m^{-3}	4	-
Data Capture (%) PM_{10}	98%	-

* Estimated following the methodology in TG(03)
TEOM measurements corrected by factor of 1.3 to estimate µg/m^3 (Gravimetric)

6 Further Assessment for PM_{10}

This further assessment has been undertaken by means of computer dispersion modelling validated using diffusion tube monitoring. The locations at which detailed modelling was carried out are Perth City Centre focusing on Atholl Street and South Street and AQMA wide modelling was also completed.

6.1 METEOROLOGICAL DATA

Hourly sequential meteorological data for the nearest suitable meteorological station with adequate data capture; Leuchars near St. Andrews, some 29 miles northeast of Perth, was obtained for 2005. The meteorological data provided information on wind speed and direction and the extent of cloud cover for each hour of 2005.

6.2 TRAFFIC MODELLING SUMMARY

In this study, the concentrations of PM_{10} at receptors close to the roads and junctions of interest have been modelled using ADMS-3.3 as a dispersion kernel model.

The roads were defined as volume sources, 3m deep, and were broken up in to a series of adjoining segments. The length of these segments was dictated by the way in which the OS LandLine data was digitised and varied from one or two metres in length (where the road rapidly changed direction) to hundreds of metres in length (where the road was essentially straight). The OS LandLine data was used to provide the co-ordinates of the centre line of the road, and the road widths. Therefore, the position of the volume sources (here the roads) were accurate to approximately a metre.

Where queuing of vehicles was reported, emissions from stationary vehicles exhausts were estimated on the basis that the engine power output and hence emissions were the same as those at a speed of 5 kph. Queuing vehicles were assumed to be 5 m apart.

6.3 SOURCES OF BACKGROUND (NON-TRAFFIC) EMISSIONS DATA

Background emissions of oxides of PM_{10} from sources not modelled in detail have been taken from the UK National Atmospheric Emissions Inventory 2004 (www.naei.org.uk) and scaled to the year of interest where necessary following the recommended procedure in LAQM. TG(03). The contribution to emissions from the roads modelled in detail have been omitted where this would lead to double counting of the local impact of emissions.

6.4 MODEL BIAS AND VERIFICATION

For PM_{10} the LADSUrban model does not include background, this has to be added either from the background maps or using the automatic monitoring available. The average background difference of 18 $\mu g\ m^{-3}$ between the 2 automatic monitors and the model was used and added as background to the modelling results. This gave good agreement, with the model under predicting at Atholl Street by 9% and overpredicting at the High Street automatic monitor by 12% (Table 6.1). In comparison, the background PM_{10} maps gave a concentration of 15 $\mu g\ m^{-3}$ for 2005 for Perth. As the model results now includes both roads and background, the added fixed background of 18 $\mu g\ m^{-3}$ may therefore report an additional component of local urban background resulting from the relatively high rise nature of the town.

Table 6.1: Comparison of modelled and measured concentrations for 2005 (Base Case)

Monitoring Site	Type	Location	With 15 $\mu g\ m^{-3}$ for background			With 18 $\mu g\ m^{-3}$ for background		
			% Error of model relative to monitor	PM_{10} concentration, $\mu g\ m^{-3}$ (gravimetric)		% Error of model relative to monitor	PM_{10} concentration, $\mu g\ m^{-3}$ (gravimetric)	
				Modelled	Measured		Modelled	Measured
Automatic	R	High Street	-5	17	18	12	20	18
Automatic	R	Atholl Street	-21	20	25	-9	23	25

R - Roadside

6.5 MODEL VALIDATION

In simple terms, model validation is where the model is tested at a range of locations and is judged suitable to use for a given application. The modelling approach used in this assessment has been validated, and used in numerous AEA Energy & Environment air quality review and assessments. Statistical techniques have been used to assess the likelihood that there will be an exceedance of the air quality objectives given the modelled concentration. The validation statistics are given in Appendix 3. Confidence limits for the predicted concentrations were calculated based on the validation studies by applying statistical techniques based on Student's t distribution. The confidence limits took account of uncertainties resulting from:

- Model errors at the receptor site;
- Model errors at the reference site;
- Uncertainty resulting from year to year variations in atmospheric conditions.

The confidence limits have been used to estimate the likelihood of exceeding the objectives at locations close to the roads. The following descriptions have been assigned to levels of risk of exceeding the objectives.

It would be recommended that Perth and Kinross Council generally consider declaring an AQMA where the probability of exceedance in 2005 or 2010 is greater than 50% ("Probable").

Table 6.2: Uncertainties in the modelled concentrations for PM_{10} in 2004

Description	Chance of exceeding daily objective for 2005	Predicted number of days PM_{10} over 50 $\mu g/m^3$ gravimetric
Very unlikely	Less than 5%	<12
Unlikely	5-20%	12-24
Possible	20-50%	24-35
Probable	50-80%	35-50
Likely	80-95%	50-73
Very likely	More than 95%	>73

Table 6.3: Uncertainties in the modelled concentrations for PM_{10} in 2010

Description	Chance of exceeding annual mean objective for 2010	Modelled annual average PM_{10} ($\mu g/m^3$ gravimetric)
Very unlikely	Less than 5%	<11
Unlikely	5-20%	11-15
Possible	20-50%	15-18
Probable	50-80%	18-21
Likely	80-95%	21-25
Very likely	More than 95%	>25

The confidence limits for the 'probable' and 'likely' daily objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedances of the PM_{10} objectives since a greater geographical area will be included using the smaller confidence intervals.

6.6 RESULTS OF MODELLING

PM_{10} – 2005 Base Case (BC)

2004 Annual Mean Objective

Figure 6.1 shows modelled annual mean PM_{10} concentrations in the area of central Perth in 2005. The model predicts that the UK 2004 annual average objective of 40 $\mu g\ m^{-3}$ for PM_{10} will not be exceeded in the city centre or city wide AQMA as the model predicts a maximum concentration of 24 $\mu g\ m^{-3}$ at a relevant receptor. When compared with the automatic monitor's annual means (Table 5.1), the monitoring supports the likelihood that the 2004 annual average objective for PM_{10} was not exceeded in 2005.

2004 Daily Mean Objective

Figure 6.2 shows modelled number of days exceeding 50 $\mu g\ m^{-3}$ in the area of central Perth. The model predicts that the UK 2004 daily mean objective not to be exceeded more than 35 times a year will not be exceeded in the AQMA as the model predicts a maximum number of days of 10 at a relevant receptor. It is at most "very unlikely" that the daily mean objective will be exceeded at all of the 2005 monitoring locations. When compared with the automatic monitors' number of days over 50 $\mu g\ m^{-3}$ (Table 5.1), the monitoring supports the likelihood that the 2004 daily mean objective for PM_{10} was not exceeded in 2005.

PM_{10} – 2005 with CCTMR

2004 Annual Mean Objective

Figure 6.3 shows the annual mean PM_{10} concentrations in the area of central Perth in 2005 with the CCTMR in place. Again, like the 2005 BC modelling, the model predicts that 2004 UK annual mean objective for PM_{10} will not be exceeded at any location in Perth in this year.

2004 Daily Mean Objective

Figure 6.4 the daily mean modelled PM_{10} concentrations in the area of central Perth in 2005 with the CCTMR in place. Again, like the 2005 BC modelling, the model predicts that the 2004 UK daily mean objective for PM_{10} will not be exceeded at any location in Perth in this year.

Impact of measures

The CCTMR slightly reduces pollutant concentrations in the northeast of Perth City Centre and reduces the extent of the 22 $\mu g\ m^{-3}$ concentration at the Barrack Street/Dunkeld Road. For the daily mean objective, the CCTMR improves Kinnoull Street by reducing the extent of the 7 days over 50 $\mu g\ m^{-3}$, but reveals increased concentrations at the Glasgow Road/ Caledonian Road junction.

PM_{10} – 2010

2010 Annual Mean Objective

Figure 6.5 shows modelled annual mean PM_{10} concentrations in the central Perth area in 2010. The model predicts that the more stringent 2010 annual mean objective of 18 $\mu g\ m^{-3}$ for Scotland will be exceeded in the city centre only, with the model predicting a maximum of 20 $\mu g\ m^{-3}$ at a relevant receptor. It is at most "probable" that the 2010 annual mean objective will be exceeded (Table 6.4).

2010 Daily Mean Objective

There are no exceedances of the number of days over 50 $\mu g\ m^{-3}$ predicted; therefore no map has been displayed. The maximum number of days over 50 $\mu g\ m^{-3}$ predicted for 2010 is 3 at a relevant receptor.

PM_{10} – 2010 with CCTMR

2010 Annual Mean Objective

Figure 6.6 shows modelled annual mean PM_{10} concentrations in the central Perth area in 2010 with the CCTMR in place. The model predicts that the more stringent 2010 annual mean objective of 18 $\mu g\ m^{-3}$ for Scotland will be exceeded in the city centre only, with the model predicting a maximum of 20 $\mu g\ m^{-3}$ at a relevant receptor. It is at most "probable" that the 2010 annual mean objective will be exceeded (Table 6.5).

2010 Daily Mean Objective

There are no exceedances of the daily mean objective predicted; therefore no map has been displayed. The maximum number of days over 50 $\mu g\ m^{-3}$ predicted for 2010 is 3 at a relevant receptor.

PM_{10} – 2018 with CCTMR and Regional Bridge

2010 Annual Mean Objective

Figure 6.7 shows modelled annual mean PM_{10} concentrations in central Perth in 2018 with the CCTMR and Regional Bridge in place. The model predicts that the Scottish 2010 annual mean objective of 18 $\mu g\ m^{-3}$ will be exceeded in the city centre only, with the model predicting a maximum concentration of 23 $\mu g\ m^{-3}$ at a relevant receptor. It is at most "likely" that the 2010 annual objective will be exceeded (Table 6.6).

2010 Daily Mean Objective

Figure 6.8 shows modelled number of days exceeding 50 $\mu g\ m^{-3}$ in central Perth. The model predicts that the 2010 daily mean objective not to be exceeded more than 7 times a year for Scotland will be slightly exceeded in the city centre, with the model predicting a maximum number of 8 days at a relevant receptor.

Impact of measures

The Regional Bridge improves the PM_{10} concentration across the AQMA, compared to 2005, with only the city centre now showing exceedances of both 2010 objectives. 22 out of the 34 2005 monitoring locations are predicted to be at most "likely" to exceed the 2010 PM_{10} annual mean objective (Table 6.6).

Table 6.4 Probability of exceeding the 2010 annual mean objective for PM_{10} in Perth for 2010.

Probability of Exceedance					
X	Y	Site ID	Site Name	2010 PM_{10} Annual Mean	Probability of exceeding 2010 PM_{10} annual mean objective
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	17	Possible 20-50%
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	16	Possible 20-50%
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	17	Possible 20-50%
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	16	Possible 20-50%
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	16	Possible 20-50%
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	17	Possible 20-50%
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	17	Possible 20-50%
311059	724394	P20	2 Crieff Road Perth PH1 5RT	**18**	Possible 20-50%
311092	724352	P45	Ballantine Place, Perth PH1 5RR	17	Possible 20-50%
311190	723505	P28	28 York Place Perth PH2 8EH	**19**	Probable 50-80%
311252	723518	P29	37 York Place Perth PH2 8EH	**19**	Probable 50-80%
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	**19**	Probable 50-80%
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**19**	Probable 50-80%
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**19**	Probable 50-80%
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	17	Possible 20-50%
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**19**	Probable 50-80%
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**19**	Probable 50-80%
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	17	Possible 20-50%
311591	723474	P33	216 South Street Perth PH2 8NY	**19**	Probable 50-80%
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**20**	Probable 50-80%
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**19**	Probable 50-80%
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	**18**	Possible 20-50%
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	**18**	Probable 50-80%
311700	723483	P32	135 South St, Perth, PH2 8PA	**19**	Probable 50-80%
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	**18**	Possible 20-50%
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	**18**	Possible 20-50%
311917	723465	P31	45-47 South St, Perth, PH2 8PD	**18**	Probable 50-80%
311930	723414	P35	17 Princes St, Perth, PH2 8NG	17	Possible 20-50%
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	17	Possible 20-50%
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	17	Possible 20-50%
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	**19**	Probable 50-80%
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	**19**	Probable 50-80%
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	**19**	Probable 50-80%
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	17	Possible 20-50%

Figures in bold show predicted exceedances of the annual average objective

Table 6.5 Probability of exceeding the 2010 annual mean objective for PM_{10} in Perth for 2010 with CCTMR.

Probability of Exceedance					
X	Y	Site ID	Site Name	2010+CCTMR PM_{10} Annual Mean	Probability of exceeding 2010 PM_{10} annual mean objective
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	17	Possible 20-50%
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	16	Possible 20-50%
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	17	Possible 20-50%
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	16	Possible 20-50%
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	16	Possible 20-50%
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	17	Possible 20-50%
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	17	Possible 20-50%
311059	724394	P20	2 Crieff Road Perth PH1 5RT	17	Possible 20-50%
311092	724352	P45	Ballantine Place, Perth PH1 5RR	17	Possible 20-50%
311190	723505	P28	28 York Place Perth PH2 8EH	**19**	Probable 50-80%
311252	723518	P29	37 York Place Perth PH2 8EH	**19**	Probable 50-80%
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	**19**	Probable 50-80%
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**19**	Probable 50-80%
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**19**	Probable 50-80%
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	17	Possible 20-50%
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**19**	Probable 50-80%
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**19**	Probable 50-80%
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	17	Possible 20-50%
311591	723474	P33	216 South Street Perth PH2 8NY	**19**	Probable 50-80%
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**20**	Probable 50-80%
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**19**	Probable 50-80%
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	**18**	Possible 20-50%
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	**18**	Possible 20-50%
311700	723483	P32	135 South St, Perth, PH2 8PA	**19**	Probable 50-80%
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	**18**	Possible 20-50%
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	**18**	Possible 20-50%
311917	723465	P31	45-47 South St, Perth, PH2 8PD	**18**	Possible 20-50%
311930	723414	P35	17 Princes St, Perth, PH2 8NG	17	Possible 20-50%
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	17	Possible 20-50%
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	17	Possible 20-50%
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	**19**	Probable 50-80%
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	**18**	Probable 50-80%
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	**19**	Probable 50-80%
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	17	Possible 20-50%

Figures in bold show predicted exceedances of the annual average objective

Table 6.6 Probability of exceeding the 2010 annual mean objective for PM_{10} in Perth for the 2018 Scenario (with CCTMR and Regional Bridge).

Probability of Exceedance					
X	Y	Site ID	Site Name	2018+CCTMR+Bridge PM_{10} Annual Mean	Probability of exceeding 2010 PM_{10} annual average objective
308289	724892	P47	5 East Huntingtower, Perth, PH1 3JJ	**18**	Probable 50-80%
308924	724287	P7	257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	16	Possible 20-50%
309327	724878	P46	204 A Crieff Rd, Perth, PH1 2PE	**18**	Possible 20-50%
310509	725767	P6	41 Mull Place, Perth, PH1 3DP	16	Possible 20-50%
310646	722783	P3 L, P3 R	15 Murray Cres, Perth, PH2 0HU	16	Possible 20-50%
310778	723556	P36	51 Glasgow Rd, Perth, PH2 0PE	17	Possible 20-50%
310860	723563	P37	Riggs Rd, Perth, PH1 1PR	16	Possible 20-50%
311059	724394	P20	2 Crieff Road Perth PH1 5RT	**18**	Probable 50-80%
311092	724352	P45	Ballantine Place, Perth PH1 5RR	17	Possible 20-50%
311190	723505	P28	28 York Place Perth PH2 8EH	**21**	Likely 80-95%
311252	723518	P29	37 York Place Perth PH2 8EH	**22**	Likely 80-95%
311366	724059	P19	St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	**21**	Likely 80-95%
311420	723980	P44 L, P44 R	22 Barrack St, Perth, PH1 5RD	**22**	Likely 80-95%
311465	723941	P41 L, P41 R	76 Atholl St, Perth, PH1 5NL	**22**	Likely 80-95%
311492	721849	P48	30 Edinburgh Rd, Perth, PH2 8BX	17	Possible 20-50%
311503	723481	P34 L, P34 R	10 County Place, Perth, PH2 8EE	**22**	Likely 80-95%
311570	723929	P61L, P61 C, P61 R	Atholl St, Perth real time monitor	**22**	Likely 80-95%
311586	723991	P5 L, P5 R	8 Stormont St, Perth, PH1 5NW	17	Possible 20-50%
311591	723474	P33	216 South Street Perth PH2 8NY	**21**	Probable 50-80%
311614	723933	P43 L, P43 C, P43 R	17 Atholl St, Perth, PH1 5NH	**23**	Likely 80-95%
311637	723951	P42	26-28 Atholl St, Perth, PH1 6NP	**21**	Likely 80-95%
311689	723628	P54L, P54 C, P54 R	Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	**18**	Probable 50-80%
311690	723503	P1 L, P1 C, P1 R	42 Scott St, Perth, PH1 5PH	**19**	Probable 50-80%
311700	723483	P32	135 South St, Perth, PH2 8PA	**21**	Likely 80-95%
311799	723456	P30 L, P30 C, P30 R	104 South St, Perth, PH2 8PA	**19**	Probable 50-80%
311840	723453	P13 L, P13 R	86/88 South Street Perth PH2 8PD	**19**	Probable 50-80%
311917	723465	P31	45-47 South St, Perth, PH2 8PD	**19**	Probable 50-80%
311930	723414	P35	17 Princes St, Perth, PH2 8NG	17	Possible 20-50%
312018	723405	P2	17 Speygate, Perth, PH2 8PJ	16	Possible 20-50%
312233	723927	P51	2 West Bridge St, Bridgend, Perth, PH2 7HA	17	Possible 20-50%
312244	723965	P40 L, P40 R	18 Main St, Bridgend, PH2 7HB	**19**	Probable 50-80%
312256	724015	P39 L, P39 R	39 Main St, Bridgend, PH2 7HD	**18**	Probable 50-80%
312262	723968	P14 L, P14 C, P14 R	9 Main St, Bridgend, Perth, PH2 7HD	**19**	Probable 50-80%
312262	724167	P38	93-109 Main St Bridgend, PH2 7HE	17	Possible 20-50%

Figures in bold show predicted exceedances of the annual average objective

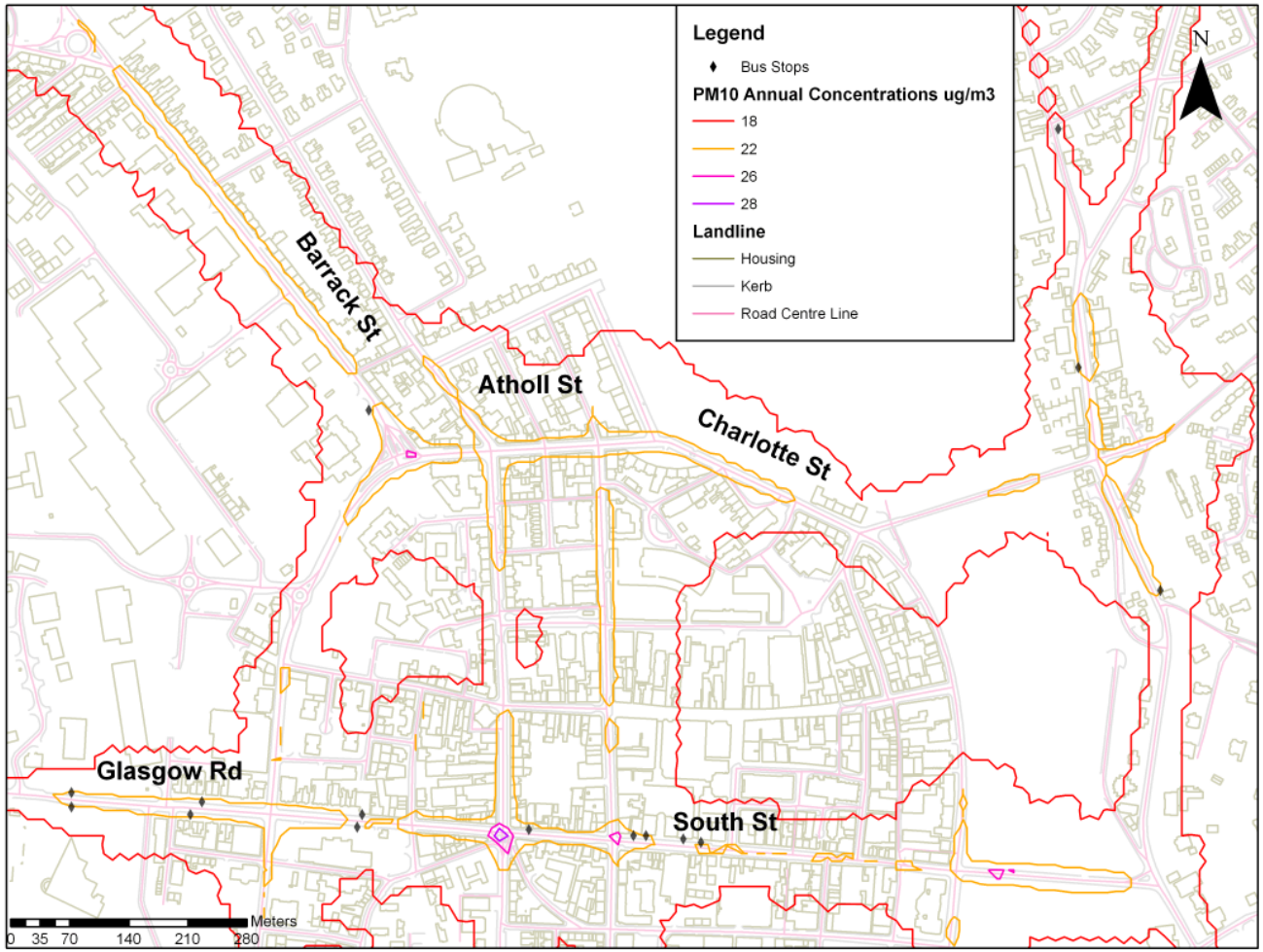

Figure 6.1 Predicted Annual Mean PM_{10} concentrations for Perth City Centre, 2005.

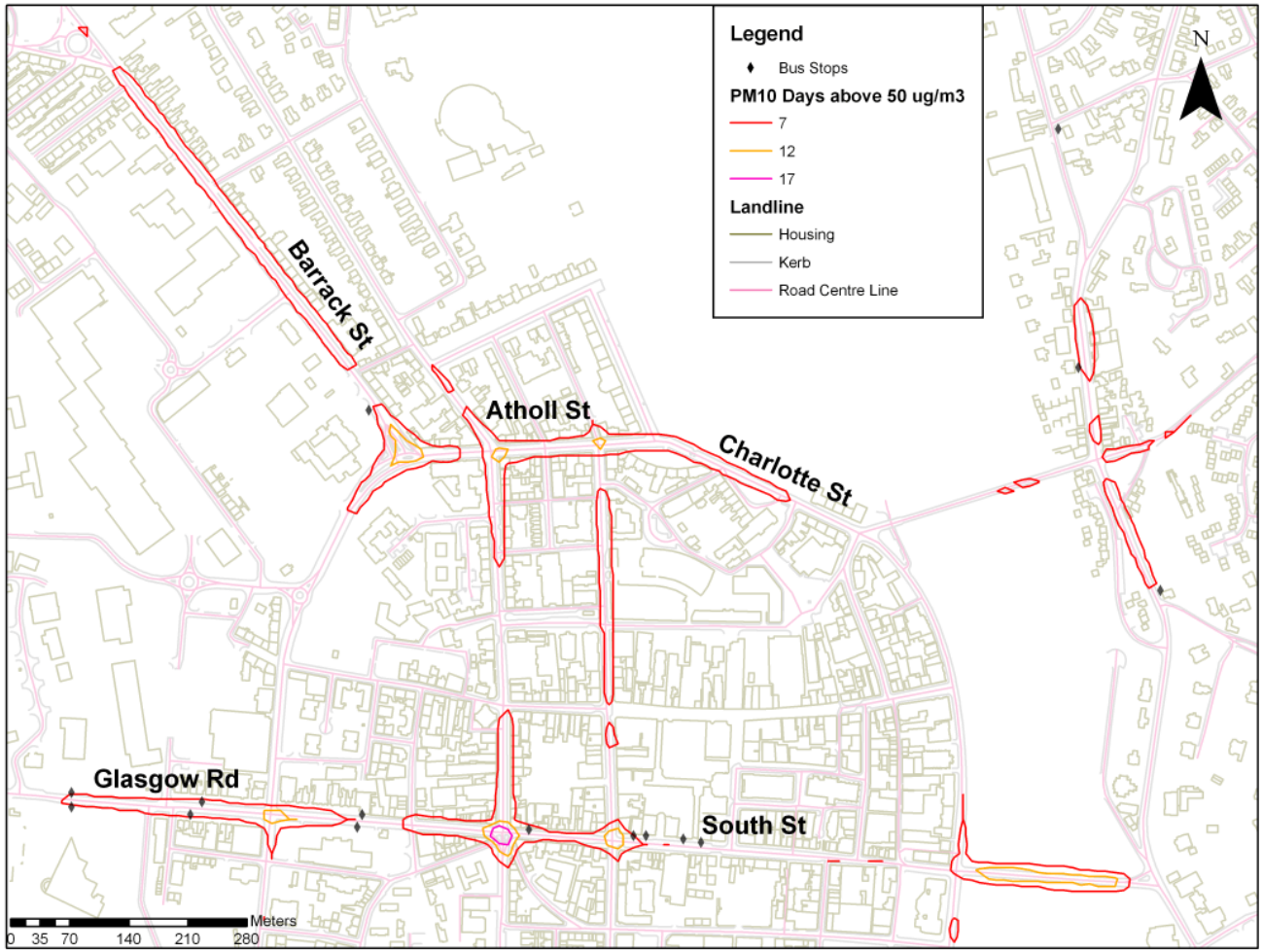

Figure 6.2 Predicted Number of Days Exceeding Daily Mean PM_{10} objective concentrations for Perth City Centre, 2005.

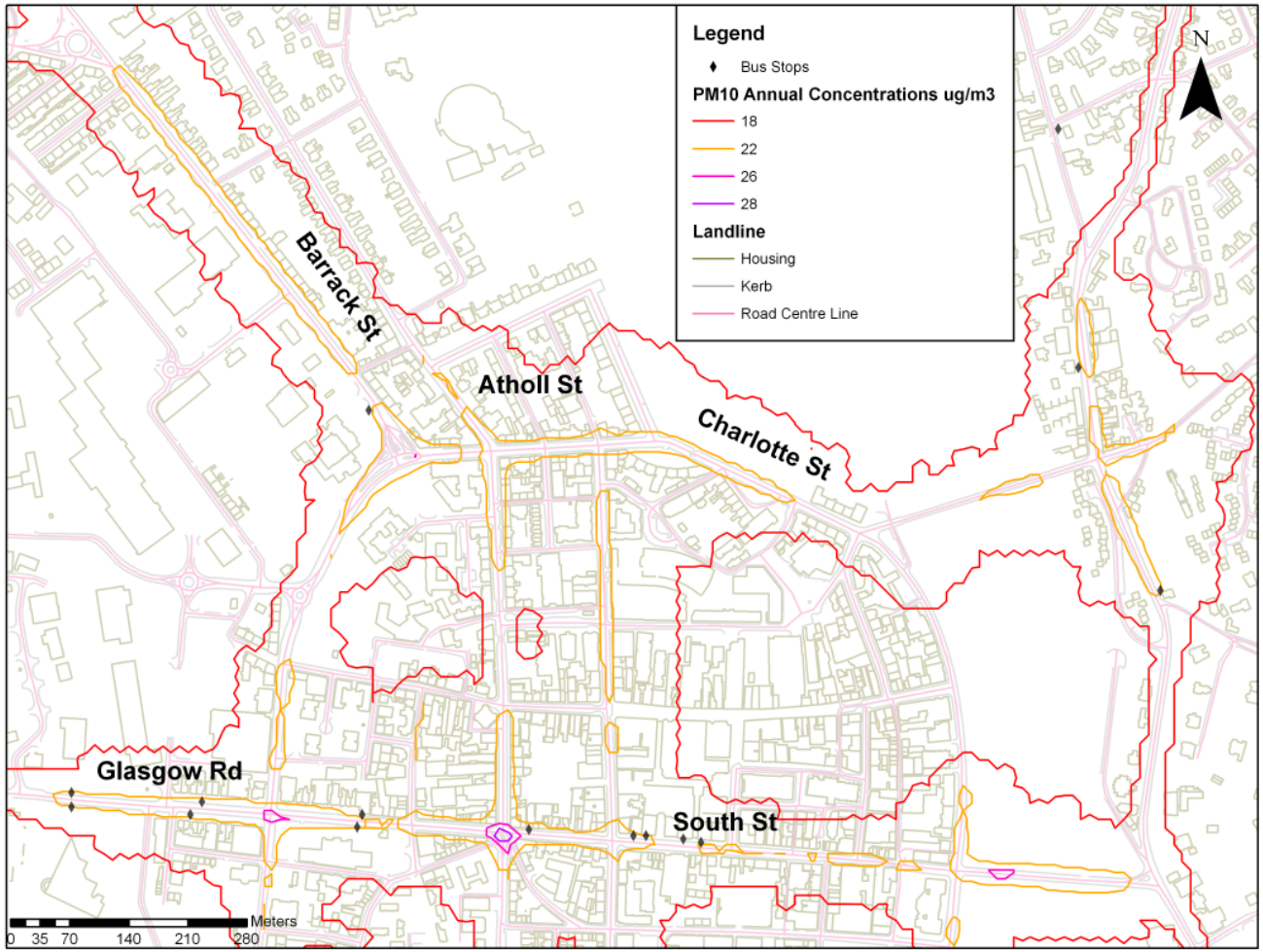

Figure 6.3 Predicted Annual Mean PM_{10} concentrations for Perth City Centre, 2005 with City Centre Management Review.

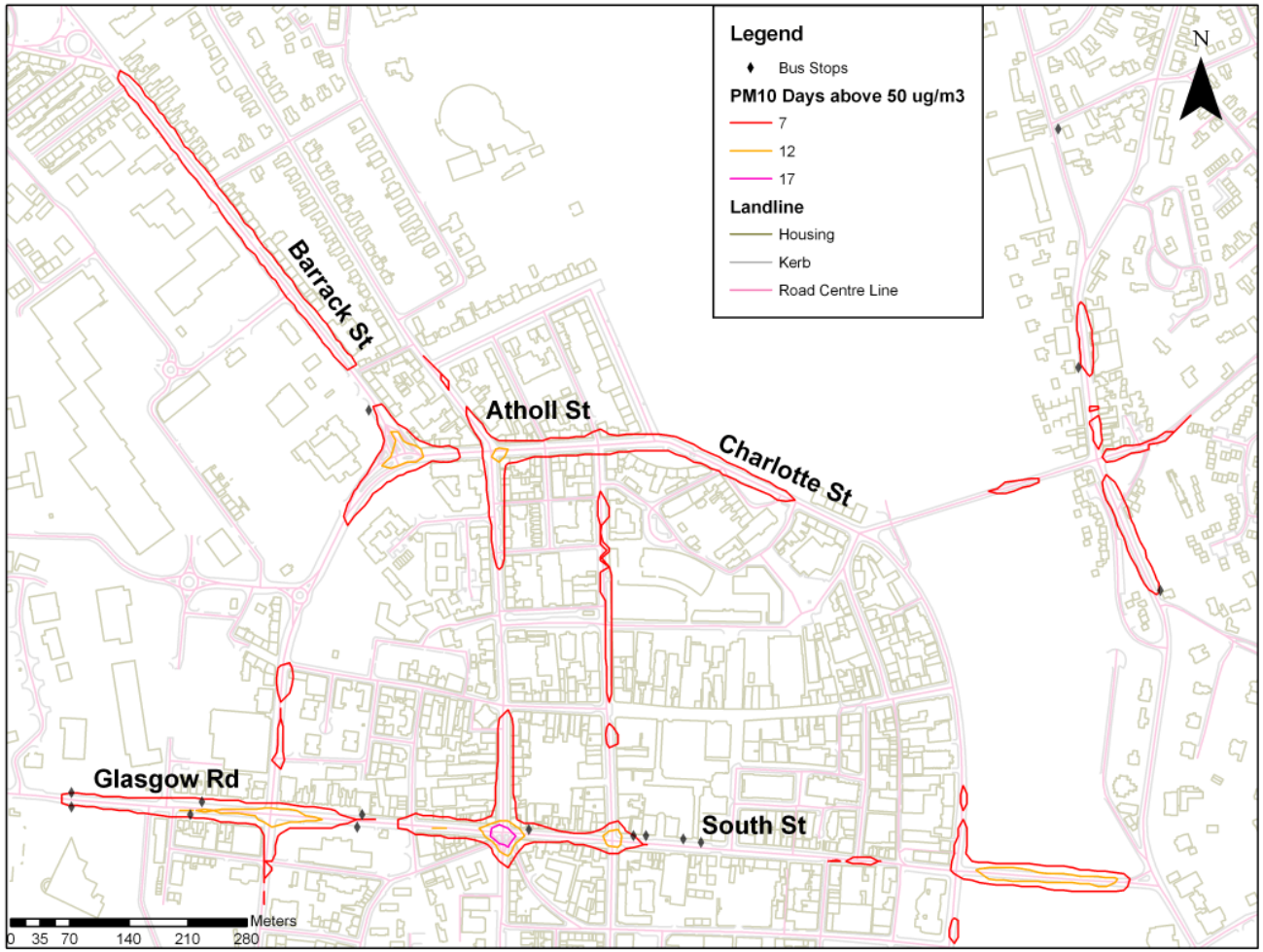

Figure 6.4 Predicted Number of Days Exceeding Daily Mean PM_{10} objective concentrations for Perth City Centre, 2005 with City Centre Management Review.

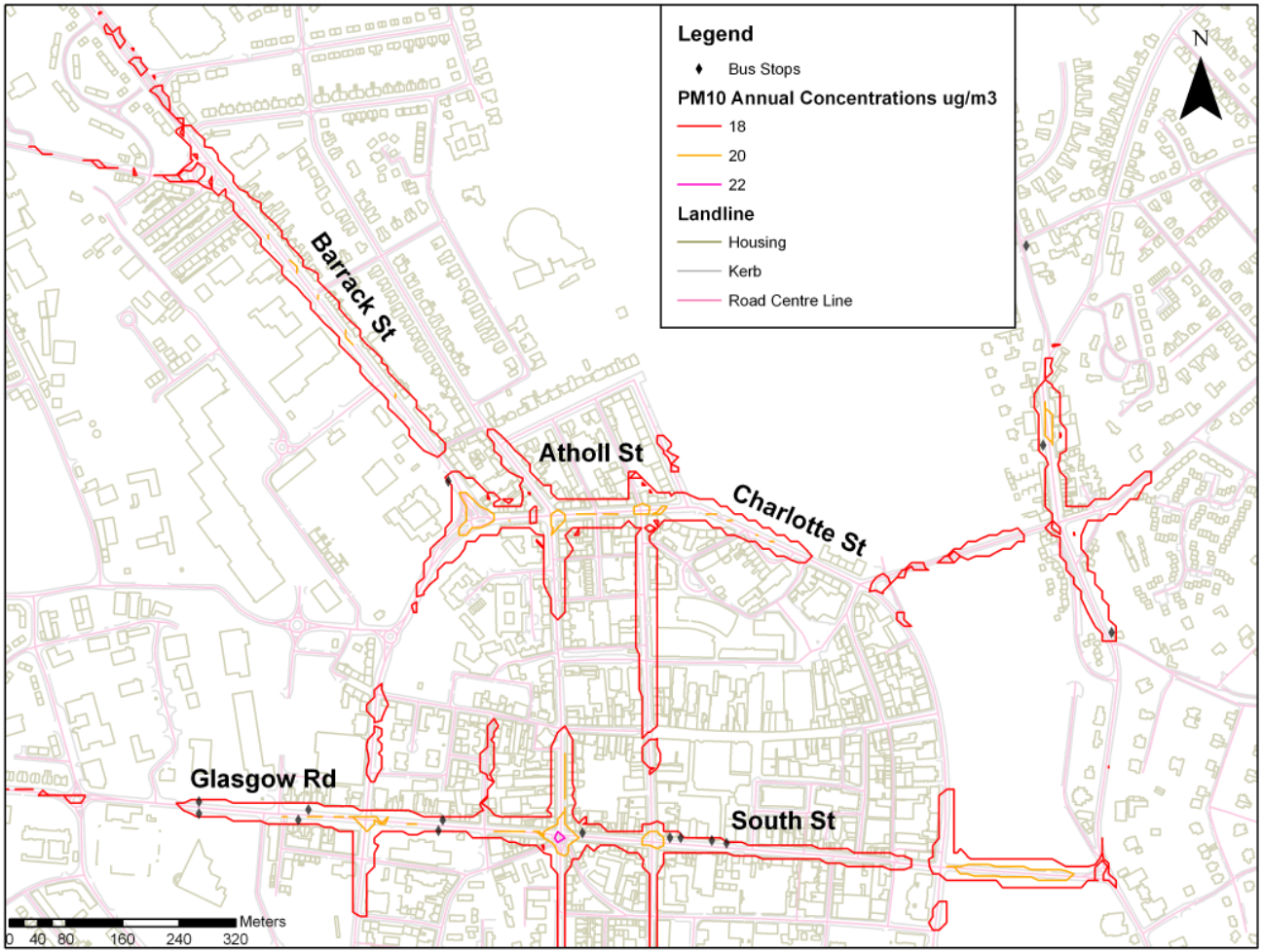

Figure 6.5 Predicted Annual Mean PM_{10} concentrations for Perth City Centre, 2010.

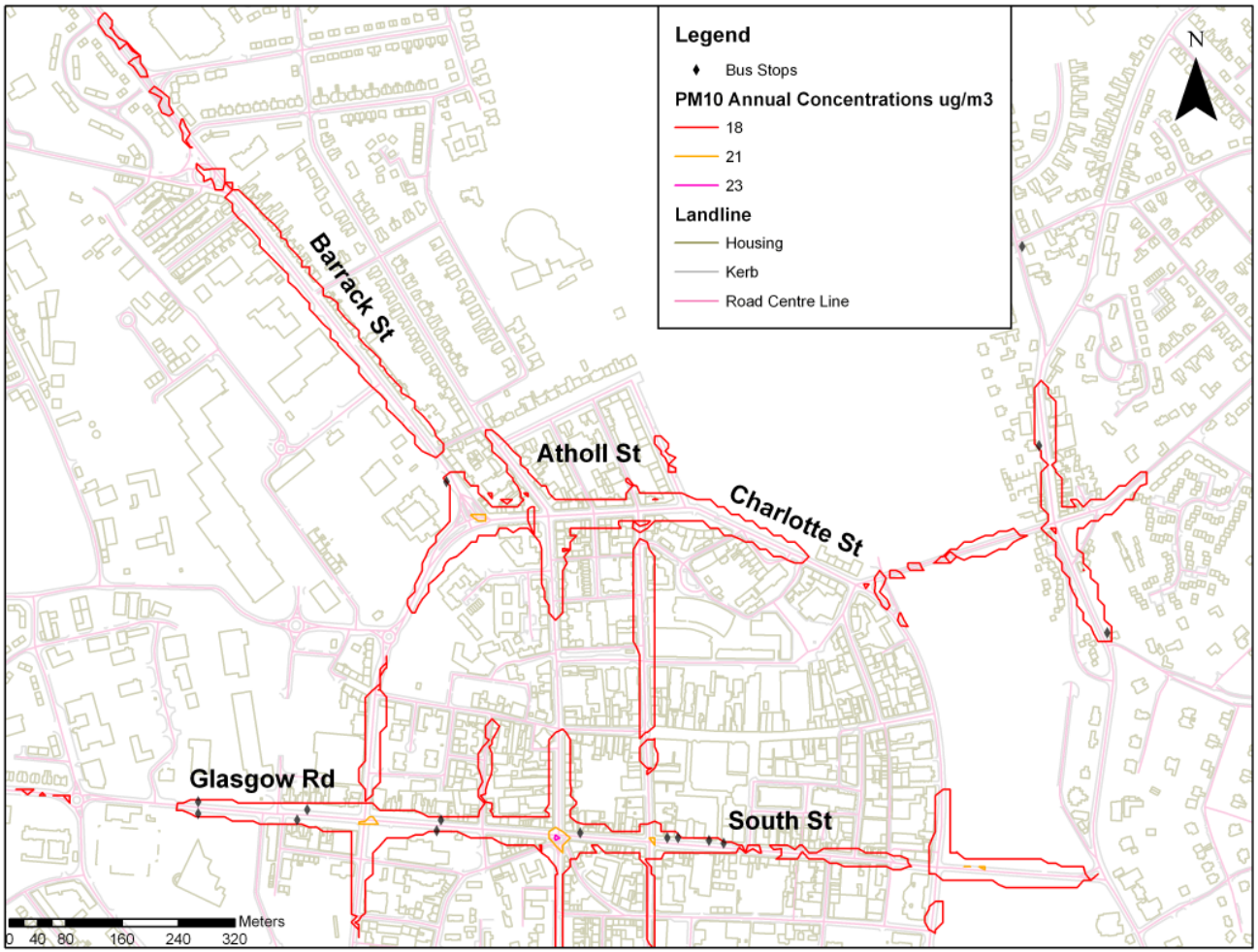

Figure 6.6 Predicted Annual Mean PM_{10} concentrations for Perth City Centre, 2010 with City Centre Management Review.

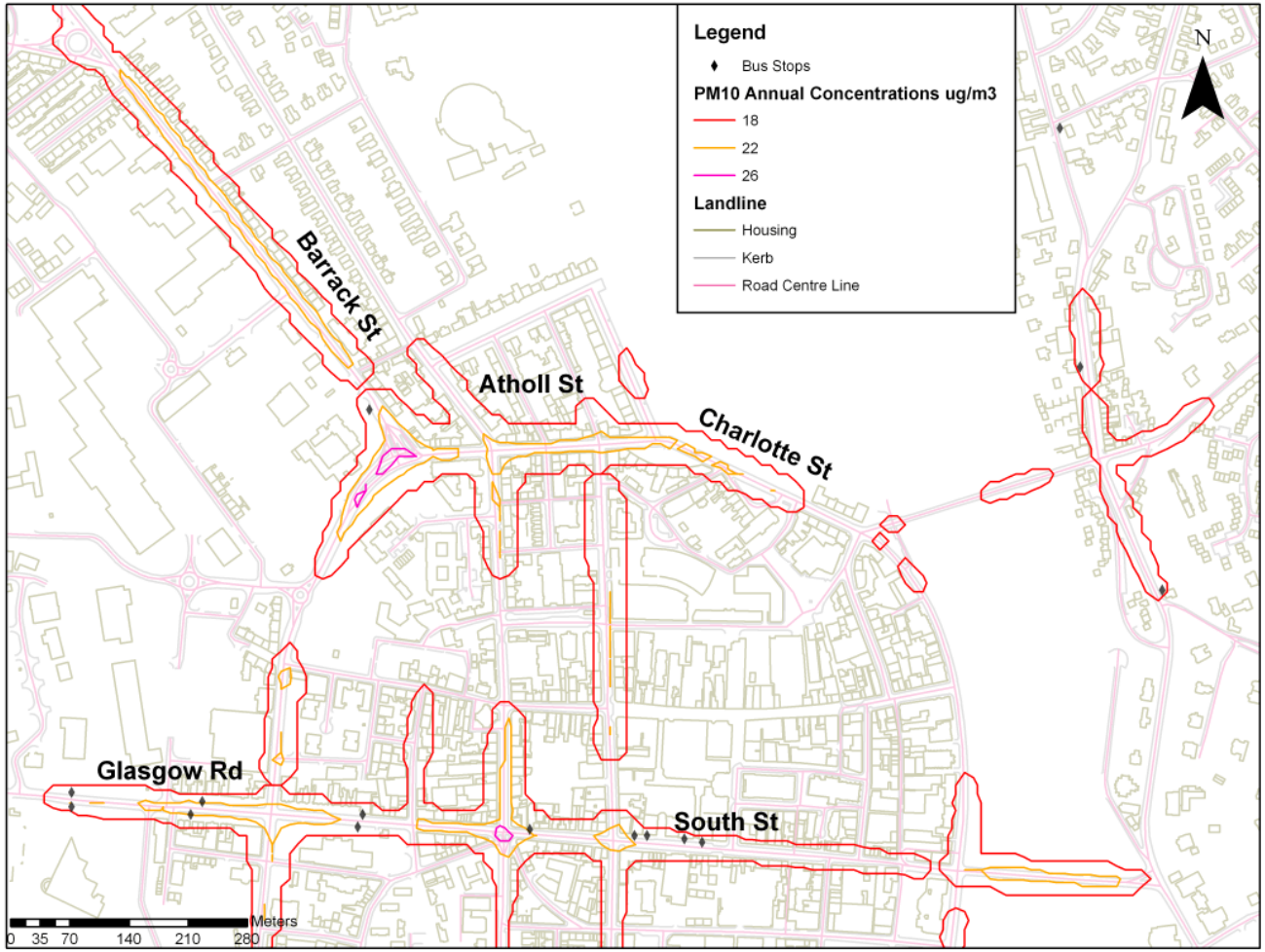

Figure 6.7 Predicted Annual Mean PM_{10} concentrations for Perth City Centre, 2018 with City Centre Management Review and Regional Bridge.

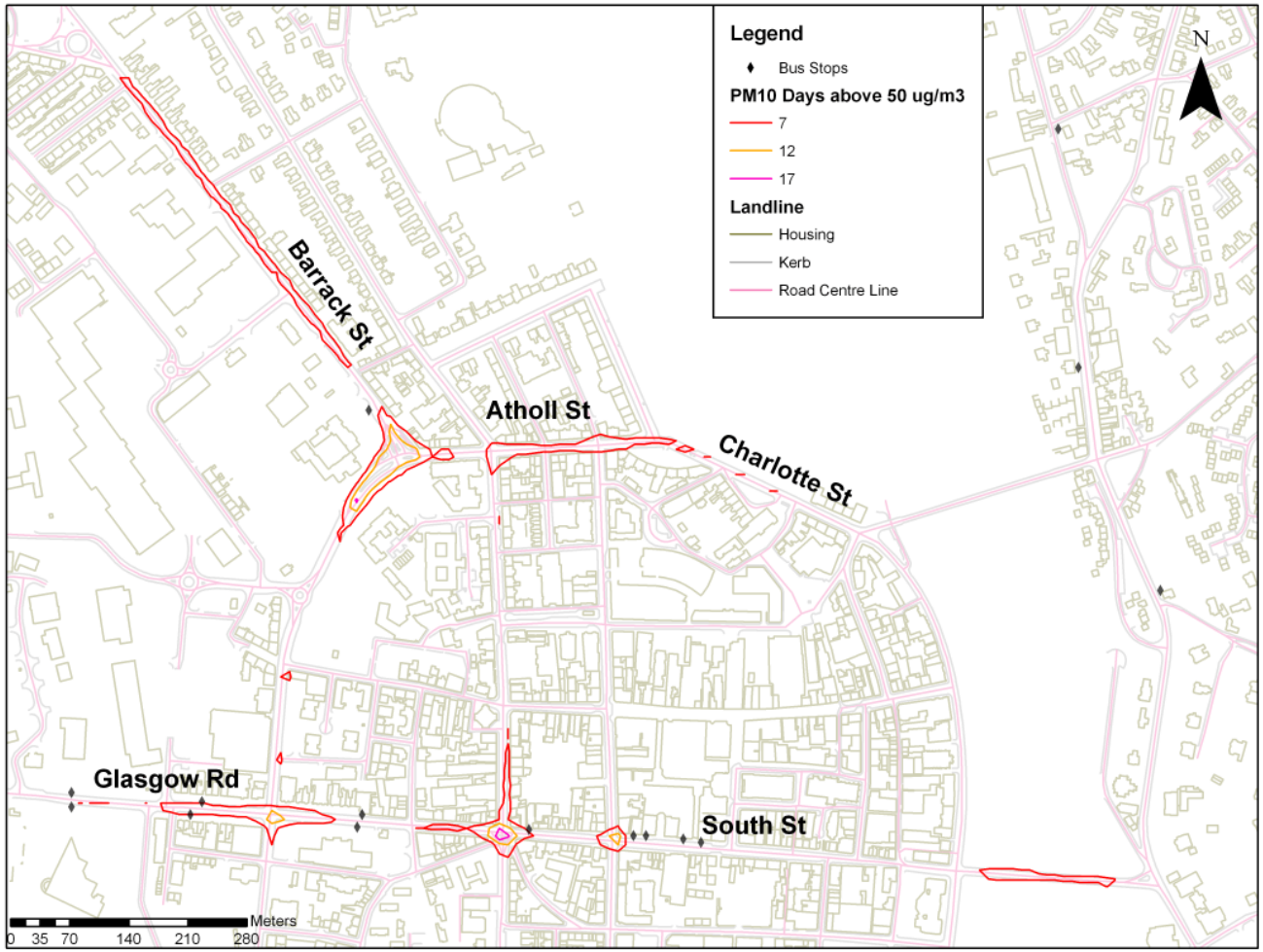

Figure 6.8 Predicted Number of Days Exceeding Daily Annual PM_{10} objective concentrations for Perth City Centre, 2018 with City Centre Management Review and Regional Bridge.

6.7 SOURCE APPORTIONMENT OF PREDICTED EXCEEDANCES

Source apportionment is the process whereby the contributions from different sources of a pollutant are determined. In local air quality, the relevant sources could include: traffic; local background; industrial and domestic. Contributions from the different types of vehicles (for example, cars, lorries and buses) can also be considered to highlight which class of vehicle is contributing most to the emissions from traffic. Source apportionment allows the most important source or sources to be identified and options to reduce ambient concentrations of pollutants can then be considered and assessed. The concentrations have been calculated using the new traffic emission factors.

The source apportionment should:

- Confirm that exceedances of PM_{10} are due to road traffic
- Determine the extent to which different vehicle types are responsible for the emission contributions to PM_{10} within predicted areas of exceedance. This will allow traffic management scenarios to be modelled/tested to reduce the exceedances
- Quantify what proportion of the exceedances of PM_{10} 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 exceedance, or, whether national measures would be a suitable approach to achieving the air quality objectives

Receptors considered

Source apportionment has been considered at those locations in Perth where the model has predicted the highest concentration of PM_{10} in 2005 at or near to a relevant receptor. These are points on the 10m x 10m receptor point grid used in the modelling, and have not necessarily been selected owing to their proximity to monitoring points. Figure 3.1 indicates the 8 locations in question:

1. Barrack Street (311284, 724165)
2. Atholl Street 1 (311476, 723942)
3. Melville Street (311521, 723981)
4. North Methven Street (311551, 723902)
5. Atholl Street 2 (311563, 7235949)
6. Main Street (312250, 724070)
7. York Place (311310, 723520)
8. Kinnoull Street (311684, 723676)

Sources of pollution considered

We have considered the effect of the following sources in this assessment at the receptor considered:

- Background concentrations used in the assessment;
- Traffic - Light Duty Vehicles on main roads in the 1 km square local area;
- Traffic - Heavy Goods Vehicles on main roads in the 1 km square local area;
- Traffic - Buses on main roads in the 1 km square local area.

It should be noted that the modelling has explicitly considered traffic on Atholl Street, York Place and Main Street in Perth City Centre. Reference in Tables 6.6 to 6.13 to 'traffic' refers to the contribution to pollutant concentrations of these traffic movements. Emissions from traffic movements on other roads in Perth and outside Perth have not been explicitly modelled. However, their contribution to pollutant concentrations in Perth is included in the modelled background concentrations. Background concentrations in Table 6.6 to 6.13 therefore include further contributions from traffic.

The modelling assumed that the contribution to PM_{10} concentration from road traffic could be estimated by using the relationships provided in LAQM.TG(03) and the AQEG report of 2005 (AQEG(2005)): the same relationships have been applied for source apportionment calculations.

The concentrations apportioned to each source category and the fraction of the total concentrations are shown in Tables 6.6. to 6.13.

Table 6.6: Site 1, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Barrack Street.

Barrack St (311284 724165) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.6	2.5%
LGV	0.5	1.9%
HGV rigid	0.3	1.4%
HGV artic	0.3	1.1%
Bus & Coach	0.3	1.2%
Car (queuing)	1.2	5.0%
LGV (queuing)	0.7	2.8%
HGV rigid (queuing)	0.7	3.0%
HGV artic (queuing)	0.6	2.3%
Bus & coach (queuing)	0.7	2.8%
Total traffic free flowing	1.9	8.2%
Total traffic queuing	3.8	15.9%
Total traffic	**5.7**	**24%**
Background	**18.0**	**76%**
Total	**23.7**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.7: Site 2, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Atholl Street 1.

Atholl St 1 (311476 723942) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.6	2.4%
LGV	0.4	1.9%
HGV rigid	0.3	1.2%
HGV artic	0.2	0.9%
Bus & Coach	0.3	1.2%
Car (queuing)	1.1	4.8%
LGV (queuing)	0.6	2.7%
HGV rigid (queuing)	0.6	2.5%
HGV artic (queuing)	0.4	1.9%
Bus & coach (queuing)	0.7	2.8%
Total traffic free flowing	1.8	7.7%
Total traffic queuing	3.4	14.7%
Total traffic	**5.2**	**22%**
Background	**18.0**	**78%**
Total	**23.2**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.8: Site 3, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Melville Street.

Melville St (311521 723981) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.1	0.4%
LGV	0.1	0.3%
HGV rigid	0.0	0.1%
HGV artic	0.0	0.1%
Bus & Coach	0.0	0.2%
Car (queuing)	1.4	6.3%
LGV (queuing)	0.7	3.3%
HGV rigid (queuing)	0.6	2.7%
HGV artic (queuing)	0.5	2.2%
Bus & coach (queuing)	1.1	4.7%
Total traffic free flowing	0.3	1.1%
Total traffic queuing	4.4	19.3%
Total traffic	**4.6**	**20%**
Background	**18.0**	**80%**
Total	**22.6**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.9: Site 4, Perth: Source apportionment of concentrations of PM_{10} in 2005 at North Methven Street.

N Methven St (311551 723902) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.2	0.7%
LGV	0.1	0.6%
HGV rigid	0.1	0.6%
HGV artic	0.1	0.5%
Bus & Coach	0.1	0.3%
Car (queuing)	1.2	5.1%
LGV (queuing)	0.6	2.8%
HGV rigid (queuing)	1.2	5.3%
HGV artic (queuing)	1.0	4.1%
Bus & coach (queuing)	0.8	3.4%
Total traffic free flowing	0.6	2.7%
Total traffic queuing	4.8	20.6%
Total traffic	**5.5**	**23%**
Background	**18.0**	**77%**
Total	**23.5**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.10: Site 5, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Atholl Street 2.

Atholl St 2 (311563 723949) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.3	1.4%
LGV	0.3	1.3%
HGV rigid	0.1	0.4%
HGV artic	0.2	0.7%
Bus & Coach	0.2	0.8%
Car (queuing)	1.0	4.7%
LGV (queuing)	0.6	2.7%
HGV rigid (queuing)	0.3	1.5%
HGV artic (queuing)	0.6	2.7%
Bus & coach (queuing)	0.7	3.3%
Total traffic free flowing	1.0	4.5%
Total traffic queuing	3.3	14.7%
Total traffic	**4.3**	**19%**
Background	**18.0**	**81%**
Total	**22.3**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.11: Site 6, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Main Street.

Main St (312250 724070) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.6	2.5%
LGV	0.5	2.2%
HGV rigid	0.3	1.1%
HGV artic	0.2	1.0%
Bus & Coach	0.2	0.9%
Car (queuing)	1.3	5.5%
LGV (queuing)	0.7	3.1%
HGV rigid (queuing)	0.7	2.9%
HGV artic (queuing)	0.6	2.3%
Bus & coach (queuing)	0.6	2.6%
Total traffic free flowing	1.8	7.8%
Total traffic queuing	3.9	16.4%
Total traffic	**5.7**	**24%**
Background	**18.0**	**76%**
Total	**23.7**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.12: Site 7, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Barrack York Place.

York Place (311310 723519) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.1	0.5%
LGV	0.1	0.5%
HGV rigid	0.1	0.3%
HGV artic	0.0	0.2%
Bus & Coach	0.1	0.3%
Car (queuing)	0.6	2.9%
LGV (queuing)	0.3	1.6%
HGV rigid (queuing)	0.5	2.4%
HGV artic (queuing)	0.3	1.5%
Bus & coach (queuing)	0.5	2.4%
Total traffic free flowing	0.4	1.9%
Total traffic queuing	2.2	10.8%
Total traffic	**2.6**	**13%**
Background	**18.0**	**87%**
Total	**20.6**	**100%**

Figures are rounded to the nearest 1 decimal place

Table 6.13: Site 8, Perth: Source apportionment of concentrations of PM_{10} in 2005 at Kinnoull Street.

Kinnoull St (311684 723676) Source category	PM_{10} concentration, Contribution	
	$\mu g\ m^{-3}$	%
Car	0.1	0.5%
LGV	0.1	0.5%
HGV rigid	0.1	0.3%
HGV artic	0.1	0.5%
Bus & Coach	0.1	0.3%
Car (queuing)	1.1	4.8%
LGV (queuing)	0.6	2.5%
HGV rigid (queuing)	0.9	3.8%
HGV artic (queuing)	1.3	5.7%
Bus & coach (queuing)	1.2	4.9%
Total traffic free flowing	0.5	2.1%
Total traffic queuing	5.1	21.7%
Total traffic	**5.6**	**24%**
Background	**18.0**	**76%**
Total	**23.6**	**100%**

Figures are rounded to the nearest 1 decimal place

Total traffic contribution to PM_{10} ranges from 13% to 18%. The split between free flowing and queuing varies greatly (compare NO_2) across the locations from 1.1% to 8.2% for free flowing and 10.8% to 21.7% for queuing traffic contribution.

From the above it may be seen that at these locations free-flowing traffic accounts for one tenth of the local PM_{10} concentrations, and off this traffic contribution, HDVs account for approximately half.

Queuing traffic accounts for less than one fifth of the local PM_{10} concentration, and of this contribution HDVs account for over half.

Total HDV traffic, for both free flowing and queuing, contributes to over one tenth to the local PM_{10} concentrations.

6.8 CONCLUSIONS AND RECOMMENDATIONS FOR PM_{10}

PM_{10} 2005 Base Case
Both monitoring and modelling indicate that in 2005 concentrations were below the required concentrations in both the city centre and city wide AQMA.

PM_{10} 2005 with the CCTMR
Both monitoring and modelling indicate that in 2005, with the CCTMR in place, concentrations were below the required concentrations in both the city centre and city wide AQMA.

PM_{10} 2010 Base Case
This Further Assessment has however, confirmed a significant risk of exceedance of the Scottish annual mean objective for PM_{10} in Perth. For 2010 Base Case projected from the 2005 Base Case concentrations are not predicted to exceed the daily mean objective set for Scotland.

PM_{10} 2010 with the CCTMR
This Further Assessment has however, confirmed a significant risk of exceedance of the Scottish annual mean objective for PM_{10} in 2010 with the CCTMR in place in Perth. For 2010 with the CCTMR in place concentrations are not predicted to exceed the daily mean objective set for Scotland.

PM_{10} 2018 with the CCTMR
Modelling for 2018 with the CCTMR and Regional Bridge in place confirmed a significant risk of exceedance of the both the 2010 Scottish annual mean objective for PM_{10} and the 2010 daily mean objective set for Scotland.

PM_{10} Source apportionment
Results for 2005 indicate that at the location of highest predicted roadside concentrations, free-flowing traffic accounts for one tenth of the local PM_{10} concentrations, and of this traffic contribution, HDVs account for approximately half. Queuing traffic accounts for less than one fifth of the local PM_{10} concentration, and of this contribution HDVs account for over half. Total HDV traffic, for both free flowing and queuing, contributes to over one tenth to the local PM_{10} concentrations. Reductions in queuing and congestion, particularly aimed at HDV traffic, are therefore likely to lead to a significant reduction in roadside PM_{10}.

If local background is at or just below 18 $\mu g\ m^{-3}$, it will be necessary not only to reduce roadside PM_{10} but also urban background concentrations generally. To this, the city wide AQMA should remain in force and action planning should seek to reduce city wide emissions of PM_{10}.

PM_{10} Recommendations
It is therefore recommended that Perth and Kinross Council retain their city wide air quality management area for PM_{10}, and proceed with preparation of their action plan to reduce PM_{10} concentrations. Perth and Kinross Council should continue to monitor in this area. Reductions in queuing and congestion, particularly aimed at HDV traffic, are needed to lead to a significant reduction in roadside PM_{10}.

7 Conclusions and Recommendations

7.1 CONCLUSIONS FOR NO_2 AND PM_{10}

NO_2 2005 Base Case
This Further Assessment has confirmed a significant risk of exceedance of the UK annual mean objective for NO_2 in 2005 in central Perth only. Both monitoring and modelling generally indicate that in 2005, for the Base Case, concentrations were above the required concentration at a maximum of 14 monitoring locations in Perth City Centre. At one monitoring location it is possible that the hourly NO_2 objective was exceeded.

NO_2 2005 with the CCTMR
This Further Assessment has confirmed a significant risk of exceedance of the UK annual mean objective for NO_2 in 2005, with the CCTMR in place, in central Perth only. Modelling generally indicates that in 2005, with the CCTMR in place, concentrations were above the required concentration at a maximum of 13 monitoring locations in Perth City Centre. At 3 monitoring locations it is possible that the hourly NO_2 objective was exceeded.

NO_2 2010
Concentrations in 2010, based on 2005 projected forward traffic data, are predicted to be lower, although the EU Limit Value for annual mean NO_2 may still be exceeded at these city centre locations in that year.

NO_2 2018
Modelling for 2018 with City Centre Management Review and Regional Bridge in place showed that again 13 monitoring locations would exceed the annual mean objective. The number of monitoring locations predicting a possible exceedance of the hourly mean is predicted to increase from 3 in 2005 with the CCTMR to 8 by 2018.

NO_2 source apportionment
Results for 2005 indicate that at the locations of highest predicted roadside concentrations, free-flowing traffic accounts for less than one eighth of the local NO_x and NO_2 concentrations, and of this traffic contribution, HDVs account for approximately three quarters. Queuing traffic accounts for three quarters of the local NO_x and NO_2 concentrations, and of this traffic contribution HDVs account for well over half. Total HDV traffic, both free flowing and queuing, therefore contributes to over three-fifths to the local NO_2 concentrations. Reductions in HDV queuing and congestion are therefore likely to lead to a significant reduction in roadside NO_x and NO_2.

PM_{10} 2005 Base Case
Both monitoring and modelling indicate that in 2005 concentrations were below the required concentrations in both the city centre and city wide AQMA.

PM_{10} 2005 with the CCTMR
Both monitoring and modelling indicate that in 2005, with the CCTMR in place, concentrations were below the required concentrations in both the city centre and city wide AQMA.

PM_{10} 2010 Base Case
This Further Assessment has however, confirmed a significant risk of exceedance of the Scottish annual mean objective for PM_{10} in Perth. For 2010 Base Case projected from the 2005 Base Case concentrations are not predicted to exceed the daily mean objective set for Scotland.

PM_{10} 2010 with the CCTMR
This Further Assessment has however, confirmed a significant risk of exceedance of the Scottish annual mean objective for PM_{10} in 2010 with the CCTMR in place in Perth. For 2010 with the CCTMR in place concentrations are not predicted to exceed the daily mean objective set for Scotland.

PM_{10} 2018 with the CCTMR
Modelling for 2018 with the CCTMR and Regional Bridge in place confirmed a significant risk of exceedance of the both the 2010 Scottish annual mean objective for PM_{10} and the 2010 daily mean objective set for Scotland.

PM_{10} Source apportionment
Results for 2005 indicate that at the location of highest predicted roadside concentrations, free-flowing traffic accounts for one tenth of the local PM_{10} concentrations, and of this traffic contribution, HDVs account for approximately half. Queuing traffic accounts for less than one fifth of the local PM_{10} concentration, and of this contribution HDVs account for over half. Total HDV traffic, for both free flowing and queuing, contributes to over one tenth to the local PM_{10} concentrations. Reductions in queuing and congestion, particularly aimed at HDV traffic, are therefore likely to lead to a significant reduction in roadside PM_{10}.

If local background is at or just below 18 $\mu g\ m^{-3}$, it will be necessary not only to reduce roadside PM_{10} but also urban background concentrations generally. To this, the city wide AQMA should remain in force and action planning should seek to reduce city wide emissions of PM_{10}.

7.2 CITY CENTRE MANAGEMENT REVIEW AND REGIONAL BRIDGE

The impacts on air quality of the CCTMR reveal little overall improvement in or difference to both NO_2 and PM_{10} concentrations for 2005.

Modelling of 2010 concentrations both with and without the CCTMR in place for PM_{10} predicts exceedances of the 2010 PM_{10} annual mean objective for Scotland. No exceedances of the 2010 daily mean objective are expected for this year.

Predictions of NO_2 in the 2018 with the CCTMR and Regional Bridge scenario indicate exceedances of the 2005 NO_2 annual mean objective and an increase in the number of locations, from 3 to 8, which are likely to exceed the 2005 hourly mean NO_2 objective.

The Regional Bridge in the 2018 scenario greatly improves the PM_{10} concentrations across the whole of Perth, although, under the more stringent 2010 annual mean objective an exceedance area is predicted in the city centre.

The Regional Bridge scenario sees a reduced re-directed flow on Perth's roads, but it is more likely that by 2018 the uptake of cleaner diesel vehicles through increasing Euro standards and the fitting of more particulate traps as standard reaps greater benefits on PM_{10} concentrations. The model also now takes into account the new NO_2: NO_x relationship, which is revealing higher concentrations than originally modelled in previous years.

Action planning is needed that targets congestion, particularly HDVs, along the more central Perth Streets namely Atholl Street and South Street where the highest NO_2 and PM_{10} concentrations occur.

7.3 RECOMMENDATIONS AND FURTHER ACTIONS TO BE TAKEN

It is recommended that Perth and Kinross Council retain their city wide air quality management area for NO_2, and proceed with preparation of their action plan to reduce NO_2 concentrations, specifically aimed at HDV traffic and queuing and congestion. Perth and Kinross Council should continue to monitor at this location.

It is also recommended that Perth and Kinross Council retain their city wide air quality management area for PM_{10}, and proceed with preparation of their action plan to reduce PM_{10} concentrations. Perth and Kinross Council should continue to monitor in this area. Reductions in queuing and congestion, particularly aimed at HDV traffic, are needed to lead to a significant reduction in roadside PM_{10}.

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Appendices

Appendix 1: Road Traffic Data

Appendix 2: Monitoring Data

Appendix 3: Model Validation for NO_2

Appendix 4: Model Validation for PM_{10}

Appendix 5: The UK Air Quality Strategy

Appendix 1

Road Traffic Data

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Table A1.1a – 2005 AADT for Perth City Centre

2005 Base Average Peak- City Centre (adjusted by a factor of 2.2)											
			A	B	C	D	E	F	G	H	
Junction	Junction Name	Arm	Caledonian Rd Nthbnd Exit	York Place Exit	Caledonian Rd Sthbnd Exit	Glasgow Road Exit	York Place Approach	Caledonian Rd Nthbnd Approach	Caledonian Rd Sthbnd Approach	Glasgow Rd Approach	
28	Glasgow Road / Caledonian Rd / York Place Crossroads	Car	3766	5053	2024	5069	3727	2479	4268	5438	
		LGV	493	653	312	645	469	295	565	774	
		OGV1	95	194	62	150	139	51	121	189	
		OGV2	40	29	20	68	66	22	35	33	
		Single Decker Bus	59	207	35	264	165	88	97	216	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	4	2	0	2	0	
		Coach	2	7	2	4	0	13	0	2	
		Total	4455	6142	2455	6204	4567	2948	5089	6653	
		%HDV	5%	9%	5%	9%	10%	8%	5%	7%	
		Speed (mph)	17	25	17	20	9	3	5	12	
		Speed (kmph)	28	41	27	32	14	5	8	19	
Junction	Junction Name	Arm	York Place Estbnd Approach	New Row Nthbnd Exit	York Place Estbnd Exit	New Row Sthbnd Exit	York Place Wstbnd Exit	New Row Nthbnd Approach	York Place Wstbnd Approach	New Row Sthbnd Approach	
29	York Place / New Row	Car	5053	1703	5641	1164	3727	1560	3824	2138	
		LGV	653	187	792	136	469	211	462	310	
		OGV1	194	53	227	33	139	51	147	59	
		OGV2	29	20	42	7	66	24	66	15	
		Single Decker Bus	207	42	209	26	165	40	174	22	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	13	2	0	15	0	
		Coach	7	0	7	0	0	0	0	0	
		Total	6142	2004	6917	1379	4567	1885	4688	2546	
		%HDV	9%	7%	8%	6%	10%	7%	10%	4%	
		Speed (mph)	29	11	9	13	20	6	20	6	
		Speed (kmph)	47	17	14	20	32	10	33	10	
Junction	Junction Name	Arm	South St Estbnd Exit	Scott St Sthbnd Exit	Scott St Nthbnd Exit	Scott St Sthbnd Approach	Scott St Nthbnd Approach	South St Estbnd Approach			
30	South St / Scott St	Car	6054	2576	2013	2565	2105	7097			
		LGV	938	343	312	260	279	978			
		OGV1	284	128	121	48	121	330			
		OGV2	66	37	59	24	59	70			
		Single Decker Bus	154	158	84	121	77	185			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	2	2	11	2	11	2			
		Coach	7	0	0	0	0	7			
		Total	8285	3245	2600	3021	2653	8661			
		%HDV	8%	13%	11%	11%	10%	8%			
		Speed (mph)	17	13	24	5	4	11			
		Speed (kmph)	27	21	39	9	7	18			
Junction	Junction Name	Arm	County Place Wstbnd Exit	Sth Methven St Exit	King St Approach	Sth Methven St Approach	County Place Estbnd Approach	South St Exit			
31	County Place / Sth Methven St , King St	Car	3824	1984	5942	2493	5641	6976			
		LGV	462	235	695	323	792	957			
		OGV1	147	88	279	139	227	354			
		OGV2	66	40	130	40	42	73			
		Single Decker Bus	174	128	189	152	209	191			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	15	0	4	13	0	0			
		Coach	0	0	0	0	7	7			
		Total	4688	2475	7240	3159	6917	8558			
		%HDV	10%	11%	9%	12%	8%	8%			
		Speed (mph)	20	18	11	3	16	11			
		Speed (kmph)	33	29	17	5	26	18			
Junction	Junction Name	Arm	South St Approach	Tay St Nthbnd Exit	Queens Bridge Exit	Tay St Sthbnd Exit	Tay St Sthbnd Approach	Tay St Nthbnd Approach	Queens Bridge Approach		
32	South St / Tay St	Car	8131	1562	8290	7355	1905	1969	5201		
		LGV	913	202	893	964	205	231	711		
		OGV1	381	75	387	418	48	108	343		
		OGV2	99	20	110	163	15	37	141		
		Single Decker Bus	209	95	143	200	44	55	130		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	7	4	2	0	0	0	0		
		Coach	7	0	7	9	0	0	9		
		Total	9746	1958	9832	9108	2218	2400	6534		
		%HDV	9%	11%	9%	9%	6%	9%	10%		
		Speed (mph)	7	24	17	14	3	6	9		
		Speed (kmph)	11	38	27	22	5	9	15		
Junction	Junction Name	Arm	Atholl St Wstbnd Approach	Atholl St Estbnd Exit	Kinnoull St Exit	Atholl St Wstbnd Exit	Barossa St Exit	Atholl St Estbnd approach	Kinnoull St Approach	Barossa St Approach	
33	Atholl St / Kinnoull St	Car	5672	4323	2182	6415	451	5216	2174	356	
		LGV	803	563	275	873	62	673	257	37	
		OGV1	77	20	22	145	13	24	99	7	
		OGV2	26	4	18	51	4	11	44	0	
		Single Decker Bus	187	73	152	222	7	145	110	15	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	4	0	2	2	0	0	0	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	6769	4983	2651	7709	537	6078	2684	416	
		%HDV	4%	2%	7%	6%	4%	3%	12%	7%	
		Speed (mph)	4	21	15	7	19	12	3	5	
		Speed (kmph)	7	34	24	12	31	19	5	8	

Junction	Junction Name	Arm	Atholl St Approach	Atholl St Exit	N Methven St Exit	Caledonian Rd Exit	Melville St Exit	N Methven St Approach	Melville St Approach	Caledonian Rd Approach	
34	Atholl St / N Methven St / Melville St	Car	6426	5210	3379	8096	1135	2160	1287	8074	
		LGV	878	673	433	1098	139	262	158	1054	
		OGV1	145	24	163	224	22	99	26	165	
		OGV2	51	11	46	81	11	44	7	51	
		Single Decker Bus	222	145	97	268	51	97	55	189	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	2	0	0	13	0	11	0	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	7724	6063	4118	9781	1357	2673	1533	9533	
		%HDV	6%	3%	8%	6%	7%	10%	7%	4%	
		Speed (mph)	3	17	21	11	23	4	3	5	
		Speed (kmph)	5	28	34	18	36	6	4	8	
Junction	Junction Name	Arm	Atholl St Wstbnd	Atholl St Estbnd Exit	Atholl St Wstbnd Exit	Atholl St Estbnd Approach					
35	Atholl St / Stormont St	Car	6415	5216	6426	5210					
		LGV	873	673	878	673					
		OGV1	145	24	145	24					
		OGV2	51	11	51	11					
		Single Decker Bus	222	145	222	145					
		Double Decker Bus	0	0	0	0					
		Minibus	2	0	2	0					
		Coach	0	0	0	0					
		Total	7709	6070	7724	6063					
		%HDV	6%	3%	6%	3%					
		Speed (mph)	7	12	3	17					
		Speed (kmph)	12	19	5	28					
Junction	Junction Name	Arm	Atholl St Estbnd Exit	Atholl St Wstbnd Exit	Rose Terrace Exit	Atholl St Estbnd Approach	Atholl St Wstbnd Approach	Rose Terrace Approach			
36	Atholl St / Rose Terrace	Car	5029	5672	1685	4323	7225	843			
		LGV	638	803	216	563	999	99			
		OGV1	29	77	24	20	95	15			
		OGV2	9	26	7	4	31	7			
		Single Decker Bus	86	187	31	73	207	24			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	4	0	0	4	0			
		Coach	0	0	0	0	0	0			
		Total	5790	6769	1962	4983	8560	988			
		%HDV	2%	4%	3%	2%	4%	5%			
		Speed (mph)	18	4	10	21	11	4			
		Speed (kmph)	29	7	16	34	17	7			
Junction	Junction Name	Arm	Caledonian Road Exit	Atholl St Approach	Atholl Street to Barrack Street turn	Caledonian Rd Approach to Barrack Street	Caledonian Rd Approach to Barrack St	Barrack Street Approach to Caledonian Rd	Barrack St Approach to Atholl St	Atholl St Exit	O+C
37	Barrack Street / Atholl St / Caledonian Road	Car	4748	8096	5392	2724	2724	2044	5652	8074	8116
		LGV	645	1098	744	361	361	298	706	1054	1104
		OGV1	123	224	167	46	46	66	154	165	213
		OGV2	31	81	66	22	22	15	48	51	88
		Single Decker Bus	123	268	178	31	31	33	169	189	209
		Double Decker Bus	0	0	0	0	0	0	0	0	0
		Minibus	13	13	11	0	0	11	0	0	11
		Coach	0	0	0	2	2	0	0	0	2
		Total	5683	9781	6558	3186	3186	2468	6730	9533	9744
		%HDV	5%	6%	7%	3%	3%	5%	6%	4%	5%
		Speed (mph)	18	9	31	3	35	3	3	5	17
		Speed (kmph)	28	14	50	5	56	4	5	8	28
Junction	Junction Name	Arm	Bridge Lane Approach	Perth Bridge Exit	Tay St Exit	Charlotte St Exit	Tay St Approach	Charlotte St Approach	Perth Bridge Approach		
38	Charlotte St / Tay St / West Bridge St / Bridge Lane	Car	1434	4506	2178	7258	1243	5047	6217		
		LGV	176	592	266	1001	154	646	884		
		OGV1	13	0	42	95	44	29	51		
		OGV2	4	0	11	31	7	9	22		
		Single Decker Bus	73	125	48	207	15	86	198		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	2	2	0	4	0	0	4		
		Coach	0	0	0	0	0	0	0		
		Total	1703	5225	2537	8595	1463	5815	7377		
		%HDV	12%	3%	4%	4%	5%	2%	4%		
		Speed (mph)	1	11	23	24	4	7	10		
		Speed (kmph)	2	18	37	39	6	11	16		
Junction	Junction Name	Arm	East Bridge St Exit	West Bridge St Exit	Main St Exit	Gowrie St Approach	East Bridge St Approach	Main St Approach	West Bridge St Approach	Gowrie St Exit	
39	Main St / Gowrie St / West Bridge St	Car	442	6217	8474	4949	1170	9017	4506	4398	
		LGV	84	884	999	574	158	1313	592	671	
		OGV1	0	51	286	286	33	257	0	240	
		OGV2	0	22	70	70	26	81	0	86	
		Single Decker Bus	9	198	198	101	48	198	125	66	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	4	2	0	4	0	2	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	535	7377	10030	5881	1441	10857	5225	5460	
		%HDV	2%	4%	7%	10%	8%	5%	3%	7%	
		Speed (mph)	9	14	19	4	2	12	4	25	
		Speed (kmph)	14	23	31	7	4	19	6	40	

Table A1.1b – 2005 AADT for Perth other major roads

2005 Base Average Peak - Major Road Links (adjusted by a factor of 3.5)														
			A	B	C	D	E	F	G	H	I			
Junction	Junction Name	Arm	Dunkeld Rd Approach	A9 North Approach	A9 Western Bypass Approach	Dunkeld Rd Exit	A9 Western Bypass Exit	Industrial Estate Exit	A9 North Exit	Industrial Estate Approach				
1	Inveralmond Roundabout	Car	12611	13601	16818	14217	14445	6199	13846	5677				
		LGV	1680	1778	2440	1820	1855	1022	1845	644				
		OGV1	161	693	998	175	1050	277	781	431				
		OGV2	67	235	368	70	368	105	270	144				
		Single Decker Bus	161	525	620	137	742	140	571	284				
		Double Decker Bus	0	0	0	0	0	0	0	0				
		Minibus	0	0	0	0	0	0	0	0				
		Coach	4	0	0	0	0	0	4	0				
		Total	14683	16832	21242	16419	18459	7742	17315	7179				
		%HDV	3%	9%	9%	2%	13%	8%	11%	13%				
		Speed (mph)	12	22	33	26	51	46	39	4				
		Speed (kmph)	19	35	52	41	82	74	62	7				
Junction	Junction Name	Arm	Bute Drive Exit	Dunkeld Rd South Exit	Dunkeld Rd North Exit	Dunkeld Road South Approach	Dunkeld Rd North Approach	Bute Drive Approach						
2	Dunkeld Road / Bute Drive	Car	4484	13650	11382	11760	12726	5030						
		LGV	557	1687	1540	1558	1586	641						
		OGV1	60	175	154	175	140	74						
		OGV2	18	56	67	70	42	28						
		Single Decker Bus	42	144	161	186	119	42						
		Double Decker Bus	0	0	0	0	0	0						
		Minibus	0	0	0	0	0	0						
		Coach	0	0	4	4	0	0						
		Total	5159	15712	13307	13752	14613	5814						
		%HDV	3%	2%	3%	3%	2%	3%						
		Speed (mph)	22	24	28	13	9	5						
		Speed (kmph)	35	39	45	21	14	8						
Junction	Junction Name	Arm	Dunkeld Rd South Approach	Gowans Terrace Exit	Dunkeld Rd North Approach	Gowans Terrace Approach	Dunkeld Rd South Exit	Dunkeld Rd North Exit						
3	Dunkeld Rd / Gowans Terrace	Car	11820	5138	12936	4298	11739	11624						
		LGV	1628	648	1561	511	1421	1540						
		OGV1	207	32	179	46	203	175						
		OGV2	74	14	60	18	53	70						
		Single Decker Bus	200	39	154	32	147	186						
		Double Decker Bus	0	0	0	0	0	0						
		Minibus	0	0	0	0	0	0						
		Coach	4	0	0	0	0	4						
		Total	13930	5870	14889	4904	13563	13598						
		%HDV	4%	2%	3%	2%	3%	3%						
		Speed (mph)	12	24	4	15	15	15						
		Speed (kmph)	19	39	7	25	24	25						
Junction	Junction Name	Arm	Ballantine Place Approach	Crieff Rd Approach	Dunkeld Rd North Approach	Dunkeld Rd South Exit	Dunkeld Rd South Approach	Ballantine Place Exit	Crieff Rd Exit	Dunkeld Rd North Exit				
4	Dunkeld Rd / Crieff Rd	Car	494	8085	14424	14259	12747	63	9258	12170				
		LGV	60	1085	1813	1813	1715	0	1131	1729				
		OGV1	18	214	256	389	277	0	140	235				
		OGV2	7	74	81	116	105	0	53	88				
		Single Decker Bus	11	270	182	357	319	0	186	238				
		Double Decker Bus	0	0	0	0	0	0	0	0				
		Minibus	0	18	0	18	18	0	18	0				
		Coach	0	0	0	0	4	0	0	4				
		Total	588	9744	16755	16951	15183	63	10794	14462				
		%HDV	6%	6%	3%	5%	5%	0%	4%	4%				
		Speed (mph)	6	7	11	10	9	15	13	9				
		Speed (kmph)	9	12	18	16	14	24	20	12				
Junction	Junction Name	Arm	Dunkeld Road South Exit	St Catherines Road Exit	Dunkeld Rd North Exit	St Catherines Road Entry	Dunkeld Rd South Entry	Dunkeld Rd North Entry						
5	Dunkeld Rd / St Catherines Rd / Barrack Street	Car	12408	3479	13073	1663	12873	14424						
		LGV	1621	403	1771	207	1764	1824						
		OGV1	354	56	343	21	340	392						
		OGV2	112	7	140	0	140	119						
		Single Decker Bus	347	28	333	11	333	364						
		Double Decker Bus	0	0	0	0	0	0						
		Minibus	18	0	18	0	18	18						
		Coach	0	0	4	0	4	0						
		Total	14858	3973	15680	1901	15470	17140						
		%HDV	6%	2%	6%	1%	6%	5%						
		Speed (mph)	7	16	26	2	11	10						
		Speed (kmph)	11	26	41	3	17	15						
Junction	Junction Name	Arm	Western Bypass Nbnd Offslip	Crieff Road Eastbound Approach	Western Bypass Nbnd Onslip	Crieff Rd Westbound Approach	Crieff Rd Eastbound Exit	Crieff Rd Westbound Exit						
6	A9 / Crieff Rd Roundabout Dobbies Roundabout	Car	5058	9839	4939	9912	10829	9041						
		LGV	693	1302	700	1243	1397	1141						
		OGV1	95	210	60	217	175	287						
		OGV2	49	144	49	74	119	98						
		Single Decker Bus	84	231	84	214	291	154						
		Double Decker Bus	0	0	0	0	0	0						
		Minibus	0	18	0	18	18	18						
		Coach	0	0	0	0	0	0						
		Total	5978	11743	5831	11676	12828	10738						
		%HDV	4%	5%	3%	5%	5%	6%						
		Speed (mph)	15	4	22	27	9	18						
		Speed (kmph)	24	7	35	43	14	29						

Junction	Junction Name	Arm	Crieff Rd Eastbound Entry	Crieff Rd Eastbound Exit	Newhouse Rd Approach	A9 On / Off slip approach	Crieff Rd westbound Approach	Newhouse Rd Exit	Crieff Rd Westbound Exit	A9 On / Off Slip Exit	
7	A9 / Crieff Rd Roundabout	Car	11823	7651	8061	4375	8117	8120	11316	4680	
	Newhouse Rd Roundabout	LGV	1526	987	1033	560	1040	1089	1446	585	
		OGV1	179	70	56	88	137	49	224	112	
		OGV2	112	46	21	21	70	14	77	88	
		Single Decker Bus	305	144	67	39	151	84	221	109	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	21	18	4	0	18	4	21	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	13965	8915	9240	5082	9531	9359	13304	5572	
		%HDV	5%	3%	2%	3%	4%	2%	4%	5%	
		Speed (mph)	8	11	9	5	12	13	16	18	
		Speed (kmph)	13	17	14	8	19	21	26	29	
Junction	Junction Name	Arm	Fairfield Avenue Approach	Crieff Rd Westbound Entry	Crieff Rd Eastbound Entry	Feus Rd Approach	Crieff Rd Eastbound Exit	Feus Rd Exit	Crieff Rd Westbound Exit	Fairfield Avenue Exit	
8	Crieff Rd / Feus Rd Roundabout	Car	1036	9170	8897	6045	8985	5625	9401	1138	
		LGV	102	1099	1106	816	1187	683	1068	186	
		OGV1	165	144	116	242	217	168	126	154	
		OGV2	60	67	56	105	74	74	63	77	
		Single Decker Bus	88	189	182	133	266	88	144	95	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	18	18	0	18	0	18	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	1449	10686	10374	7340	10745	6636	10819	1649	
		%HDV	22%	4%	4%	7%	5%	5%	4%	22%	
		Speed (mph)	6	10	17	6	10	15	14	14	
		Speed (kmph)	9	17	27	10	16	24	22	23	
Junction	Junction Name	Arm	M90 Edinburgh Approach	M90 Edinburgh Exit (not Inc traffic from Glasgow Rd)	A9 Stirling Exit	A9 Inverness Exit	Glasgow Road Exit	A9 Western Bypass Approach	A9 Stirling Approach	Glasgow Road Approach (not inc traffic to M90)	Glasgow Rd - M90 Slip
9	Broxden Roundabout	Car	18729	14585	14644	16937	8901	14749	15085	6503	3248
		LGV	2814	1890	2016	2433	1365	1880	2163	847	441
		OGV1	1005	1404	1288	1033	350	1075	1673	322	161
		OGV2	417	518	494	368	112	434	522	119	46
		Single Decker Bus	679	938	970	620	291	812	1057	270	112
		Double Decker Bus	0	0	0	0	0	0	0	0	0
		Minibus	0	0	0	0	0	0	0	0	0
		Coach	0	0	7	0	4	0	4	7	0
		Total	23643	19334	19418	21389	11022	18949	20503	8068	4008
		%HDV	9%	15%	14%	9%	7%	13%	16%	9%	8%
		Speed (mph)	10	35	49	47	41	30	10	17	34
		Speed (kmph)	17	56	80	75	66	48	15	27	55
Junction	Junction Name	Arm	Glasgow Rd Eastbound Exit	Glasgow Rd Westbound Approach	Necessity Brae Approach	Glasgow Rd Westbound Exit	Glasgow Rd Eastbound Approach	Necessity Brae Exit			
10	Glasgow Rd / Necessity Brae Roundabout	Car	7396	8859	3868	9345	7875	3861			
		LGV	1082	1092	427	1089	1243	592			
		OGV1	217	350	11	354	245	35			
		OGV2	39	119	0	119	49	11			
		Single Decker Bus	277	413	7	413	312	42			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	7	0	7	0	0			
		Coach	4	7	0	7	4	0			
		Total	9013	10847	4312	11333	9727	4540			
		%HDV	6%	9%	0%	9%	6%	1%			
		Speed (mph)	20	16	13	15	19	13			
		Speed (kmph)	32	25	21	24	30	21			
Junction	Junction Name	Arm	Glasgow Rd Eastbound Approach	Glasgow Rd Eastbound Exit	Murray Crescent Exit	Glasgow Rd Westbound Exit	Murray Place Exit	Glasgow Rd Westbound Approach	Murray Place Approach	Murray Crescent Approach	
11	Glasgow Rd / Murray Place / Murray Crescent	Car	5891	6363	2849	6465	385	6027	1383	2692	
		LGV	805	872	340	861	63	739	193	378	
		OGV1	200	242	53	270	11	252	21	91	
		OGV2	42	53	11	112	0	102	7	25	
		Single Decker Bus	256	256	18	361	14	336	4	53	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	7	0	7	0	0	
		Coach	4	4	0	7	0	7	0	0	
		Total	7196	7788	3269	8082	473	7469	1607	3238	
		%HDV	7%	7%	3%	10%	5%	11%	2%	5%	
		Speed (mph)	22	30	20	29	24	29	9	8	
		Speed (kmph)	35	49	31	46	39	46	14	12	
Junction	Junction Name	Arm	Glover Street Approach	Riggs Road Approach	Glasgow Rd Eastbound Exit	Glasgow Road Eastbound Entry	Glasgow Rd Westbound Entry	Glover Street Exit	Glasgow Rd Westbound Exit	Riggs Road Exit	
12	Glasgow Rd / Riggs Rd Rbt	Car	7028	5695	9741	11634	9114	7826	10591	5313	
		LGV	928	697	1414	1596	1152	924	1316	718	
		OGV1	242	221	322	277	284	168	340	193	
		OGV2	74	95	77	56	116	67	116	81	
		Single Decker Bus	109	144	357	343	438	105	445	126	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	4	0	0	4	7	4	11	0	
		Coach	0	0	4	4	7	0	7	0	
		Total	8383	6850	11914	13913	11116	9093	12824	6430	
		%HDV	6%	7%	7%	5%	9%	4%	9%	7%	
		Speed (mph)	3	5	26	10	19	13	24	13	
		Speed (kmph)	5	8	41	16	30	20	38	21	

Junction	Junction Name	Arm	Caledonian Rd Sthbnd Approach	Caledonian Rd Northbound Exit	Alexandra St Exit	Caledonian Rd Sthbnd Exit	Caledonian Rd Nthbnd Approach	Alexandra St Approach		
13	Caledonian Rd / Alexandra St	Car	3304	3952	504	2779	3045	840		
		LGV	515	515	67	406	410	74		
		OGV1	112	91	18	95	84	7		
		OGV2	42	35	7	35	21	14		
		Single Decker Bus	53	158	14	39	144	14		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	0	0	0	0	0	0		
		Coach	4	21	0	4	21	0		
		Total	4029	4771	609	3357	3724	949		
		%HDV	5%	8%	7%	5%	8%	4%		
		Speed (mph)	25	18	18	21	18	16		
		Speed (kmph)	40	30	29	34	29	25		
Junction	Junction Name	Arm	Leonard St Nthbnd Approach	Leonard St Sthbnd Approach	St Andrew St Approach	Leonard St Nthbnd Exit	Leonard St Sthbnd Exit	St Andrew St Exit		
14	St Andrew St / Leonard St	Car	4652	2912	2478	1841	5114	3042		
		LGV	602	417	368	238	746	396		
		OGV1	126	109	84	32	189	84		
		OGV2	32	28	35	11	63	21		
		Single Decker Bus	147	165	32	28	158	144		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	0	39	0	0	39	0		
		Coach	0	25	4	0	7	21		
		Total	5558	3693	3000	2149	6314	3707		
		%HDV	5%	11%	6%	3%	8%	8%		
		Speed (mph)	31	30	15	31	22	14		
		Speed (kmph)	49	48	24	49	35	22		
Junction	Junction Name	Arm	St Leonards Bank Approach	Kings Pl Estbnd Exit	St Leonards Bank Exit	Kings Place Westbnd Exit	Kings Pl Westbnd Approach	Kings Pl Estbnd Approach		
15	Kings Place / St Leonards Bank	Car	5173	5995	3959	4368	4235	4715		
		LGV	665	784	525	585	560	658		
		OGV1	119	193	126	126	137	189		
		OGV2	42	77	25	32	28	63		
		Single Decker Bus	137	147	133	161	203	102		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	4	21	4	0	0	21		
		Coach	0	4	0	18	18	4		
		Total	6139	7221	4771	5289	5180	5751		
		%HDV	5%	7%	7%	7%	9%	7%		
		Speed (mph)	15	25	24	21	29	15		
		Speed (kmph)	24	41	38	33	46	24		
Junction	Junction Name	Arm	Marshall Place Estbnd Approach	Princes Street Exit	Marshall Place Estbnd Exit	Edinburgh Road Exit	Marshall Place Wstbnd Exit	Marshall Place Wstbnd Approach	Edinburgh Rd Approach	
16	Marshall Place / Edinburgh Road	Car	5971	2191	2930	7242	6374	5768	7077	
		LGV	837	333	410	987	802	739	879	
		OGV1	249	95	266	256	240	259	361	
		OGV2	84	32	109	70	70	77	139	
		Single Decker Bus	154	98	158	147	137	105	280	
		Double Decker Bus	0	0	0	0	0	0	0	
		Minibus	0	0	0	0	0	0	0	
		Coach	4	0	0	4	18	14	4	
		Total	7298	2748	3871	8624	7648	6962	8719	
		%HDV	7%	9%	14%	6%	7%	7%	9%	
		Speed (mph)	9	20	20	18	22	7	4	
		Speed (kmph)	14	32	32	29	35	11	6	
Junction	Junction Name	Arm	South Street Approach	Tay St Northbound Exit	Queens Bridge Exit	Tay St Southbound Exit	Tay St Southbound Appproach	Tay St Northbound Approach	Queens Bridge Approach	
17	Tay St / South St Crossroads	Car	12936	2485	13188	11781	3031	3133	8274	
		LGV	1453	322	1421	1533	326	368	1131	
		OGV1	606	119	616	665	77	172	546	
		OGV2	158	32	175	259	25	60	224	
		Single Decker Bus	333	151	228	319	70	88	207	
		Double Decker Bus	0	0	0	0	0	0	0	
		Minibus	11	7	4	0	0	0	0	
		Coach	11	0	11	14	0	0	14	
		Total	15505	3115	15642	14490	3528	3819	10395	
		%HDV	9%	11%	9%	9%	6%	9%	10%	
		Speed (mph)	7	24	17	14	3	6	9	
		Speed (kmph)	11	38	27	22	5	9	15	
Junction	Junction Name	Arm	Tay St Southbound Exit	High Street Exit	Tay St Northbound Exit	High Street Approach	Tay St Northbound Approach	Tay St Southbound Approach		
18	Tay Street / High Street	Car	3031	861	1957	46	2485	3255		
		LGV	326	116	242	21	322	399		
		OGV1	77	35	84	0	119	70		
		OGV2	25	7	18	0	32	18		
		Single Decker Bus	70	109	39	0	151	60		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	0	7	0	0	7	0		
		Coach	0	0	0	0	0	0		
		Total	3528	1134	2338	67	3115	3801		
		%HDV	6%	15%	8%	0%	11%	4%		
		Speed (mph)	14	21	23	13	28	15		
		Speed (kmph)	22	34	38	20	45	24		
Junction	Junction Name	Arm	Queens Bridge Approach	Dundee Road Southbound Exit	Dundee Rd Nthbnd Approach	Dundee Rd Sthbnd Approach	Queens Bridge Exit	Dundee Rd Northbound Exit		
19	South St / Dundee Rd Crossroads	Car	13188	9615	7042	7616	8274	9958		
		LGV	1421	1236	984	1113	1131	1152		
		OGV1	616	294	354	427	546	557		
		OGV2	175	102	119	168	224	137		
		Single Decker Bus	228	168	203	123	207	179		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	4	0	0	0	0	4		
		Coach	11	11	14	0	14	0		
		Total	15642	11424	8715	9447	10395	11984		
		%HDV	9%	6%	8%	8%	10%	9%		
		Speed (mph)	17	26	6	5	9	19		
		Speed (kmph)	27	41	10	8	15	31		
Junction	Junction Name	Arm	Dundee Rd Total from Motorway	Walnut Grove From Perth	M90 Edinburgh Offslip	M90 Edinburgh Onslip	Walnut Grove to Perth	A90 Dundee Onslip	A90 Dundee Offslip	Dundee Rd Total To Motorway
20	Dundee Rd / M90 / A90 Motorway Junction	Car	6545	564	2086	2457	473	6185	4603	8589
		LGV	928	70	329	336	46	756	637	1078
		OGV1	326	11	112	98	11	175	203	284
		OGV2	112	0	25	21	11	70	77	91
		Single Decker Bus	200	11	53	56	11	95	137	161
		Double Decker Bus	0	0	0	0	0	0	0	0
		Minibus	0	0	0	0	0	0	0	0
		Coach	14	0	0	0	0	11	14	11
		Total	8124	655	2604	2968	550	7291	5670	10213
		%HDV	8%	3%	7%	6%	5%	5%	8%	6%
		Speed (mph)	53	23	59	45	57	38	33	54
		Speed (kmph)	86	37	95	72	92	62	53	86

Junction	Junction Name	Arm	Strathmore Street Exit	Main St Exit	Isla Road Exit	Strathmore St Approach	Isla Road Approach	Main St Approach		
21	Dundee Rd / Strathmore St / Isla	Car	8505	14329	3234	9975	4407	13482		
	Crossroads	LGV	1029	2090	343	1383	700	1589		
		OGV1	336	410	105	312	98	455		
		OGV2	70	130	39	84	46	112		
		Single Decker Bus	256	315	60	242	74	315		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	4	0	0	0	0	4		
		Coach	0	0	0	0	0	0		
		Total	10199	17273	3780	11995	5324	15957		
		%HDV	8%	5%	7%	5%	4%	7%		
		Speed (mph)	28	14	30	10	5	10		
		Speed (kmph)	45	23	48	16	7	16		
Junction	Junction Name	Arm	Dundee Rd Exit	Gowrie St Exit	Bowerswll Rd Approach	Dundee Rd Approach	Gowrie St Approach			
22	Gowrie St / Bowerswall Rd /	Car	7585	8638	1145	8162	6083			
	Dundee Rd T Junction	LGV	1113	1026	144	942	1064			
		OGV1	427	497	46	497	382			
		OGV2	165	123	29	123	137			
		Single Decker Bus	119	161	25	151	105			
		Double Decker Bus	0	0	0	0	0			
		Minibus	0	0	0	4	0			
		Coach	0	0	0	0	0			
		Total	9408	10444	1386	9877	8670			
		%HDV	8%	9%	7%	9%	7%			
		Speed (mph)	17	10	8	17	25			
		Speed (kmph)	28							
Junction	Junction Name	Arm	Edinburgh Rd Nthbnd Exit	Edinburgh Rd Sthbnd Exit	Glenearn Rd Exit	Edinburgh Rd Nthbnd Approach	Glenearn Rd Approach	Edinburgh Rd Sthbnd Approach		
23	Edinburgh Road / Glenearn Rd	Car	6493	9282	6152	10164	5558	6991		
		LGV	875	1103	784	1292	707	763		
		OGV1	347	427	273	553	161	336		
		OGV2	130	126	63	175	49	102		
		Single Decker Bus	259	224	137	347	95	182		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	0	0	0	0	0	0		
		Coach	4	4	0	4	0	4		
		Total	8106	11165	7410	12534	6570	7777		
		%HDV	9%	8%	7%	9%	5%	10%		
		Speed (mph)	17	29	19	11	4	9		
		Speed (kmph)	28	46	30	17	6	14		
Junction	Junction Name	Arm	Tesco Exit	Tesco Approach	Breadalbane Terrace Approach	Edinburgh Rd Nthbnd Approach	Edinburgh Rd Sthbnd Approach	Breadalbane Terrace Exit	Edinburgh Rd Sthbnd Exit	Edinburgh Rd Nthbnd Exit
24	Edinburgh Rd / Tesco /	Car	3385	2800	1288	7553	9282	756	6619	10164
	Breadalbane Terrace	LGV	347	378	179	907	1103	84	644	1292
		OGV1	28	35	98	473	427	88	364	553
		OGV2	7	7	21	158	126	25	105	175
		Single Decker Bus	21	21	84	266	224	46	182	347
		Double Decker Bus	0	0	0	0	0	0	0	0
		Minibus	0	0	0	0	0	0	0	0
		Coach	0	0	0	4	4	0	4	4
		Total	3787	3241	1670	9359	11165	998	8117	12534
		%HDV	2%	3%	12%	10%	8%	16%	9%	9%
		Speed (mph)	18	14	10	5	7	8	5	8
		Speed (kmph)	29	22	17	9	12	13	8	12
Junction	Junction Name	Arm	Friarton Rd Exit	Edinburgh Rd Sthbnd Exit	Edinburgh Rd Nthbnd Exit	Edinburgh Rd Nthbnd Approach	Friarton Rd Approach	Edinburgh Rd Sthbnd Approach		
25	Edinburgh Rd / Friarton Rd	Car	1859	9104	9121	8747	2345	8999		
		LGV	245	1159	1089	1068	280	1152		
		OGV1	137	581	529	620	270	441		
		OGV2	49	231	168	182	112	158		
		Single Decker Bus	70	336	340	371	147	252		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	0	0	0	0	0	0		
		Coach	0	4	4	4	0	4		
		Total	2359	11414	11249	10990	3154	11004		
		%HDV	11%	11%	9%	10%	28%	9%		
		Speed (mph)	12	28	31	14	3	32		
		Speed (kmph)	19	45	50	23	5	52		
Junction	Junction Name	Arm	Rhynd Road Approach	Edinburgh Rd Sthbnd Exit	Edinburgh Road Northbound Exit	Edinburgh Rd Sthbnd Approach	Edinburgh Rd Nthbnd Approach			
26	Edinburgh Rd / Rhynd Rd	Car	263	8138	8691	8138	8197			
		LGV	42	963	1064	963	991			
		OGV1	21	543	613	543	585			
		OGV2	4	221	179	221	175			
		Single Decker Bus	14	312	371	312	350			
		Double Decker Bus	0	0	0	0	0			
		Minibus	0	0	0	0	0			
		Coach	0	4	4	4	4			
		Total	343	10178	10920	10178	10301			
		%HDV	12%	13%	10%	13%	10%			
		Speed (mph)	20	32	47	42	69			
		Speed (kmph)	32	52	76	67	111			
Junction	Junction Name	Arm	M90 Northbound Off Slip to Broxden	M90 Nthbnd off slip to Edinburgh Rd	Sthbnd On Slip from Edinburgh Rd	Sthbnd On Slip from Broxden	Nthbnd on slip from Broxden	Sthbnd off slip to Broxden		
27	Edinburgh Road / M90 Motorway	Car	7494	4900	4953	8117	9716	11235		
		LGV	1082	616	595	1019	1313	1733		
		OGV1	364	459	413	465	1110	641		
		OGV2	161	126	147	189	375	256		
		Single Decker Bus	231	238	224	322	728	448		
		Double Decker Bus	0	0	0	0	0	0		
		Minibus	0	0	0	0	0	0		
		Coach	0	4	4	0	0	0		
		Total	9331	6342	6335	10101	13241	14312		
		%HDV	8%	12%	14%	11%	17%	9%		
		Speed (mph)	69	68	40	69	65	61		
		Speed (kmph)	111	110	64	111	105	99		

Table A1.1c – 2005 with CCTMR AADT for Perth City Centre

2005 Base Average Peak - City Centre Road Links (adjusted by a factor of 2.2)												
Junction	Junction Name	Arm	A	B	C	D	E	F	G	H	I	
Junction	Junction Name	Arm	Caledonian Rd Nthbnd Exit	York Place Exit	Caledonian Rd Sthbnd Exit	Glasgow Road Exit	York Place Approach	Caledonian Rd Nthbnd Approach	Caledonian Rd Sthbnd Approa	Glasgow Rd Approach		
28	Glasgow Road / Caledonian F	Car	3892	4781	2248	4961	3626	2453	4574	5229		
	York Place Crossroads	LGV	539	596	277	598	427	361	537	686		
		OGV1	141	121	53	200	185	77	132	121		
		OGV2	53	62	18	75	77	29	42	59		
		Single Decker Bus	90	229	44	233	176	99	68	253		
		Double Decker Bus	0	0	0	0	0	0	0	0		
		Minibus	0	0	0	4	2	0	2	0		
		Coach	2	7	2	4	0	13	0	2		
		Total	4717	5795	2642	6076	4492	3032	5355	6351		
		%HDV	7%	9%	5%	10%	13%	9%	5%	7%		
		Speed (mph)	17	25	17	20	8	3	5	11		
		Speed (kmph)	28	41	27	32	13	6	8	18		
Junction	Junction Name	Arm	York Place Estbnd Approach	New Row Nthbnd Exit	York Place Estbnd Exit	New Row Sthbnd Exit	York Place Wstbnd Exit	New Row Nthbnd Approach	York Place Wstbnd Approach	New Row Sthbnd Approach		
29	York Place / New Row	Car	4781	1822	5529	922	3626	1562	4253	1641		
		LGV	596	229	706	147	427	193	530	260		
		OGV1	121	68	163	40	185	55	227	59		
		OGV2	62	35	70	11	77	24	92	15		
		Single Decker Bus	229	26	244	22	176	42	169	29		
		Double Decker Bus	0	0	0	0	0	0	0	0		
		Minibus	0	0	0	13	2	0	15	0		
		Coach	7	0	7	0	0	0	0	0		
		Total	5795	2180	6719	1155	4492	1866	5287	1998		
		%HDV	9%	7%	8%	7%	13%	7%	12%	5%		
		Speed (mph)	30	11	9	12	22	6	19	5		
		Speed (kmph)	49	17	14	20	35	9	31	8		
Junction	Junction Name	Arm	South St Estbnd Exit	Scott St Sthbnd Exit	Scott St Nthbnd Exit	Scott St Sthbnd Approach	Scott St Nthbnd Approach	South St Estbnd Approach				
30	South St / Scott St	Car	6690	2644	2009	2121	2035	7434				
		LGV	803	326	326	262	323	906				
		OGV1	244	123	95	55	95	286				
		OGV2	99	46	35	22	35	119				
		Single Decker Bus	147	150	125	88	77	235				
		Double Decker Bus	0	0	0	0	0	0				
		Minibus	2	2	11	2	11	2				
		Coach	7	0	0	0	0	7				
		Total	7993	3291	2600	2550	2576	8989				
		%HDV	8%	13%	10%	13%	9%	8%				
		Speed (mph)	39	25	44	11	8	21				
		Speed (kmph)	63	40	72	18	14	34				
Junction	Junction Name	Arm	County Place Wstbnd Exit	Sth Methven St Exit	King St Approach	Sth Methven St Approach	County Place Estbnd Approach	South St Exit				
31	County Place / Sth Methven	Car	4253	1533	5685	3021	5529	7293				
	King St	LGV	530	191	706	365	706	917				
		OGV1	227	75	326	165	163	310				
		OGV2	92	26	136	62	70	123				
		Single Decker Bus	169	79	191	130	244	249				
		Double Decker Bus	0	0	0	0	0	0				
		Minibus	15	0	4	13	0	0				
		Coach	0	0	0	0	7	7				
		Total	5287	1905	7049	3755	6719	8899				
		%HDV	12%	10%	10%	11%	8%	9%				
		Speed (mph)	19	16	11	3	16	11				
		Speed (kmph)	31	26	18	5	26	17				
Junction	Junction Name	Arm	South St Approach	Tay St Nthbnd Exit	Queens Bridge Exit	Tay St Sthbnd Exit	Tay St Sthbnd Approach	Tay St Nthbnd Approach	Queens Bridge Approach			
32	South St / Tay St	Car	8087	1496	8261	7359	2072	1837	5119			
		LGV	983	187	1021	997	266	260	695			
		OGV1	365	99	356	451	64	103	374			
		OGV2	163	48	136	165	15	35	136			
		Single Decker Bus	205	77	167	194	40	64	132			
		Double Decker Bus	0	0	0	0	0	0	0			
		Minibus	7	4	2	0	0	0	0			
		Coach	7	0	7	9	0	0	9			
		Total	9816	1912	9951	9174	2457	2299	6466			
		%HDV	9%	13%	9%	9%	6%	10%	10%			
		Speed (mph)	7	24	18	14	3	6	10			
		Speed (kmph)	12	38	29	22	4	10	15			
Junction	Junction Name	Arm	Atholl St Wstbnd Approach	Atholl St Estbnd Exit	Kinnoull St Exit	Atholl St Wstbnd Exit	Barossa St Exit	Atholl St Estbnd approach	Kinnoull St Approach	Barossa St Approach		
33	Atholl St / Kinnoull St	Car	5458	4385	195	6703	334	5273	2231	440		
		LGV	713	616	282	843	51	759	295	37		
		OGV1	101	11	35	156	7	29	66	11		
		OGV2	31	4	2	46	2	2	15	4		
		Single Decker Bus	130	79	117	174	0	152	95	0		
		Double Decker Bus	0	0	0	0	0	0	0	0		
		Minibus	4	0	2	2	0	0	0	0		
		Coach	0	0	0	0	0	0	0	0		
		Total	6437	5095	2389	7924	394	6215	2702	493		
		%HDV	4%	2%	7%	5%	2%	3%	9%	4%		
		Speed (mph)	4	29	17	7	19	15	3	6		
		Speed (kmph)	7	46	27	11	30	23	4	10		
Junction	Junction Name	Arm	Atholl St Approach	Atholl St Exit	N Methven St Exit	Caledonian Rd Exit	Melville St Exit	N Methven St Approach	Melville St Approach	Caledonian Rd Approach		

		Speed (kmph)	5	33	34	19	35	6	5	8		
Junction	Junction Name	Arm	Atholl St Wstbnd	Atholl St Estbnd Exit	Atholl St Wstbnd Exit	Atholl St Estbnd Approach						
35	Atholl St / Stormont St	Car	6703	5273	6717	5260						
		LGV	843	759	845	759						
		OGV1	156	29	156	29						
		OGV2	46	2	46	2						
		Single Decker Bus	174	152	176	152						
		Double Decker Bus	0	0	0	0						
		Minibus	2	0	2	0						
		Coach	0	0	0	0						
		Total	7924	6215	7942	6202						
		%HDV	5%	3%	5%	3%						
		Speed (mph)	7	15	3	20						
		Speed (kmph)	11	23	5	33						
Junction	Junction Name	Arm	Atholl St Estbnd Exit	Atholl St Wstbnd Exit	Rose Terrace Exit	Atholl St Estbnd Approach	Atholl St Wstbnd Approach	Rose Terrace Approach				
36	Atholl St / Rose Crescent	Car	5245	5458	2055	4385	7427	950				
		LGV	704	713	249	616	950	101				
		OGV1	26	101	35	11	132	20				
		OGV2	4	31	18	4	46	2				
		Single Decker Bus	95	130	35	79	165	15				
		Double Decker Bus	0	0	0	0	0	0				
		Minibus	0	4	0	0	4	0				
		Coach	0	0	0	0	0	0				
		Total	6074	6437	2391	5095	8725	1089				
		%HDV	2%	4%	3%	2%	4%	3%				
		Speed (mph)	25	4	10	29	11	7				
		Speed (kmph)	41	7	16	46	18	11				
Junction	Junction Name	Arm	Caledonian Road Exit	Atholl St Approach	Atholl Street to Barrack Street	Caledonian Rd Approach to Barrack Str	Caledonian Rd Approach to Barrack	Barrack Street Approach to Caledonian	Barrack St Approach to Atholl	Atholl St Exit	D+C	F+G	
37	Barrack Street / Atholl St /	Car	5150	8131	5181	2829	2829	2200	5661	8030	8010	7861	
	Caledonian Road	LGV	620	1038	678	367	367	260	783	1111	1045	1043	
		OGV1	123	218	152	81	81	57	158	172	233	216	
		OGV2	44	75	57	24	24	26	51	57	81	77	
		Single Decker Bus	88	218	161	48	48	31	141	169	209	172	
		Double Decker Bus	0	0	0	0	0	0	0	0	0	0	
		Minibus	13	13	11	0	0	11	0	0	11	11	
		Coach	0	0	0	2	2	0	0	0	2	0	
		Total	6039	9693	6239	3353	3353	2585	6794	9539	9592	9379	
		%HDV	5%	6%	6%	5%	5%	5%	5%	4%	6%	5%	
		Speed (mph)	21	9	32	3	3	35	3	5	17	3	
		Speed (kmph)	34	15	51	5	56	4	5	8	28	5	
Junction	Junction Name	Arm	Bridge Lane Approach	Perth Bridge Exit	Tay St Exit	Charlotte St Exit	Tay St Approach	Charlotte St Approach	Perth Bridge Approach				
38	Charlotte St / Tay St /	Car	1232	4514	2378	7460	1375	5260	6486				
	West Bridge St / Bridge Lane	LGV	178	594	330	950	143	708	845				
		OGV1	24	0	59	132	64	26	77				
		OGV2	15	0	18	46	26	4	18				
		Single Decker Bus	48	128	37	165	15	95	172				
		Double Decker Bus	0	0	0	0	0	0	0				
		Minibus	2	2	0	4	0	0	4				
		Coach	0	0	0	0	0	0	0				
		Total	1500	5238	2823	8758	1624	6094	7601				
		%HDV	10%	3%	4%	4%	7%	2%	4%				
		Speed (mph)	2	8	25	25	4	7	10				
		Speed (kmph)	2	13	40	40	6	12	16				
Junction	Junction Name	Arm	East Bridge St Exit	West Bridge St Exit	Main St Exit	Gowrie St Approach	East Bridge St Approach	Main St Approach	West Bridge St Approach	Gowrie St Exit			
39	Main St / Gowrie St /	Car	510	6486	8397	4906	1135	9137	4514	4299			
	West Bridge St	LGV	53	845	1065	596	169	1208	594	605			
		OGV1	0	77	235	235	24	304	0	251			
		OGV2	0	18	95	97	18	77	0	79			
		Single Decker Bus	18	172	227	147	35	183	128	77			
		Double Decker Bus	0	0	0	0	0	0	0	0			
		Minibus	0	4	2	0	4	0	2	0			
		Coach	0	0	0	0	0	0	0	0			
		Total	581	7601	10021	5982	1386	10908	5238	5311			
		%HDV	3%	4%	7%	10%	6%	5%	3%	8%			
		Speed (mph)	9	13	19	4	2	10	4	18			
		Speed (kmph)	14	21	30	7	3	16	6	30			

Table A1.1d – 2005 with CCTMR AADT for Perth other major roads

2005 Base Average Peak - Major Road Links (adjusted by a factor of 3.5)											
Junction	Junction Name	Arm	A	B	C	D	E	F	G	H	I
Junction	Junction Name	Arm	Dunkeld Rd Approach	A9 North Approach	A9 Western Bypass Approach	Dunkeld Rd Exit	A9 Western Bypass Exit	Industrial Estate Exit	A9 North Exit	Industrial Estate Approach	
1	Inveralmond Roundabout	Car	8411	11011	10906	12411	9230	7126	9608	6920	
		LGV	1264	1540	1593	1817	1390	1050	1243	879	
		OGV1	168	396	651	298	690	175	620	399	
		OGV2	56	133	245	77	252	67	224	151	
		Single Decker Bus	179	259	378	165	431	102	364	259	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	0	0	0	0	0	
		Coach	4	0	0	0	0	0	4	0	
		Total	10080	13339	13773	14767	11991	8519	12061	8607	
		%HDV	4%	6%	7%	4%	10%	4%	10%	12%	
		Speed (mph)	15	21	18	26	29	24	22	8	
		Speed (kmph)	24	34	29	41	47	38	36	13	
Junction	Junction Name	Arm	Bute Drive Exit	Dunkeld Rd South Exit	Dunkeld Rd North Exit	Dunkeld Road South Approach	Dunkeld Rd North Approach	Bute Drive Approach			
2	Dunkeld Road / Bute Drive	Car	6489	7865	10133	5299	9576	3598			
		LGV	697	1260	1376	858	1383	525			
		OGV1	119	151	193	151	214	74			
		OGV2	56	42	74	49	63	35			
		Single Decker Bus	63	95	165	98	140	63			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	0	0	4	4	0	0			
		Total	7424	9412	11942	6458	11375	4295			
		%HDV	3%	3%	4%	4%	4%	4%			
		Speed (mph)	24	17	18	13	14	5			
		Speed (kmph)	39	27	29	21	23	8			
Junction	Junction Name	Arm	Dunkeld Rd South Approach	Gowans Terrace Exit	Dunkeld Rd North Approach	Gowans Terrace Approach	Dunkeld Rd South Exit	Dunkeld Rd North Exit			
3	Dunkeld Rd / Gowans Terrac	Car	11711	5268	6948	4522	6629	12054			
		LGV	1425	662	1169	644	1152	1414			
		OGV1	242	81	210	77	259	256			
		OGV2	109	42	49	21	53	119			
		Single Decker Bus	140	74	123	21	105	168			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	4	0	0	0	0	4			
		Total	13629	6125	8498	5285	8197	14014			
		%HDV	4%	3%	6%	2%	6%	4%			
		Speed (mph)	17	19	13	10	9	13			
		Speed (kmph)	27	30	21	16	15	20			
Junction	Junction Name	Arm	Ballantine Place Approach	Crieff Rd Approach	Dunkeld Rd North Approach	Dunkeld Rd South Exit	Dunkeld Rd South Approach	Ballantine Place Exit	Crieff Rd Exit	Dunkeld Rd North Exit	
4	Dunkeld Rd / Crieff Rd	Car	4893	5446	11543	9125	10147	7420	2986	5138	
		LGV	539	826	1694	1414	1316	655	571	854	
		OGV1	137	168	459	413	200	165	39	130	
		OGV2	46	60	144	126	84	84	0	53	
		Single Decker Bus	81	196	231	231	214	91	109	84	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	18	0	18	18	0	18	0	
		Coach	0	0	0	0	4	0	0	4	
		Total	5695	6713	14070	11326	11981	8414	3721	6262	
		%HDV	2%	7%	6%	7%	4%	2%	4%	4%	
		Speed (mph)	12	13	12	7	14	13	14	8	
		Speed (kmph)	20	21	20	11	22	21	22	13	
Junction	Junction Name	Arm	Dunkeld Road South Exit	St Catherines Road Exit	Dunkeld Rd North Exit	St Catherines Road Entry	Dunkeld Rd South Entry	Dunkeld Rd North Entry			
5	Dunkeld Rd / St Catherines R	Car	14004	2884	14147	6846	7448	7984			
	Barrack Street	LGV	1824	410	1775	760	1138	1344			
		OGV1	445	151	375	382	273	361			
		OGV2	168	49	126	154	77	91			
		Single Decker Bus	266	25	273	207	210	224			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	18	0	18	0	18	18			
		Coach	0	0	4	0	4	0			
		Total	16723	3518	16716	8348	9167	10021			
		%HDV	6%	6%	5%	5%	6%	6%			
		Speed (mph)	7	20	23	8	8	9			
		Speed (kmph)	11	32	37	12	12	14			
Junction	Junction Name	Arm	Western Bypass Nbnd Offslip	Crieff Road Eastbound Approa	Western Bypass Nbnd Onslip	Crieff Rd Westbound Approach	Crieff Rd Eastbound Exit	Crieff Rd Westbound Exit			
6	A9 / Crieff Rd Roundabout	Car	6804	8656	4176	9797	4879	8054			
	Dobbies Roundabout	LGV	788	1239	515	1201	823	1089			
		OGV1	158	224	119	236	140	154			
		OGV2	53	35	25	63	21	35			
		Single Decker Bus	98	147	60	298	158	165			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	18	0	18	18	18			
		Coach	0	0	0	0	0	0			
		Total	7900	10318	4893	11631	6038	9513			
		%HDV	4%	4%	4%	6%	4%	4%			
		Speed (mph)	10	17	20	16	14	16			
		Speed (kmph)	16	27	32	26	23	26			

Junction	Junction Name	Arm	Orleff Rd Eastbound Entry	Orleff Rd Eastbound Exit	Newhouse Rd Approach	A6 On / Off slip approach	Orleff Rd Westbound Approach	Newhouse Rd Exit	Orleff Rd Westbound Exit	A6 On / Off Slip Exit	
7	A9 / Orleff Rd Roundabout	Car	10961	8850	5223	9366	3886	4620	5387	9331	
	Newtongate Rd Roundabout	LGV	1436	1075	788	1198	530	752	848	1092	
		OGV1	294	84	113	217	118	102	118	137	
		OGV2	60	4	46	70	14	28	25	46	
		Single Decker Bus	259	154	91	161	168	119	210	95	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	21	18	4	0	18	4	21	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	12929	9984	7270	10992	4816	5604	6638	10700	
		%HDV	5%	3%	4%	4%	6%	5%	4%	3%	
		Speed (mph)	6	16	8	8	18	9	9	11	
		Speed (kmph)	9	26	25	13	29	14	15	18	
Junction	Junction Name	Arm	Fairfield Avenue Approach	Orleff Rd Westbound Entry	Orleff Rd Eastbound Entry	Feus Rd Approach	Orleff Rd Eastbound Exit	Feus Rd Exit	Orleff Rd Westbound Exit	Fairfield Avenue Exit	
8	Orleff Rd / Feus Rd Roundabo	Car	6654	7070	10385	6981	3990	2654	2720	366	
		LGV	686	1092	1341	879	579	455	818	53	
		OGV1	284	46	245	112	109	77	53	23	
		OGV2	74	0	53	42	22	14	14	19	
		Single Decker Bus	126	161	207	179	161	25	147	53	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		MiniBus	0	18	18	0	18	0	18	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	7763	9386	12247	8194	4877	3266	3769	441	
		%HDV	13%	3%	4%	5%	6%	4%	7%	28%	
		Speed (mph)	6	13	10	14	10	15	14	14	
		Speed (kmph)	9	20	16	23	16	24	22	23	
Junction	Junction Name	Arm	M90 Edinburgh Approach	M90 Edinburgh Exit	A9 Stirling Exit	A9 Inverness Exit	Glasgow Road Exit	A9 Western Bypass Approach	A9 Stirling Approach	Glasgow Road Approach	Glasgow Rd - M90 E
9	Broxden Roundabout	Car	14186	10529	7888	12747	10689	6405	7624	2443	1358
		LGV	1922	1477	1145	1841	1383	1043	1334	420	301
		OGV1	445	1078	667	595	354	627	1095	189	67
		OGV2	137	366	283	224	137	217	406	74	26
		Single Decker Bus	273	504	367	354	366	357	696	137	35
		Double Decker Bus	0	0	0	0	0	0	0	0	0
		Minibus	0	0	0	0	0	0	0	0	0
		Coach	0	0	0	0	4	0	4	0	0
		Total	16961	14014	10184	15761	13040	8649	11164	3266	1786
		%HDV	4%	12%	9%	6%	6%	10%	19%	12%	7%
		Speed (mph)	18	19	30	37	35	19	8	20	34
		Speed (kmph)	29	31	48	60	42	31	13	32	55
Junction	Junction Name	Arm	Glasgow Rd Eastbound Exit	Glasgow Rd Westbound Appro	Necessity Brae Approach	Glasgow Rd Westbound Exit	Glasgow Rd Eastbound Approach	Necessity Brae Exit			
10	Glasgow Rd / Necessity Brae	Car	8054	10076	5926	6824	7084	4498			
	Roundabout	LGV	1019	1351	676	749	1180	707			
		OGV1	209	409	123	242	179	94			
		OGV2	91	147	49	95	81	42			
		Single Decker Bus	264	389	176	291	277	60			
		Double Decker Bus	0	0	0	0	0	0			
		MiniBus	0	7	0	7	0	0			
		Coach	4	7	0	7	0	4			
		Total	9653	13279	6881	7214	8663	5390			
		%HDV	7%	9%	2%	8%	6%	3%			
		Speed (mph)	19	12	22	9	25	8			
		Speed (kmph)	31	20	35	14	40	13			
Junction	Junction Name	Arm	Glasgow Rd Eastbound Approa	Glasgow Rd Eastbound Exit	Murray Crescent Exit	Glasgow Rd Westbound Exit	Murray Place Exit	Glasgow Rd Westbound Approach	Murray Place Approach	Murray Crescent Approach	
11	Glasgow Rd / Murray Place /	Car	3864	7172	3621	6936	1884	7266	6853	1141	
	Murray Crescent	LGV	481	875	459	1040	175	909	588	203	
		OGV1	116	98	98	308	88	186	84	53	
		OGV2	60	46	25	108	34	60	18	21	
		Single Decker Bus	221	294	85	340	7	305	133	32	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	7	0	7	0	0	
		Coach	4	0	0	7	0	7	0	0	
		Total	4844	8488	4188	10742	2182	8739	6886	1449	
		%HDV	7%	6%	6%	9%	6%	9%	9%	7%	
		Speed (mph)	13	18	22	27	14	17	11	9	
		Speed (kmph)	20	29	35	44	23	28	18	15	
Junction	Junction Name	Arm	Glover Street Approach	Riggs Road Approach	Glasgow Rd Eastbound Exit	Glasgow Road Eastbound Entry	Glasgow Rd Westbound Entry	Glover Street Exit	Glasgow Rd Westbound Exit	Riggs Road Exit	
12	Glasgow Rd / Riggs Rd Slip	Car	9147	7581	13374	9870	3717	10911	7746	5490	
		LGV	599	882	1666	1349	632	1208	1089	700	
		OGV1	123	269	266	231	214	343	238	265	
		OGV2	53	49	109	95	74	88	81	118	
		Single Decker Bus	109	294	420	371	340	161	389	172	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		MiniBus	4	0	0	4	7	4	11	0	
		Coach	0	0	4	4	7	4	7	0	
		Total	9973	8964	15838	11921	4984	12100	9499	6738	
		%HDV	7%	7%	6%	5%	11%	6%	8%	8%	
		Speed (mph)	7	9	25	7	12	11	14	15	
		Speed (kmph)	11	14	40	12	19	18	22	24	

Junction	Junction Name	Arm	Caledonian Rd SthBnd Approach	Caledonian Rd NorthBound Exit	Alexandra St Exit	Caledonian Rd SthBnd Exit	Caledonian Rd NthBnd Approach	Alexandra St Approach			
13	Caledonian Rd / Alexandra S	Car	1309	1390	166	1005	1166	256			
		LGV	262	264	46	280	231	67			
		OGV1	77	70	28	53	83	18			
		OGV2	7	95	4	4	28	7			
		Single Decker Bus	18	151	7	14	130	25			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	4	21	0	4	21	0			
		Total	1666	1960	246	1278	1688	371			
		%HDV	6%	14%	14%	6%	14%	13%			
		Speed (mph)	23	21	17	21	18	16			
		Speed (kmph)	38	33	28	33	29	25			
Junction	Junction Name	Arm	Leonard St Nthbnd Approach	Leonard St Stbnd Approach	St Andrew St Approach	Leonard St Nthbnd Exit	Leonard St Stbnd Exit	St Andrew St Exit			
14	St Andrew St / Leonard St	Car	1712	1108	854	669	1901	1078			
		LGV	389	256	164	154	399	248			
		OGV1	98	68	53	46	140	59			
		OGV2	42	21	4	11	21	29			
		Single Decker Bus	91	144	14	14	105	130			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	39	0	0	39	0			
		Coach	0	25	4	0	7	21			
		Total	2331	1664	1092	907	2611	1547			
		%HDV	19%	19%	7%	19%	12%	19%			
		Speed (mph)	31	26	15	34	22	14			
		Speed (kmph)	49	40	25	54	35	22			
Junction	Junction Name	Arm	St Leonards Bank Approach	Kings Pl Estbnd Exit	St Leonards Bank Exit	Kings Place Wstbnd Exit	Kings Pl Wstbnd Approach	Kings Pl Estbnd Approach			
15	Kings Place / St Leonards Ba	Car	1866	2030	1383	1621	1474	1656			
		LGV	392	431	263	369	322	340			
		OGV1	109	165	70	98	84	140			
		OGV2	46	86	32	42	42	21			
		Single Decker Bus	81	119	50	105	154	49			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	4	21	4	0	0	21			
		Coach	0	4	0	18	18	4			
		Total	2496	2804	1810	2251	2093	2230			
		%HDV	19%	12%	9%	12%	14%	11%			
		Speed (mph)	15	15	14	21	19	16			
		Speed (kmph)	26	41	38	33	46	25			
Junction	Junction Name	Arm	Marshall Place Estbnd Approac	Princes Street Exit	Marshall Place Estbnd Exit	Edinburgh Road Exit	Marshall Place Wstbnd Exit	Marshall Place Wstbnd Approach	Edinburgh Rd Approach		
16	Marshall Place / Edinburgh R	Car	1665	994	1257	2342	2632	2174	3119		
		LGV	419	159	263	392	525	345	509		
		OGV1	165	48	196	146	182	137	238		
		OGV2	28	36	53	33	77	67	96		
		Single Decker Bus	91	74	105	70	88	63	193		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	0	0	0	0	0	0	0		
		Coach	4	0	0	4	18	14	4		
		Total	2684	1302	1873	2991	3532	2783	4249		
		%HDV	11%	18%	19%	7%	10%	10%	12%		
		Speed (mph)	7	20	21	18	21	8	5		
		Speed (kmph)	11	33	33	28	34	13	8		
Junction	Junction Name	Arm	South Street Approach	Tay St Northbound Exit	Queens Bridge Exit	Tay St Southbound Exit	Tay St Southbound Approach	Tay St Northbound Approach	Queens Bridge Approach		
17	Tay St / South St Crossroad	Car	4029	917	2774	5835	768	998	4067		
		LGV	700	172	675	670	140	236	455		
		OGV1	389	63	395	336	32	112	343		
		OGV2	168	95	151	109	7	39	91		
		Single Decker Bus	280	112	168	102	28	70	49		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	11	7	4	0	0	0	0		
		Coach	11	0	11	14	0	0	14		
		Total	5594	1306	4121	6643	969	1453	6128		
		%HDV	15%	17%	14%	8%	7%	15%	9%		
		Speed (mph)	9	23	17	13	3	9	7		
		Speed (kmph)	15	37	27	22	4	13	12		
Junction	Junction Name	Arm	Tay St Southbound Exit	High Street Exit	Tay St Northbound Exit	High Street Approach	Tay St Northbound Approach	Tay St Southbound Approach			
18	Tay Street / High Street	Car	753	265	564	7	941	1008			
		LGV	140	60	96	4	172	210			
		OGV1	32	32	42	0	63	25			
		OGV2	7	21	18	0	35	11			
		Single Decker Bus	28	56	21	0	112	28			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	7	0	0	7	0			
		Coach	0	0	0	0	0	0			
		Total	960	465	739	11	1306	1291			
		%HDV	7%	21%	11%	0%	17%	9%			
		Speed (mph)	24	21	23	14	28	18			
		Speed (kmph)	38	34	37	23	44	29			
Junction	Junction Name	Arm	Queens Bridge Approach	Dundee Road Southbound Exit	Dundee Rd NthBnd Approach	Dundee Rd SthBnd Approach	Queens Bridge Exit	Dundee Rd Northbound Exit			
19	South St / Dundee Rd	Car	3714	3497	3335	3668	4057	3154			
	Crossroads	LGV	579	590	592	648	655	574			
		OGV1	396	200	118	252	263	299			
		OGV2	151	62	35	77	91	118			
		Single Decker Bus	105	105	74	49	49	140			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	4	0	0	0	0	4			
		Coach	11	11	14	0	14	0			
		Total	5121	4557	4167	4694	5128	4291			
		%HDV	14%	8%	6%	8%	6%	13%			
		Speed (mph)	17	25	5	6	7	22			
		Speed (kmph)	27	41	9	10	12	36			
Junction	Junction Name	Arm	Dundee Rd Total from Motorwa	Walnut Grove From Perth	M90 Edinburgh Offslip	M90 Edinburgh Onslip	Walnut Grove to Perth	A90 Dundee Onslip	A90 Dundee Offslip	Dundee Rd Total To Motorway	
20	Dundee Rd / M90 / A90	Car	3234	294	980	966	154	2428	2415	3960	
	Motorway Junction	LGV	567	46	168	203	21	491	494	623	
		OGV1	109	4	74	28	4	164	92	109	
		OGV2	28	0	14	0	7	60	7	60	
		Single Decker Bus	63	4	42	28	4	70	18	102	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	0	0	0	0	0	
		Coach	14	0	0	0	0	11	14	11	
		Total	4014	347	1278	1215	189	3157	2911	4847	
		%HDV	6%	2%	10%	6%	7%	10%	2%	6%	
		Speed (mph)	54	24	60	45	56	39	31	54	
		Speed (kmph)	86	38	96	72	89	62	49	86	

Junction	Junction Name	Arm	Strathmore Street Exit	Main St Exit	Isla Road Exit	Strathmore St Approach	Isla Road Approach	Main St Approach			
21	Dundee Rd / Strathmore St /	Car	2545	7168	882	4634	2541	4067			
	Crossroads	LGV	459	1155	175	753	406	770			
		OGV1	210	249	42	189	63	266			
		OGV2	63	60	35	46	14	98			
		Single Decker Bus	193	165	46	126	39	245			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	4	0	0	0	0	4			
		Coach	0	0	0	0	0	0			
		Total	3472	8796	1180	5747	3063	5450			
		%HDV	14%	5%	10%	6%	4%	11%			
		Speed (mph)	27	9	30	6	5	8			
		Speed (kmph)	44	15	48	10	8	12			
Junction	Junction Name	Arm	Dundee Rd Exit	Gowrie St Exit	Bowerswll Rd Approach	Dundee Rd Approach	Gowrie St Approach				
22	Gowrie St / Bowerswell Rd /	Car	3651	2853	564	2562	3420				
	Dundee Rd T Junction	LGV	648	490	95	441	602				
		OGV1	252	273	32	273	221				
		OGV2	77	102	18	102	60				
		Single Decker Bus	49	126	11	116	49				
		Double Decker Bus	0	0	0	0	0				
		Minibus	0	0	0	4	0				
		Coach	0	0	0	0	0				
		Total	4676	3843	718	3497	4351				
		%HDV	8%	13%	8%	14%	8%				
		Speed (mph)	14	10	5	20	20				
		Speed (kmph)	22	17	8	31	32				
Junction	Junction Name	Arm	Edinburgh Rd Nthbnd Exit	Edinburgh Rd Sthbnd Exit	Glenearn Rd Exit	Edinburgh Rd Nthbnd Approach	Glenearn Rd Approach	Edinburgh Rd Sthbnd Approach			
23	Edinburgh Road / Glenearn R	Car	3248	2779	2048	4302	2429	1533			
		LGV	665	483	378	879	382	291			
		OGV1	221	207	168	347	98	161			
		OGV2	105	46	74	168	18	39			
		Single Decker Bus	179	144	77	238	49	116			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	4	4	0	4	0	4			
		Total	4421	3661	2744	5936	2975	2142			
		%HDV	11%	11%	12%	13%	6%	15%			
		Speed (mph)	17	28	18	10	4	9			
		Speed (kmph)	28	45	30	16	7	14			
Junction	Junction Name	Arm	Tesco Exit	Tesco Approach	Breadalbane Terrace Approach	Edinburgh Rd Nthbnd Approach	Edinburgh Rd Sthbnd Approach	Breadalbane Terrace Exit	Edinburgh Rd Sthbnd Exit	Edinburgh Rd Nthbnd Exit	
24	Edinburgh Rd / Tesco /	Car	798	550	693	3332	483	336	1918	4302	
	Breadalbane Terrace	LGV	126	130	126	693	483	70	357	879	
		OGV1	14	21	53	301	207	53	168	347	
		OGV2	4	11	28	140	46	7	46	168	
		Single Decker Bus	7	7	63	182	144	21	130	238	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	0	0	0	0	0	
		Coach	0	0	0	4	4	0	4	4	
		Total	949	718	963	4652	3661	487	2622	5936	
		%HDV	3%	5%	15%	13%	11%	17%	13%	13%	
		Speed (mph)	18	15	11	5	8	8	5	6	
		Speed (kmph)	29	24	17	8	12	13	8	10	
Junction	Junction Name	Arm	Friarton Rd Exit	Edinburgh Rd Sthbnd Exit	Edinburgh Rd Nthbnd Exit	Edinburgh Rd Nthbnd Approach	Friarton Rd Approach	Edinburgh Rd Sthbnd Approach			
25	Edinburgh Rd / Friarton Rd	Car	1089	2846	4232	4715	665	2793			
		LGV	221	518	816	889	123	543			
		OGV1	81	329	378	410	214	210			
		OGV2	25	74	179	196	46	56			
		Single Decker Bus	63	210	235	277	74	172			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	0	4	4	4	0	4			
		Total	1477	3980	5842	6489	1120	3777			
		%HDV	11%	15%	14%	14%	30%	12%			
		Speed (mph)	10	27	28	14	3	32			
		Speed (kmph)	17	44	45	22	5	51			
Junction	Junction Name	Arm	Rhynd Road Approach	Edinburgh Rd Sthbnd Exit	Edinburgh Road Northbound Exit	Edinburgh Rd Sthbnd Approach	Edinburgh Rd Nthbnd Approach				
26	Edinburgh Rd / Rhynd Rd	Car	81	2160	4697	2160	4536				
		LGV	21	406	882	406	947				
		OGV1	4	298	406	298	403				
		OGV2	4	70	193	70	179				
		Single Decker Bus	0	193	273	193	263				
		Double Decker Bus	0	0	0	0	0				
		Minibus	0	0	0	0	0				
		Coach	0	4	4	4	4				
		Total	109	3129	6454	3129	6230				
		%HDV	6%	18%	14%	18%	14%				
		Speed (mph)	20	32	46	41	68				
		Speed (kmph)	32	51	73	66	109				
Junction	Junction Name	Arm	M90 Northbound Off Slip to Br	M90 Nthbnd off slip to Edinbur	Sthbnd On Slip from Edinburgh Rd	Sthbnd On Slip from Broxden	Nthbnd on slip from Broxden	Sthbnd off slip to Broxden			
27	Edinburgh Road / M90 Motor	Car	3987	2870	1400	2562	4729	4806			
		LGV	602	536	270	522	812	781			
		OGV1	228	329	207	301	753	186			
		OGV2	84	144	56	105	256	53			
		Single Decker Bus	102	179	116	151	375	98			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	0	4	0	0	0	0			
		Total	5002	4060	2051	3640	6923	5922			
		%HDV	8%	16%	19%	15%	20%	6%			
		Speed (mph)	69	67	39	70	64	62			
		Speed (kmph)	111	108	63	113	104	100			

Table A1.1e – 2018 with CCTMR AADT for Perth City Centre

2005 Base Average Peak - City Centre Road Links (adjusted by a factor of 2.2)												
Junction	Junction Name	Arm	A	B	C	D	E	F	G	H	I	
Junction	Junction Name	Arm	Caledonian Rd Nthbnd Exit	York Place Exit	Caledonian Rd Sthbnd Exit	Glasgow Road Exit	York Place Approach	Caledonian Rd Nthbnd Approach	Caledonian Rd Sthbnd Approa	Glasgow Rd Approach		
28	Glasgow Road / Caledonian F	Car	3474	3830	3115	3661	3047	2999	3907	4127		
	York Place Crossroads	LGV	451	497	394	471	394	361	515	543		
		OGV1	132	169	125	167	172	99	180	143		
		OGV2	130	141	152	132	125	110	187	132		
		Single Decker Bus	73	244	73	229	180	121	95	222		
		Double Decker Bus	0	0	0	0	0	0	0	0		
		Minibus	0	0	0	4	2	0	2	0		
		Coach	2	7	2	4	0	13	0	2		
		Total	4261	4888	3861	4668	3920	3703	4886	5170		
		%HDV	8%	12%	10%	12%	14%	10%	10%	10%		
		Speed (mph)	17	25	17	19	9	3	5	11		
		Speed (kmph)	27	41	28	31	15	5	8	18		
Junction	Junction Name	Arm	York Place Estbnd Approach	New Row Nthbnd Exit	York Place Estbnd Exit	New Row Sthbnd Exit	York Place Wstbnd Exit	New Row Nthbnd Approach	York Place Wstbnd Approach	New Row Sthbnd Approach		
29	York Place / New Row	Car	4530	1806	5007	964	3564	1408	4209	1511		
		LGV	548	194	594	114	447	154	497	194		
		OGV1	154	51	209	33	158	57	169	70		
		OGV2	99	26	119	24	86	20	92	44		
		Single Decker Bus	227	37	242	37	194	37	211	35		
		Double Decker Bus	0	0	0	0	0	0	0	0		
		Minibus	0	0	0	13	2	0	15	0		
		Coach	7	0	7	0	0	0	0	0		
		Total	5564	2114	6178	1186	4451	1676	5194	1855		
		%HDV	10%	6%	10%	10%	13%	8%	12%	8%		
		Speed (mph)	31	11	9	13	22	6	21	6		
		Speed (kmph)	49	17	14	20	35	10	33	9		
Junction	Junction Name	Arm	South St Estbnd Exit	Scott St Sthbnd Exit	Scott St Nthbnd Exit	Scott St Sthbnd Approach	Scott St Nthbnd Approach	South St Estbnd Approach				
30	South St / Scott St	Car	5863	2424	2138	1958	2132	6571				
		LGV	682	295	260	231	224	816				
		OGV1	213	119	136	31	136	308				
		OGV2	101	62	59	37	51	169				
		Single Decker Bus	141	180	150	108	88	279				
		Double Decker Bus	0	0	0	0	0	0				
		Minibus	2	2	11	2	11	2				
		Coach	7	0	0	0	0	7				
		Total	7009	3082	2754	2367	2642	8153				
		%HDV	8%	16%	13%	12%	11%	10%				
		Speed (mph)	19	12	23	6	4	11				
		Speed (kmph)	31	20	37	9	7	18				
Junction	Junction Name	Arm	County Place Wstbnd Exit	Sth Methven St Exit	King St Approach	Sth Methven St Approach	County Place Estbnd Approach	South St Exit				
31	County Place / Sth Methven	Car	4209	1408	5438	2631	5007	6464				
	King St	LGV	497	145	629	326	594	794				
		OGV1	169	62	273	130	209	323				
		OGV2	92	31	132	73	119	180				
		Single Decker Bus	211	88	187	209	242	293				
		Double Decker Bus	0	0	0	0	0	0				
		Minibus	15	0	4	13	0	0				
		Coach	0	0	0	0	7	7				
		Total	5194	1734	6664	3381	6178	8061				
		%HDV	12%	11%	10%	14%	10%	11%				
		Speed (mph)	21	17	12	3	16	11				
		Speed (kmph)	33	27	19	5	25	18				
Junction	Junction Name	Arm	South St Approach	Tay St Nthbnd Exit	Queens Bridge Exit	Tay St Sthbnd Exit	Tay St Sthbnd Approach	Tay St Nthbnd Approach	Queens Bridge Approach			
32	South St / Tay St	Car	7161	1643	7379	7097	2103	1905	4950			
		LGV	856	235	871	880	227	260	645			
		OGV1	284	99	255	363	35	112	286			
		OGV2	147	42	117	174	20	31	134			
		Single Decker Bus	187	88	139	185	29	66	130			
		Double Decker Bus	0	0	0	0	0	0	0			
		Minibus	7	4	2	0	0	0	0			
		Coach	7	0	7	9	0	0	9			
		Total	8648	2112	8769	8708	2413	2374	6153			
		%HDV	9%	12%	8%	8%	4%	9%	9%			
		Speed (mph)	7	24	17	14	3	7	10			
		Speed (kmph)	12	38	27	23	5	12	16			
Junction	Junction Name	Arm	Atholl St Wstbnd Approach	Atholl St Estbnd Exit	Kinnoull St Exit	Atholl St Wstbnd Exit	Barossa St Exit	Atholl St Estbnd approach	Kinnoull St Approach	Barossa St Approach		
33	Atholl St / Kinnoull St	Car	4437	3216	2156	5075	376	4314	1745	352		
		LGV	653	374	279	671	73	550	169	33		
		OGV1	77	40	26	136	11	57	86	0		
		OGV2	53	33	44	92	7	66	55	9		
		Single Decker Bus	103	59	130	154	7	139	95	13		
		Double Decker Bus	0	0	0	0	0	0	0	0		
		Minibus	4	0	2	2	0	0	0	0		
		Coach	0	0	0	0	0	0	0	0		
		Total	5328	3722	2638	6131	473	5126	2149	407		
		%HDV	4%	4%	8%	6%	5%	5%	13%	7%		
		Speed (mph)	5	29	17	9	18	14	3	6		
		Speed (kmph)	8	47	27	15	30	23	5	9		

Junction	Junction Name	Arm	Atholl St Approach	Atholl St Exit	N Methven St Exit	Caledonian Rd Exit	Melville St Exit	N Methven St Approach	Melville St Approach	Caledonian Rd Approach	
34	Atholl St / N Methven St /	Car	5082	4305	2664	6609	1115	1916	1021	6818	
	Melville St	LGV	671	546	343	803	145	216	112	840	
		OGV1	139	57	114	246	33	119	18	187	
		OGV2	92	66	81	165	24	75	15	163	
		Single Decker Bus	154	136	90	205	57	101	53	180	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	2	0	0	13	0	11	0	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	6140	5111	3293	8041	1375	2438	1219	8188	
		%HDV	6%	5%	9%	8%	9%	13%	9%	7%	
		Speed (mph)	3	20	21	11	22	4	3	5	
		Speed (kmph)	5	33	34	18	35	6	6	8	
Junction	Junction Name	Arm	Atholl St Wstbnd	Atholl St Estbnd Exit	Atholl St Wstbnd Exit	Atholl St Estbnd Approach					
35	Atholl St / Stormont St	Car	5075	4314	5082	4305					
		LGV	671	550	671	546					
		OGV1	136	57	139	57					
		OGV2	92	66	92	66					
		Single Decker Bus	154	139	154	136					
		Double Decker Bus	0	0	0	0					
		Minibus	2	0	2	0					
		Coach	0	0	0	0					
		Total	6131	5126	6140	5111					
		%HDV	6%	5%	6%	5%					
		Speed (mph)	9	14	3	20					
		Speed (kmph)	15	23	5	33					
Junction	Junction Name	Arm	Atholl St Estbnd Exit	Atholl St Wstbnd Exit	Rose Terrace Exit	Atholl St Estbnd Approach	Atholl St Wstbnd Approach	Rose Terrace Approach			
36	Atholl St / Rose Crescent	Car	3670	4437	1252	3216	5537	594			
		LGV	427	653	158	374	790	73			
		OGV1	44	77	26	40	99	9			
		OGV2	42	53	18	33	68	11			
		Single Decker Bus	70	103	42	59	141	15			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	4	0	0	4	0			
		Coach	0	0	0	0	0	0			
		Total	4253	5328	1496	3722	6640	702			
		%HDV	4%	4%	5%	4%	5%	4%			
		Speed (mph)	26	5	10	29	15	6			
		Speed (kmph)	42	8	16	47	24	9			
Junction	Junction Name	Arm	Caledonian Road Exit	Atholl St Approach	Atholl Street to Barrack Street	Caledonian Rd Approach to Barrack Str	Caledonian Rd Approach to Barrack	Barrack Street Approach to Caledonian	Barrack St Approach to Atholl	Atholl St Exit	D+C
37	Barrack Street / Atholl St /	Car	5416	6609	4057	3104	3104	2864	4523	6818	7161
	Caledonian Road	LGV	733	803	449	438	438	378	594	840	887
		OGV1	92	246	222	222	222	68	152	187	444
		OGV2	33	165	156	235	235	24	132	163	392
		Single Decker Bus	84	205	172	161	161	51	158	180	332
		Double Decker Bus	0	0	0	0	0	0	0	0	0
		Minibus	13	13	11	0	0	11	0	0	11
		Coach	0	0	0	2	2	0	0	0	2
		Total	6371	8041	5067	4162	4162	3397	5559	8188	9229
		%HDV	4%	8%	11%	15%	15%	5%	8%	7%	13%
		Speed (mph)	21	9	28	3	33	3	4	5	15
		Speed (kmph)	34	14	45	5	53	4	6	8	25
Junction	Junction Name	Arm	Bridge Lane Approach	Perth Bridge Exit	Tay St Exit	Charlotte St Exit	Tay St Approach	Charlotte St Approach	Perth Bridge Approach		
38	Charlotte St / Tay St /	Car	1342	2702	2347	5570	1395	3678	4204		
	West Bridge St / Bridge Lane	LGV	145	293	268	803	174	431	614		
		OGV1	24	24	24	99	59	44	20		
		OGV2	11	18	26	68	44	42	15		
		Single Decker Bus	68	103	29	141	15	70	119		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	2	2	0	4	0	0	4		
		Coach	0	0	0	0	0	0	0		
		Total	1593	3142	2695	6686	1687	4266	4976		
		%HDV	11%	5%	3%	5%	7%	4%	3%		
		Speed (mph)	2	19	24	27	4	7	13		
		Speed (kmph)	3	31	38	43	6	11	22		
Junction	Junction Name	Arm	East Bridge St Exit	West Bridge St Exit	Main St Exit	Gowrie St Approach	East Bridge St Approach	Main St Approach	West Bridge St Approach	Gowrie St Exit	
39	Main St / Gowrie St /	Car	416	4204	6160	4565	1093	6851	2702	4431	
	West Bridge St	LGV	88	614	640	530	156	887	293	524	
		OGV1	0	20	130	110	40	136	24	161	
		OGV2	0	15	48	35	31	59	18	79	
		Single Decker Bus	15	119	156	101	29	110	103	53	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	4	2	0	4	0	2	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	519	4976	7137	5342	1353	8043	3142	5247	
		%HDV	4%	3%	6%	5%	8%	4%	5%	6%	
		Speed (mph)	8	17	22	4	2	16	4	28	
		Speed (kmph)	14	27	35	7	4	26	6	44	

Table A1.1f – 2018 with CCTMR AADT for Perth other major roads

2005 Base Average Peak - Major Road Links (adjusted by a factor of 3.5)														
Junction	Junction Name	Arm	A		B	C	D		E	F	G		H	I
Junction	Junction Name	Arm	Dunkeld Rd Approach		A9 North Approach	A9 Western Bypass Approach	Dunkeld Rd Exit		A9 Western Bypass Exit	Industrial Estate Exit	A9 North Exit			
1	Inveralmond Roundabout	Car	10080		18039	16055	13388		11498	3098	16191			
		LGV	1246		2307	2020	1694		1495	424	1960			
		OGV1	361		1292	1386	287		1152	249	1351			
		OGV2	301		756	560	221		662	161	574			
		Single Decker Bus	270		921	802	217		798	172	805			
		Double Decker Bus	0		0	0	0		0	0	0			
		Minibus	0		0	0	0		0	0	0			
		Coach	4		0	0	0		0	0	4			
		Total	12261		23314	20822	15806		15603	4102	20885			
		%HDV	8%		13%	13%	5%		17%	15%	14%			
		Speed (mph)	11		6	4	28		75	43	33			
		Speed (kmph)	17		9	7	45		121	69	54			
Junction	Junction Name	Arm	Bute Drive Exit		Dunkeld Rd South Exit	Dunkeld Rd North Exit	Dunkeld Road South Approach		Dunkeld Rd North Approach	Bute Drive Approach				
2	Dunkeld Road / Bute Drive	Car	4302		11081	11589	11529		10822	4620				
		LGV	476		1481	1383	1355		1411	574				
		OGV1	77		193	396	403		189	74				
40		OGV2	60		193	354	312		193	102				
		Single Decker Bus	39		179	277	270		158	67				
		Double Decker Bus	0		0	0	0		0	0				
		Minibus	0		0	0	0		0	0				
		Coach	0		0	4	4		0	0				
		Total	4953		13125	14000	13871		12772	5436				
		%HDV	4%		4%	8%	8%		4%	4%				
		Speed (mph)	22		19	28	12		8	3				
		Speed (kmph)	36		30	45	20		13	6				
Junction	Junction Name	Arm	Dunkeld Rd South Approach		Gowans Terrace Exit	Dunkeld Rd North Approach	Gowans Terrace Approach		Dunkeld Rd South Exit	Dunkeld Rd North Exit				
3	Dunkeld Rd / Gowans Terrac	Car	11666		4365	10276	4358		10007	11417				
		LGV	1400		508	1365	546		1407	1337				
		OGV1	389		42	193	109		224	403				
		OGV2	277		60	189	63		140	308				
		Single Decker Bus	270		49	182	42		175	263				
		Double Decker Bus	0		0	0	0		0	0				
		Minibus	0		0	0	0		0	0				
		Coach	4		0	0	0		0	4				
		Total	14004		5023	12205	5117		11953	13731				
		%HDV	7%		3%	5%	4%		5%	8%				
		Speed (mph)	11		24	4	15		15	15				
		Speed (kmph)	17		39	7	24		23	25				
Junction	Junction Name	Arm	Ballantine Place Approach		Crieff Rd Approach	Dunkeld Rd North Approach	Dunkeld Rd South Exit		Dunkeld Rd South Approach	Ballantine Place Exit	Crieff Rd Exit		Dunkeld Rd North Exit	
4	Dunkeld Rd / Crieff Rd	Car	473		7105	11897	11739		11543	53	7550		11676	
		LGV	53		914	1628	1575		1379	7	994		1397	
		OGV1	18		277	270	413		553	0	385		399	
		OGV2	32		252	161	308		466	0	326		277	
		Single Decker Bus	18		235	186	347		466	0	256		301	
		Double Decker Bus	0		0	0	0		0	0	0		0	
		Minibus	0		18	0	18		18	0	18		0	
		Coach	0		0	0	0		4	0	0		4	
		Total	592		8799	14140	14399		14427	60	9447		14053	
		%HDV	11%		9%	5%	8%		11%	0%	9%		7%	
		Speed (mph)	4		7	13	11		8	15	11		8	
		Speed (kmph)	6		11	21	18		14	24	18		12	
Junction	Junction Name	Arm	Dunkeld Road South Exit		St Catherines Road Exit	Dunkeld Rd North Exit	St Catherines Road Entry		Dunkeld Rd South Entry	Dunkeld Rd North Entry				
5	Dunkeld Rd / St Catherines R	Car	11876		1702	11795	2265		11340	11858				
	Barrack Street	LGV	1579		266	1418	228		1404	1631				
		OGV1	368		165	613	28		707	410				
		OGV2	256		238	490	42		623	319				
		Single Decker Bus	347		95	480	35		529	357				
		Double Decker Bus	0		0	0	0		0	0				
		Minibus	18		0	18	0		18	18				
		Coach	0		0	4	0		4	0				
		Total	14441		2555	14816	2597		14623	14592				
		%HDV	7%		17%	11%	3%		12%	8%				
		Speed (mph)	10		15	21	2		11	15				
		Speed (kmph)	16		24	34	3		17	24				
Junction	Junction Name	Arm	Western Bypass Nbnd Offslip		Crieff Road Eastbound Approach	Western Bypass Nbnd Onslip	Crieff Rd Westbound Approach		Crieff Rd Eastbound Exit	Crieff Rd Westbound Exit				
6	A9 / Crieff Rd Roundabout	Car	6339		7438	8862	9142		8848	8971				
	Dobbies Roundabout	LGV	861		970	1131	1096		1169	1120				
		OGV1	294		623	571	497		312	707				
		OGV2	252		634	462	455		389	669				
		Single Decker Bus	221		536	518	438		417	497				
		Double Decker Bus	0		0	0	0		0	0				
		Minibus	0		18	0	18		18	18				
		Coach	0		0	0	0		0	0				
		Total	7966		10217	11543	11645		11151	11961				
		%HDV	9%		18%	14%	13%		10%	16%				
		Speed (mph)	6		5	15	28		20	26				
		Speed (kmph)	9		9	23	45		32	42				

Junction	Junction Name	Arm	Crieff Rd Eastbound Entry	Crieff Rd Eastbound Exit	Newhouse Rd Approach	A9 On / Off slip approach	Crieff Rd westbound Approach	Newhouse Rd Exit	Crieff Rd Westbound Exit	A9 On / Off Slip Exit	
7	A9 / Crieff Rd Roundabout	Car	9068	7880	9909	0	6678	6987	9778	0	
	Newhouse Rd Roundabout	LGV	1117	970	1162	0	725	914	1128	0	
		OGV1	394	302	333	0	286	252	407	0	
		OGV2	357	469	375	0	382	266	389	0	
		Single Decker Bus	392	347	449	0	268	270	392	0	
		Double Decker Bus	0	0	0	0	8	0	0	0	
		Minibus	21	18	4	0	18	4	21	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	11888	9954	12830	0	7448	8631	12181	0	
		%HDV	10%	12%	9%	0%	17%	10%	11%	0%	
		Speed (mph)	5	18	4	0	4	11	18	0	
		Speed (kmph)	8	30	7	0	6	18	29	0	
Junction	**Junction Name**	**Arm**	**Fairfield Avenue Approach**	**Crieff Rd Westbound Approach**	**Crieff Rd Eastbound Entry**	**Fmus Rd Approach**	**Fairfield Avenue Exit**	**Crieff Rd Eastbound Exit**	**Crieff Rd Westbound Exit**	**Fmus Rd Exit**	
8	Crieff Rd / Feus Rd Roundabo	Car	966	10666	7403	6918	1012	7991	8204	8145	
		LGV	140	1359	934	739	118	970	1033	1032	
		OGV1	151	536	388	378	140	273	441	520	
		OGV2	53	560	335	312	47	249	611	410	
		Single Decker Bus	109	378	259	235	74	228	348	312	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	18	18	0	0	18	18	0	
		Coach	0	0	0	0	0	0	0	0	
		Total	1419	13514	9272	7980	1428	9727	10574	10478	
		%HDV	23%	11%	10%	13%	21%	8%	13%	13%	
		Speed (mph)	3	6	5	5	19	17	16	19	
		Speed (kmph)	6	9	9	8	30	28	26	31	
Junction	**Junction Name**	**Arm**	**M90 Edinburgh Approach**	**M90 Edinburgh Exit**	**A9 Stirling Exit**	**A9 Inverness Exit**	**Glasgow Road Exit**	**A9 Western Bypass Approach**	**A9 Stirling Approach**	**Glasgow Road Approach**	**Glasgow Rd - M90 E**
9	Broaden Roundabout	Car	21116	15457	15937	12677	9338	15897	11658	5136	3602
		LGV	2925	2013	2179	1665	1151	1995	1514	675	473
		OGV1	1389	1925	1886	718	894	1792	1189	203	179
		OGV2	689	942	951	378	221	984	476	123	86
		Single Decker Bus	895	1176	1022	441	817	1355	662	144	109
		Double Decker Bus	0	0	0	0	0	0	0	0	0
		Minibus	0	0	0	0	0	0	0	0	0
		Coach	0	0	7	0	4	0	4	7	0
		Total	26764	21582	21681	15876	11884	21753	16238	6290	4417
		%HDV	19%	19%	18%	18%	29%	19%	18%	8%	8%
		Speed (mph)	11	32	47	50	40	6	4	3	34
		Speed (kmph)	18	51	75	80	65	10	6	5	55
Junction	**Junction Name**	**Arm**	**Glasgow Rd Eastbound Exit**	**Glasgow Rd Westbound Approach**	**Necessity Brae Approach**	**Glasgow Rd Westbound Exit**	**Glasgow Rd Eastbound Approach**	**Necessity Brae Exit**			
10	Glasgow Rd / Necessity Brae	Car	6548	6930	3833	7501	3288	3864			
	Roundabout	LGV	813	823	466	861	466	581			
		OGV1	140	224	35	238	196	77			
		OGV2	119	123	42	151	104	49			
		Single Decker Bus	224	277	14	267	232	32			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	7	0	7	0	0			
		Coach	4	7	0	4	0	0			
		Total	7896	8390	4389	9061	4771	4603			
		%HDV	7%	8%	2%	4%	7%	3%			
		Speed (mph)	19	16	13	15	18	13			
		Speed (kmph)	31	25	21	25	30	21			
Junction	**Junction Name**	**Arm**	**Glasgow Rd Eastbound Approach**	**Glasgow Rd Eastbound Exit**	**Murray Crescent Exit**	**Glasgow Rd Westbound Exit**	**Murray Place Exit**	**Glasgow Rd Westbound Approach**	**Murray Place Approach**	**Murray Crescent Approach**	
11	Glasgow Rd / Murray Place /	Car	5140	5740	3113	5180	624	5177	1610	2609	
	Murray Crescent	LGV	651	728	348	694	91	630	137	840	
		OGV1	109	158	84	161	48	203	88	105	
		OGV2	102	109	88	84	18	109	32	68	
		Single Decker Bus	210	277	66	252	18	264	11	98	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	7	0	7	0	0	
		Coach	4	0	0	0	0	7	0	0	
		Total	6215	7014	3579	6385	803	6416	1817	3820	
		%HDV	7%	8%	8%	9%	9%	11%	9%	8%	
		Speed (mph)	21	30	19	29	24	11	11	7	
		Speed (kmph)	34	48	31	46	38	18	18	11	
Junction	**Junction Name**	**Arm**	**Glover Street Approach**	**Riggs Road Approach**	**Glasgow Rd Eastbound Exit**	**Glasgow Road Eastbound Entry**	**Glasgow Rd Westbound Entry**	**Glover Street Exit**	**Glasgow Rd Westbound Exit**	**Riggs Road Exit**	
12	Glasgow Rd / Riggs Rd Rbt	Car	7210	6304	8355	9135	9366	7605	9111	6044	
		LGV	858	696	1054	1124	1168	1050	1083	840	
		OGV1	368	366	270	240	525	252	259	490	
		OGV2	208	207	195	144	207	156	174	270	
		Single Decker Bus	259	301	354	305	420	172	389	371	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	4	0	0	4	7	4	11	0	
		Coach	0	0	4	0	7	0	7	0	
		Total	9089	8155	10241	10994	11442	9289	10976	9023	
		%HDV	11%	13%	8%	5%	10%	7%	9%	14%	
		Speed (mph)	3	5	25	6	14	19	22	13	
		Speed (kmph)	5	8	40	10	22	30	35	21	

Junction	Junction Name	Arm	Caledonian Rd SBind Approach	Caledonian Rd Northbound Exit	Alexandra St Exit	Caledonian Rd SBind Exit	Caledonian Rd NBind Approach	Alexandra St Approach			
13	Caledonian Rd / Alexandra S	Car	3829	3990	681	3189	3171	711			
		LGV	400	400	70	410	424	74			
		OGV1	184	109	26	123	84	25			
		OGV2	161	98	32	130	70	25			
		Single Decker Bus	118	175	18	95	144	29			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	4	21	0	4	21	0			
		Total	4750	4803	726	3948	3913	864			
		%HDV	19%	9%	19%	9%	9%	9%			
		Speed (mph)	26	17	17	20	17	15			
		Speed (kmph)	40	27	28	32	28	24			
Junction	Junction Name	Arm	Leonard St NBind Approach	Leonard St SBind Approach	St Andrew St Approach	Leonard St NBind Exit	Leonard St SBind Exit	St Andrew St Exit			
14	St Andrew St / Leonard St	Car	4802	2667	2821	1852	5205	3161			
		LGV	502	302	371	200	569	409			
		OGV1	175	148	119	70	273	81			
		OGV2	98	109	186	42	317	67			
		Single Decker Bus	141	203	84	56	245	137			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	39	0	0	39	0			
		Coach	0	25	4	0	7	21			
		Total	5835	3501	3525	2219	6654	3866			
		%HDV	9%	16%	10%	8%	12%	8%			
		Speed (mph)	34	28	14	27	20	14			
		Speed (kmph)	55	45	23	43	33	23			
Junction	Junction Name	Arm	St Leonards Bank Approach	Kings Pl Estbnd Exit	St Leonards Bank Exit	Kings Place Wstbnd Exit	Kings Pl Wstbnd Approach	Kings Pl Estbnd Approach			
15	Kings Place / St Leonards B	Car	5749	6293	3763	4504	4483	4816			
		LGV	630	756	452	581	515	627			
		OGV1	168	273	182	172	189	273			
		OGV2	91	252	25	95	63	217			
		Single Decker Bus	116	228	186	175	203	109			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	4	21	4	0	0	21			
		Coach	0	4	0	18	18	4			
		Total	6163	7830	4443	5504	5355	6146			
		%HDV	7%	11%	6%	8%	6%	13%			
		Speed (mph)	13	25	24	21	28	15			
		Speed (kmph)	19	41	38	34	46	24			
Junction	Junction Name	Arm	Marshall Place Estbnd Approach	Princes Street Exit	Marshall Place Estbnd Exit	Edinburgh Road Exit	Marshall Place Wstbnd Exit	Marshall Place Wstbnd Approach	Edinburgh Rd Approach		
16	Marshall Place / Edinburgh R	Car	6146	2659	2783	7700	6724	5099	7711		
		LGV	760	340	384	949	774	753	974		
		OGV1	297	105	388	210	207	217	329		
		OGV2	195	85	114	109	104	70	140		
		Single Decker Bus	252	123	186	228	130	158	256		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	0	0	0	0	0	0	0		
		Coach	4	0	4	0	18	14	4		
		Total	7644	3161	3784	9198	7959	7210	9352		
		%HDV	11%	9%	17%	9%	6%	7%	8%		
		Speed (mph)	8	20	22	18	19	7	4		
		Speed (kmph)	13	32	36	29	30	11	6		
Junction	Junction Name	Arm	South Street Approach	Tay St Northbound Exit	Queens Bridge Exit	Tay St Southbound Exit	Tay St Southbound Approach	Tay St Northbound Approach	Queens Bridge Approach		
17	Tay St / South St Crossroad	Car	11393	2615	11739	11291	3346	3031	7876		
		LGV	1362	375	1386	1400	361	419	1026		
		OGV1	468	158	405	578	65	179	465		
		OGV2	235	67	186	277	52	42	214		
		Single Decker Bus	348	140	831	294	46	105	287		
		Double Decker Bus	0	0	0	0	0	0	0		
		Minibus	11	7	4	0	0	0	0		
		Coach	11	0	11	14	0	0	14		
		Total	13759	3360	13961	12853	3840	3777	9798		
		%HDV	9%	12%	9%	8%	4%	9%	9%		
		Speed (mph)	7	24	17	14	3	7	10		
		Speed (kmph)	11	38	27	23	5	12	16		
Junction	Junction Name	Arm	Tay St Southbound Exit	High Street Exit	Tay St Northbound Exit	High Street Approach	Tay St Northbound Approach	Tay St Southbound Approach			
18	Tay Street / High Street	Car	3346	630	2191	69	2615	3490			
		LGV	351	105	355	0	378	417			
		OGV1	54	42	119	0	138	90			
		OGV2	32	11	70	4	67	82			
		Single Decker Bus	46	112	92	0	140	42			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	7	0	0	7	0			
		Coach	0	0	0	0	0	0			
		Total	3840	907	2678	67	3360	4018			
		%HDV	4%	19%	9%	4%	12%	3%			
		Speed (mph)	19	21	24	14	28	18			
		Speed (kmph)	29	34	39	22	46	29			
Junction	Junction Name	Arm	Queens Bridge Approach	Dundee Road Southbound Exit	Dundee Rd NBind Approach	Dundee Rd SBind Approach	Queens Bridge Exit	Dundee Rd Northbound Exit			
19	South St / Dundee Rd	Car	11739	9891	7647	7504	7876	9123			
	Crossroads	LGV	1386	1148	1029	875	1026	1117			
		OGV1	405	302	208	315	465	652			
		OGV2	186	105	115	133	214	116			
		Single Decker Bus	831	182	848	102	807	175			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	4	0	0	0	4	0			
		Coach	11	11	14	0	14	0			
		Total	13961	11648	9249	8829	9740	10791			
		%HDV	9%	9%	9%	9%	9%	9%			
		Speed (mph)	17	25	9	6	18	23			
		Speed (kmph)	27	41	9	10	16	37			

Junction	Junction Name	Arm	Dundee Rd Total from Motorway	Walnut Grove From Perth	M90 Edinburgh Offslip	M90 Edinburgh Onslip	Walnut Grove To Perth	A90 Dundee Onslip	A90 Dundee Offslip	Dundee Rd Total To Motorway	
20	Dundee Rd / M90 / A90	Car	7161	581	1960	2307	469	6510	6295	8894	
	Motorway Junction	LGV	959	60	270	294	49	802	787	1019	
		OGV1	897	11	63	49	18	242	117	301	
		OGV2	112	4	18	4	4	91	91	98	
		Single Decker Bus	214	7	18	35	11	139	186	175	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	0	0	0	0	0	
		Coach	14	0	0	0	0	14	14	14	
		Total	8747	662	2317	2618	550	7798	6610	10437	
		%HDV	7%	3%	4%	3%	6%	7%	7%	6%	
		Speed (mph)	57	24	59	45	49	38	30	53	
		Speed (kmph)	109	39	95	72	78	62	49	86	
Junction	Junction Name	Arm	Strathmore Street Exit	Main St Exit	Isla Road Exit	Strathmore St Approach	Isla Road Approach	Main St Approach			
21	Dundee Rd / Strathmore St	Car	5744	10899	2118	7641	9322	9800			
	Crossroads	LGV	885	1411	288	1026	889	1019			
		OGV1	91	247	67	144	74	207			
		OGV2	49	95	14	63	28	77			
		Single Decker Bus	154	175	74	139	39	249			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	4	0	0	0	0	4			
		Coach	0	0	0	0	0	0			
		Total	6927	12796	2471	9006	10452	11354			
		%HDV	6%	4%	6%	4%	3%	5%			
		Speed (mph)	28	16	29	10	5	11			
		Speed (kmph)	46	26	46	17	8	18			
Junction	Junction Name	Arm	Dundee Rd Exit	Gowrie St Exit	Bowerswell Rd Approach	Dundee Rd Approach	Gowrie St Approach				
22	Gowrie St / Bowerswell Rd /	Car	7466	7980	1141	7487	7884				
	Dundee Rd T Junction	LGV	872	950	133	885	823				
		OGV1	312	333	66	200	265				
		OGV2	133	74	7	74	126				
		Single Decker Bus	103	161	36	147	84				
		Double Decker Bus	0	0	0	0	0				
		Minibus	0	0	0	4	0				
		Coach	0	0	0	0	0				
		Total	8883	9377	1378	8796	8892				
		%HDV	6%	5%	7%	6%	6%				
		Speed (mph)	18	19	10	27	29				
		Speed (kmph)	32	35	16	43	46				
Junction	Junction Name	Arm	Edinburgh Rd NBnd Exit	Edinburgh Rd SBnd Exit	Glenearn Rd Exit	Edinburgh Rd NBnd Approach	Glenearn Rd Approach	Edinburgh Rd SBnd Approach			
23	Edinburgh Road / Glenearn Rd	Car	6755	9275	5282	9615	5030	6692			
		LGV	889	1176	596	1102	739	819			
		OGV1	305	420	333	578	175	309			
		OGV2	130	189	242	350	98	119			
		Single Decker Bus	235	326	259	448	105	263			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	4	4	0	4	0	4			
		Total	8236	11389	6884	12160	6156	8044			
		%HDV	8%	12%	13%	13%	6%	10%			
		Speed (mph)	18	28	19	10	9	9			
		Speed (kmph)	28	45	30	16	15	14			
Junction	Junction Name	Arm	Tesco Exit	Tesco Approach	Broadalbane Terrace Approach	Edinburgh Rd NBnd Approach	Edinburgh Rd SBnd Approach	Broadalbane Terrace Exit	Edinburgh Rd SBnd Exit	Edinburgh Rd NBnd Exit	
24	Edinburgh Rd / Tesco /	Car	3353	2957	1292	6941	9278	749	5817	9615	
	Broadalbane Terrace	LGV	378	305	242	837	1176	196	893	1162	
		OGV1	42	101	147	375	420	69	286	578	
		OGV2	25	154	56	269	189	47	144	350	
		Single Decker Bus	33	95	67	312	385	56	363	448	
		Double Decker Bus	0	0	0	0	0	0	0	0	
		Minibus	0	0	0	0	0	0	0	0	
		Coach	0	0	0	4	0	4	0	4	
		Total	3829	3546	1802	8605	11389	1043	8344	12156	
		%HDV	9%	12%	14%	18%	9%	16%	11%	12%	
		Speed (mph)	17.88	18.88	19.88	28.88	21.88	28.88	29.88	24.88	
		Speed (kmph)	29	30	32	34	35	37	38	40	
Junction	Junction Name	Arm	Frierton Rd Exit	Edinburgh Rd SBnd Exit	Edinburgh Rd NBnd Exit	Edinburgh Rd NBnd Approach	Frierton Rd Approach	Edinburgh Rd SBnd Approach			
25	Edinburgh Rd / Frierton Rd	Car	1890	9373	8596	8442	2394	9041			
		LGV	247	1871	1104	1102	218	1250			
		OGV1	158	666	997	864	101	601			
		OGV2	58	231	814	235	116	179			
		Single Decker Bus	112	436	385	436	182	340			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	0	4	4	4	0	4			
		Total	2566	11970	10819	10861	3308	11923			
		%HDV	13%	19%	17%	19%	21%	18%			
		Speed (mph)	11	28	25	12	2	32			
		Speed (kmph)	18	45	40	19	4	51			
Junction	Junction Name	Arm	Rhynd Road Approach	Edinburgh Rd SBnd Exit	Edinburgh Road Northbound Exit	Edinburgh Rd SBnd Approach	Edinburgh Rd NBnd Approach				
26	Edinburgh Rd / Rhynd Rd	Car	887	6386	8379	6386	7864				
		LGV	11	1099	1188	1099	1141				
		OGV1	26	598	850	598	816				
		OGV2	25	198	235	198	200				
		Single Decker Bus	7	365	488	365	417				
		Double Decker Bus	0	0	0	0	0				
		Minibus	0	0	0	0	0				
		Coach	4	4	4	4	4				
		Total	964	10650	10794	10650	10819				
		%HDV	8%	13%	12%	13%	11%				
		Speed (mph)	19	32	46	42	59				
		Speed (kmph)	31	52	74	67	111				
Junction	Junction Name	Arm	M90 Northbound Off Slip to Broaden	M90 NBnd off slip to Edinburgh Rd	SBnd On Slip from Edinburgh Rd	Bnd On Slip from Broaden	NBnd on slip from Broaden	SBnd off slip to Broaden			
27	Edinburgh Road / M90 Motor	Car	8575	4613	6250	8712	18357	19541			
		LGV	1175	672	597	1141	1944	1649			
		OGV1	539	375	474	660	1452	770			
		OGV2	286	151	137	294	704	354			
		Single Decker Bus	322	201	252	382	983	574			
		Double Decker Bus	0	0	0	0	0	0			
		Minibus	0	0	0	0	0	0			
		Coach	0	4	4	0	0	0			
		Total	10868	6204	6773	11190	14749	15887			
		%HDV	10%	11%	14%	11%	20%	10%			
		Speed (mph)	58	58	40	60	63	61			
		Speed (kmph)	109	109	64	110	103	98			

Table A1.2 - Traffic Growth Factors used to predict traffic flows in future years

Year		Growth
From	To	Central
2005	2006	**1.000**
2005	2007	**1.009**
2005	2008	**1.019**
2005	2009	**1.032**
2005	2010	**1.043**
2005	2011	**1.053**
2005	2012	**1.064**
2005	2013	**1.076**
2005	2014	**1.088**
2005	2015	**1.099**
2005	2016	**1.110**
2005	2017	**1.124**
2005	2018	**1.138**

Appendix 2

Monitoring Data

Contents

Table A2.1 - Diffusion tube locations and raw monitoring results in Perth in 2005

Site Name	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05
42 Scott St, Perth, PH1 5PH	47	43	44	37	39	37	37	36	40	51	49	58
42 Scott St, Perth, PH1 5PH	45	48	49	38	40	36	41	30	40	49	49	54
42 Scott St, Perth, PH1 5PH	45	43	50	47	38	35	43	29	38	50	49	55
17 Speygate, Perth, PH2 8PJ	34	30	35	23	15	16	21	20	25	31	34	43
15 Murray Cres, Perth, PH2 0HU	23	23	24	16	15	13	13	14	20	25	26	38
15 Murray Cres, Perth, PH2 0HU	27	23	25	15	14	16	15	14	19	26	25	40
8 Stormont St, Perth, PH1 5NW	32	26	26	19	17	16	15	17	27	27	29	33
8 Stormont St, Perth, PH1 5NW	31	23	25	17	18	19	14	20	24	28	28	32
41 Mull Place, Perth, PH1 3DP	21	16	18	9	9	9	8	8	13	17	19	28
257 Rannoch Rd/Newhouse Road Roundabout, Perth, PH1 2DW	19	21	22	19	14	12	16	13	17	25	25	32
86/88 South Street Perth PH2 8PD	42	40	45	38	36	34	30	34	39	51	47	51
86/88 South Street Perth PH2 8PD	41	43	44	38	36	34	38	36	40	45	47	x
9 Main St, Bridgend, Perth, PH2 7HD	33	40	43	41	38	37	42	30	35	42	42	48
9 Main St, Bridgend, Perth, PH2 7HD	37	45	45	49	40	35	40	29	37	45	36	46
9 Main St, Bridgend, Perth, PH2 7HD	39	44	47	42	39	38	41	29	40	46	42	44
St Ninian's School ,Dunkeld Rd, Perth, PH1 5RF	36	38	37	24	29	25	26	24	38	45	38	46
2 Crieff Road Perth PH1 5RT	32	28	33	24	27	22	27	20	30	35	38	42
28 York Place Perth PH2 8EH	47	45	49	44	39	35	38	32	45	59	51	53
37 York Place Perth PH2 8EH	40	42	50	37	30	x	38	26	36	46	42	49
104 South St, Perth, PH2 8PA	41	40	43	41	37	36	41	38	43	45	48	54
104 South St, Perth, PH2 8PA	48	40	47	42	39	39	38	34	44	42	47	56
104 South St, Perth, PH2 8PA	49	43	45	34	37	37	40	35	41	46	45	56
45-47 South St, Perth, PH2 8PD	39	42	40	32	27	21	33	25	29	38	38	46
135 South St, Perth, PH2 8PA	46	48	47	39	38	32	37	29	39	45	47	53
216 South Street Perth PH2 8NY	42	41	44	35	34	26	31	31	38	46	47	53
10 County Place, Perth, PH2 8EE	44	47	43	49	49	46	46	44	54	56	53	60
10 County Place, Perth, PH2 8EE	51	44	46	59	46	49	46	42	53	45	52	62
17 Princes St, Perth, PH2 8NG	37	36	39	25	28	26	31	31	33	35	40	x
51 Glasgow Rd, Perth, PH2 0PE	38	34	38	30	30	27	28	22	31	36	44	47
Riggs Rd, Perth, PH1 1PR	35	31	36	28	27	26	21	22	31	38	41	44
93-109 Main St Bridgend, PH2 7HE	31	32	35	33	30	28	32	22	28	40	32	35
39 Main St, Bridgend, PH2 7HD	42	47	50	48	43	41	46	31	46	52	44	46
39 Main St, Bridgend, PH2 7HD	45	48	55	53	40	41	45	27	44	52	49	51
18 Main St, Bridgend, PH2 7HB	48	46	46	42	39	39	43	38	48	46	45	56
18 Main St, Bridgend, PH2 7HB	49	49	51	37	43	39	47	44	46	45	48	56
76 Atholl St, Perth, PH1 5NL	39	58	57	55	42	45	54	33	43	57	54	63
76 Atholl St, Perth, PH1 5NL	53	56	57	57	44	42	44	34	46	61	58	64
26-28 Atholl St, Perth, PH1 6NP	48	57	53	41	45	40	46	39	47	48	53	63
17 Atholl St, Perth, PH1 5NH	52	51	54	50	48	51	49	48	55	56	58	59
17 Atholl St, Perth, PH1 5NH	51	53	51	46	51	56	56	44	55	54	54	48
17 Atholl St, Perth, PH1 5NH	56	53	54	37	51	52	52	46	55	54	54	61
22 Barrack St, Perth, PH1 5RD	45	47	44	38	34	33	35	31	40	51	52	55
22 Barrack St, Perth, PH1 5RD	47	48	50	41	37	37	35	29	39	56	56	55
Ballantine Place, Perth PH1 5RR	29	29	31	x	21	18	20	x	20	35	33	40

Site Name	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05
204 A Crieff Rd, Perth, PH1 2PE	25	32	30	30	25	27	26	21	26	36	34	42
5 East Huntingtower, Perth, PH1 3JJ	22	11	25	23	18	24	19	18	22	36	9	33
30 Edinburgh Rd, Perth, PH2 8BX	x	29	31	24	18	20	22	16	25	36	29	40
2 West Bridge St, Bridgend, Perth, PH2 7HA	38	36	36	29	26	27	29	24	30	36	41	37
Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	36	40	34	25	26	24	26	23	29	34	37	42
Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	36	39	35	27	28	22	24	21	30	33	35	41
Real Time Monitor adjacent to 176 High St, Perth PH1 5EW	37	41	38	25	27	24	20	23	26	34	40	44
Atholl St, Perth real time monitor	58	51	50	51	53	53	56	48	56	59	56	51
Atholl St, Perth real time monitor	57	50	49	55	49	53	52	50	58	59	55	56
Atholl St, Perth real time monitor	50	52	50	51	49	46	51	50	61	58	60	52
Opp Wood'n Garden, Glencarse, PH2 7LX	21	22	25	27	19	23	22	19	27	34	22	33
Linden Garden Centre, Glencarse, PH2 7LX	22	36	22	28	22	22	26	18	27	35	26	34
7 West High st, Crieff	39	x	31	39	38	34	36	31	x	42	37	44
39, High St, Crieff	34	33	38	37	35	29	34	32	31	42	36	39
The Highland Trading Company, 62, High St, Crieff	32	35	31	32	28	23	32	25	22	36	35	38
9 East High St, Crieff	31	x	39	36	33	33	34	32	34	42	41	44
9 East High St, Crieff	34	x	38	36	35	31	36	30	34	45	39	44
12 Dunkeld Street, Aberfeldy	25	28	27	22	23	22	25	20	28	27	28	32
Highland Gift Shop, Bridgend, Aberfeldy	20	20	22	19	21	17	18	17	21	23	20	23
Highland Gift Shop, Bridgend, Aberfeldy	20	20	23	20	17	16	15	15	21	23	19	23

Notes :
1. All concentrations are µg m^{-3} expressed as NO_2.

These data have not been bias adjusted

Table A2.2 – Perth 1 Automatic Monitoring Data (High Street)

PERTH
01 January to 31 December 2005
These data are provisional from 01/07/2005 and may be subject to further quality control

POLLUTANT	NO_2	NO_X	PM_{10}+
Number Very High	0	-	0
Number High	0	-	0
Number Moderate	0	-	0
Number Low	8689	-	8715
Maximum 15-minute mean	397 µg m^{-3}	1024 µg m^{-3}	225 µg m^{-3}
Maximum hourly mean	149 µg m^{-3}	678 µg m^{-3}	135 µg m^{-3}
Maximum running 8-hour mean	105 µg m^{-3}	444 µg m^{-3}	59 µg m^{-3}
Maximum running 24-hour mean	77 µg m^{-3}	282 µg m^{-3}	41 µg m^{-3}
Maximum daily mean	70 µg m^{-3}	263 µg m^{-3}	40 µg m^{-3}
Average	28 µg m^{-3}	63 µg m^{-3}	14 µg m^{-3}
Data capture	99.2 %	99.2 %	99.2 %

+ PM_{10} instrument is a TEOM
All mass units are at 20'C and 1013mb
NO_X mass units are NO_X as NO_2

Pollutant	Air Quality Regulations (2000) and Air Quality (Scotland) Amendment Regulations 2002	Exceedences	Days
Nitrogen Dioxide	Annual mean > 40 µg m^{-3}	0	-
Nitrogen Dioxide	Hourly mean > 200 µg m^{-3}	0	0
PM_{10} (Gravimetric)	Daily mean > 50 µg m^{-3}	1	1
PM_{10} (Gravimetric)	Annual mean > 40 µg m^{-3}	0	-
PM_{10} (Gravimetric)	Annual mean > 18 µg m^{-3}	1	-

Produced by netcen on behalf of Perth and Kinross Council

Perth Air Monitoring
Hourly Mean Data for 01 January to 31 December 2005

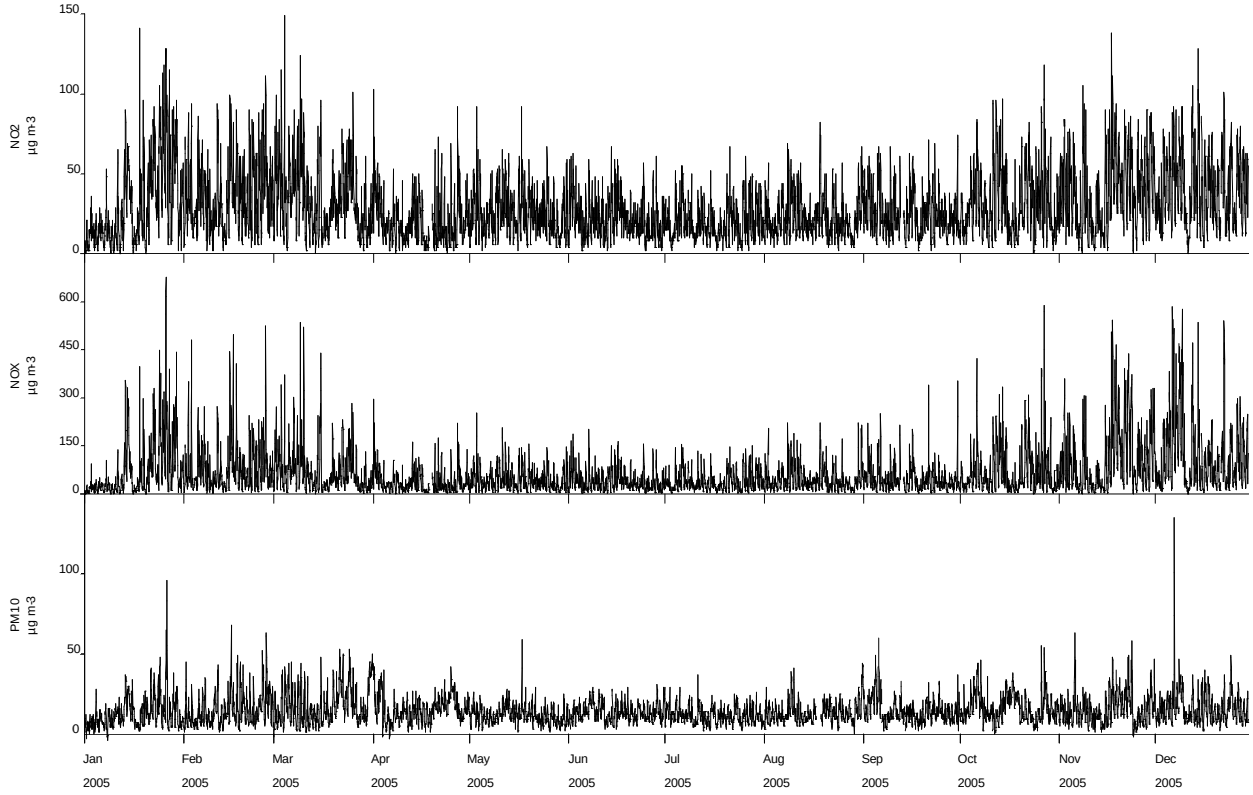


Table A2.3 - Perth 2 Automatic Monitoring Data (Atholl Street)

PERTH 2
01 January to 31 December 2005
These data are provisional from 01/07/2005 and may be subject to further quality control

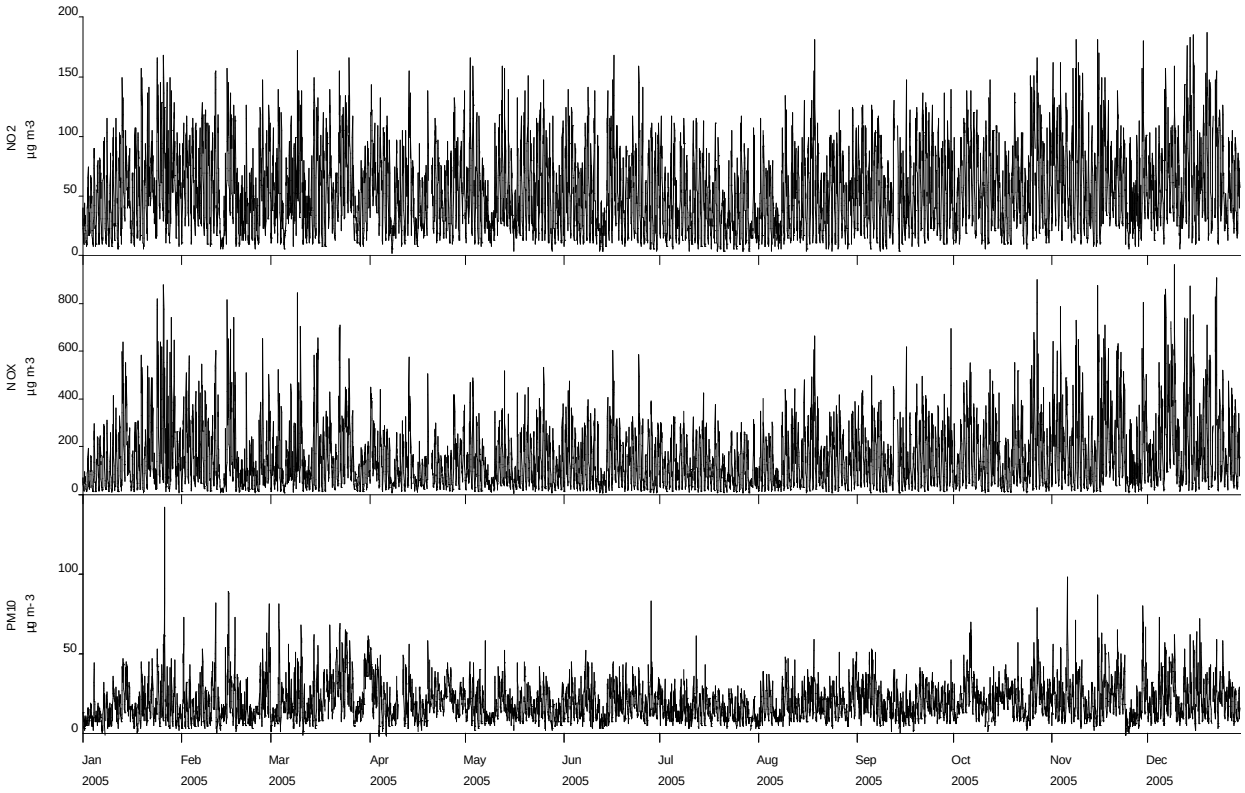
POLLUTANT	NO_2	NO_X	PM_{10}+
Number Very High	0	-	0
Number High	0	-	0
Number Moderate	0	-	0
Number Low	8681	-	8634
Maximum 15-minute mean	308 µg m^{-3}	1217 µg m^{-3}	205 µg m^{-3}
Maximum hourly mean	187 µg m^{-3}	963 µg m^{-3}	142 µg m^{-3}
Maximum running 8-hour mean	157 µg m^{-3}	677 µg m^{-3}	71 µg m^{-3}
Maximum running 24-hour mean	99 µg m^{-3}	427 µg m^{-3}	47 µg m^{-3}
Maximum daily mean	95 µg m^{-3}	394 µg m^{-3}	46 µg m^{-3}
Average	54 µg m^{-3}	153 µg m^{-3}	19 µg m^{-3}
Data capture	99.1 %	99.1 %	98.1 %

+ PM_{10} instrument is a TEOM
All mass units are at 20'C and 1013mb
NO_X mass units are NO_X as NO_2

Pollutant	Air Quality Regulations (2000) and Air Quality (Scotland) Amendment Regulations 2002	Exceedences	Days
Nitrogen Dioxide	Annual mean > 40 µg m^{-3}	1	-
Nitrogen Dioxide	Hourly mean > 200 µg m^{-3}	0	0
PM_{10} (Gravimetric)	Daily mean > 50 µg m^{-3}	4	4
PM_{10} (Gravimetric)	Annual mean > 40 µg m^{-3}	0	-
PM_{10} (Gravimetric)	Annual mean > 18 µg m^{-3}	1	-

Produced by netcen on behalf of Perth and Kinross Council

Perth 2 Air Monitoring
Hourly Mean Data for 01 January to 31 December 2005



Appendix 3

Model validation
Nitrogen dioxide roadside concentrations

Contents

INTRODUCTION

The dispersion model ADMS-3 was used to predict nitrogen dioxide concentrations at roadside locations. ADMS-3 is a PC-based model that includes an up-to-date representation of the atmospheric processes that contribute to pollutant dispersion.

The model was used to predict

- the local contribution to pollutant concentrations from roads; and
- The contribution from urban background sources.

The contribution from urban background sources was calculated from the ADMS-3 output using the NETCEN Local Area Dispersion System (LADS) model. The LADS model provides efficient algorithms for applying the results of the dispersion model over large areas.

The model was verified by comparison with monitoring data obtained at a number of roadside, kerbside or near-road monitoring sites in London.

- London Marylebone
- Camden Roadside
- Haringey Roadside
- London Bloomsbury
- London North Kensington
- London A3 Roadside

London Marylebone site is located in a purpose built cabin on Marylebone Road opposite Madame Tussauds. The sampling point is located at a height of 3 m, around 1 m from the kerbside. Traffic flows of over 80,000 vehicles per day pass the site on six lanes. The road is frequently congested. The surrounding area forms a street canyon and comprises of education buildings, tourist attractions, shops and housing

Camden Roadside site (TQ267843) is located in a purpose built cabin on the north side of the Swiss Cottage Junction. The site is at the southern end of a broad street canyon. Sampling points are approximately 1 m from the kerbside of Finchley Road at a height of 3 m. Traffic flows of 37,000 vehicles per day pass the site and the road is often congested. Pedestrian traffic is also high. The surrounding area mainly consists of shops and offices.

London North Kensington site (TQ240817) is located within the grounds of Sion Manning School. The sampling point is located on a cabin, in the school grounds next to St Charles Square, at a height of 3 m. The surrounding area is mainly residential.

London A3 monitoring station (TQ193653) is within a self-contained, air-conditioned housing immediately adjacent to the A3 Kingston Bypass (6 lane carriageway). Traffic flow along the bypass is approximately 112,000 vehicles per day and is generally fast and free flowing with little congestion. The manifold inlet is approximately 2.5 m from the kerbside at a height of approximately 3 m. The surrounding area is generally open and comprises residential dwellings and light industrial and commercial properties.

London Bloomsbury monitoring station (TQ302820) is within a self-contained, air-conditioned housing located at within the southeast corner of central London gardens. The gardens are generally laid to grass with many mature trees. All four sides of the gardens are surrounded by a busy (35,000 vehicles per day), 2/4 lane one-way road system which is subject to frequent congestion. The nearest road lies at a distance of approximately 35 metres from the station. The manifold inlet is approximately 3 metres high. The area in the vicinity of the manifold is open, but there are mature trees within about 5 metres.

London Haringey site (TQ339906) is located in a purpose built cabin within the grounds of the Council Offices. The sampling point is at a height of 3 m located 5 m from High Road Tottenham (A1010) with traffic flows of around 20,000 vehicles per day. The road is frequently congested. The surrounding area consists of shops, offices and housing.

MODEL APPLICATION

Study area

Two study areas were defined- a local study area and an urban background study area. The local study area was defined for each of the monitoring sites extending 200 m in each direction (NSEW) from the monitoring site. Roads in the study area were identified. Each road in the study area was then treated as a quadrilateral volume source with depth 3 m, with spatial co-ordinates derived from OS maps. The urban background study area extended over an 80 km x 80 km area covering the London area. The background study area was divided into 1 km x 1 km squares-each 1 km square was then treated as a square volume source with depth 10 m.

Traffic flows in the local study area

Traffic flows, by vehicle category, on each of the roads within the local study area for 1996 were obtained from the DETR traffic flow database. The traffic flows were scaled to 1998 by factors shown in Table A3.1 obtained by linear interpolation from Transport Statistics GB, 1997.

Table A3.1 Traffic growth 1998:1996

Vehicle Type	Growth factor
Cars	1.05
Light goods vehicles	1.05
Heavy goods vehicles	1.04
Buses	1.00
Motorcycles	1.00

Traffic flows follow a diurnal variation. Table A3.2 shows the assumed diurnal variation in traffic flows.

Table A3.2 Assumed diurnal traffic variation

Hour	Normalised traffic flow
0	0.20
1	0.11
2	0.10
3	0.07
4	0.08
5	0.18
6	0.49
7	1.33
8	1.97
9	1.50
10	1.33
11	1.46
12	1.47
13	1.51
14	1.62
15	1.74
16	1.94
17	1.91
18	1.53
19	1.12
20	0.88
21	0.68
22	0.46
23	0.33

Vehicle speeds in the local study area
Vehicle speeds were estimated on the basis of TSGB, 1997 data for central area, inner area and outer area average traffic speeds in London, 1968-1995 and for non-urban and urban roads for 1996. Table A3.3 shows the traffic speeds applied to each of the sites. The low speeds in Central London reflect the generally high levels of congestion in the area.

Table A3.3 Traffic speeds used in the modelling

Site	Road class	Vehicle speed, kph
London Marylebone	Central London	17.5
Camden Roadside	Central London	17.5
London Bloomsbury	Central London	17.5
London A3 Roadside	Non-urban dual carriageway	88
London Haringey	Outer London	32
London North Kensington	Background site	Not applicable

Vehicle emissions in the local study area
Vehicle emissions of oxides of nitrogen were estimated using the Highways Agency Design Manual for Roads and Bridges, 1999 (DMRB). DMRB provides a series of nomograms that allow the effect on emission rates of the proportion of heavy goods vehicles and the average vehicle speed to be taken into account. The estimated emissions are based on average speeds and take account of the variations in emissions that follow from normal patterns of acceleration and deceleration. DMRB provides estimates of the emissions of particulate material from vehicle exhausts.

Emissions in the urban background study area
Emission estimates for each 1 km square in the urban background study area were obtained from two emission inventories. The London inventory for 1995/6 (LRC, 1997) was used for most of the urban background study area: the National Atmospheric Emission Inventory 1996 was used for areas within the urban background study area not covered by the London inventory.

The emission estimates for each square for 1996 were scaled to 1998 using factors taken from DMRB.

Meteorological data
Meteorological data for Heathrow Airport 1998 was used to represent meteorological conditions. The data set included wind speed and direction and cloud cover for each hour of the year. It was assumed that a surface roughness of 0.5 m was representative of the suburban area surrounding Heathrow Airport.

The meteorological conditions over London are affected by heat emissions from buildings and vehicles. This “urban heat island” effect reduces the frequency and severity of the stable atmospheric conditions that often lead to high pollutant concentrations. In order to take this into account the Monin-Obukhov length (a parameter used to characterise atmospheric stability in the model) has been assigned a lower limit as shown in Table A3.4.

Table A3.4: Monin-Obukhov limits applied

Site	Limit, m	Note
London Marylebone	100	Large conurbation
Camden Roadside	100	Large conurbation
London Bloomsbury	100	Large conurbation
London A3 Roadside	30	Mixed urban/industrial
London Haringey	30	Mixed urban/industrial
London North Kensington	100	Large conurbation
Small towns <50,000	10	
Urban background area	100	
Rural	1	

Surface roughness
The surface roughness is used in dispersion modelling to represent the roughness of the ground. Table A3.5 shows the surface roughness values applied.

Table A3.5 Surface roughness

Site	Surface roughness, m	Note
London Marylebone	2	Street canyon
Camden Roadside	1	City
London Bloomsbury	1	City
London A3 Roadside	0.5	Suburban
London Haringey	1	City
London North Kensington	1	Suburban
Urban background area	1	

Model output
The local model was used to estimate:

- Annual average road contribution of oxides of nitrogen;
- Road contribution to oxides of nitrogen concentrations for each hour of the year.

The urban background model was used to estimate:

- The contribution from urban background sources to annual average oxides of nitrogen concentrations;
- The contribution from roads considered in the local model to urban background concentrations;
- The contribution from urban background sources to oxides of nitrogen concentrations for each hour of the year.

Background concentrations
A rural background concentration of 20 μg m^{-3} was added to the urban background oxides of nitrogen concentration.

Calculation of annual average nitrogen dioxide concentrations
Nitrogen dioxide is formed as the result of the oxidation of nitrogen oxides in air, primarily by ozone. The relationship between oxides of nitrogen concentrations and nitrogen dioxide concentrations is complex; an empirical approach has been adopted.

The contribution from locally modelled roads to urban background oxides of nitrogen concentrations was first subtracted from the calculated urban background concentration. The annual average urban background nitrogen dioxide concentration was then calculated from the corrected annual average urban background oxides of nitrogen concentration using the following empirical relationship based on monitoring data from AUN sites:

For NO_x>23.6 μg m^{-3}

$$NO_2 = 0.348.NO_x + 11.48 \ \mu g\ m^{-3}$$

For NO_x<23.6 μg m^{-3}

$$NO_2 = 0.833.NO_x \ \mu g\ m^{-3}$$

The contribution of road sources to nitrogen dioxide concentrations was then calculated using the following empirical relationship (Stedman):

$$NO_2 = 0.162.NO_x$$

The contributions from road and background sources to annual average nitrogen dioxide concentrations were then summed.
The calculated value was then corrected so that there was agreement between modelled and measured concentrations at a reference site (London North Kensington (LNK)):

NO_2(corrected, site)= NO_2(modelled, site)+ NO_2(measured, LNK)- NO_2(modelled, LNK)

Calculation of 99.8th percentile hourly average concentrations
A simple approach has been used to estimate 99.8th percentile values. The approach relies on an empirical relationship between 99.8th percentile of hourly mean nitrogen dioxide and annual mean concentrations at kerbside/roadside sites, 1990-1998:

NO_2(99.8th percentile)=3.0 NO_2(annual mean)

99.8 th percentile values were calculated on the basis of the modelled annual mean.

The calculated value was then corrected so that there was agreement between modelled and measured concentrations at a reference site (London North Kensington (LNK)):

NO_2(corrected, site)= NO_2(modelled, site)+ NO_2(measured, LNK)- NO_2(modelled, LNK)

RESULTS

Modelled results are shown in Table A3.6. Fig. A3.1 shows modelled annual average nitrogen dioxide concentrations plotted against the measured values. Similarly Fig. A3.2 shows modelled 99.8th percentile average nitrogen dioxide concentrations plotted against measured values.

Table A3.6 Comparison of modelled and measured concentrations

Site	Nitrogen dioxide concentration, ppb			
	Annual average		99.8th percentile hourly	
	Modelled	Measured	Modelled	Measured
London A3	32	30	94	73
North Kensington	24	24	70	70
Bloomsbury	28	34	83	78
Camden	32	33	95	89
London Marylebone	45	48	134	121
Haringey	22	28	65	77

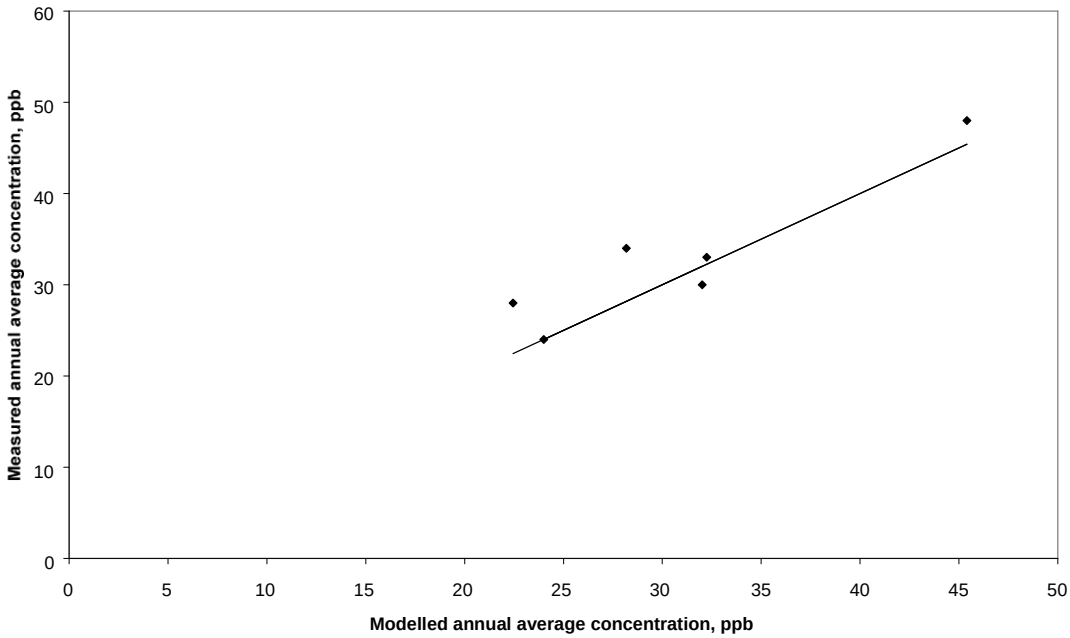


Fig. A3.1 Comparison of modelled and measured annual average nitrogen dioxide concentrations

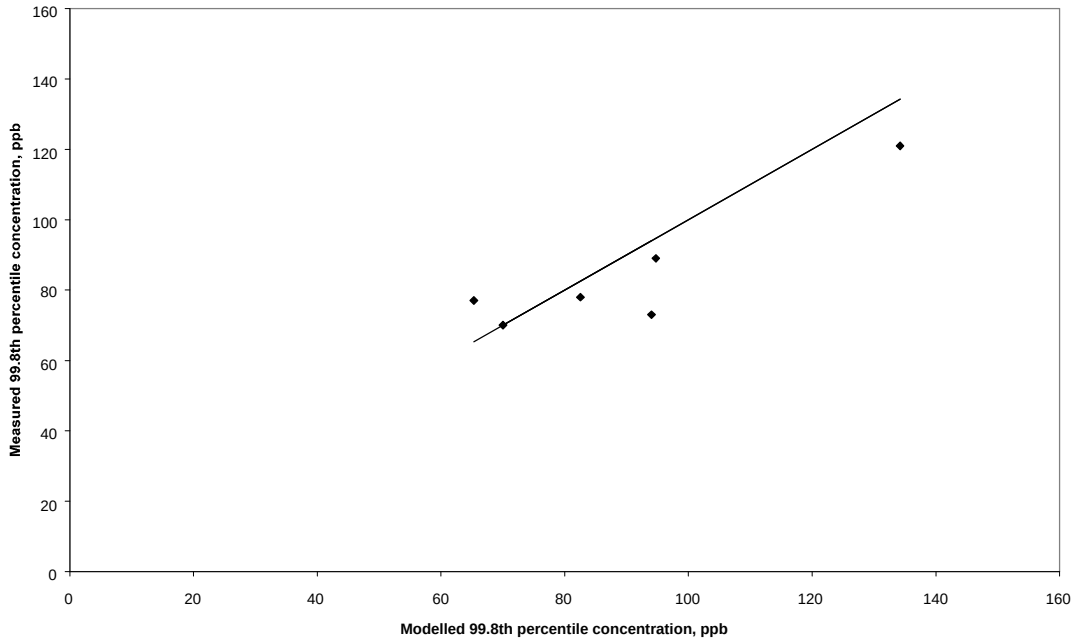


Fig. A3.2 Comparison of modelled and measured 99.8th percentile hourly average nitrogen dioxide concentrations

DISCUSSION

Model errors
The error in the modelled annual average at each site was calculated as a percentage of the modelled value. The standard deviation of the errors was then calculated: it was 12% with five degrees of freedom.

The error in the 99.8th percentile concentration at each site was calculated as a percentage of the modelled value. The standard deviation of the errors was then calculated: it was also 12% with five degrees of freedom.

Year to year variation in background concentrations
Nitrogen dioxide concentrations at monitoring sites show some year to year variations. Reductions in emissions in the United Kingdom are responsible for some of the variation, but atmospheric influences and local effects also contribute to the variation.

In order to quantify the year to year variation monitoring data from AUN stations with more than 75% data in the each of the years 1996-1998 was analysed using the following procedure.

First, the expected concentrations in 1997 and 1996 were calculated from the 1998 data.

$$c_e = \frac{d_{1998}}{d_y}.c_{1998}$$

where c_{1996} is the concentration in 1998;
d_{1998}, d_y are correction factors to estimate nitrogen dioxide concentrations in future years (1996=1, 1997=0.95, 1998=0.91) from DETR guidance;

The difference between the measured value and the expected value was then determined for each site and normalised by dividing by the expected value. The standard deviation of normalised differences was determined for each site. A best estimate of the standard deviation from all sites was then calculated. The standard deviation of the annual mean was 0.097 with 2 degrees of freedom. The standard deviation of the 99.8th percentile hourly concentration was 0.21 with 2 degrees of freedom.

Short periods of monitoring data
Additional errors can be introduced where monitoring at the reference site (used to calibrate the modelling results against) takes place over periods less than a complete year, typically of three or six months.

In this case, a whole year of data was available at the monitoring site (1999 in Glasgow Centre), and so no correction was necessary for short periods of monitoring.

Confidence limits
Upper confidence limits for annual mean and 99.8th percentile concentrations were estimated statistically from the standard deviation of the model error and the year to year standard deviation:

$$u = c + \sqrt{(t_m s_m)^2 \cdot \left(1 + \frac{1}{k}\right) + (t_y s_y)^2 + \sum (t_p s_p)^2 / k}$$

where:

s_m, s_y, s_p are the model error standard deviation , the year to year standard deviation and the standard error introduced using part year data;

c is the concentration calculated for the modelled year;

t_m, t_y, t_p are the values of Student's t distribution for the appropriate number of degrees of freedom at the desired confidence level;

k is the number of reference sites used in the estimation of the modelled concentration.

In many cases, the concentration estimate is based on a single reference site (k=1). However, improved estimates can be obtained where more than one reference site is used.

Table A3.7 shows confidence levels for predictions as a percentage of modelled values

Table A3.7 Upper confidence levels (k=1) for modelled concentrations for future years

Confidence level	Annual mean	99.8th percentile
80 %	+19%	+27%
90%	+31%	+47%
95%	+44%	+70%

In practical terms,

- There is less than 1:5 chance (i.e.100-80=20%) that the 40 μg m^{-3} objective will be exceeded if the modelled annual average concentration in 2005 is less than 34 μg m^{-3} (i.e. 40/1.19);
- There is less than 1:20 (i.e. 100-5=5%) chance that the objective will be exceeded if the modelled roadside concentration is less than 28 μg m^{-3} (i.e. 40/1.44).

- Similarly, there is less than 1:5 chance that the 200 μg m^{-3} 99.8th percentile concentration will be exceeded if the modelled concentration for 2005 is less than 157 μg m^{-3};
- There is less than 1:20 chance that the objective will be exceeded if the modelled concentration in 2005 is less than 117 μg m^{-3}.

In the figures shown in the report, the intervals of confidence limits for the 'probable' and 'likely' annual average and hourly objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedances of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals.

A simple linear relationship can be used to predict the 99.8th percentile concentration of NO_2 from the annual concentration: the 99.8th percentile is three times the annual mean at kerbside/roadside locations. Therefore, plots of the modelled annual mean NO_2 concentrations can be used to show exceedances of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedances of the hourly objective need to be adjusted so they may be used directly with the plots of annual concentration. This has been performed by simply dividing the concentrations of the confidence limits by three.

The following table shows the difference between assigning symmetrical confidence intervals and assigning intervals based directly on the statistics.

Table A3.8a Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations (μg m^{-3})			
		Annual average objective (symmetrical intervals)	Symmetrical intervals	Annual average objective (intervals based on statistics)	Interval
Very unlikely	Less than 5%	< 28		< 28	
Unlikely	5 to 20%	28 to 34	6.0	28 to 34	6.0
Possible	20 to 50%	34 to 40	6.3	34 to 40	6.3
Probable	50 to 80%	40 to 46	6.3	40 to 47	7.5
Likely	80 to 95%	46 to 52	6.0	47 to 58	10.3
Very likely	More than 95%	> 52		> 58	

Table A3.8b Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations ($\mu g\ m^{-3}$)			
		Hourly average objective (symmetrical intervals)	Symmetrical intervals	Hourly average objective (intervals based on statistics)	Interval
Very unlikely	Less than 5%	< 39		< 39	
Unlikely	5 to 20%	39 to 52	13.2	39 to 52	13.2
Possible	20 to 50%	52 to 67	14.3	52 to 67	14.3
Probable	50 to 80%	67 to 81	14.3	67 to 85	18.1
Likely	80 to 95%	81 to 94	13.2	85 to 113	28.7
Very likely	More than 95%	> 94		> 113	

Appendix 4

Model validation PM_{10}

INTRODUCTION

The dispersion model ADMS-3 was used to predict PM_{10} concentrations at roadside locations. ADMS-3 is a PC-based model that includes an up-to-date representation of the atmospheric processes that contribute to pollutant dispersion.

The model was verified by comparison with monitoring data obtained at a number of roadside, kerbside or near-road monitoring sites in London. The monitoring sites considered were:

- London Marylebone
- Camden Roadside
- Haringey Roadside
- London Bloomsbury
- London North Kensington
- London A3 Roadside

London Marylebone site is located in a purpose built cabin on Marylebone Road opposite Mme Tussauds. The sampling point is located at a height of 3m, around 1m from the kerbside. Traffic flows of over 80,000 vehicles per day pass the site on six lanes. The road is frequently congested. The surrounding area forms a street canyon and comprises of education buildings, tourist attractions, shops and housing

Camden Roadside site (TQ267843) is located in a purpose built cabin on the north side of the Swiss Cottage Junction. The site is at the southern end of a broad street canyon. Sampling points are approximately 1 m from the kerbside of Finchley Road at a height of 3m. Traffic flows of 37,000 vehicles per day pass the site and the road is often congested. Pedestrian traffic is also high. The surrounding area mainly consists of shops and offices.

London North Kensington site (TQ240817) is located within the grounds of Sion Manning School. The sampling point is located on a cabin, in the school grounds next to St Charles Square, at a height of 3m. The surrounding area is mainly residential.

London A3 monitoring station (TQ193653) is within a self-contained, air-conditioned housing immediately adjacent to the A3 Kingston Bypass (6 lane carriageway). Traffic flow along the bypass is approximately 112,000 vehicles per day and is generally fast and free flowing with little congestion. The manifold inlet is approximately 2.5 m from the kerbside at a height of approximately 3m. The surrounding area is generally open and comprises residential dwellings and light industrial and commercial properties.

London Bloomsbury monitoring station (TQ302820) is within a self-contained, air-conditioned housing located at within the southeast corner of central London gardens. The gardens are generally laid to grass with many mature trees. All four sides of the gardens are surrounded by a busy (35,000 vehicles per day), 2/4 lane one-way road system which is subject to frequent congestion. The nearest road lies at a distance of approximately 35 metres from the station. The manifold inlet is approximately 3 metres high. The area in the vicinity of the manifold is open, but there are mature trees within about 5 metres.

London Haringey site (TQ339906) is located in a purpose built cabin within the grounds of the Council Offices. The sampling point is at a height of 3 m located 5m from High Road Tottenham (A1010) with traffic flows of around 20,000 vehicles per day. The road is frequently congested. The surrounding area consists of shops, offices and housing.

Model application

Study area

A study area was defined for each of the monitoring sites extending 200 m in each direction (NSEW) from the monitoring site. Roads in the study area were identified. Each road in the study area was then treated as a quadrilateral volume source with depth 3m, with spatial coordinates derived from OS maps.

Traffic flows

Traffic flows, by vehicle category, on each of the roads within the study area for 1996 were obtained from the DETR traffic flow database. The traffic flows were scaled to 1998 by factors shown in Table A4.1 obtained by linear interpolation from Transport Statistics GB, 1997.

Table A4.1: Traffic growth 1998:1996

	Growth factor
Cars	1.05
Light goods vehicles	1.05
Heavy goods vehicles	1.04
Buses	1.00
Motorcycles	1.00

Traffic flows follow a diurnal variation. Table A4.2 shows the assumed diurnal variation in traffic flows.

Table A4.2: Assumed diurnal traffic variation

Hour	Normalised traffic flow
0	0.20
1	0.11
2	0.10
3	0.07
4	0.08
5	0.18
6	0.49
7	1.33
8	1.97
9	1.50
10	1.33
11	1.46
12	1.47
13	1.51
14	1.62
15	1.74
16	1.94
17	1.91
18	1.53
19	1.12
20	0.88
21	0.68
22	0.46
23	0.33

Vehicle speeds

Vehicle speeds were estimated on the basis of TSGB, 1997 data for central area, inner area and outer area average traffic speeds in London, 1968-1995 and for non-urban and urban roads for 1996. Table A4.3 shows the traffic speeds applied to each of the sites. The low speeds in Central London reflect the generally high levels of congestion in the area.

Table A4.3: Traffic speeds used in the modelling

Site	Road class	Vehicle speed, kph
London Marylebone	Central London	17.5
Camden Roadside	Central London	17.5
London Bloomsbury	Central London	17.5
London A3 Roadside	Non-urban dual carriageway	88
London Haringey	Outer London	32
London North Kensington	Background site	Not applicable

Vehicle emissions
Vehicle emissions were estimated using the Highways Agency Design Manual for Roads and Bridges, 1999 (DMRB). DMRB provides a series of nomograms that allow the effect on emission rates of the proportion of heavy goods vehicles and the average vehicle speed to be taken into account. The estimated emissions are based on average speeds and take account of the variations in emissions that follow from normal patterns of acceleration and deceleration. DMRB provides estimates of the emissions of particulate material from vehicle exhausts. Nearly all the exhaust material is in the sub 10 μm range and so it was assumed that all the particulate material released in the exhaust was PM_{10}.

PM_{10} is also released as the result of resuspension of roadside dusts from tyre wear, brake pad wear etc.. The rate of emission is uncertain: it has been suggested that resuspended dusts may be emitted at rates approaching those from vehicle exhausts. The rate of resuspension is expected to depend to some extent on wind speed, with relatively little resuspension occurring at low wind speeds. For this assessment it has been assumed that resuspended dusts are emitted at a rate of half the exhaust emissions when calculating annual average PM_{10}concentrations but resuspension has been ignored when calculating PM_{10}concentrations for the meteorological conditions (generally low wind speeds) corresponding to the 90^{th} percentile 24 hour average.

Meteorological data
Meteorological data for Heathrow Airport 1998 was used to represent meteorological conditions. The data set included wind speed and direction and cloud cover for each hour of the year. It was assumed that a surface roughness of 0.5 m was representative of the suburban area surrounding Heathrow Airport.

The meteorological conditions over London are affected by heat emissions from buildings and vehicles. This “urban heat island” effect reduces the frequency and severity of the stable atmospheric conditions that often lead to high pollutant concentrations. In order to take this into account the Monin-Obukhov length (a parameter used to characterise atmospheric stability in the model) has been assigned a lower limit as shown in Table A4.4.

Table A4.4: Monin-Obukhov limits applied

Site	Limit, m	Note
London Marylebone	100	Large conurbation
Camden Roadside	100	Large conurbation
London Bloomsbury	100	Large conurbation
London A3 Roadside	30	Mixed urban/industrial
London Haringey	30	Mixed urban/industrial
London North Kensington	100	Large conurbation
Small towns <50,000	10	
Rural	1	

Surface roughness
The surface roughness is used in dispersion modelling to represent the roughness of the ground. Table A4.5 shows the surface roughness values applied.

Table A4.5: Surface roughness

Site	Surface roughness, m	Note
London Marylebone	2	Street canyon
Camden Roadside	1	City
London Bloomsbury	1	City
London A3 Roadside	0.5	Suburban
London Haringey	1	City
London North Kensington	1	Suburban

Model output

The model was used to estimate:

- Annual average road contribution ;
- 90 th percentile 24 hour average road contribution;
- road contribution for each hour of the year.

Background concentrations
The London North Kensington site was used to provide an estimate of the background concentration of PM_{10}. The background concentration was then estimated at other sites on the basis of DETR background maps (http://www.aeat.co.uk/netcen/airqual/) for 1996. The background maps were corrected to 1998 by multiplying the concentrations by 0.82 (0.9 for 1997), based on the comparison of monitoring data at 17 monitoring sites with greater than 75% data capture in both years. Thus, background annual average concentrations at other sites were estimated using:

$C_{av}(site, 1998)=C_{av}(LNK,measured,1998)+0.82*(C_{av}(site,map,1996)-C_{av}(LNK,map,1996))$

The 90^{th} percentile 24 hour average concentration at other sites were estimated using:

$C_{90}(site, 1998)=C_{av}(LNK,measured,1998)*1.68+0.82*1.68*(C_{av}(site,map,1996)-C_{av}(LNK,map,1996))$

The background concentrations for each hour used in the calculation of 90^{th} %ile concentrations at other sites were estimated using:

$C (site, 1998)=C (LNK,measured,1998)+0.82*1.68*(C_{av}(site,map,1996)-C_{av}(LNK,map,1996))$

The factor 1.68 in the above equations is taken from an analysis of the relationship between the 90^{th} percentile 24 hour average PM_{10} and the annual average PM_{10} concentration at UK Automatic Network sites 1992-1997.

The background concentrations and the DETR background map were based on TEOM measurements. In order to convert to gravimetric measurements the values were multiplied by a factor 1.3, following Pollutant Specific Guidance.

Adding background concentrations
The modelled road contribution to PM_{10} were added to the background concentrations in a number of ways. For total annual average gravimetric concentrations:

$C_{av}(total, site,1998)= C_{av}(background, site, 1998)*1.3+ C_{av}(roads, site, 1998)- C_{av}(roads, LNK, 1998)$

90^{th} percentile 24 hour average concentrations were estimated (Method 1):

$C_{90}(total, site,1998)= C_{90}(background, site, 1998)*1.3+ C_{90}(roads, site, 1998)- C_{90}(roads, LNK, 1998)$

The 90^{th} %ile 24 hour average concentration was also estimated more formally by first calculating for each hour (Method 2):

$C (total, site,1998)= C (background, site, 1998)*1.3+ C (roads, site, 1998)- C (roads, LNK, 1998)$

then calculating the average concentration for each day and then determining the 36th highest daily average concentration.

Results

Modelled results are shown in Table A4.6. Fig.A4.1 shows modelled annual average PM_{10} concentrations plotted against the measured values. Similarly Fig. A4.2 shows modelled 90 th percentile 24 hour average PM_{10} concentrations plotted against measured values (Method 1).

The two methods of calculating the 90th percentile concentration are compared in Fig. A4.3. It shows the value calculated by adding the 90th percentile road contribution to the 90th percentile background concentrated compared with the value calculated more formally by taking the 90th percentile of daily average background plus road concentrations.

Table A4.6: Model results summary

	Measured				Background, TEOM		Modelled road contribution, gravimetric		Modelled, gravimetric		
	Mean (TEOM)	Mean, gravimetric	90%ile TEOM	90 % gravimetric	DETR1996 map	Corrected to model year	Mean	90th%ile	Mean	90th%ile (1)	90th%ile (2)
1998 Haringey	22	28.6	35	45.5	27	18.36	2.28	3.08	26.15	43.18	41.34
London Marylebone	32	41.6	45	58.5	29	20	17.60	21.55	43.60	65.23	61.33
Camden	25	32.5	36	46.8	29	20	9.39	12.08	35.39	55.76	53.23
Bloomsbury	23	29.9	32	41.6	29	20	1.20	1.46	27.20	45.14	43.87
London A3	24	31.2	39	50.7	25	16.72	8.76	11.85	30.50	48.37	47.28
North Kensington	20	26	33	42.9	29	20	0.00	0.00	26.00	43.68	42.80
1997 Camden	32	41.6	48	62.4	29	24	10.43	13.42	41.63	65.84	
Haringey	26	33.8	43	55.9	27	22.2	2.53	3.42	31.39	51.91	
North Kensington	24	31.2	38	49.4	29	24	0.00	0.00	31.20	52.42	

(1) 90th percentile 24 hour average value calculated by adding background and road 90th percentiles

(2) 90th percentile 24 hour average value calculated by adding daily mean background and road concentrations and then calculating the 90 th percentile value

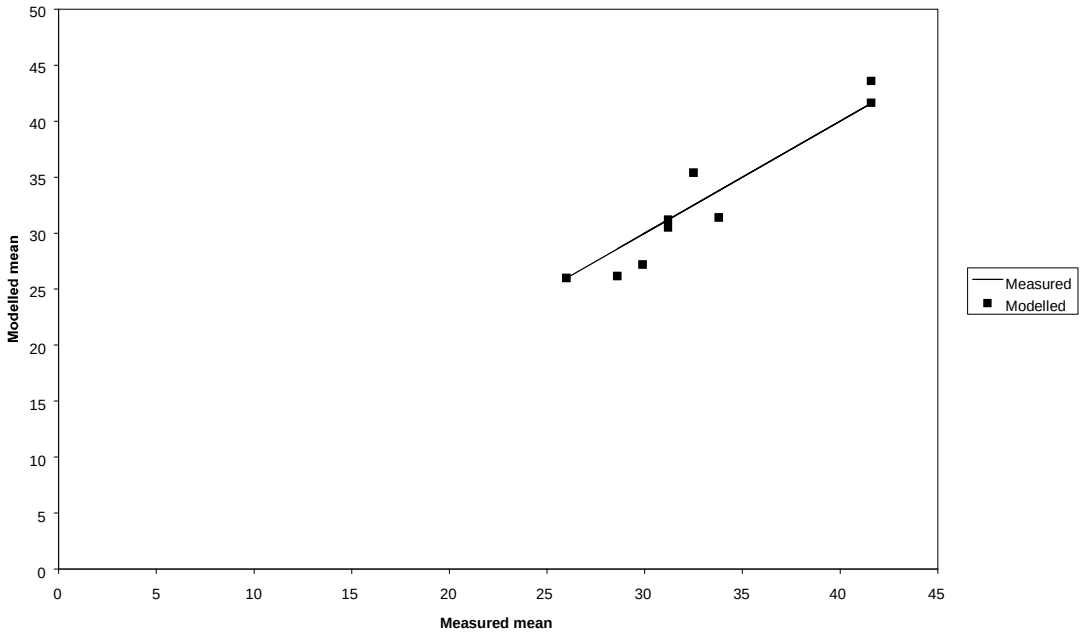


Fig. A4.1:Comparison of modelled and measured annual mean PM_{10} concentrations, $\mu g/m^3$ gravimetric

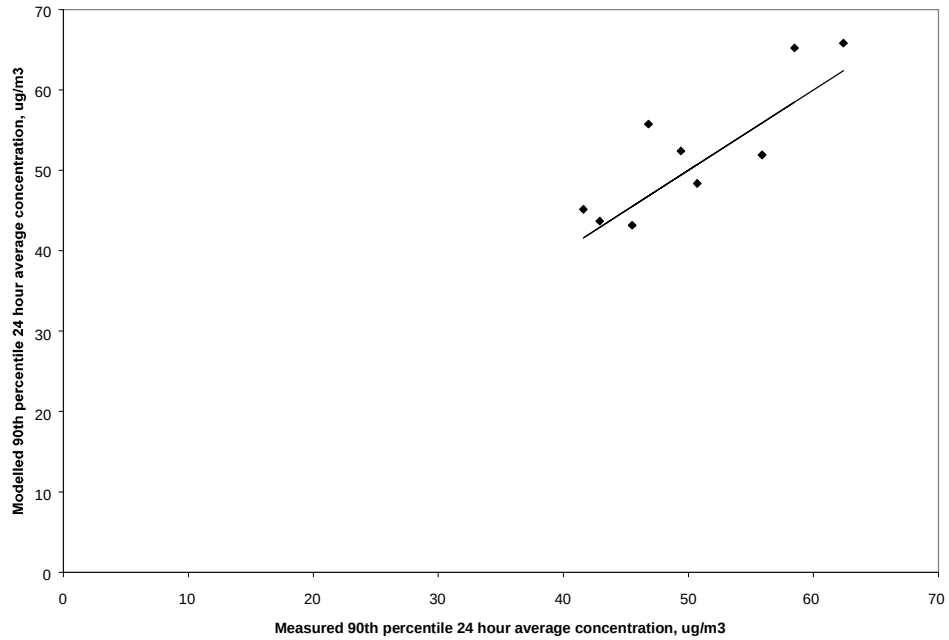


Fig. A4.2: Comparison of modelled and measured 90th percentile 24 hour average PM_{10} concentrations (Method 1), $\mu g/m^3$ gravimetric.

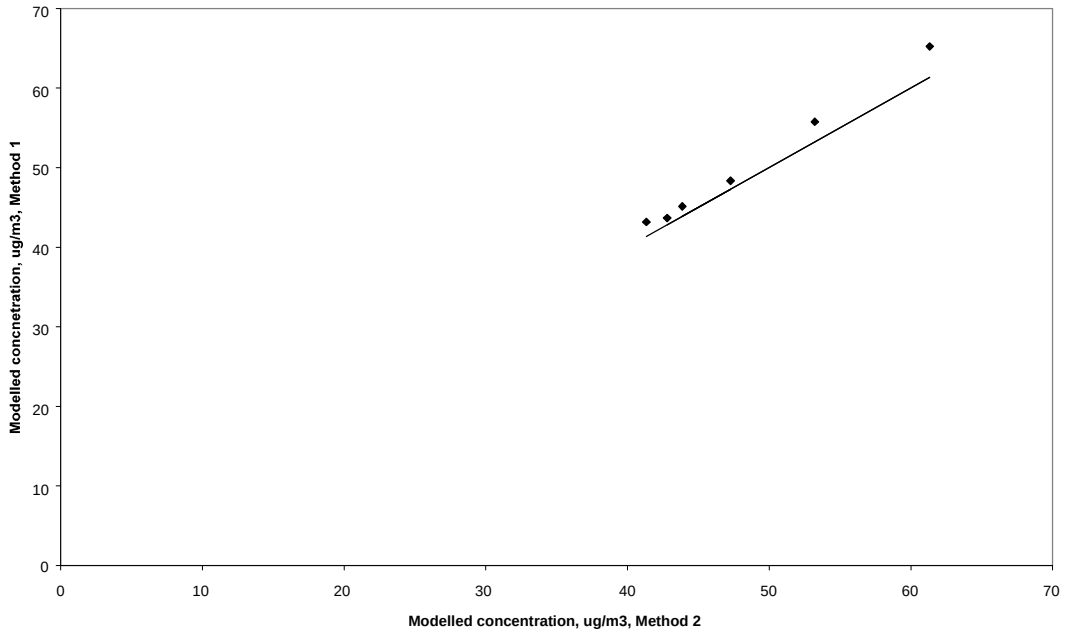


Fig. A4.3: Comparison of 90th percentile calculation methods, gravimetric units

Discussion

Model errors

The difference between the modelled and measured values were calculated. The standard deviation of the difference was then determined.

The estimated standard error was 2.0 μg m^{-3} and 4.3 μg m^{-3} (gravimetric) for the annual mean and 90th percentile concentrations respectively with 5 degrees of freedom.

Year to year variation in background concentrations

PM_{10} concentrations at background sites show wide year to year variations. The year 1996 showed exceptionally high PM_{10} concentrations while 1998 showed relatively low concentrations. Reductions in emissions in the United Kingdom are responsible for some of the variation, but atmospheric influences have a significant effect.

Measurements of PM_{10} concentrations in Epping Forest District were carried out for a limited period (August 1 – November 5) during 1999. Monitoring data from other measurement sites in the London area was therefore assessed to determine whether measurements made over this period were representative of concentrations in 1996.

In order to quantify the year to year variation monitoring data from monitoring stations in the London area with more than 75% data in the each of the years 1996-1998 was analysed using the following procedure.

First, the expected annual average concentrations in 1999 were calculated from the 199x data.

$$c_e = (c_{av,199x} - 1.3.c_m.b_{199x} - 10.5).\frac{a_{199x}}{a_{1999}} + 1.3 \times b_{1999} \times c_m + 10.5$$

where $c_{av,199x}$ is the average concentration (gravimetric) in 199x;
the factor 1.3 is used to convert TEOM measurements to gravimetric;
c_m is the annual average secondary concentration (TEOM) from DETR map for 1996;
a_{1999}, a_{199x} are correction factors to estimate primary combustion PM_{10} concentration in 2004 from DETR guidance;
b_{year} is a correction factor to estimate secondary PM_{10} in future years from 1996 mapped data;
the factor 10.5 represents the contribution of coarse dusts to annual average concentrations (gravimetric).

The expected concentrations are plotted against the average concentration over the measurement period in Fig. A4.4. The difference between the measured average concentration for the period August 1 –November 5 1999 and the expected value was then determined for each site. The average difference and the standard deviation of the differences was determined.

The average difference in annual average (the bias) was –0.06 μg m^{-3} with standard deviation 1.95 μg m^{-3} with 26 degrees of freedom (both in TEOM units).

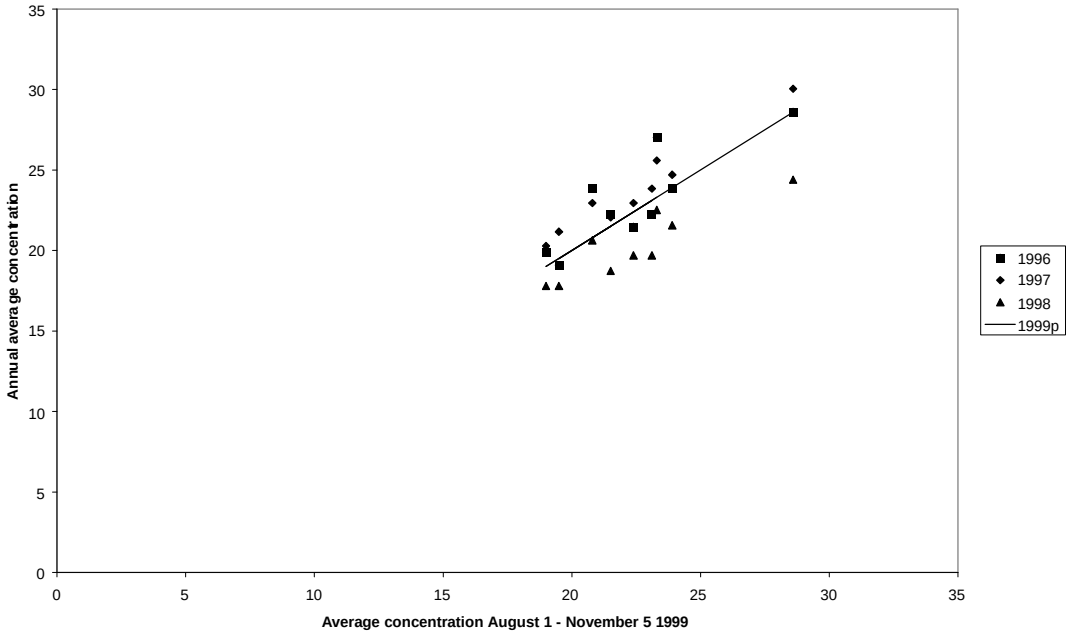


Fig. A4.4: Comparison of average concentrations (μg m^{-3} TEOM) during August 1-November 5 1999 with annual average concentrations

Confidence limits
Upper confidence limits for predicted 90th percentile 24 hour average concentrations were estimated from the standard deviation of the model error and the year to year standard deviation:

$$u = c + 1.68.b + \sqrt{2.(t_m s_m)^2 + (1.68 t_y s_y)^2}$$

where s_m, s_y are the model error standard deviation and the standard deviation in the yearly bias, b;
c is the concentration calculated for the modelled year;
b is the bias between average annual concentrations and the concentrations for the measurement period at the reference site;
t_m, t_y are the values of Student's t distribution for the appropriate number of degrees of freedom at the desired confidence level;
the factor 2 allows for uncertainty in the estimates of concentrations at the reference site;
the factor 1.68 applies to 90th percentile concentrations only.

Table A4.7 shows confidence levels for predictions of concentrations in future years based on the use as reference of data from the Epping Forest District monitoring site.

Table A4.7: Confidence levels for prediction of concentrations in future years based on Epping Forest monitoring data

One sided confidence level	Upper confidence limits, μg m^{-3} gravimetric	
	Mean	90th percentile 24 hour average
80%	+3.3	+6.5
90%	+5.2	+10.4
95%	+7.0	+14

In practical terms, there is less than 1:5 chance that the 50 ug/m3 objective will be exceeded in 2004 if the modelled 90th percentile 24 hour average concentration is less than 43.5 ug/m3: there is less than 1:20 chance that the objective will be exceeded if the modelled roadside concentration is less than 36 ug/m3.

Alternative method of calculation

Figure A2.3 shows that the simple method of adding 90th percentile backgrounds and road contributions provides a good estimate of the value calculated as the 90th percentile of daily average background plus road concentrations.

Appendix 5

The UK Air Quality Strategy

Contents

The Need for an Air Quality Strategy

The Government published its proposals for review of the National Air Quality Strategy in early 1999 (DETR, 1999). These proposals included revised objectives for many of the regulated pollutants. A key factor in the proposals to revise the objectives was the agreement in June 1998 at the European Union Environment Council of a Common Position on Air Quality Daughter Directives (AQDD).

Following consultation on the Review of the National Air Quality Strategy, the Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

The Environment Act (1995) provides the legal framework for requiring LA's to review air quality and for implementation of an AQMA. The main constituents of this Act are summarised in the table below.

A4.1 Major elements of the Environment Act 1995

Part IV Air Quality	Commentary
Section 80	Obliges the Secretary of State (SoS) to publish a National Air Quality Strategy as soon as possible.
Section 81	Obliges the Environment Agency to take account of the strategy.
Section 82	Requires local authorities, any unitary or Borough, to review air quality and to assess whether the air quality standards and objectives are being achieved. Areas where standards fall short must be identified.
Section 83	Requires a local authority, for any area where air quality standards are not being met, to issue an order designating it an air quality management area (AQMA).
Section 84	Imposes duties on a local authority with respect to AQMAs. The local authority must carry out further assessments and draw up an action plan specifying the measures to be carried out and the timescale to bring air quality in the area back within limits.
Section 85	Gives reserve powers to cause assessments to be made in any area and to give instructions to a local authority to take specified actions. Authorities have a duty to comply with these instructions.
Section 86	Provides for the role of County Councils to make recommendations to a district on the carrying out of an air quality assessment and the preparation of an action plan.
Section 87	Provides the SoS with wide ranging powers to make regulations concerning air quality. These include standards and objectives, the conferring of powers and duties, the prohibition and restriction of certain activities or vehicles, the obtaining of information, the levying of fines and penalties, the hearing of appeals and other criteria. The regulations must be approved by affirmative resolution of both Houses of Parliament.
Section 88	Provides powers to make guidance which local authorities must have regard to.

Overview of the principles and main elements of the National Air Quality Strategy
The main elements of the AQS can be summarised as follows:

- The use of a health effects based approach using national air quality standards and objectives.
- The use of policies by which the objectives can be achieved and which include the input of important factors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with target dates of 2003, 2004, 2005, 2008 and 2010 for the achievement of objectives and a commitment to review the Strategy every three years.

It is intended that the AQS will provide a framework for the improvement of air quality that is both clear and workable. In order to achieve this, the Strategy is based on several principles which include:

- the provision of a statement of the Government's general aims regarding air quality;
- clear and measurable targets;
- a balance between local and national action and
- a transparent and flexible framework.

Co-operation and participation by different economic and governmental sectors is also encouraged within the context of existing and potential future international policy commitments.

National Air Quality Standards
At the centre of the AQS is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. Most of the proposed standards have been based on the available information concerning the health effects resulting from different ambient concentrations of selected pollutants and are the consensus view of medical experts on the Expert Panel on Air Quality Standards (EPAQS). These standards and associated specific objectives to be achieved between 2003 and 2010 are shown in Table A4.2. The table shows the standards in ppb and $\mu g\ m^{-3}$ with the number of exceedances that are permitted (where applicable) and the equivalent percentile.

Specific objectives relate either to achieving the full standard or, where use has been made of a short averaging period, objectives are sometimes expressed in terms of percentile compliance. The use of percentiles means that a limited number of exceedances of the air quality standard over a particular timescale, usually a year, are permitted. This is to account for unusual meteorological conditions or particular events such as November 5th. For example, if an objective is to be complied with at the 99.9th percentile, then 99.9% of measurements at each location must be at or below the level specified.

Table A4.2 Objectives included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management

Air Quality Objectives			
Pollutant	Concentration	Measured as	Date to be achieved by
Benzene All authorities	16.25 μg m-3	running annual mean	31.12.2003
Authorities in England and Wales only	5.00 μg m-3	annual mean	31.12.2010
Authorities in Scotland and Northern Ireland only [a]	*3.25 μg m-3*	*running annual mean*	*31.12.2010*
1,3-Butadiene	2.25 μg m-3	running annual mean	31.12.2003
Carbon monoxide Authorities in England, Wales and Northern Ireland only [a]	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 μg m-3 0.25 μg m-3	annual mean annual mean	31.12.2004 31.12.2008
Nitrogen dioxide [b]	200 μg m-3 not to be exceeded more than 18 times a year 40 μg m-3	1 hour mean annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)[c] All authorities	50 μg m-3 not to be exceeded more than 35 times a year 40 μg m-3	24 hour mean annual mean	31.12.2004 31.12.2004
Authorities in Scotland only [d]	*50 μg m-3 not to be exceeded more than 7 times a year* *18 μg m-3*	*24 hour mean* *annual mean*	*31.12.2010* *31.12.2010*
Sulphur dioxide	350 μg m-3 not to be exceeded more than 24 times a year 125 μg m-3 not to be exceeded more than 3 times a year 266 μg m-3 not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31.12.2004 31.12.2004 31.12.2005

a. Air Quality (Northern Ireland) Regulations (2003)
b. The objectives for nitrogen dioxide are provisional.
c. Measured using the European gravimetric transfer sampler or equivalent.
d. These 2010 Air Quality Objectives for PM_{10} apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

Relationship between the UK National Air Quality Standards and EU air quality Limit Values
As a member state of the EU, the UK must comply with EU Directives.

There are three EU ambient air quality directives that the UK has transposed in to UK law. These are:

- **96/62/EC** Council Directive of 27 September 1996 on ambient air quality assessment and management (the Ambient Air Framework Directive).

- **1999/30/EC** Council Directive of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide, oxides of nitrogen, PM_{10} and lead in ambient air (the First Daughter Directive).

- **2000/69/EC** Directive of the European Parliament and the Council of 16 Nov 2000 relating to limit values for benzene and carbon monoxide in ambient air (the Second Daughter Directive).

The first and second daughter directives contain air quality Limit Values for the pollutants that are listed in the directives. The United Kingdom (i.e. Great Britain and Northern Ireland) must comply with these Limit Values. The UK air quality strategy should allow the UK to comply with the EU Air Quality Daughter Directives, but the UK air quality strategy also includes some stricter national objectives for some pollutants, for example, the 15-minute sulphur dioxide objective.

The Government is ultimately responsible for achieving the EU limit values. However, it is important that Local Air Quality Management is used as a tool to ensure that the necessary action is taken at local level to work towards achieving the EU limit values by the dates specified in those EU Directives.

Additional particle objectives (not included in Regulations[4])
For particulates (as PM_{10}) additional objectives apply. It should be noted that only the objectives for Scotland have been included in Regulations.
- For all parts of the UK, except London and Scotland, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 times a year and an annual mean of 20 $\mu g/m^3$, both to be achieved by the end of 2010;
- For London, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 10 times a year and an annual mean of 23 $\mu g/m^3$, both to be achieved by the end of 2010;
- For Scotland, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 times a year and an annual mean of 18 $\mu g/m^3$, both to be achieved by the end of 2010.

Policies in place to allow the objectives for the pollutants in AQS to be achieved
The policy framework to allow these objectives to be achieved is one that takes a local air quality management approach. This is superimposed upon existing national and international regulations in order to effectively tackle local air quality issues as well as issues relating to wider spatial scales. National and EC policies that already exist provide a good basis for progress towards the air quality objectives set for 2003 to 2008. For example, the Environmental Protection Act 1990 allows for the monitoring and control of emissions from industrial processes and various EC Directives have ensured that road transport emission and fuel standards are in place. These policies are being developed to include more stringent controls. Developments in the UK include the announcement by the Environment Agency/SEPA in January 2000 of controls on emissions of SO_2 from coal and oil fired power stations. This system of controls intended that by the end of 2005 coal and oil fired power stations would have met the air quality standards set out in the AQS.

Local air quality management provides a strategic role for local authorities in response to particular air quality problems experienced at a local level. This builds upon current air quality control responsibilities and places an emphasis on bringing together issues relating to transport, waste, energy and planning in an integrated way. This integrated approach involves a number of different aspects. It includes the development of an appropriate local framework that allows air quality issues to be considered alongside other issues relating to polluting activity. It should also enable co-operation with and participation by the general public in addition to other transport, industrial and governmental authorities.

[4] The exception is the Scottish Executive which has incorporated the PM10 objectives in their Regulations.

An important part of the Strategy is the requirement for local authorities to carry out air quality reviews and assessments of their area against which current and future compliance with air quality standards can be measured. Over the longer term, these will also enable the effects of policies to be studied and therefore help in the development of future policy. The Government has prepared guidance to help local authorities to use the most appropriate tools and methods for conducting a review and assessment of air quality in their District. This is part of a package of guidance being prepared to assist with the practicalities of implementing the AQS. Other guidance covers air quality and land use planning, air quality and traffic management and the development of local air quality action plans and strategies.

Timescales to achieve the objectives
In most local authorities in the UK, objectives will be met for most of the pollutants within the timescale of the objectives shown in Table A4.2. It is important to note that the objectives for NO_2 remain provisional. The Government has recognised the problems associated with achieving the standard for ozone and this will not therefore be a statutory requirement. Ozone is a secondary pollutant and transboundary in nature and it is recognised that local authorities themselves can exert little influence on concentrations when they are the result of regional primary emission patterns.

Air Quality Reviews
A range of Technical Guidance has been issued to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This includes LAQM.TG(03), on 'Local Air Quality Management: Technical Guidance, February 2003 and subsequent update issued in January 2006. This review and assessment has considered the procedures set out in the guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed in the second round that reviews should be carried out in two stages. Every authority is expected to undertake at least a first stage Updating and screening Assessment (USA) of air quality in their authority area. Where the USA has identified a risk that an air quality objective will be exceeded at a location with relevant public exposure, the authority will be required to undertake a detailed assessment. The Stages are briefly described in the following table, Table A4.3.

Table A4.3 The phased approach to review and assessment.

Level of assessment	Objective	Approach
Updating and screening assessment (USA)	To identify those matters that have changed since the last review and assessment, which might lead to a risk of the air quality objective being exceeded.	Use a check list to identify significant changes that require further consideration. Where such changes are identified, apply simple screening tools to decide whether there is sufficient risk of an exceedance of an objective to justify a detailed assessment
Detailed assessment	To provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment or any necessary AQMAs.	Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.

Locations that the review and assessment must concentrate on

For the purpose of review and assessment, the authority should focus their work on locations where members of the public are likely to be exposed over the averaging period of the objective. Table A4.4 summarises the locations where the objectives should and should not apply.

Table A4.4 Typical locations where the objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	• 1,3 Butadiene • Benzene • Lead • Nitrogen dioxide • PM_{10}	• All background locations where members of the public might be regularly exposed.	• Building facades of offices or other places of work where members of the public do not have regular access.
		• Building facades of residential properties, schools, hospitals, libraries etc.	• Gardens of residential properties.
			• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term
24 hour mean and 8-hour mean	• Carbon monoxide • PM_{10} • Sulphur dioxide	• All locations where the annual mean objective would apply.	• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
		• Gardens of residential properties.	

Table A4.4 (contd.) Typical locations where the objectives should and should not apply

Averaging Period	Pollutants	Objectives should apply at …	Objectives should generally not apply at …
1 hour mean	• Nitrogen dioxide • Sulphur dioxide	• All locations where the annual mean and 24 and 8-hour mean objectives apply.	• Kerbside sites where the public would not be expected to have regular access.
		• Kerbside sites (e.g. pavements of busy shopping streets).	
		• Those parts of car parks and railway stations etc. which are not fully enclosed.	
		• Any outdoor locations to which the public might reasonably be expected to have access.	
15 minute mean	• Sulphur dioxide	• All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

It is unnecessary to consider exceedances of the objectives at any location where public exposure over the relevant averaging period would be unrealistic, and the locations should represent non-occupational exposure.

Key Points

- The Environment Act 1995 has required the development of a National Air Quality Strategy for the control of air quality.
- A central element in the Strategy is the use of air quality standards and associated objectives based on human health effects that have been included in the Air Quality Regulations.
- The Strategy uses a local air quality management approach in addition to existing national and international legislation. It promotes an integrated approach to air quality control by the various factors and agencies involved.
- Air quality objectives, with the exception of ozone, are to be achieved by specified dates up to the end of 2010.
- A number of air quality reviews are required in order to assess compliance with air quality objectives. The number of reviews necessary depends on the likelihood of achieving the objectives.