West Lothian Council

Detailed Assessment for Broxburn, West Lothian

Report for West Lothian Council

Restricted Commercial
AEAT/ENV/R/3136
ED56042001
Issue Number 1
Date 25/02/2011

Customer:

West Lothian Council

Customer reference:

WESTLOTHIAN/DA/BROX/FEB11

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AEA reference:

ID: AEAT/ENV/R/3136

Ref: ED56042001- Issue Number 1

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Executive summary

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

This Detailed Assessment, in consultation with recent traffic, monitoring and meteorological data, focuses on the area of Broxburn, West Lothian.

The study has confirmed the findings of the previous Progress Report for West Lothian, namely that there are exceedences of the Scottish annual mean PM_{10} (18 $\mu g\ m^{-3}$) and NO_2 (40 $\mu g\ m^{-3}$) objectives at locations where relevant exposure exists. As such, an AQMA should be declared in this area.

Within the study area it is estimated that approximately 8 properties lie within the area of NO_2 exceedance equating to an exposed population of 20.

Additionally, it is estimated that approximately 43 properties lie within the area of PM_{10} exceedance equating to an exposed population of 102.

The modelled NO_2 concentrations at various residential receptors within the study area were estimated to exceed the NO_2 annual mean objective of 40 $\mu g\ m^{-3}$ for the 2010 calendar year. As such West Lothian Council should declare an AQMA which, as a minimum, should encompasses these properties. To reflect unavoidable uncertainty in the model predictions it may be prudent to declare a wider area.

The modelled PM_{10} concentrations at various residential receptors within the study area were estimated to exceed the PM_{10} annual mean objective of 18 $\mu g\ m^{-3}$ for the 2010 calendar year. Similarly, West Lothian Council should declare an AQMA which, as a minimum, should encompass these properties. To reflect unavoidable uncertainty in the model predictions it may be prudent to declare a wider area.

This assessment confirms that West Lothian Council should declare an AQMA for exceedances of both the NO_2 and PM_{10} annual mean objective in Broxburn. When the AQMA(s) have been declared, the Council should proceed to a Further Assessment of air quality following the prescribed timescales.

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1 Introduction

This section outlines the purpose of this Detailed Assessment for West Lothian Council and the scope of the assessment.

1.1 National Air Quality Strategy

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

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

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

National Air Quality Objectives			
Pollutant	**Air Quality Objective**		**Date to be achieved by**
	Concentration	**Measured as**	
Benzene			
All authorities	16.25 µg.m^{-3}	running annual mean	31.12.2003
Authorities in England and Wales only	5 µg.m^{-3}	annual mean	31.12.2010
Authorities in Scotland and Northern Ireland only	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	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	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)[a] 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[b]	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. Measured using the European gravimetric transfer sampler or equivalent.
b. These 2010 Air Quality Objectives for PM_{10} apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

1.2 Purpose of the Detailed Assessment

This study is a Detailed Assessment of air quality, which aims to confirm the findings of the 2010 Progress Report, and determine with reasonable certainty whether or not there is a likelihood of the NO_2 and PM_{10} annual mean air quality objectives being exceeded at parts of East Main Street, Broxburn. If an exceedance is predicted the assessment will estimate the spatial extent of the exceedance. The Detailed Assessment also requires that an estimate of the number of people exposed to the pollutant concentrations above the objective is included. Finally, the maximum pollutant concentrations at relevant receptor locations in the model domain are included.

1.3 Locations where the Air Quality Objectives apply

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

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

Examples of where the Air Quality Objectives should/should not apply			
Averaging Period	**Pollutants**	**Objectives *should* apply at …**	**Objectives should *not* generally apply at …**
Annual mean	NO_2	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live their as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
1 hour mean	NO_2	All locations where the annual mean and 24 and 8-hour mean objectives apply. 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.	Kerbside sites where the public would not be expected to have regular access.

1.4 Overview of the approach taken

The general approach taken to this Detailed Assessment was to:

- Collect and interpret data from previous review and assessment reports;
- Collect and analyse all available traffic data, air quality monitoring data and background concentration data for use in the models;

- Identify potential locations where it is likely that the air quality objectives would not be met;
- Model NO_2 and PM_{10} concentrations surrounding these locations;
- Produce contour plots of the modelled pollutant concentrations;
- Recommend whether West Lothian Council should declare an Air Quality Management Area (AQMA) along part of East Main Street, Broxburn; and
- Estimate the population exposure resulting from exceedance of the relevant AQS objectives.

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

The report will focus on the NO_2 annual mean objective as none of the monitoring results recorded in Broxburn have exceeded the 60 µg/m^3 level.

Additionally, LAQM TG(09) notes that "it is not straightforward to either measure or predict exceedences of the 1-hour objective for NO_2. By its nature, exceedences of the 1-hour objective will be highly variable from year to year, and from site to site. If monitoring is to be relied upon, then this must be carried out for an extended period, and often a full calendar year, to ensure that the occurrence of occasional peaks is adequately captured. Dispersion models are inevitably poorer at predicting short-term peaks than they are at predicting annual mean concentrations, and the process of model verification can be challenging.

Previous research carried out on behalf of Defra and the Devolved Administrations identified a relationship between the annual mean and the 1-hour mean objective, such that exceedances of the latter were considered unlikely where the annual mean was below 60 µg/m^3. The report identified the need to re-evaluate the monitoring data from time to time in order to confirm that this relationship remained appropriate."

1.5 Conclusions of previous reports

The most recent 2010 Progress Report concluded that "monitoring data from the station located at East Main Street Broxburn exceeds the 2010 annual Air Quality Objective for PM_{10}". Additionally, monitoring carried out in 2010 shows that the NO_2 annual mean objective was also exceeded at this location, and at diffusion tube locations in Broxburn. As such, this Detailed Assessment will aim to define the extent of both NO_2 and PM_{10} exceedances.

Relevant exposure is present along this stretch of road, and as such the Scottish Government requested that a Detailed Assessment be carried out for PM_{10} and NO_2 at this location to assess whether the AQMA should be extended in the area of East Main Street, Broxburn.

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

2 Information used to support this assessment

2.1 Maps

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

2.2 Road traffic data

2.2.1 Average flow, speed and fleet split

Annual average daily traffic (AADT) flow data and percentage of cars, light goods vehicles, buses and heavy goods vehicles were derived from a traffic count study carried out on East Main Street and Greendykes Road. Expansion factors were used to scale turning count data from 2hr study sets to 24hr AADT flows. The approach with regards to collection of traffic data was agreed with West Lothian Council prior to commencing the study.

In addition West Lothian Council provided estimates of speed along particular roads within the study area. Appendix 3 summarises the traffic data used.

2.2.2 Emissions factors

The most recent version of the Emissions Factors Toolkit[2] (EfT V4.1) was used in this assessment and the factors derived were used in the ADMS-Roads 2.3 model in preference to the dated emission factors in the model. Parameters such as traffic volume, speed and fleet composition are entered into the EfT, and an emissions factor in grams of NOx(and PM_{10})/second/kilometre is generated for input into the dispersion model. The version of the EfT used incorporates the latest emission factors published in 2009 by Department for Transport.

2.3 Ambient monitoring

2.3.1 NO_2 and PM_{10}

NO_2 and PM_{10} concentrations are monitored by an automatic monitor located at the intersection between Greendykes Road and East Main Street, Broxburn. Additional monitoring was also carried out for a seven month period (June – December) using diffusion tubes at locations throughout Broxburn. Details of the type, locations, and concentrations recorded by the diffusion tubes used in this assessment are provided in Section 3.

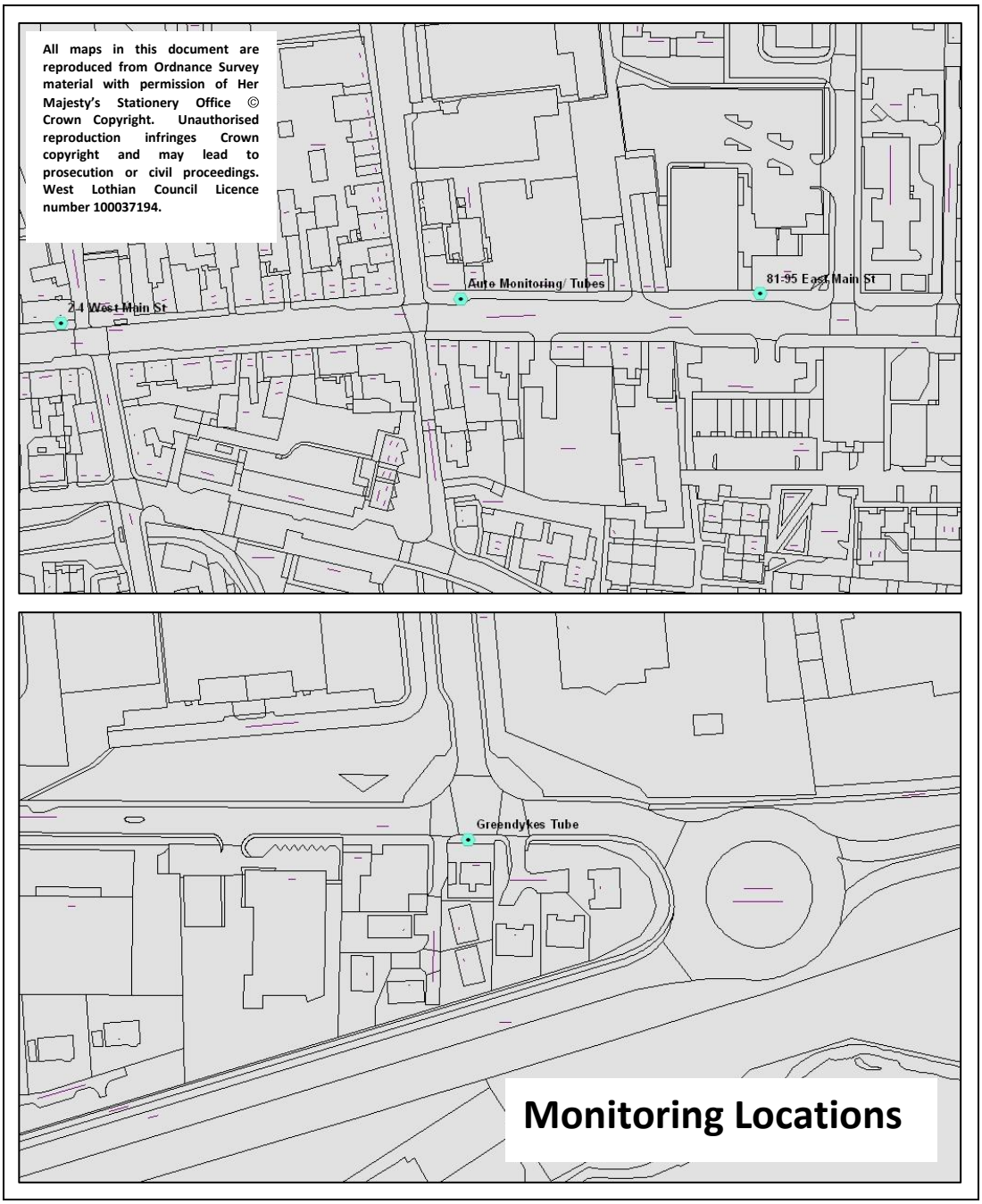
[2] http://laqm1.defra.gov.uk/documents/tools/EFT_Version_4_2.zip

3 Monitoring

3.1 Locations

All monitoring locations in Broxburn are shown in Figure 3-1 below.

Figure 3-1 Monitoring Locations in Broxburn, West Lothian



3.2 NO_2

West Lothian Council currently monitors NO_2 across the authority using passive diffusion tubes, and NO_2 using a continuous analyser on East Main Street, Broxburn. All NO_2 monitoring data used in this assessment is shown in Table 4-1 below.

The automatic monitoring data used in the assessment spans the period 01 January to 31 December 2010.

Diffusion tube monitoring used in this assessment spans the period June to December 2010. As the diffusion tube data collected covers a period of less than 12 months the data has been annualised following the methodology shown in Box 3.2 of LAQM.TG(09) in order to estimate annual mean concentrations from the short term diffusion tube monitoring study.

However, before period mean adjustment calculations were applied to the diffusion tube data all diffusion tube monitoring data was bias corrected.

The locally calculated factor from the collocation study in Broxburn suggested a local bias adjustment factor of **0.94** be applied to all diffusion tube data. The national study of bias adjustment factors spreadsheet had not been updated with 2010 studies and as such no national bias adjustment factor was available. A copy of the both the local bias adjustment spreadsheet used is provided in Appendix 2.

Once each diffusion tube had been adjusted using the locally derived factor, a period mean adjustment factor (**1.09**) was applied to data. Calculation of the period mean adjustment factor is shown in Appendix 5.

A summary of relevant monitoring data for 2010 is presented in Table 3-1 and 3-2**.**

Table 3-1 NO_2 Automatic Monitoring Data for 2010

Site	Type	OS x,y	Data Capture (%)	Annual mean ($\mu g\ m^{-3}$)
East Main St Automatic Monitor	R	308314,672231	99.7	**46.0**
Exceedances of the annual mean objective in **bold**				
K = Kerbside, 0-1m from the kerb of a busy road R = Roadside, 1-5m from the kerb				

Table 3-2 NO_2 Diffusion Tube Monitoring Data for 2010

Site	Type	OS x,y	Data Capture (%)	Raw Mean ($\mu g\ m^{-3}$)	Bias Adj Mean ($\mu g\ m^{-3}$)	Period Adj Mean ($\mu g\ m^{-3}$)
Broxburn 2-4 West Main Street	R	308165,672222	58	33.6	31.6*	34.4**
Broxburn 81-95 East Main Street	R	308426,672233	58	33.6	31.6*	34.4**
Broxburn Unit	R	308314,672231	58	41.4	38.9*	**42.4****
Broxburn – Kilpunt Roundabout/ Dunnet Way	R	309368, 672213	58	34.2	32.2*	35.1**
Exceedances of the annual mean objective in **bold**						
K = Kerbside, 0-1m from the kerb of a busy road R = Roadside, 1-5m from the kerb *Locally derived bias adjustment of 0.94 applied. **Period Mean Adjustment of 1.09 applied						

3.2.1 QA/QC

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

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

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

The Workplace Analysis Scheme for Proficiency (WASP) is an independent analytical performance-testing scheme, operated by the Health and Safety Laboratory (HSL). WASP formed a key part of the former UK NO_2 Network's QA/QC, and remains an important QA/QC exercise for laboratories supplying diffusion tubes to Local Authorities for use in the context of Local Air Quality Management (LAQM). The laboratory participants analyse four spiked tubes, and report the results to HSL. HSL assign a performance score to each laboratory's result, based on their deviation from the known mass of nitrite in the analyte.

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

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

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

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

Edinburgh Scientific Services were awarded the GOOD performance status when assessed against both the old and new performance criteria.

3.3 PM_{10}

West Lothian Council currently monitors PM_{10} using a continuous FDMS analyser on East Main Street, Broxburn. All PM_{10} monitoring data used in this assessment is shown in Table 4-3 below.

Table 3-3 PM_{10} Automatic Monitoring Data for 2010

Site	Type	OS x,y	Data Capture (%)	Annual mean ($\mu g\ m^{-3}$)
East Main St Automatic Monitor	R	308314,672231	95.0	**21.0**
Exceedances of the annual mean objective in **bold**				
K = Kerbside, 0-1m from the kerb of a busy road R = Roadside, 1-5m from the kerb				

4 Modelling

4.1 Modelling methodology

Annual mean concentrations of NO_2 for the 2010 calendar period have been modelled within the study area using ADMS Roads (version 2.3) for the Broxburn study area. The model was verified and outputs adjusted by comparing the modelled predictions for road NO_x and road PM_{10} with local monitoring results.

Monitoring data shown in Table 3-1 and 3-2 was used to verify the Broxburn model for NO_2. Monitoring data presented in Table 3-3 was used to verify the model for PM_{10}. Further information on model verification is provided in Appendix 1.

Hourly sequential meteorological data for the period January 2010 to December 2010 for Edinburgh Airport (approx 7 km from the study area) was found to be of good quality and so was used in the model. For the Broxburn model domain a surface roughness of 1.0m was used to represent the urban conditions in each model domain. Similarly, a limit for the Monin-Obukhov length of 30 m was applied to the model.

The intelligent gridding option was used in ADMS-Roads, which provides spatially resolved concentrations along the roadside, with a wider grid spaced at approximately 20 m being used to represent concentrations further away from the road. These predictions were added to ArcGIS 10 and values between grid points are derived using interpolation in the Spatial Analyst tool. This allows contour concentrations to be estimated and added to the base map provided by West Lothian Council.

Background concentrations of NO_x, NO_2 and PM_{10} were derived from the recently updated Defra maps[3]. A CSV file containing concentrations across the Broxburn region was obtained and the appropriate grid square was selected with the appropriate concentrations for the assessment.

A mapped NO_x background concentration of 18.1 $\mu g.m^{-3}$ was used for the assessment of Broxburn. The mapped NO_2 background concentration was 12.4 $\mu g.m^{-3}$, and PM_{10} background concentration was 14.8 $\mu g.m^{-3}$.

4.1.1 Treatment of modelled NO_x road contribution

It was necessary to convert the modelled NO_x concentrations to NO_2 for comparison with the relevant objectives. The recently published Defra NO_x/NO_2 model[4] was used to calculate NO_2 concentrations from the NO_x concentrations predicted by ADMS-Roads. The model requires input of the background NO_x, the modelled road contribution and the proportion of NO_x released as primary NO_2. For the purposes of this assessment we have assumed that 19% of NO_x is released as primary NO_2- the value associated with the "UK Traffic" option in the model. Additionally, the NO_x/NO_2 model has also been used to convert the monitored NO_2 back to NO_x to allow comparison of modelled and monitored NO_x.

4.1.2 Validation of ADMS-Roads

In simple terms, validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications.

Cambridge Environmental Research Consultants (CERC) have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK

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

M4 and M25 motorway field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and DEFRA.

4.1.3 Verification of the model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. LAQM.TG(09) recommends making the adjustment to the road contribution only and not the background concentration these are superimposed onto. The approach outlined in Example 2 of LAQM.TG(09) has been used, and a correction factor was calculated which was applied to all modelled data.

The model generated in this study was verified using all available monitoring sites in the study area. The comparison of monitored against modelled NO_x revealed that the model under-predicted the Road NO_x component when compared with the local measurements.

The Broxburn modelled Road NO_x contribution required adjustment by an average factor of 1.394 to bring the predicted NO_2 concentrations within good agreement of those results obtained from the monitoring data. This factor was applied to all Road NO_x concentrations predicted by the Broxburn ADMS Roads model, with the final NO_2 model predictions being calculated using the Defra NO_x/NO_2 model. A secondary adjustment figure of 1.0054 was then applied.

Adjusting modelling data to diffusion tubes will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The adjusted model for Broxburn agrees well with available local monitoring and has therefore been assessed to perform sufficiently well for use within this Detailed Assessment.

In the case of PM_{10} the model was corrected using a correction factor of 2.0667, which was based on a comparison of the monitored road contribution of PM_{10} and the modelled road contribution of PM_{10} at the automatic monitor site.

Further discussion on the calculation of verification factors is provided in Appendix 1. Additional information on the methodology of model verification for both NO_x and PM_{10} models is provided in LAQM TG(09) Annex 3.

4.2 Modelling Results- NO_2

Numerical

Table 4-1 below shows the predicted modelled concentrations at each of the monitoring points in the model domain and compares the modelled concentration against the monitored results at each location.

The report will focus on the NO_2 annual mean objective as none of the monitoring results recorded in the study area exceeded the 60 µg/m^3 level.

The modelled NO_2 concentrations at various residential receptors within the study area have been estimated to exceed the NO_2 annual mean objective of 40 µg m^{-3} for the 2010 calendar year. As such West Lothian Council should declare an AQMA for a suitable area in Broxburn.

Table 4-1 Modelled/measured NO_2 concentrations in model domain after adjustment

Site	NO_2 Concentration (µg m^{-3})		Difference (%)
	Adjusted Modelled NO_2 PrimaryADJ – 1.394 Secondary ADJ – 1.0054	Measured	
Auto Site	**44.9**	**46.0**	-2
Co-located Tubes	**44.9**	**42.4**	6
2-4 West Main St	36.6	34.4	6
81-95 West Main	29.9	34.4	-13
Kilpunt Roundabout	34.8	35.1	-1
Exceedences of the annual mean objective in **bold**			

Figure 4-1 Monitored Vs Modelled Concentrations – Broxburn, West Lothian

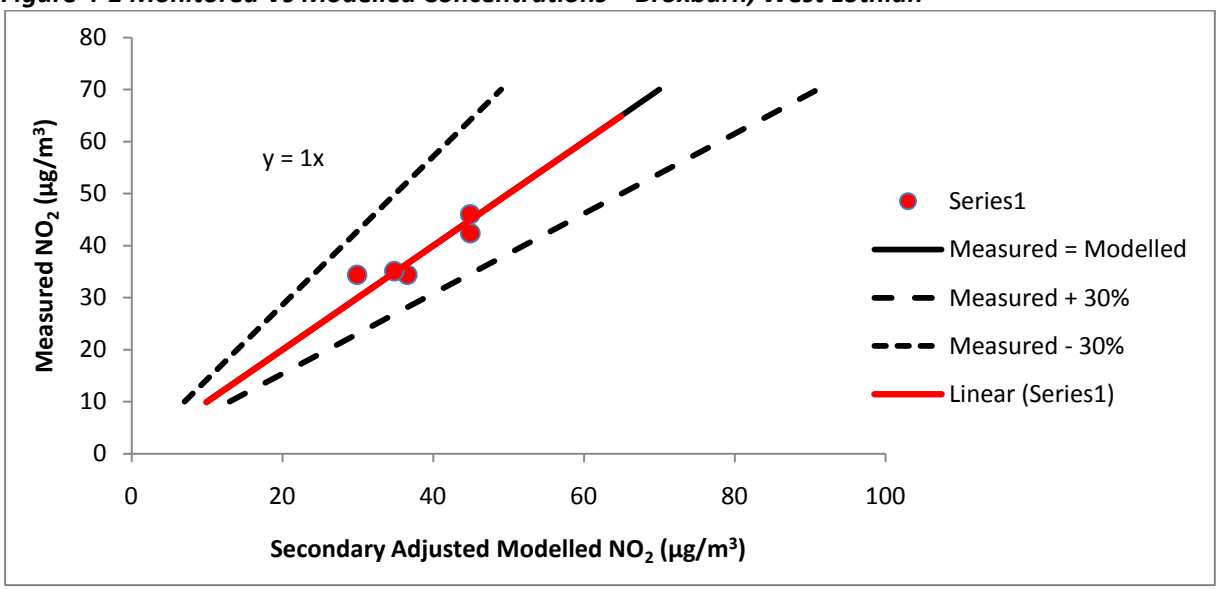


Figure 4-2 Receptor Locations- Broxburn, West Lothian

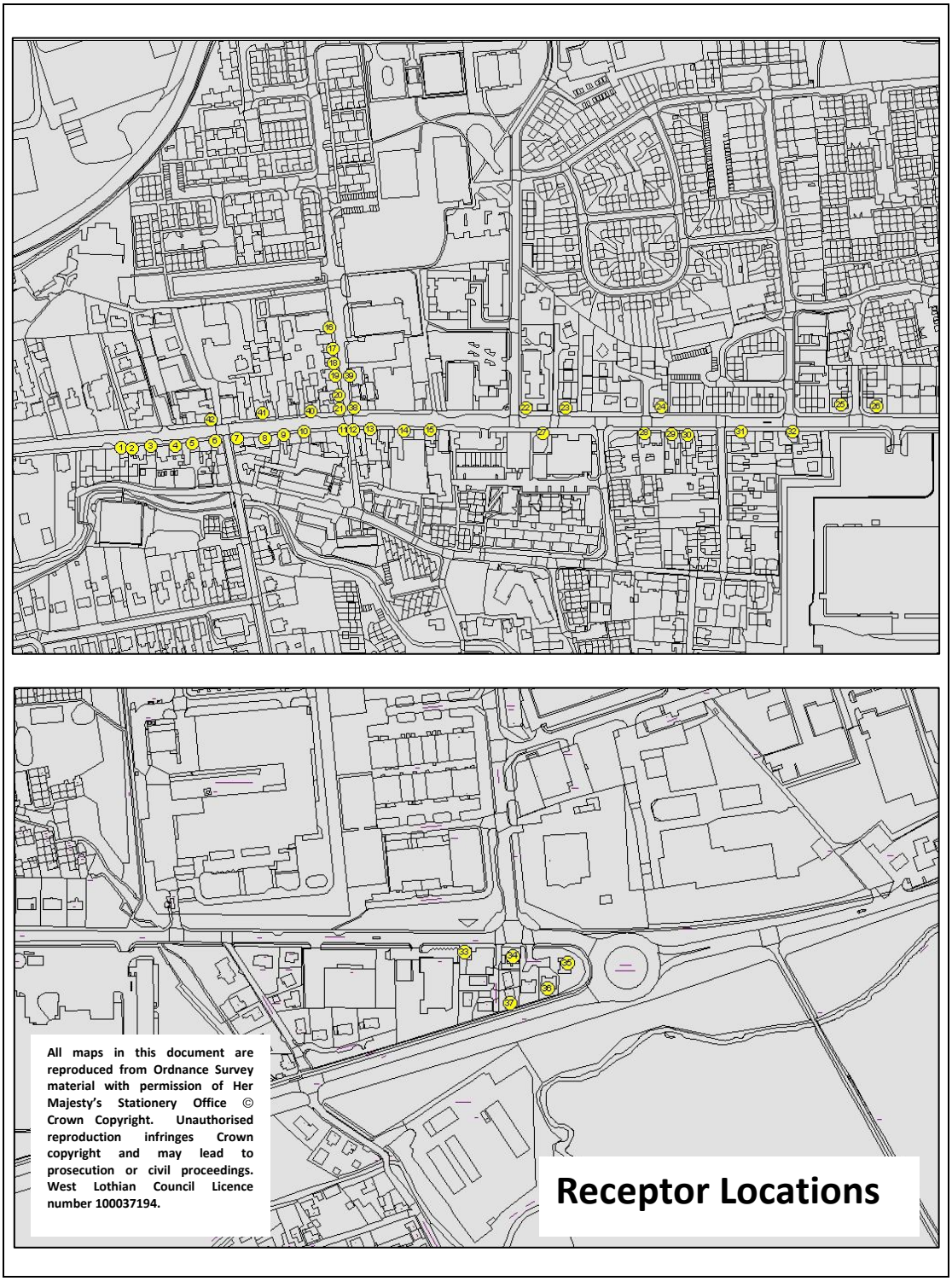


Table 4-2 Modelled NO_2 concentrations at specified receptors in Broxburn

Site	OS x,y	Adjusted Modelled NO_2 Concentration ($\mu g\ m^{-3}$) PrimaryADJ – 1.394 Secondary ADJ – 1.0054
R1	308079,672198	26.5
R2	308089,672197	25.0
R3	308107,672199	25.9
R4	308131,672199	24.9
R5	308147,672202	26.6
R6	308169,672204	28.1
R7	308190,672207	32.0
R8	308217,672207	29.2
R9	308235,672210	31.9
R10	308255,672213	39.8
R11	308293,672215	**42.7**
R12	308302,672215	**47.2**
R13	308318,672216	**45.3**
R14	308351,672214	33.8
R15	308376,672215	37.3
R16	308279,672313	20.4
R17	308282,672293	21.8
R18	308283,672279	22.5
R19	308285,672267	24.3
R20	308288,672248	29.9
R21	308289,672235	37.7
R22	308468,672236	22.9
R23	308506,672236	21.2
R24	308598,672237	19.7
R25	308771,672239	18.7
R26	308805,672238	18.5
R27	308484,672212	21.5
R28	308582,672212	20.5
R29	308608,672211	19.9
R30	308624,672210	19.5
R31	308675,672213	21.0
R32	308725,672213	21.0
R33	309326,672207	25.0
R34	309371,672203	28.0
R35	309422,672197	36.3
R36	309403,672173	31.3
R37	309368,672159	28.0
R38	308303,672236	**43.8**
R39	308299,672267	32.5
R40	308261,672233	**44.2**
R41	308215,672231	31.5
R42	308165,672225	34.0
Exceedences of the annual mean objective in **bold**		

Contour plots

Figures 4-3 and 4-4 show scaled contour plots of the estimated NO_2 annual average concentrations during 2010 within the study area. As shown, it has been confirmed by the monitoring and subsequent modelling that the NO_2 40 μg m^{-3} annual average objective has been exceeded at locations with relevant exposure within the study area below. Table 4.2 provide details of concentrations at specific modelled receptors.

Figure 4-3 Annual mean NO_2 concentrations East Main/ Greendykes Road 2010

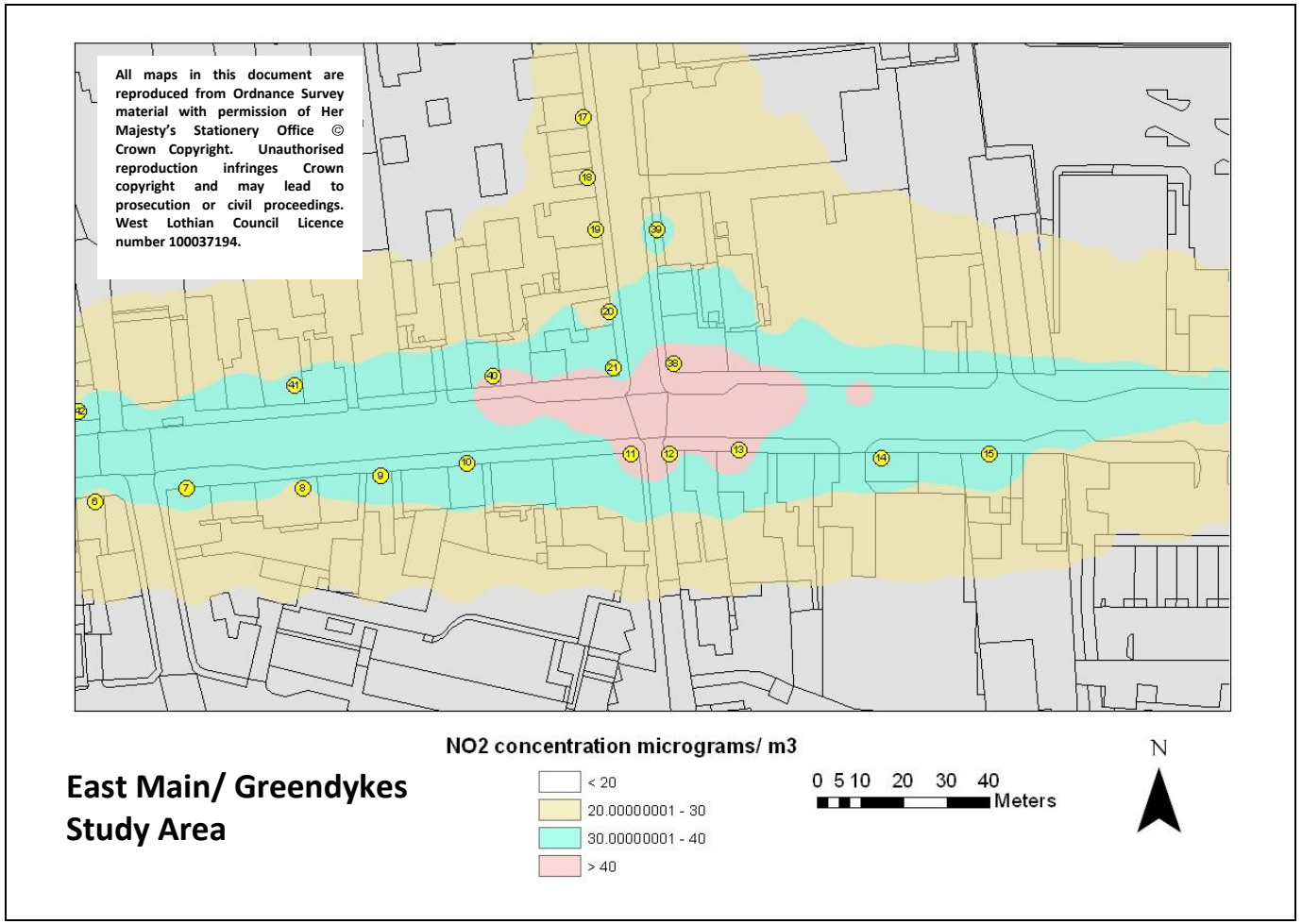
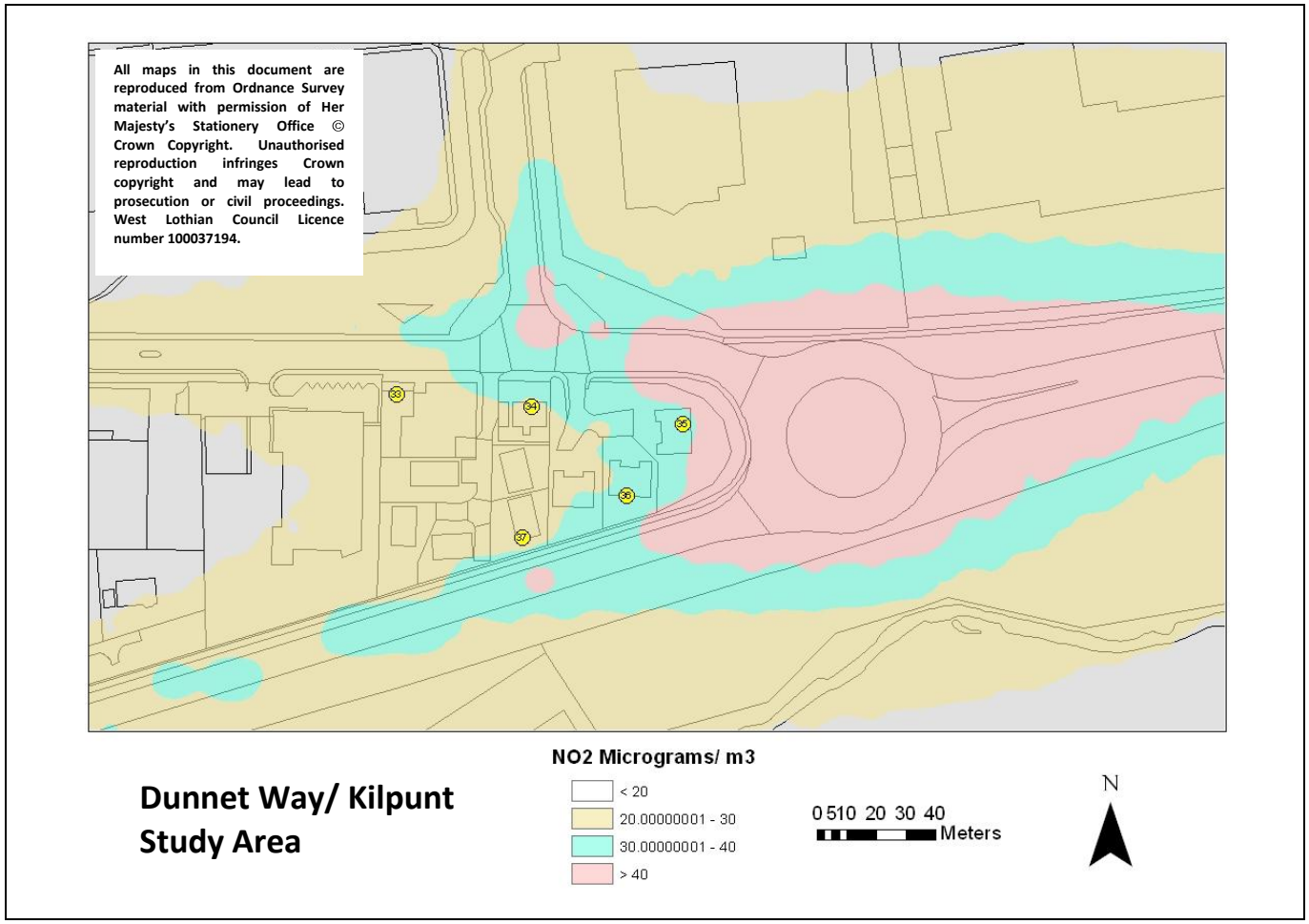


Figure 4-4 Annual mean NO_2 concentrations Dunnet Way/ Kilpunt Roundabout 2010



Figures 4-5 and 4-6 show a contour lines of the estimated NO_2 , 36, 38 and 40 µg/m^3 exceedance line concentrations during the 2010 study period within the study area.

Figure 4-5 Contour Lines(36 to 40μg m^{-3}) for East Main/ Greendykes Road 2010

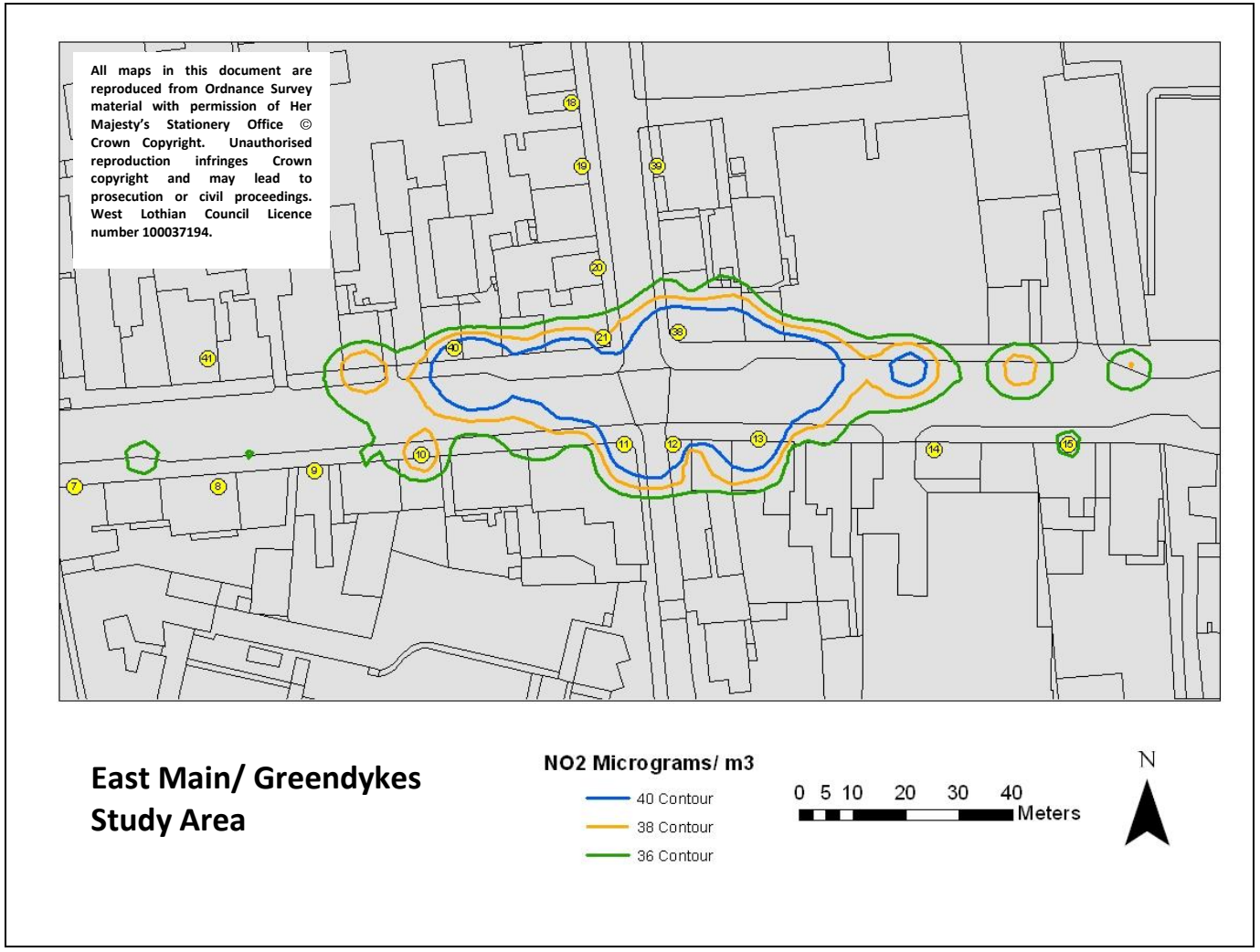
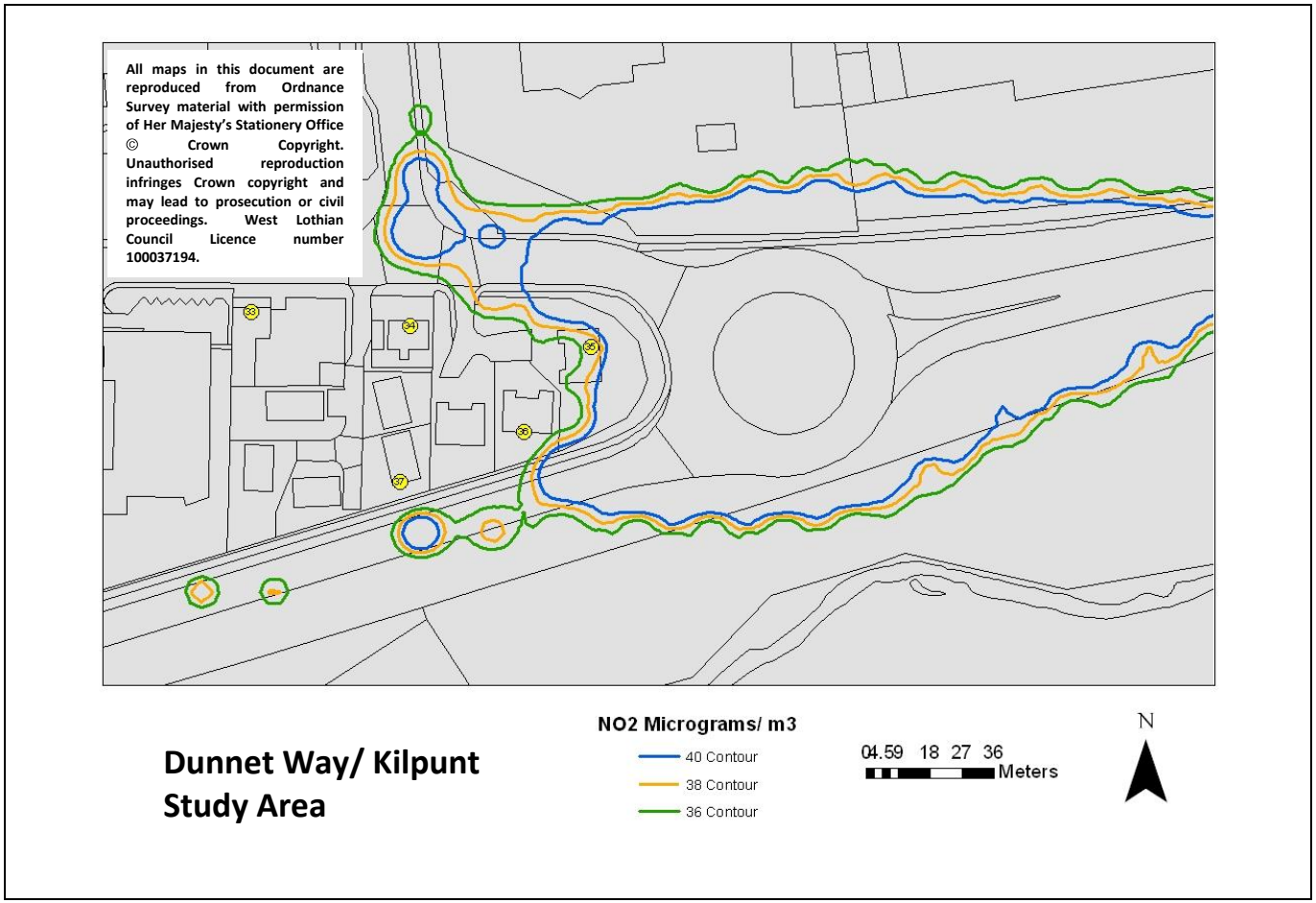


Figure 4-6 Contour Lines (36 to 40μg m^{-3}) for Dunnet Way/ Kilpunt Roundabout 2010



4.2.1 People exposed to exceedences of the annual mean NO_2 objective

Based on available information it is estimated that approximately 8 properties lie within the exceedance area, equating to an exposed population of around 20 (based on census data which suggests an average occupancy per household of 2.36 in England and Wales[5]).

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

4.3 Modelling Results – PM_{10}

Numerical

Table 4-3 below shows the predicted modelled concentrations at the single PM_{10} monitoring point in the model domain and compares the modelled concentration against the monitored results at each location.

The modelled PM_{10} concentrations at various residential receptors within the study area have been estimated to exceed the PM_{10} annual mean objective of 18 μg m^{-3} for the 2010 calendar year. As such West Lothian Council should declare an AQMA for a suitable area in Broxburn.

Table 4-3 Modelled/measured PM_{10} concentrations in model domain after adjustment

Site	PM_{10} Concentration (μg m^{-3})		Difference (%)
	Adjusted Modelled NO_2 Adj Factor – 2.0667	Measured	
Auto Site	**21**	**21**	0
Exceedences of the annual mean objective in **bold**			

Figure 4-7 Monitored Vs Modelled Concentrations – Broxburn, West Lothian

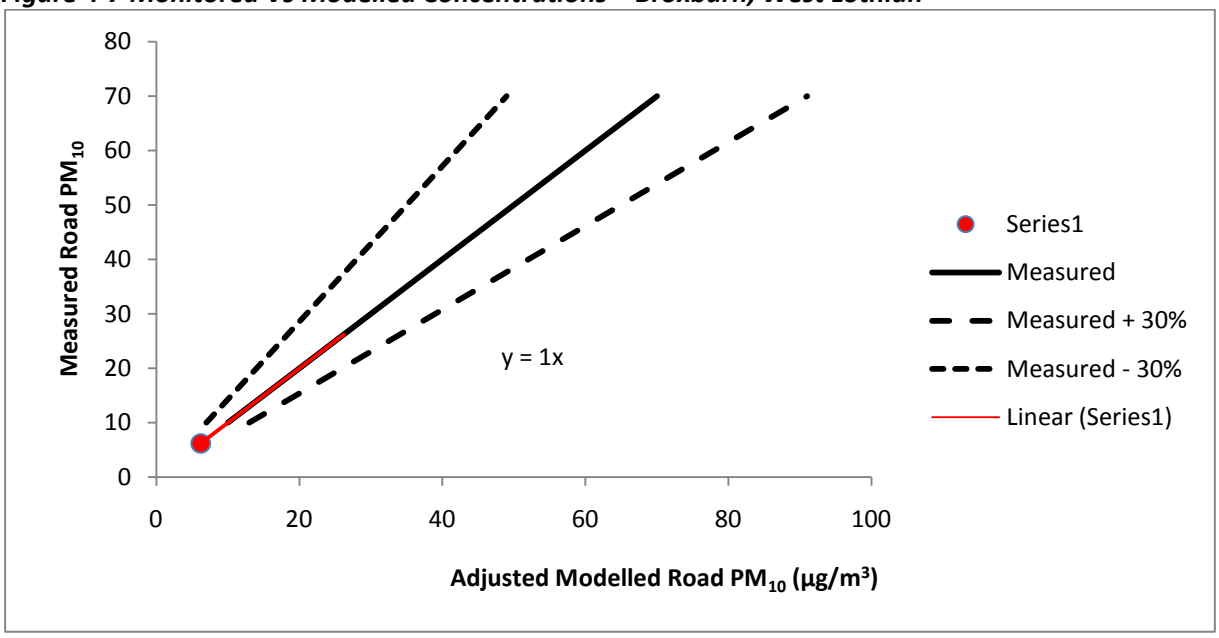


Table 4-4 Modelled PM_{10} concentrations at specified receptors in Broxburn

Site	OS x,y	Adjusted Modelled PM_{10} Concentration ($\mu g\ m^{-3}$) Adj Factor – 2.0667
R1	308079,672198	17.8
R2	308089,672197	17.5
R3	308107,672199	17.6
R4	308131,672199	17.4
R5	308147,672202	17.7
R6	308169,672204	**18.1**
R7	308190,672207	**18.8**
R8	308217,672207	**18.1**
R9	308235,672210	**18.7**
R10	308255,672213	**20.5**
R11	308293,672215	**20.9**
R12	308302,672215	**21.8**
R13	308318,672216	**21.2**
R14	308351,672214	**18.8**
R15	308376,672215	**19.8**
R16	308279,672313	16.3
R17	308282,672293	16.6
R18	308283,672279	16.7
R19	308285,672267	17.0
R20	308288,672248	18.0
R21	308289,672235	**19.6**
R22	308468,672236	17.0
R23	308506,672236	16.8
R24	308598,672237	16.5
R25	308771,672239	16.3
R26	308805,672238	16.3
R27	308484,672212	16.9
R28	308582,672212	16.7
R29	308608,672211	16.6
R30	308624,672210	16.5
R31	308675,672213	16.9
R32	308725,672213	16.9
R33	309326,672207	17.6
R34	309371,672203	**18.1**
R35	309422,672197	**20.0**
R36	309403,672173	**19.0**
R37	309368,672159	**18.3**
R38	308303,672236	**20.9**
R39	308299,672267	**18.7**
R40	308261,672233	**21.2**
R41	308215,672231	**18.6**
R42	308165,672225	**19.3**
Exceedences of the annual mean objective in **bold**		

Contour plots

Figures 4-8 and 4-9 show scaled contour plots of the estimated PM_{10} annual average concentrations during 2010 within the study area. As shown, it has been confirmed by the monitoring and subsequent modelling that the PM_{10} 18 μg m^{-3} annual average objective has been exceeded at locations with relevant exposure within the study area below. Table 4.4 provide details of concentrations at specific modelled receptors.

Figure 4-8 Annual mean PM_{10} concentrations East Main/ Greendykes Road 2010

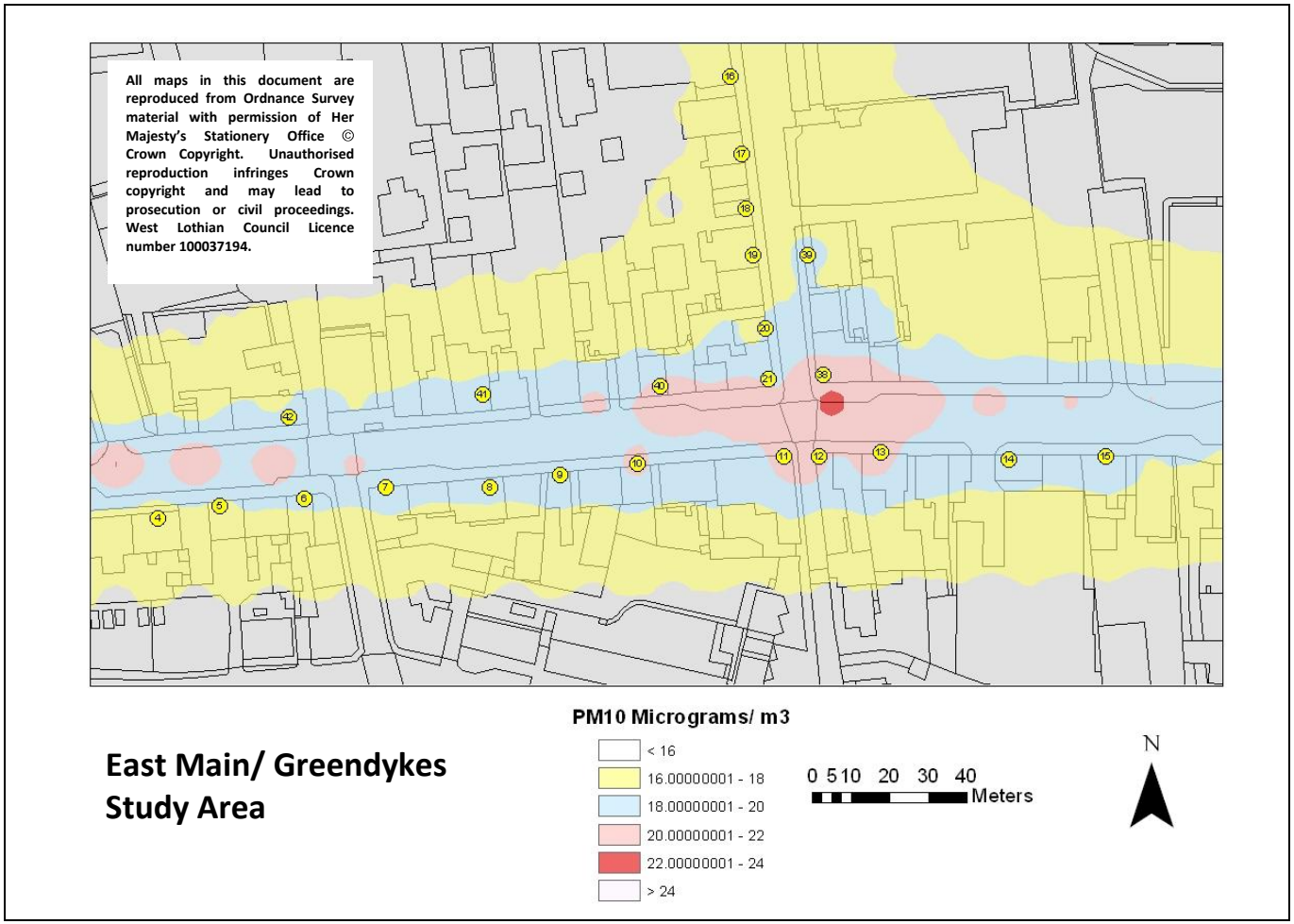


Figure 4-9 Annual mean PM_{10} concentrations Dunnet Way/ Kilpunt Roundabout 2010

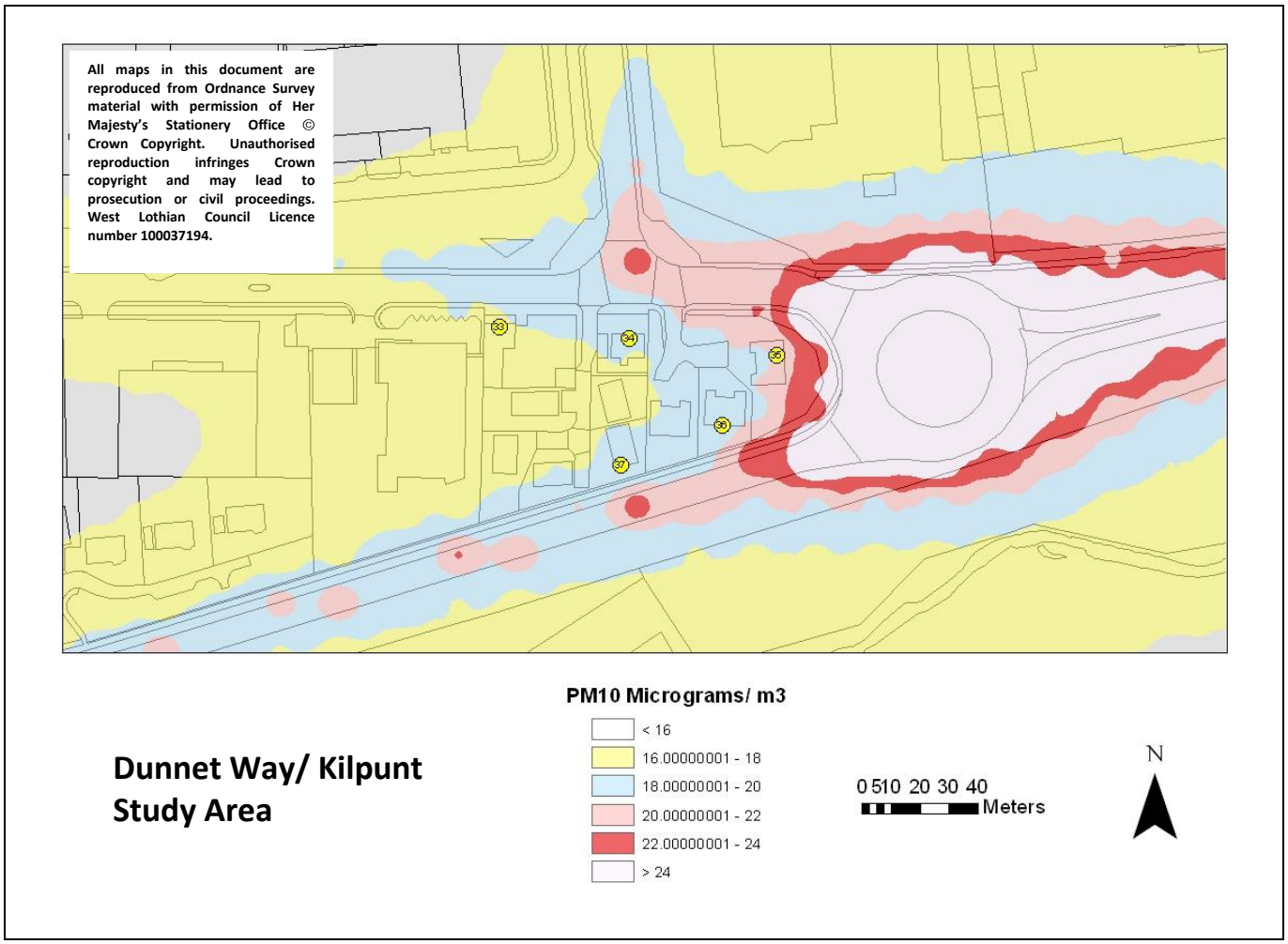


Figure 4-10 Contour Lines(16 to 18 $\mu g\ m^{-3}$) for East Main/ Greendykes Road 2010

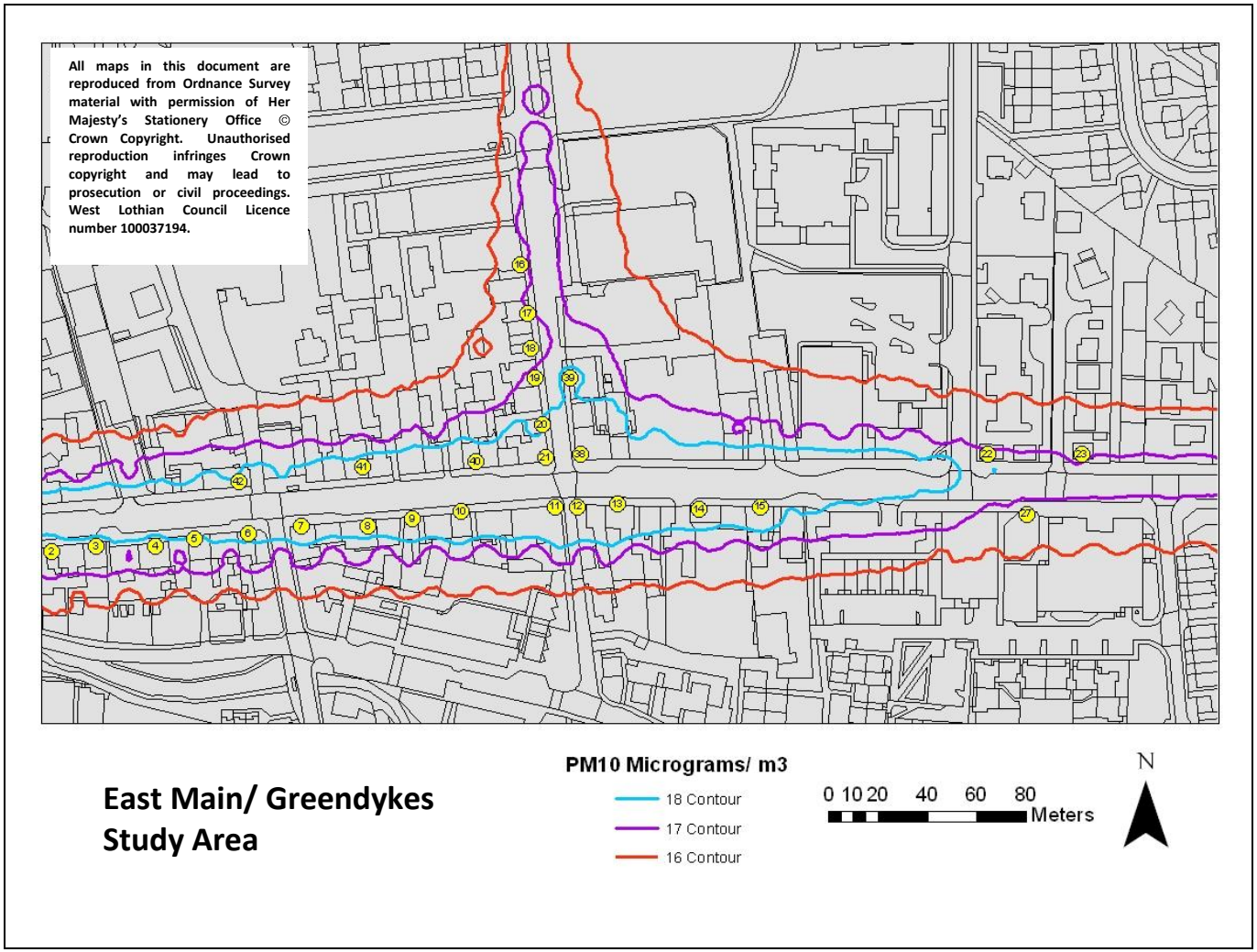
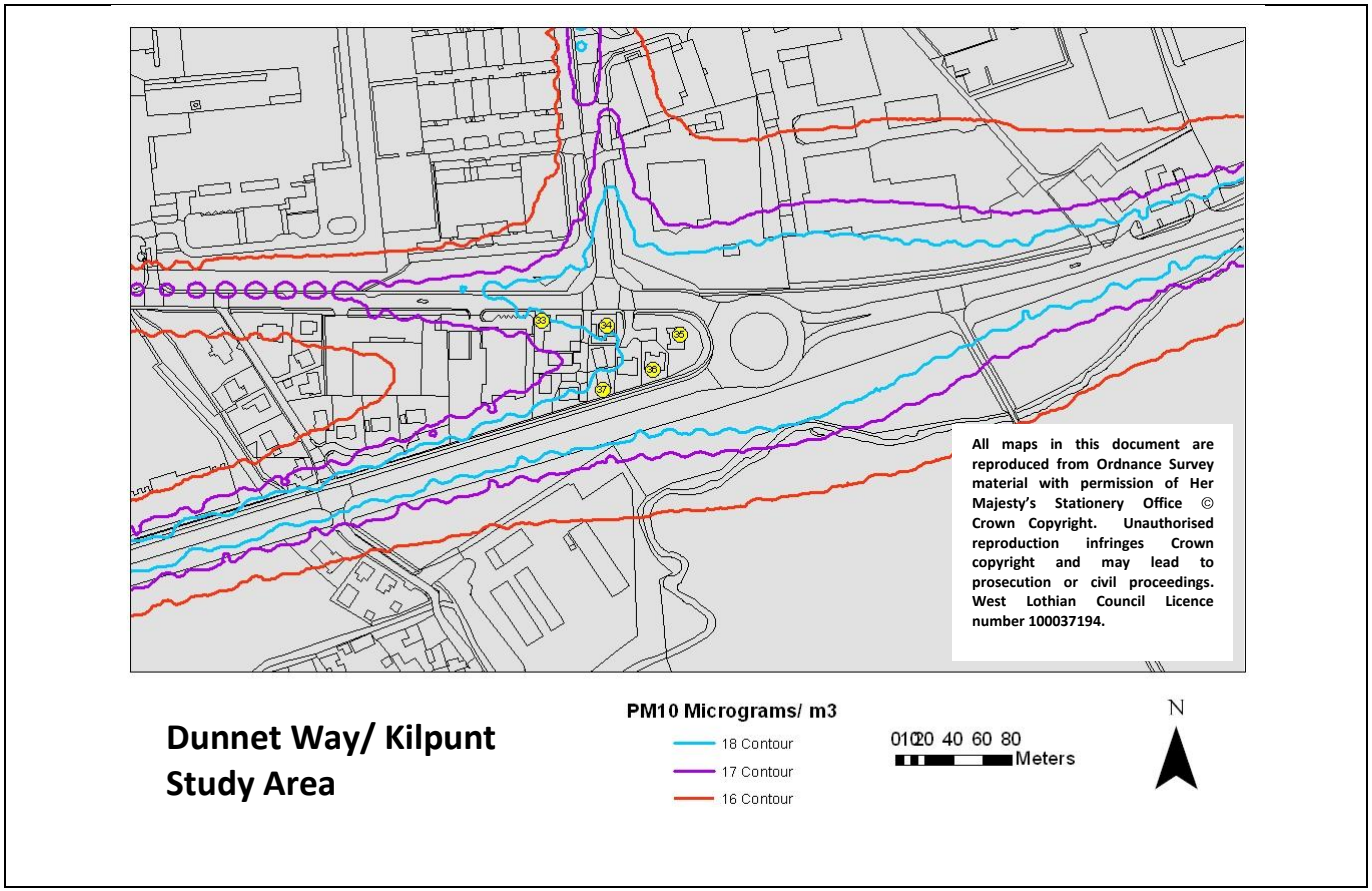


Figure 4-11 Contour Lines(16 to 18 $\mu g\ m^{-3}$) for Dunnet Way/ Kilpunt Roundabout 2010



4.3.1 People exposed to exceedences of the annual mean PM_{10} objective

Based on available information it is estimated that approximately 43 properties lie within the exceedance area, equating to an exposed population of around 102 (based on census data which suggests an average occupancy per household of 2.36 in England and Wales[6]).

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

5 Summary and Conclusion

In this Detailed Assessment concentrations of NO_2 and PM_{10} have been assessed in and around the Broxburn, West Lothian for the period 01 January 2010 to 31 December 2010. A combination of available monitoring data and a dispersion modelling techniques using ADMS-Roads were used throughout the study. The study took account of traffic conditions in each area and meteorological data available for the specified study period.

The study has confirmed the findings of the previous Progress Report for West Lothian, namely that there are exceedences of the annual mean PM_{10} and NO_2 objective at locations where relevant exposure exists.

Within the study area it is estimated that approximately 8 properties lie within the area of NO_2 exceedance equating to an exposed population of 20.

Additionally, it is estimated that approximately 43 properties lie within the area of PM_{10} exceedance equating to an exposed population of 102.

The modelled NO_2 concentrations at various residential receptors within the study area were estimated to exceed the NO_2 annual mean objective of 40 $\mu g\ m^{-3}$ for the 2010 calendar year. As such West Lothian Council should declare an AQMA which, as a minimum, should encompasses these properties. To reflect unavoidable uncertainty in the model predictions it may be prudent to declare a wider area.

The modelled PM_{10} concentrations at various residential receptors within the study area were estimated to exceed the PM_{10} annual mean objective of 18 $\mu g\ m^{-3}$ for the 2010 calendar year. Similarly, West Lothian Council should declare an AQMA which, as a minimum, should encompasses these properties. To reflect unavoidable uncertainty in the model predictions it may be prudent to declare a wider area.

This assessment confirms that West Lothian Council should declare an AQMA for exceedances of both the NO_2 and PM_{10} annual mean objective in Broxburn. When the AQMA(s) have been declared, the Council should proceed to a Further Assessment of air quality following the prescribed timescales.

6 Acknowledgements

AEA are grateful for the support received by Brian Carmichael and colleagues of West Lothian Council in completing this assessment.

Appendices

Appendix 1: NO_2 and PM_{10} Model Verification

Appendix 2: Bias Correction Data

Appendix 3: Traffic Data

Appendix 4: Wind Rose

Appendix 5: Period Mean Adjustment Explanation

Appendix 1 – Model Verification

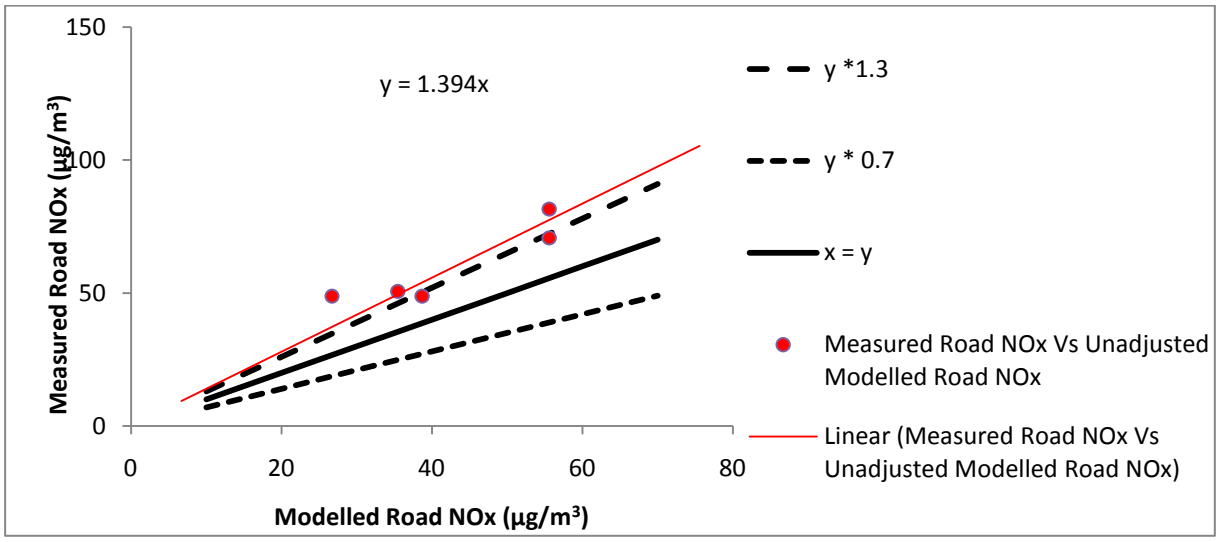
It is appropriate to verify the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides (NO_x = NO + NO_2). The model has been run to predict annual mean RoadNO_x concentrations during the 2010 calendar year at the diffusion tube sites facing onto the East Main Street, Broxburn.

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

An adjustment factor was determined as the slope of the best fit line between the model derived RoadNO_x contribution and the measured RoadNO_x contribution, and forced through the origin, as shown in Figure A.1. This factor was then applied to the modelled RoadNO_x concentration for each modelled point to provide adjusted modelled RoadNO_x concentrations. The appropriate background concentration was added to these concentrations in order to determine the adjusted total modelled NO_x concentrations. The total annual mean concentrations were then determined using the NO_x/NO_2 model.

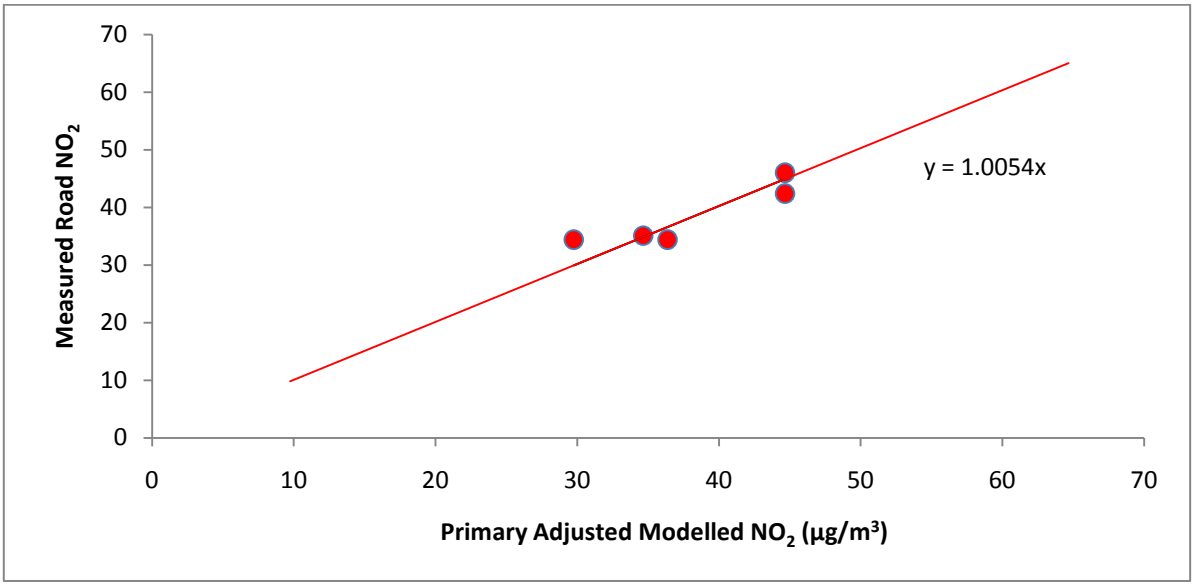
A primary adjustment factor (PAdj)of **1.394** has been applied to all modelled NO_x data.

Figure A.1 Comparison of unadjusted modelled RoadNO_x Vs Measured RoadNO_x and primary adjustment factor (1.394)



A secondary adjustment factor (SAdj)of **1.0054** has been applied to all modelled NO_2 data. The secondary correction factor accounts for error introduced by converting NO_x to NO_2 using the DEFRA NO_x/NO_2 tool.

Figure A.2 Comparison of primary adjusted modelled NO_2 Vs measured NO_2 and secondary adjustment factor (1.0054)



The results show that the model is over predicting the RoadNO_x contribution. This is a typical experience with this and other models, and probably arises from deriving predictions for a complex situation using simple metrics as model inputs.

Figure A.3 Comparison of secondary adjusted modelled NO_2 Vs measured NO_2

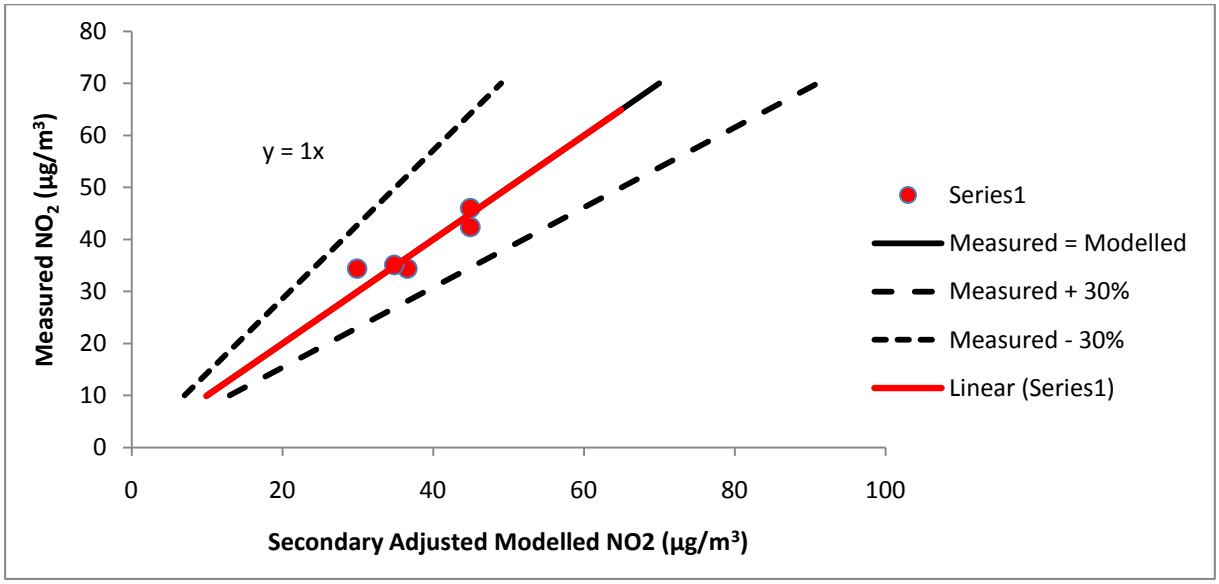


Figure A.3 compares final adjusted modelled total NO_2 at the monitoring locations, to measured NO_2, and shows a 1:1 relationship.

Similarly for PM10 it is appropriate to verify the modelled concentrations with those concentrations measured during the study period. PM_{10} is only measured at one location in Broxburn therefore the correction factor will be different than that of NOx/NO_2.

When verifying the PM_{10} results the background PM_{10} concentration is subtracted from the measured PM_{10} concentration to give the road contribution PM10. The monitored road PM_{10} is compared with the modelled road PM10 and a correction factor is established.

In this case the model under predicted the amount of PM10 by a factor of **2.0667**.

Figure A.4 Comparison of unadjusted modelled RoadPM_{10} Vs Measured RoadPM_{10} and primary adjustment factor (2.0667)

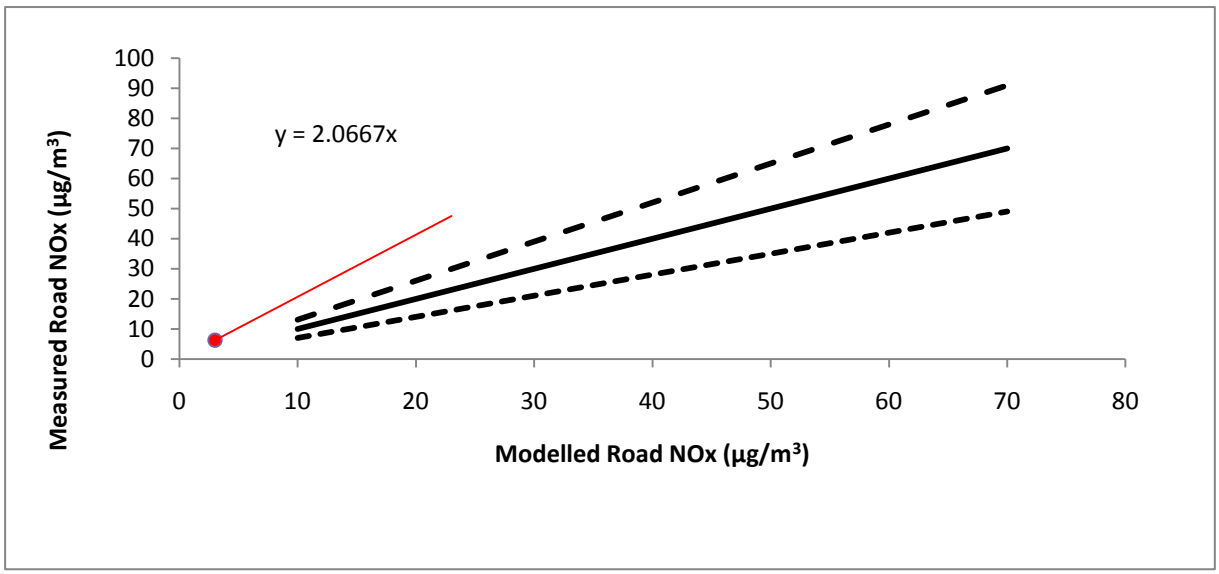
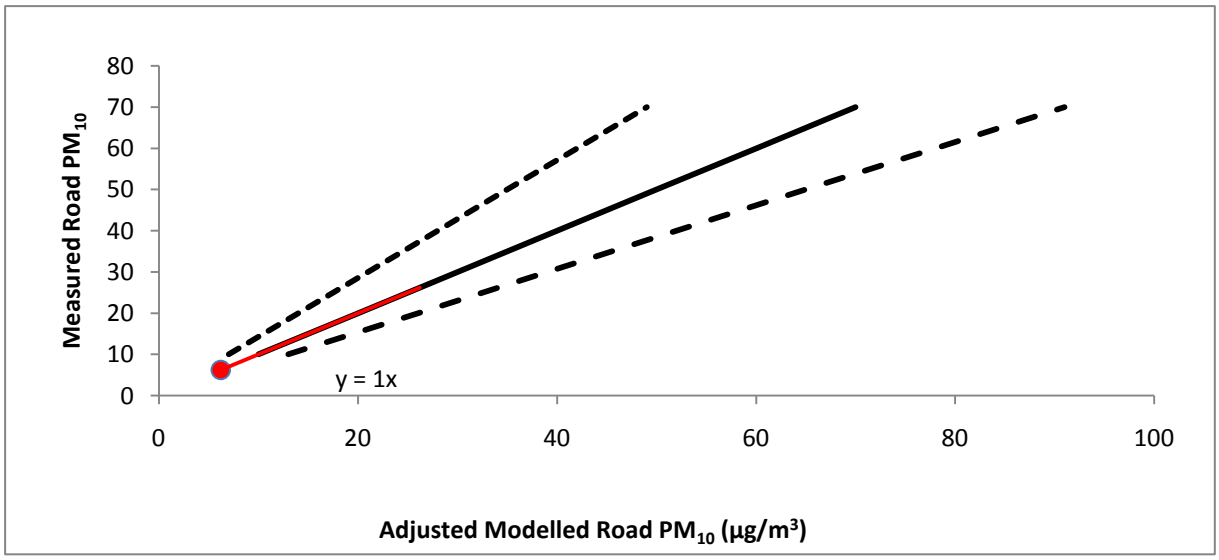
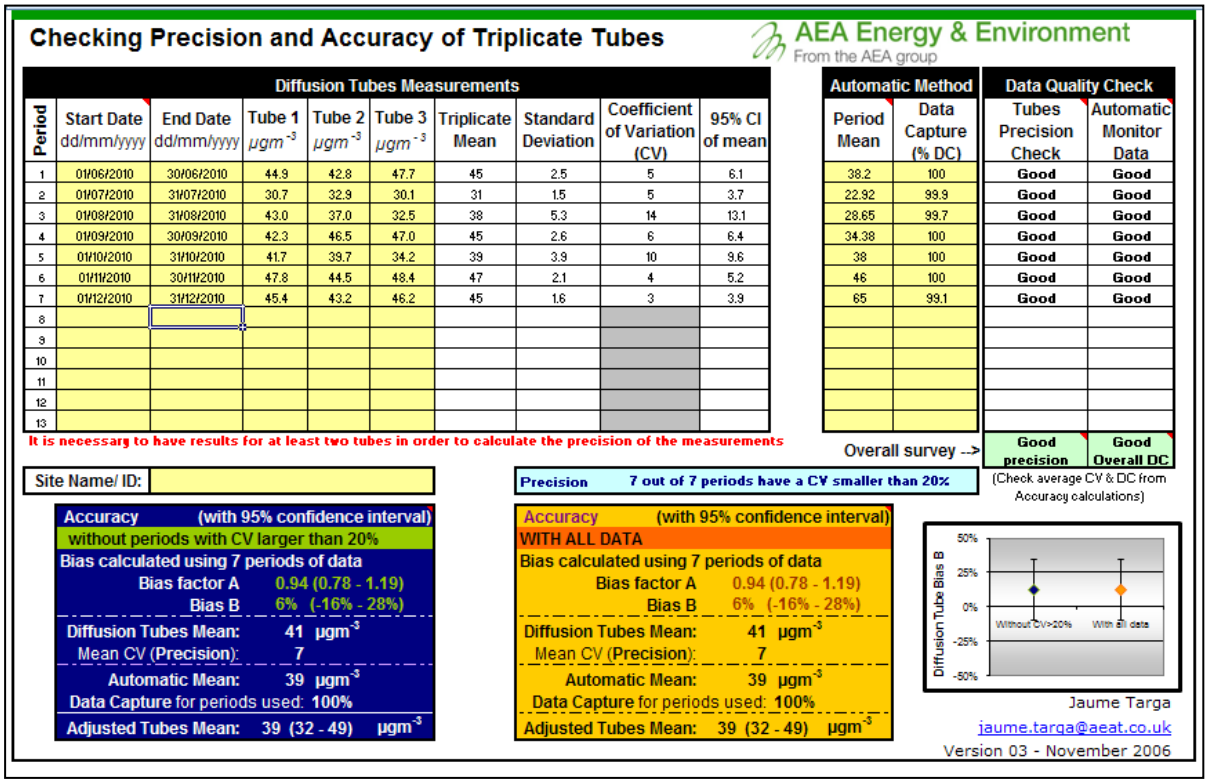


Figure A.5 Comparison of Adjusted Modelled PM_{10} Vs Measured PM_{10}



Appendix 2 – Bias Correction Data

Local Bias Correction Factor



Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements

Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean
1	01/06/2010	30/06/2010	44.9	42.8	47.7	45	2.5	5	6.1
2	01/07/2010	31/07/2010	30.7	32.9	30.1	31	1.5	5	3.7
3	01/08/2010	31/08/2010	43.0	37.0	32.5	38	5.3	14	13.1
4	01/09/2010	30/09/2010	42.3	46.5	47.0	45	2.6	6	6.4
5	01/10/2010	31/10/2010	41.7	39.7	34.2	39	3.9	10	9.6
6	01/11/2010	30/11/2010	47.8	44.5	48.4	47	2.1	4	5.2
7	01/12/2010	31/12/2010	45.4	43.2	46.2	45	1.6	3	3.9
8									
9									
10									
11									
12									
13									

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

Automatic Method		Data Quality Check	
Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
38.2	100	Good	Good
22.92	99.9	Good	Good
28.65	99.7	Good	Good
34.38	100	Good	Good
38	100	Good	Good
46	100	Good	Good
65	99.1	Good	Good
Overall survey -->		Good precision	Good Overall DC

(Check average CV & DC from Accuracy calculations)

Site Name/ ID:

Precision: 7 out of 7 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval) without periods with CV larger than 20%
Bias calculated using 7 periods of data
Bias factor A: 0.94 (0.78 - 1.19)
Bias B: 6% (-16% - 28%)
Diffusion Tubes Mean: 41 μgm^{-3}
Mean CV (Precision): 7
Automatic Mean: 39 μgm^{-3}
Data Capture for periods used: 100%
Adjusted Tubes Mean: 39 (32 - 49) μgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA
Bias calculated using 7 periods of data
Bias factor A: 0.94 (0.78 - 1.19)
Bias B: 6% (-16% - 28%)
Diffusion Tubes Mean: 41 μgm^{-3}
Mean CV (Precision): 7
Automatic Mean: 39 μgm^{-3}
Data Capture for periods used: 100%
Adjusted Tubes Mean: 39 (32 - 49) μgm^{-3}

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Version 03 - November 2006

Appendix 3 – Traffic Data

	AADT	CAR	LGV	HGV1	HGV2	BUS
West Main Street	10838	86%	10%	2%	0%	2%
Greendykes Road	5749	86%	10%	2%	0%	2%
East Main Street	10232	86%	10%	2%	0%	2%
Dunnet Way	8382	78%	13%	4%	3%	1%
A89 West of Roundabout	14747	83%	12%	3%	2%	1%
A89 East of Roundabout	20156	83%	12%	3%	2%	1%

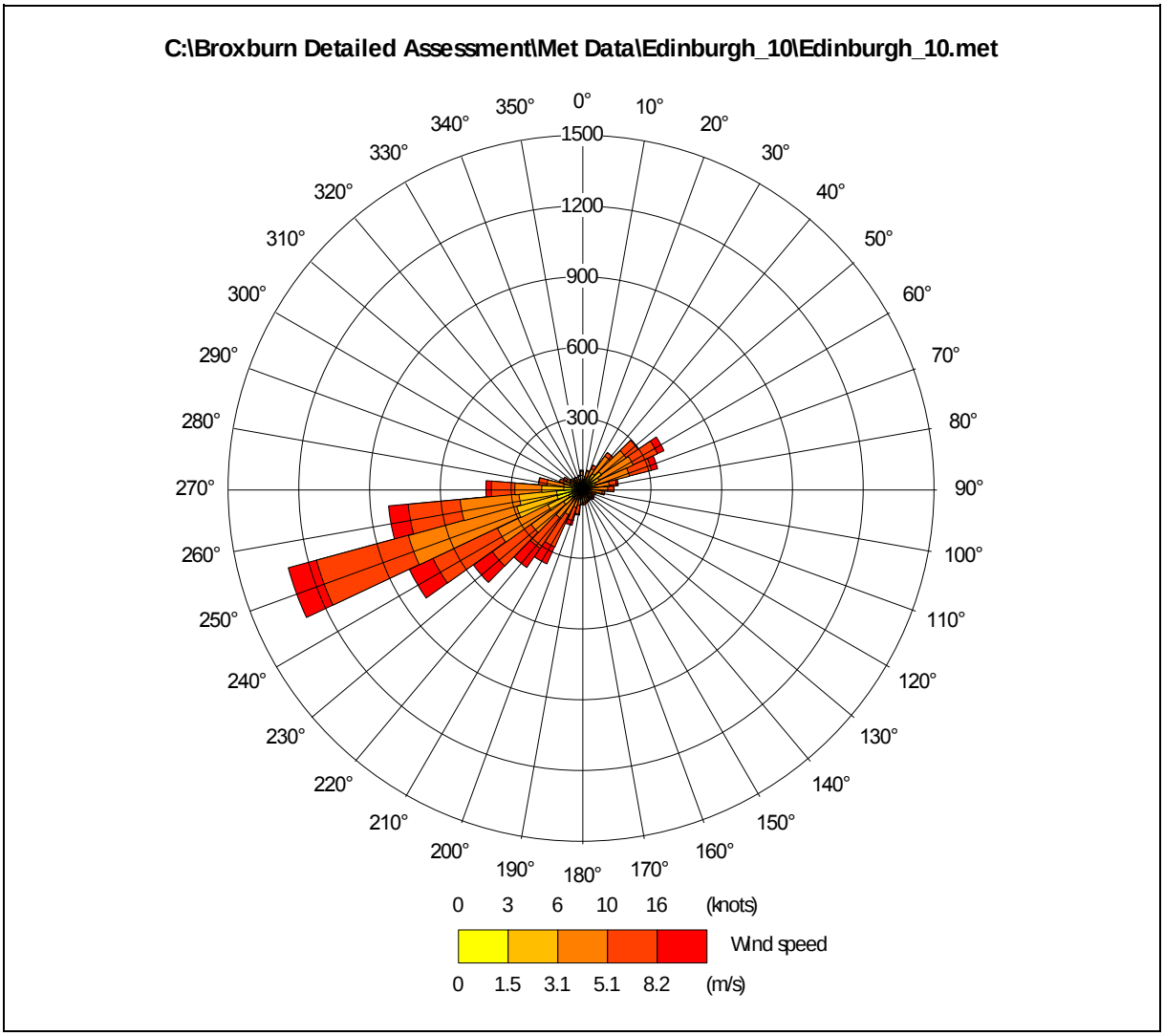
Traffic data was collected by Streetwise Services Ltd on Thursday 19th August 2010.

1600-1800 hour counts were factored up to 16hr flows by applying correction factors as per the following traffic factors as advised by traffic data supplier.

For 16hr flows an expansion factor of 5.48 was applied. To then move from 16hr flow to 24hr flow an expansion factor of 1.005 was then applied.

This approach was agreed with West Lothian Council prior to commencing the dispersion modelling.

Appendix 4 – Wind Rose



Appendix 5 – Period Mean Adjustment Factors

Where only short-term periods of monitoring data are available, the results may be adjusted to estimate an annual mean concentration using the approach set out in Box 3.2. of LAQM TG(09).

The adjustment is based on the fact that patterns in pollutant concentrations usually affect a wide region. Thus if a six month period is above average at one place it will almost certainly be above average at other locations in the region.

The adjustment procedure is as follows:

1. Identify two to four nearby, long-term, continuous monitoring sites, ideally those forming part of the national network. These should be background sites to avoid any very local effects that may occur at roadside sites, and should, wherever possible lie within a radius of about 50 miles;
2. Obtain the annual means, **Am,** for the calendar year for these sites, 2010 in this example;
3. Work out the period means, **Pm,** for the period of interest, in this case June to December 2010;
4. Calculate the ratio of the annual mean to the period mean (**Am**/**Pm**) for each of the sites;
5. Calculate the average of these ratios, **Ra.** This is then the adjustment factor; and
6. Multiply the measured period mean concentration **M** by this adjustment factor **Ra** to give the estimate of the annual mean for 2010.

The period mean adjustment figure was derived using data from the following sites.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
St Leonards	38.2	40.1	34.4	24.8	21.0	19.1	15.3	24.8	26.7	28.7	40.1	59.2
G'Mouth Moray	36.3	40.1	26.7	15.3	13.4	13.4	7.6	11.5	17.2	17.2	24.8	61.1
Bush Estate	12.4	17.6	11.5	6.7	5.7	5.5	3.2	5.0	6.5	5.9	9.2	15.5
Dalkieth	32.5	38.2	26.7	21.0	19.1	17.2	11.5	15.3	21.0	24.8	30.6	47.8

	AM	PM	Ratio
St Leonards	31.0	30.6	1.0
G'Mouth Moray	23.7	21.8	1.1
Bush Estate	8.7	7.3	1.2
Midlothian Dalkeith	25.5	24.0	1.1
		Ra	**1.09**

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