CASELLA STANGER

Winchester City Council

Air Quality Review and Assessment – ADMS-Roads Update

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1 INTRODUCTION

1.1 Project Background

Casella Stanger was originally commissioned by Winchester City Council to undertake further detailed dispersion modelling for the city centre area of Winchester in respect of NO_2 and PM_{10} concentrations for the fulfilment of duties under Part IV of the Environment Act, 1995. The modelling was undertaken in 2003 based on Breeze-Roads and it was recommended that WCC consider undertaking the assessment with the ADMS-Roads model in order to compare results and determine which model is more suitable for Winchester town centre.

The same traffic data has been used for the ADMS-Roads dispersion model and the input data is essentially the same as that for previous modelling so that a comparison can be made. The previous report provides a more full description of traffic data and roads modelled and this report is supplementary to the original study.

Additional inputs allowed within the ADMS-Roads model include the inclusion of building heights for street canyons and this facility has been used where appropriate. In addition, updated diffusion tube NO_2 monitoring has been made available to allow a update of the verification of the dispersion modelling.

This report concentrates on the predictions of NOx and NO_2. The predictions of PM_{10} from the dispersion models do not reflect the levels monitored within Winchester. A number of recommendations for further work are included at the end of this report related to further modelling and monitoring.

1.2 Air Quality Data

1.2.1 Background Automatic Monitoring Concentrations

Background air quality data was obtained from continuous monitoring undertaken by Winchester City Council. The background continuous monitoring location is shown in Figure 2.1. Both NOx/NO_2 are measured at the site and the annual concentrations for 2003/2003 are reported in Table 2.1.

1.2.2 Roadside Automatic Monitoring Concentrations

Automatic roadside air quality data was obtained from continuous monitoring undertaken by Winchester City Council. The roadside monitoring location is shown in Figure 2.2. Both NOx/NO_2 are measured at the site and the annual concentrations for 2002/2003 are reported in Table 2.1.

1.2.3 Monitoring Equipment Information

Detailed information on equipment used for monitoring purposes are provided in previous review and assessment reports (PT to provide full reference).

Figure 2.1: Location of Background Continuous Monitor, NOx/NO_2 and PM_{10}

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Figure 2.2: Location of Roadside Continuous Monitor, NOx/NO_2 and PM_{10}

Table 2.1: Automatic Monitored NO_x/NO_2 Concentrations Winchester City Council.

	Background		Roadside	
2002	**NOx**	**NO_2**	**NOx**	**NO_2**
Annual Average	57.6	29.5	190.1	46.9
% Data Capture	93		76	
No Hours >200	-	0	-	0
2003 (to end 20/3)	**NOx**	**NO_2**	**NOx**	**NO_2**
Period Average	66.1	30.8	151.9	58.9
No Hours >200	-	0	-	1

1.2.4 Projection of Background Concentrations

Projections of background concentrations to future years have been made using the guidance provided in LAQM.TG(03). Table 2.2 shows the projected 2005 background NOx and NO_2 based on the 2002 background monitoring. The 2002 and 2005 background NOx and NO_2 concentrations shown have been used throughout the air quality assessment. It has been assumed that background concentrations for 2002 are suitable for 2003 in the absence of updated continuous monitoring. Future modelling would take account of changes to background concentrations but for the purposes of the comparison of dispersion models it is not essential to update background information.

Table 2.2: Background Concentrations in Winchester. ($\mu g/m^3$)

	Background NOx	Background NO_2
2002	57.6	29.5
2005	52.1	27.5

1.2.5 Passive NO_2 Monitoring

Nitrogen dioxide concentrations have been monitored using diffusion tubes following identification of relevant roadside locations as part of the detailed dispersion modelling exercise. The diffusion tubes were deployed in September 2002 and have been changed on a 4/5 week basis (and are not part of the UK Diffusion Tube Network). Updated information for 2003 has been used in this updated assessment. However, a complete year of data for 2003 was not available. A full year of diffusion tube data will be available in October 2004 and this will provide WCC with further information regarding trends of annual average NO_2 concentrations.

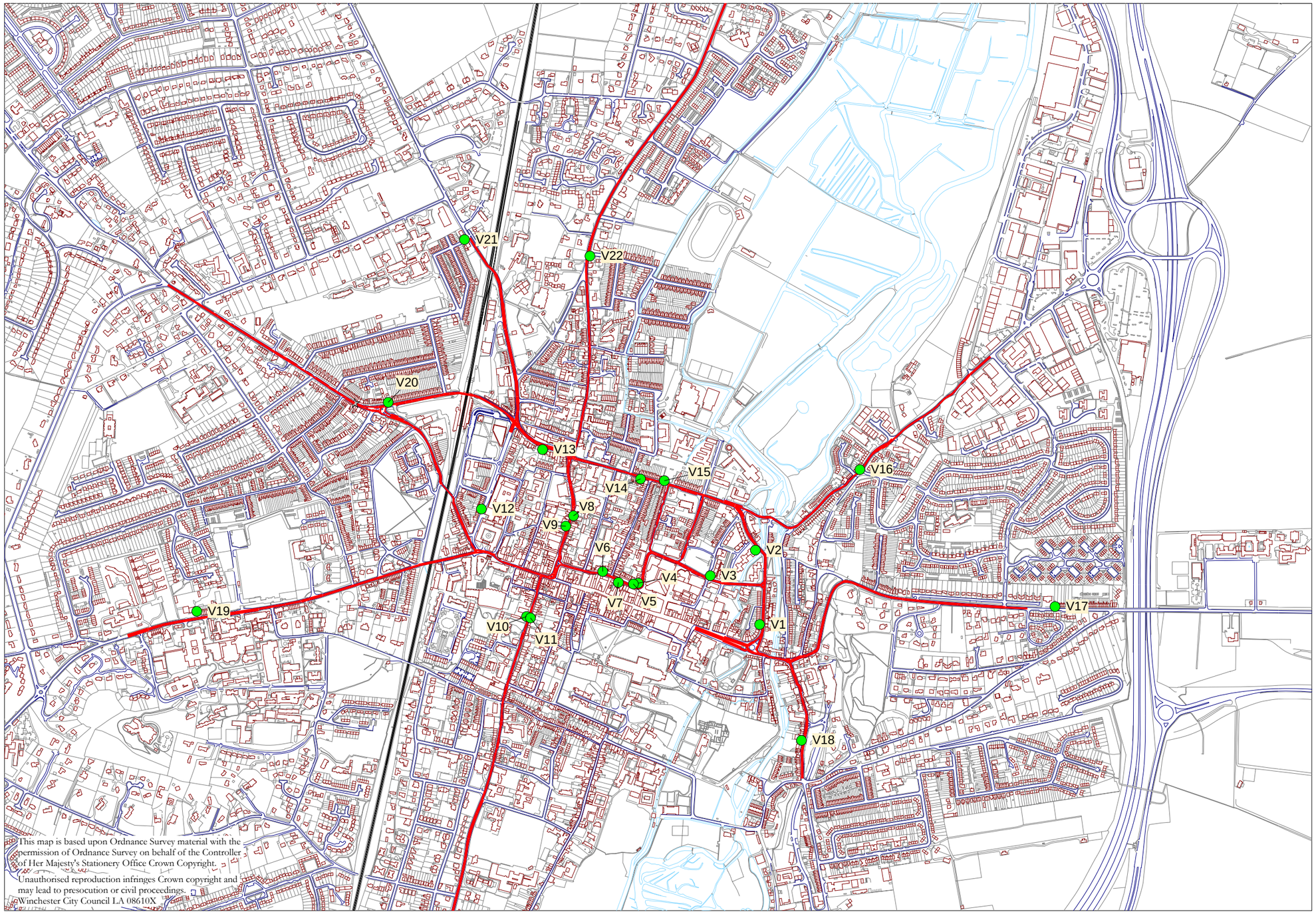
Table 2.2 gives details of the location of the diffusion tubes used in this study and their locations are shown in Figure 2.4.

Table 2.2: Winchester City Centre Diffusion Tube Location Details

Verification Receptor Number	Site code	Location	X Co-Ordinate	Y Co-Ordinate
V1	Site 1	10 Eastgate St	448563	129390
V2	Site 2,3,4	Greyfriars	448551	129596
V3	Site 5	Friarsgate	448426	129526
V4	Site 6	Middle Brook St	448226	129505
V5	Site 7,8,9	Roadside Monitor	448214	129505
V6	Site 10	St Georges St TC	448128	129537
V7	Site 11	St Georges St Lad	448172	129507
V8	Site 12	Jewry St CH	448047	129691
V9	Site 13	Jewry St FK	448026	129663
V10	Site 14	Southgate St DV	447917	129413
V11	Site 15	Southgate St CH	447928	129409
V12	Site 16	Sussex St	447792	129710
V13	Site 17	City Road	447962	129875
V14	Site 18	74 Northwalls	448233	129794
V15	Site 19	15 Northwalls	448299	129789
V16	Site 20	Wales St	448841	129819
V17	Site 21	Alresford Rd	449381	129440
V18	Site 22	Chesil St	448679	129069
V19	Site 23	Romsey Rd HL	447004	129427
V20	Site 24	Stockbridge Rd	447534	130006
V21	Site 25	Andover Rd	447746	130456
V22	Site 26,27,28	Worthy Rd	448093	130411

Diffusion tubes V21,V17 and V12 have not been used for verification because they are located on the limits of the model area and the contribution from roads have not been modelled appropriately. Tube V19 has not been used as the results reported for 2003 are below the background levels monitored.

Figure 2.3: Location of Diffusion Tubes in Winchester



Diffusion tubes are an economic and convenient method for monitoring NO_2. However, there is uncertainty with respect to the accuracy against more sophisticated methods. Consequently, validation against real-time data from more reliable continuous monitoring is desirable in order to determine the uncertainty of the diffusion tube measurements. The co-located NO_2 concentrations from continuous background site were used to calculate the percent difference or bias:

$$\% \text{ bias} = ((\text{Diff. tube } NO_2 \text{ mean} - \text{auto } NO_2 \text{ mean})/\text{Diff. tube } NO_2 \text{ mean}) * 100$$

An update of bias for 2003 data has been derived from information provided by Defra[1]. Diffusion tubes are prepared and analysed by Gradko using the 50% TEA/Water method. The bias estimate for 2002 data derived for the previous assessment was 1.27, as based on local continuous monitoring. This bias was less that the default bias for 2002 of 1.39 that was available at the time.

While local continuous monitoring for calculation of a bias factor is not yet available for this assessment, the Defra defaults have been updated for 2003 based on a larger dataset than previously. A significantly lower bias correction factor of 1.06 has been derived for 2003. This decrease in bias correction has been calculated across a number of sites and has been used to derive 2003 diffusion tube concentrations.

Table 2.3 shows the 2002 and 2003 diffusion tube concentrations for WCC. The table also shows projected concentrations to 2005 based on factors provided in LAQM.TG(03).

The diffusion tube data for both 2002 and 2003 indicates that the concentration in 2003 are similar to those in 2002 and that the monitored exceedences of the annual average objective occur in both years. An increase of approximately 13% is estimated at Sussex Street, while the similar decrease at Middle Brook Street is shown. On average across all sites there has not been substantial change in monitored levels of concentrations. It can be concluded from the data that there has been no significant change in air quality between 2002 and 2003.

It will be useful to compare 2004 results when available to these data to determine if the concentrations remain at the same levels as 2002 and 2003.

[1] Compilation of Diffusion Tube Collocation Studies Carried out by Local Authorities, Report prepared by AQC On Behalf of Defra and the Devolved Administrations, November 2002.

Table 2.3: Winchester City Centre Diffusion Tube Concentrations – Bias Corrected Annual Average NO_2 (all as µg/m³)

Verification Receptor Number	Site code	Location	2002 Concentration	2003 Concentration	% Change between 2002 and 2003	Projected 2005 from 2002 Data.	Projected 2005 from 2003 Data.
V1	Site 1	10 Eastgate St	38.4	40.6	5.7	35.4	38.5
V2	Site 2,3,4	Greyfriars	39.3	40.7	3.6	36.1	38.6
			38.6	37.8	-2.0	35.5	35.9
			40.0	39.6	-0.9	36.8	37.5
V3	Site 5	Friarsgate	34.9	33.7	-3.4	32.1	31.9
V4	Site 6	Middle Brook St	46.0	39.8	-13.5	42.3	37.7
V5	Site 7,8,9	Roadside Monitor	44.0	48.4	10.0	40.5	45.9
			47.1	50.2	6.6	43.4	47.6
			46.3	49.8	7.6	42.6	47.2
V6	Site 10	St Georges St TC	48.4	49.7	2.7	44.6	47.2
V7	Site 11	St Georges St Lad	58.8	58.4	-0.7	54.2	55.3
V8	Site 12	Jewry St CH	47.7	44.5	-6.5	43.9	42.2
V9	Site 13	Jewry St FK	49.2	46.7	-5.0	45.3	44.3
V10	Site 14	Southgate St DV	41.9	38.4	-8.4	38.6	36.4
V11	Site 15	Southgate St CH	53.2	51.1	-4.0	49.0	48.4
V12	Site 16	Sussex St	38.8	44.2	13.8	35.7	41.9
V13	Site 17	City Road	46.5	43.2	-7.0	42.8	41.0
V14	Site 18	74 Northwalls	49.9	49.7	-0.5	46.0	47.1
V15	Site 19	15 Northwalls	39.4	35.2	-10.7	36.3	33.4
V16	Site 20	Wales St	36.3	38.4	5.8	33.4	36.4
V17	Site 21	Alresford Rd	35.5	34.0	-4.2	32.7	32.2
V18	Site 22	Chesil St	39.1	43.2	10.5	36.0	41.0
V19	Site 23	Romsey Rd HL	31.7	28.3	-10.8	29.2	26.8
V20	Site 24	Stockbridge Rd	29.7	33.4	12.3	27.4	31.7
V21	Site 25	Andover Rd	38.2	35.1	-8.1	35.2	33.3
V22	Site 26,27,28	Worthy Rd	32.4	34.8	7.5	29.8	33.0
			38.0	34.3	-9.8	35.0	32.5
			35.8	32.6	-8.7	32.9	30.9

2 MODEL VERIFICATION AND COMPARISON

Predicted contributions from the road links modelled are made at each of the continuous monitor and diffusion tubes in the areas. However, it is necessary to verify the levels of road contributions modelled, and to include background concentrations, as well as consider the conversion of NOx to NO_2. The method used for verification of NOx and NO_2 has used the guidance provided in LAQM.TG(03).

Both diffusion tube and continuous monitoring data has been used to determine the performance of the model for predicting the contribution of roadside NOx levels. While continuous monitoring directly monitors NOx concentrations, diffusion tubes only provide NO_2 concentrations. Therefore diffusion tube concentrations of NO_2 are converted back to NOx using guidance in LAQM.TG(03). By comparing NOx monitored and modelled a correction factor can be derived for the modelled area.

The previous Breeze Roads verification used only the continuous monitor to derive the correction factor, however, the method using the diffusion tubes allow estimates based on more data points to be made over a wider modelled area. Note that for the purposes of the assessment of ADMS-Roads and for comparing model output with previous Breeze-Roads results, updated traffic data and inputs have not been considered.

The previous Breeze Roads modelling verification (based on continuous analyser only) provided a *Modelled Roads NOx* correction factor of 10.81. The verification was repeated for 2003 data including diffusion tubes and was calculated to be 11.11. This shows that the use of either 2002 or 2003 monitoring is not significant in the model verification for the Winchester model set-up.

The updated ADMS-Roads modelling verification for 2003 provides a *Modelled Roads NOx* correction factor of 5.96. This is approximately half of the previous correction factor.

An exercise to determine the correction factor for ADMS-Roads for monitoring data for 2002 was also carried out and this *Modelled Roads NOx* correction factor of 6.26 which is slightly higher than for the 2003 dataset, but similar.

Total NO_2 concentrations are derived from corrected modelled roadside NOx taking account of background NOx and NO_2 using the method provided in LAQM.TG(03).

Table 3.1 provides the data used for the verification procedure and the calculated steps along the way.

Table 3.2 provides a summary of results from the Breeze Roads modelling and the ADMS-Roads modelling in order to show the different performance of the models and how modelled levels at diffusion tubes compare overall. This shows that the overall final concentration of NO_2 predicted is very similar for both dispersion models – following correction of the roadside NOx component. However, it is clear from the correction factor for roadside NOx that the ADMS-Roads model effectively performs twice as well as the Breeze-Roads model. This improved performance in likely to be due in part to the ability of ADMS-Roads to incorporate street canyons but also due to advanced treatment of the meteorology conditions and improve algorithms for urban dispersion.

Table 3.1 Comparison of ADMS-Roads Modelling and Monitoring Concentrations at Roadside Diffusion Tube locations in Winchester City for 2003

Verification Site	Description	2003 Diffusion Tube NO_2 [d]	Back-ground NOx	Back-ground NO_2	Total Monitored NOx	Roadside Monitored NOx	Modelled Roadside NOx	DT Correction Factor	Corrected Modelled Roadside NOx[a]	Total NOx[b]	Modelled Roadside NO_2[c]	Total Modelled NO_2 [c]	% Difference Modelled vs Monitored NO_2 [e]	Under or Over	Correction Factor
V1	Site 1, 10 Eastgate St	40.6			110.4	52.8	9.5	5.58	56.4	114.1	11.7	41.2	1.4	over	0.99
V2	Site 2,3,4, Greyfriars	39.4			103.8	46.2	9.1	5.06	54.3	112.0	11.4	40.8	3.7	over	0.96
V3	Site 5, Friarsgate	33.7			75.4	17.8	7.2	2.47	42.9	100.5	9.3	38.8	15.1	over	0.87
V4	Site 6, Middle Brook St	39.8			105.4	47.8	10.2	4.71	60.5	118.2	12.4	41.9	5.3	over	0.95
V5	Site 7,8,9, Roadside Monitor	49.5			167.7	110.0	14.1	7.83	83.8	141.4	16.2	45.7	-7.7	under	1.08
V6	Site 10, St Georges St TC	49.7			169.1	111.5	15.3	7.27	91.4	149.1	17.3	46.8	-5.9	under	1.06
V7	Site 11, St Georges St Lad	58.4			242.0	184.3	25.8	7.13	154.0	211.7	25.5	55.0	-5.8	under	1.06
V8	Site 12, Jewry St CH	44.5			133.7	76.1	21.0	3.63	125.0	182.6	22.0	51.5	15.5	over	0.87
V9	Site 13, Jewry St FK	46.7			148.0	90.4	14.2	6.37	84.6	142.2	16.3	45.8	-2.0	under	1.02
V10	Site 14, Southgate St DV	38.4			98.4	40.8	6.6	6.20	39.2	96.9	8.6	38.1	-0.8	under	1.01
V11	Site 15, Southgate St CH	51.1	57.6	29.5	179.6	122.0	9.2	13.31	54.6	112.3	11.4	40.9	-20.0	under	1.25
V12	Site 16, Sussex St	44.2			131.8	74.2	2.5		14.6	72.2	3.5	33.0	-25.3	under	1.34
V13	Site 17, City Road	43.2			125.7	68.0	11.1	6.12	66.2	123.8	13.4	42.9	-0.9	under	1.01
V14	Site 18, 74 Northwalls	49.7			169.1	111.5	14.9	7.49	88.7	146.4	16.9	46.4	-6.6	under	1.07
V15	Site 19, 15 Northwalls	35.2			82.4	24.7	13.7	1.81	81.4	139.1	15.8	45.3	28.6	over	0.78
V16	Site 20, Wales St	38.4			98.4	40.8	6.5	6.27	38.8	96.4	8.5	38.0	-1.2	under	1.01
V17	Site 21, Alresford Rd	34.0			76.8	19.1	0.5		3.2	60.9	0.8	30.3	-10.9	under	1.12
V18	Site 22, Chesil St	43.2			125.7	68.0	6.1	11.09	36.5	94.2	8.1	37.5	-13.1	under	1.15
V19	Site 23, Romsey Rd HL	28.3			na		3.2		19.1	76.7	4.5	34.0	19.9	over	0.83
V20	Site 24, Stockbridge Rd	33.4			74.0	16.4	8.9	1.84	53.1	110.8	11.2	40.6	21.6	over	0.82
V21	Site 25, Andover Rd	35.1			81.9	24.3	1.7		10.2	67.8	2.5	32.0	-9.0	under	1.10
V22	Site 26,27,28, Worthy Rd	33.9			76.3	18.7	6.0	3.09	36.0	93.7	8.0	37.4	10.4	over	0.91
							Average	5.96				Average	0.6		1.01
							Min	1.81				Highest Under	-25.3		1.34
							Max	13.31				Highest Over	28.6		0.78

[a]: factor 5.96 applied, [b]: corrected roadside NOx + Background NOx, [c]: derived using LAQM.TG(03) method, [d]: bias corrected, [e]: (modelled/monitored)/monitored*100

Table 3.2 Comparison of ADMS-Roads and Breeze Roads Modelling Results in Winchester

		ADMS ROADS						BREEZE ROADS					
Roadside NOx Factor		6.26			5.96			11.42			11.11		
ID	**Site code and location**	**2002 Monitored**	**Final Modelled NO_2**	**% Difference NO_2**	**2003 Monitored**	**Final Modelled NO_2**	**% Difference NO_2**	**2002 Monitored**	**Final Modelled NO_2**	**% Difference NO_2**	**2003 Monitored**	**Final Modelled NO_2**	**% Difference NO_2**
V1	Site 1, 10 Eastgate St	38.4	41.1	7.0	40.6	41.2	1.4	38.4	41.4	7.8	40.6	41.7	2.6
V2	Site 2,3,4, Greyfriars	39.3	40.8	3.9	39.4	40.8	3.7	39.3	41.3	5.1	39.4	41.6	5.6
V3	Site 5, Friarsgate	34.9	38.8	11.4	33.7	38.8	15.1	34.9	40.8	17.0	33.7	41.1	22.0
V4	Site 6, Middle Brook St	46.0	41.8	-9.1	39.8	41.9	5.3	46.0	43.3	-5.9	39.8	43.6	9.5
V5	Site 7,8,9, Roadside Monitor	45.8	45.2	-1.4	49.5	45.7	-7.7	45.8	52.4	14.4	49.5	52.9	6.8
V6	Site 10, St Georges St TC	48.4	46.2	-4.6	49.7	46.8	-5.9	48.4	48.2	-0.5	49.7	48.6	-2.3
V7	Site 11, St Georges St Lad	58.8	53.2	-9.6	58.4	55.0	-5.8	58.8	46.6	-20.9	58.4	46.9	-19.6
V8	Site 12, Jewry St CH	47.7	50.2	5.4	44.5	51.5	15.5	47.7	50.7	6.3	44.5	51.1	14.7
V9	Site 13, Jewry St FK	49.2	45.3	-8.0	46.7	45.8	-2.0	49.2	45.3	-8.0	46.7	45.6	-2.4
V10	Site 14, Southgate St DV	41.9	38.2	-8.9	38.4	38.1	-0.8	41.9	37.3	-10.9	38.4	37.5	-2.2
V11	Site 15, Southgate St CH	53.2	40.8	-23.3	51.1	40.9	-20.0	53.2	40.3	-24.2	51.1	40.6	-20.6
V12	Site 16, Sussex St	38.8	33.1	-14.6	44.2	33.0	-25.3	38.8	33.8	-12.8	44.2	34.0	-23.1
V13	Site 17, City Road	46.5	42.7	-8.3	43.2	42.9	-0.9	46.5	40.2	-13.5	43.2	40.5	-6.4
V14	Site 18, 74 Northwalls	49.9	45.9	-8.1	49.7	46.4	-6.6	49.9	45.3	-9.3	49.7	45.6	-8.2
V15	Site 19, 15 Northwalls	39.4	44.9	13.8	35.2	45.3	28.6	39.4	45.3	14.8	35.2	45.6	29.5
V16	Site 20, Wales St	36.3	38.1	4.8	38.4	38.0	-1.2	36.3	39.2	7.8	38.4	39.4	2.5
V17	Site 21, Alresford Rd	35.5	30.3	-14.5	34.0	30.3	-10.9	35.5	30.7	-13.5	34.0	30.7	-9.6
V18	Site 22, Chesil St	39.1	37.7	-3.7	43.2	37.5	-13.1	39.1	37.9	-3.2	43.2	38.1	-12.0
V19	Site 23, Romsey Rd HL	31.7	34.1	7.6	28.3	34.0	19.9	31.7	34.7	9.2	28.3	34.8	22.9
V20	Site 24, Stockbridge Rd	29.7	40.6	36.5	33.4	40.6	21.6	29.7	40.2	35.1	33.4	40.4	21.0
V21	Site 25, Andover Rd	38.2	32.1	-16.0	35.1	32.0	-9.0	38.2	32.1	-16.0	35.1	32.2	-8.4
V22	Site 26,27,28, Worthy Rd	35.4	37.6	6.2	33.9	37.4	10.4	35.4	38.3	8.1	33.9	38.5	13.4
				-1.5			0.6			-0.6			1.6
				36.5			28.6			35.1			29.5
				-23.3			-25.3			-24.2			-23.1

3 RESULTS

ADMS-Roads has been used to predict concentrations across Winchester for the objective year of 2005 as shown in Figure 3.1. In addition, lines representing the concentrations of 36 and 40 $\mu g/m^3$ produced based on ADMS-Roads are shown in Figure 3.2.

The lines of exceedence from previous Breeze Roads modelling are compared to those from ADMS-Roads in Figure 3.3. This shows that the area of exceedence based on both models is very similar and it is recommended that the current size of the AQMA in Winchester is not altered.

4 RECOMMENDATIONS

The current AQMA in Winchester should remain. The size of the AQMA may be reviewed in 2005 when updated dispersion modelling is likely to be undertaken and further monitoring data is available to identify recent trends in pollutant levels.

To aid WCC in its management of air quality it also recommended that:

Automatic Traffic Count traffic data is obtained on an annual basis in order to allow updated information on traffic volumes and patterns of traffic throughout the day. In addition, updated classification of vehicles within WCC would also be useful, including percentage of heavy and light goods vehicles and buses. Data collected as part of the MIRACLES project should be combined and used within the review and assessment process as this provides a link between data for emission inventories and dispersion modelling.

It is recommended that monitoring based on diffusion tubes continue at a wide number of sites across Winchester. Continuous monitoring at the background and roadside site should also continue as this provided invaluable information on real-time pollutant levels. However, it is recommended that an additional roadside site on Jewry Street or similar location is considered as the current site on George Street may represent the worse-case location for roadside monitoring due to the number of slow moving turning vehicles and buses.

It is also recommended that WCC use ADMS-Roads for dispersion modelling and source apportionment work associated with detailed assessments and air quality action planning scenarios.

Figure 3.1: Predicted annual average NO_2 concentration in Winchester – 2005 – all as $\mu g/m^3$

Figure 3.2: Predicted annual average NO_2 36 and 40 $\mu g/m^3$ contours based on ADMS-Roads in Winchester City in 2005 – all as $\mu g/m^3$

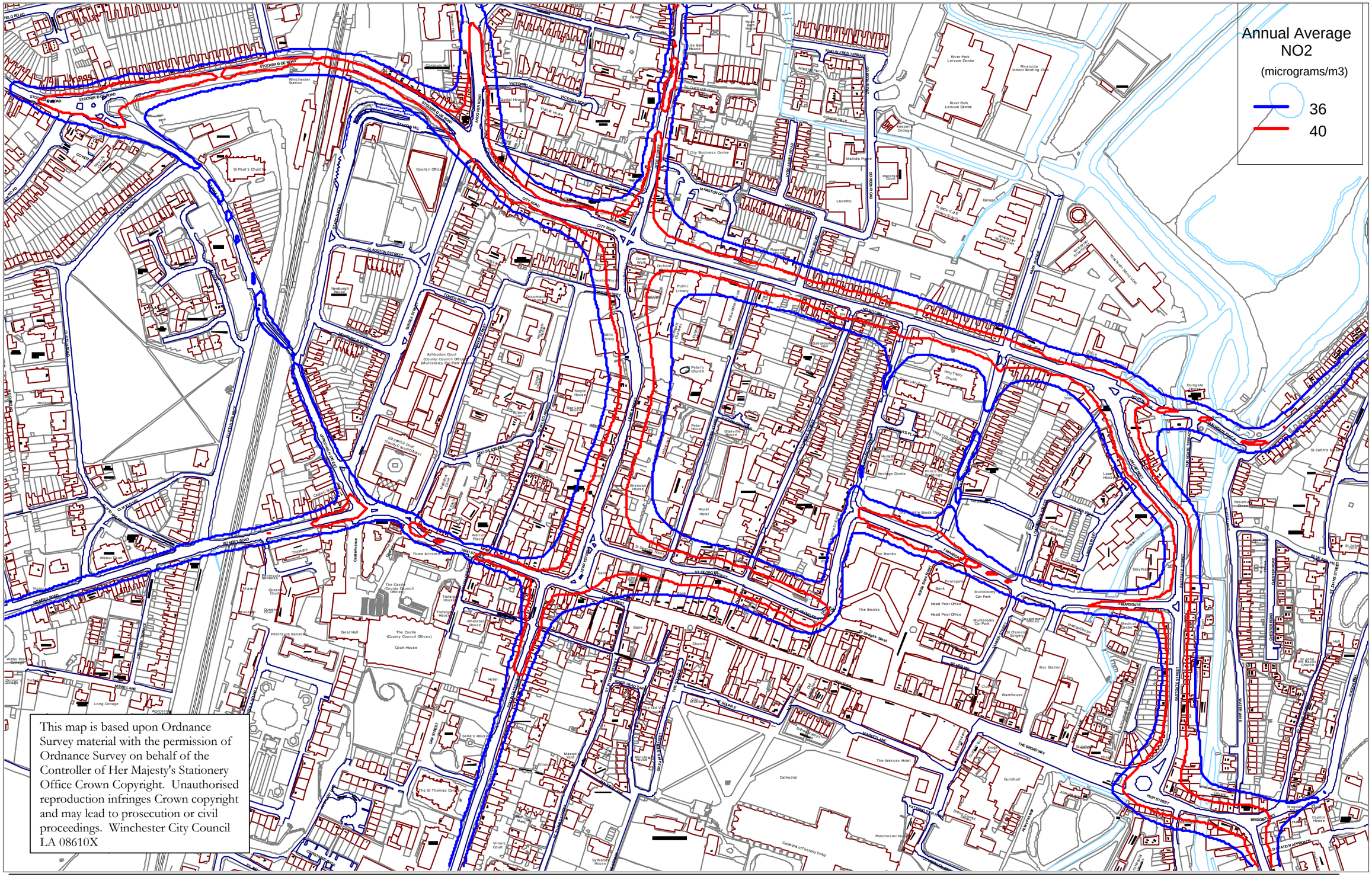
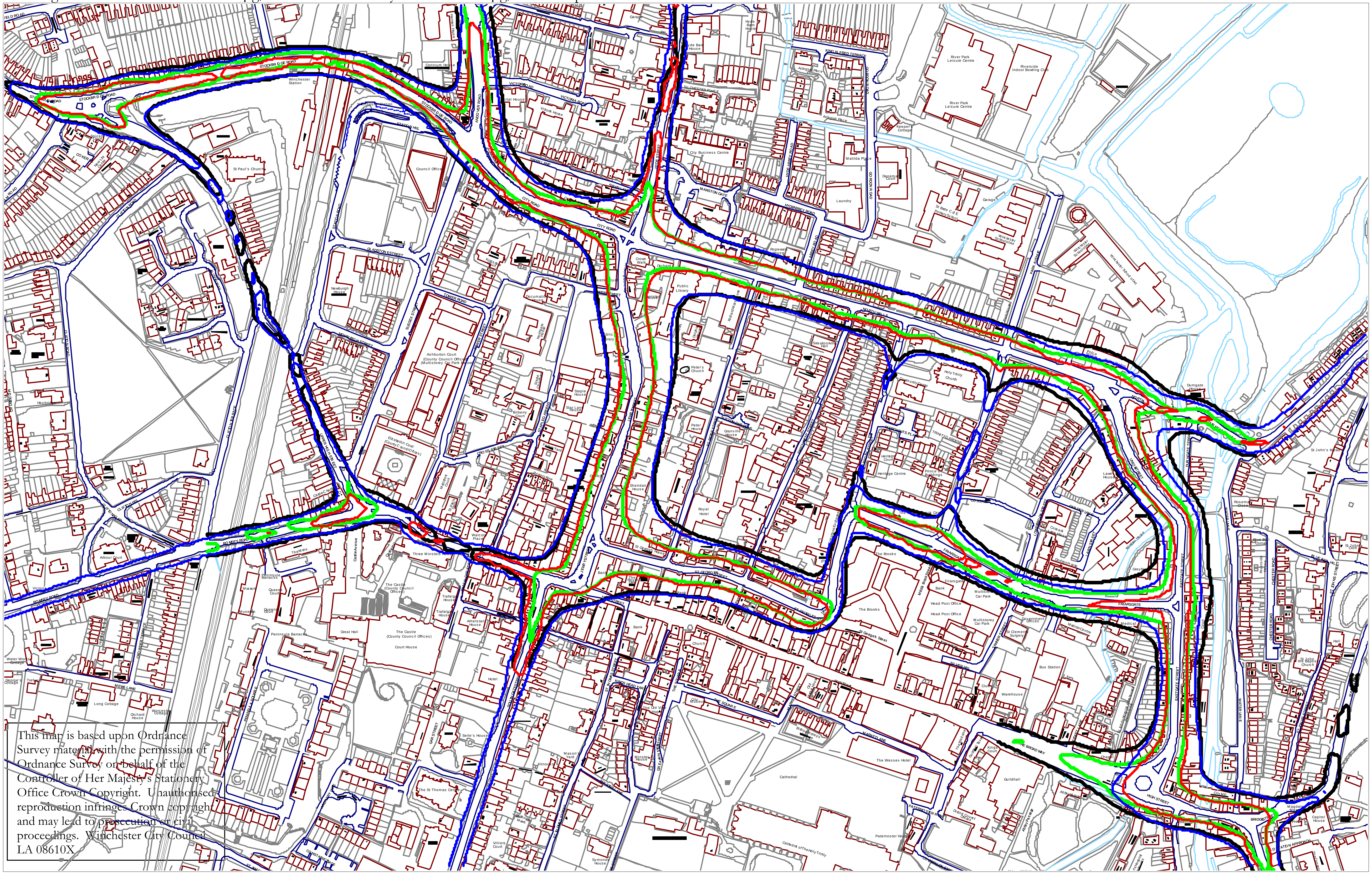


Figure 3.3: Contours of 36 and 40 μg/m³ in Winchester City in 2005 – all as μg/m³ - Comparison of Breeze Roads model and ADMS-Roads model



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