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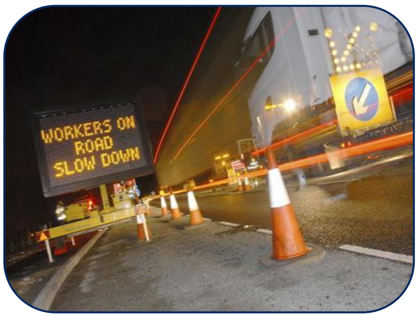

DRAFT PROJECT REPORT RPN3567

Woodbridge - Air quality modelling using local weather data

Savage A., Turpin K

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Anna Savage	Kevin Turpin
(Project Manager)	(Technical Referee)

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Contents amendment record

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Contents

1 Study background

In 2006, Suffolk Coastal District Council (SCDC) declared an Air Quality Management Area (AQMA) for exceedances of the annual average nitrogen dioxide (NO_2) objective in the town of Woodbridge. The AQMA was declared for a row of properties on Melton Hill, close to the junction with Lime Kiln Quay Road, St John's Street and The Thoroughfare (see Figure 1). The local authority currently monitors NO_2 concentrations at several diffusion tube sites around the junction and at one kerbside automatic monitoring site on Melton Hill within the AQMA. The local authority's final action plan for the AQMA was published in 2011 (SCDC, 2011). The action plan contains 20 measures aimed at improving air quality which include specific measures for the road junction such as installing queue detectors on traffic lights, extending restrictions to vehicular access to The Thoroughfare, remove the right turn from Melton Hill to St John's Street and removing on-street car parking on Melton Hill. Wider measures across the town include initiatives to improve bus emissions, car sharing schemes and promotion of travel plans. The local authority is now considering what other measures can be put in place to further improve concentrations in the AQMA and is looking to update and revise the action plan in 2016.

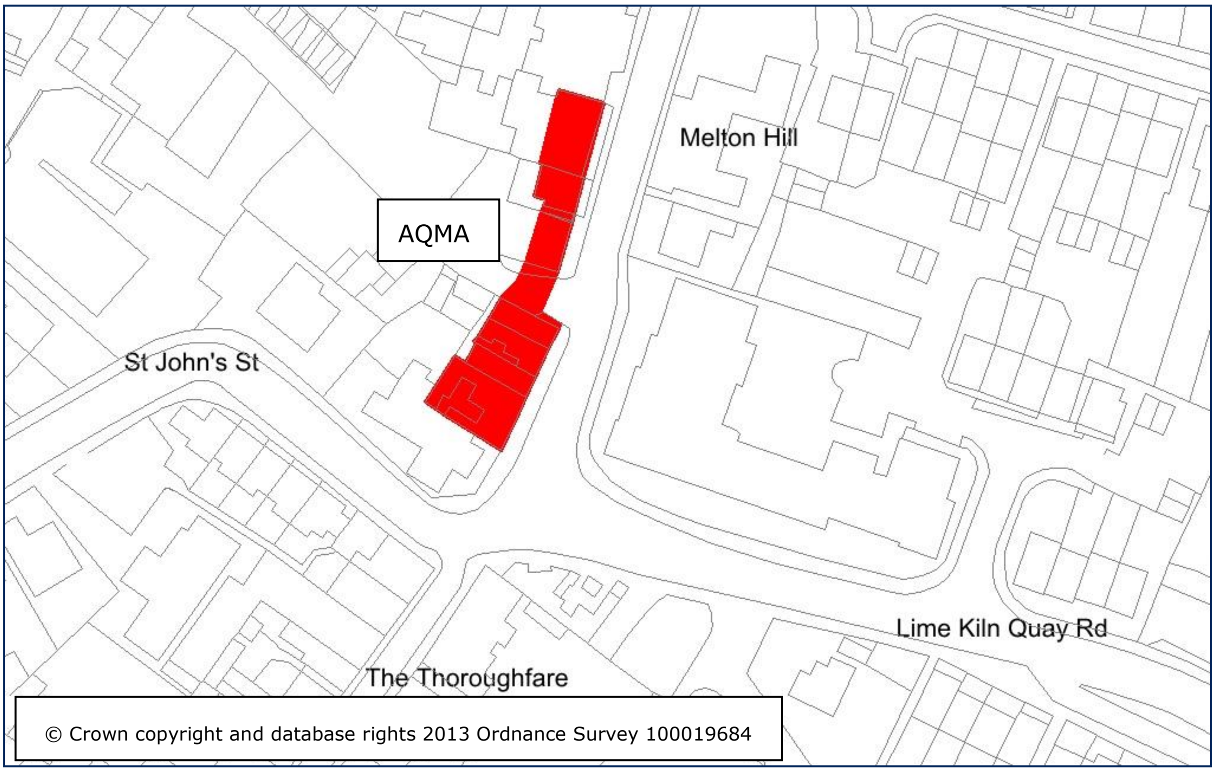

Figure 1: Boundary of Woodbridge AQMA.

In 2014, TRL conducted a detailed modelling assessment of emissions at this junction derived from instantaneous driving cycle (DC) surveys (Savage and Turpin, 2014). The impact of several scenarios on emissions was modelled, including banning the right turn from Melton Hill into St John's Street and access to The Thoroughfare. The results showed that the maximum reduction in NO_2 concentrations due to vehicle emissions was found to be 0.1 $\mu g/m^3$ at monitoring sites on Melton Hill and St John's Street.

Conversely, road NO_2 concentrations were predicted to increase at the monitoring sites in Lime Kiln Quay Road by up to 0.5 µg/m^3. This was because it was assumed that all those vehicles that previously turned right from Melton Hill to St John's Street or down The Thoroughfare now had to travel along Lime Kiln Quay Road.

The study found that the modelling could not fully understand the NO_2 concentrations measured at the automatic monitoring site. Modelled emissions from the road traffic source across the junction substantially underestimated these concentrations by an average factor of five. Following a number of detailed investigations, it was concluded that perhaps the meteorological conditions at the site were not being represented appropriately. Sensitivity testing of the meteorological data file concluded that by modifying the meteorological impacts, the performance of the model could be improved effected by up to 60 percent. It was concluded therefore that a greater understanding of localised weather conditions would assist in understanding the relationships between the emissions source contribution from the road and this monitoring site. This better understanding would help inform the Council on what new measures could be introduced in a revised action plan and what could potentially be achieved.

The study also recommended that the Council could install a meteorological station at the automatic monitoring site for a period of three months to investigate this relationship further. Two readings would be required, one at 2.6m and the other at 10m (just above roof line). The two sets of weather data could then be examined to find out if the weather conditions at the junction:

a) differed somewhat to the regional profiles applied in previous modelling exercises and
b) were favourable for emissions entrainment.

This report provides the results of this additional work to conduct air quality monitoring using the local weather data. All other model assumptions and model set up were unchanged from the original assessment.

2 Meteorological monitoring

Two masts were installed to measure meteorological parameters, specifically wind speed and direction. These masts were as close to the site of the automatic analyser on Melton Hill as possible. One site was set up with the meteorological monitoring equipment at approximately the same height as the analyser's inlet (just over 2 metres) and the other was set up at the back of the building at 9 metres, i.e. above the building height (see Figure 2).

Figure 2: Wind speed and direction masts, Melton Hill (2 metre and 9 metre masts)

The two sites recorded data during a four month period from 24th July to 20th November 2015 which was were logged at 15 minute intervals. The datasets were analysed and are presented as wind roses in Figure 3 and Figure 4. In contrast the weather data from the nearest national meteorological site at Wattisham, which was used in the original modelling study is shown in Figure 5.

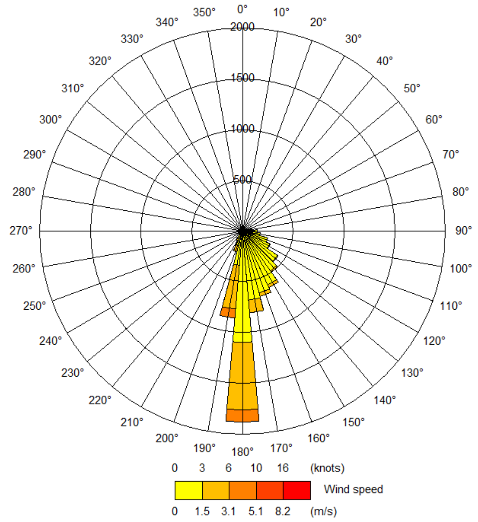

Figure 3. Wind speed and direction at roadside in 15 minute intervals (part year 2015)

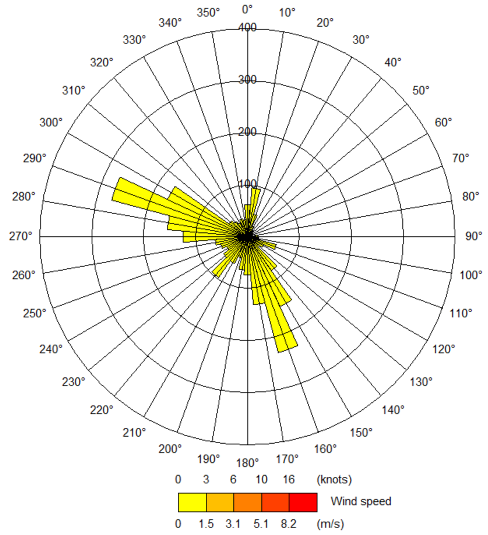

Figure 4. Wind speed and direction at 9 metres in 15 minute intervals (part year 2015)

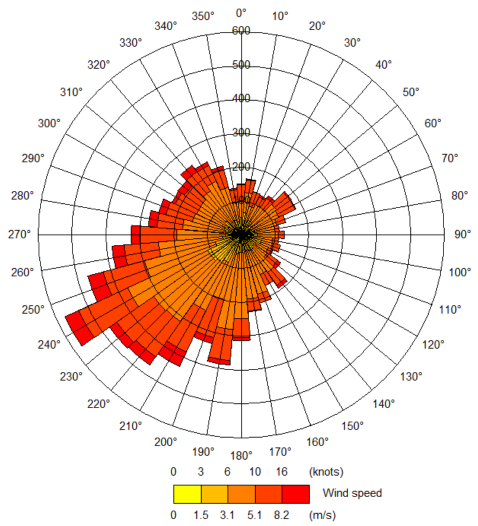

Figure 5. Wind speed and direction at Wattisham meteorological site in 60 minute intervals, 2012

Table 1 shows the average wind speed and direction recorded at the monitoring sites. The table clearly shows some significant differences between the average statistics.

Table 1: Average wind speed and direction at Woodbridge in comparison to local met sites.

Site	Average wind speed (m/s)	Average wind direction (degrees)
9 metre	0.2	282
Roadside	1.0	171
RAF Wattisham	5	206

The data illustrated in the wind roses show that at Wattisham, the wind blows predominantly from the West by Southwest directions. However, at the local Woodbridge monitoring sites, the predominant wind direction is somewhat different. Due to the shielding from the buildings, the wind direction affecting the roadside measurements is predominantly from the South (Figure 3). Wind speed above the buildings is characteristically lower than that at roadside level and it is likely that the slightly higher wind speed at roadside level would tend to push more of the emissions from the junction towards the monitoring site.

3 Pollution Modelling

Using the local meteorological data collected in 2015, the ADMS dispersion model was re-run at the monitoring sites (see Figure 6), firstly taking meteorological data from the roadside monitoring site and secondly taking meteorological data from the 9m monitoring site. Any gaps were filled in with the average statistics over the period for each site (from Table 1).

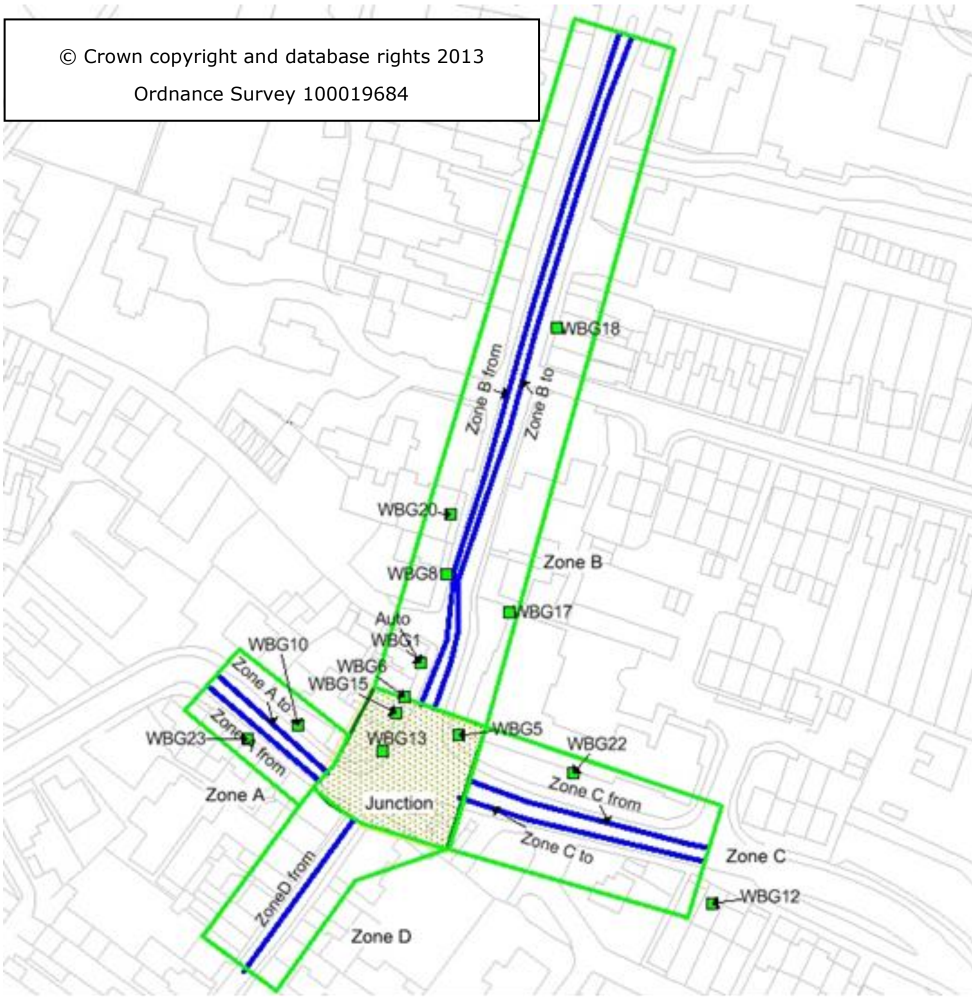

Figure 6: Location of monitoring sites in relation to modelled sources

The modelling results in terms NO_x concentrations from the road source are provided in Table 2. These results were compared with the road NO_x concentrations calculated from the monitoring sites using Defra's NO_x–NO_2 tool and with the results from the original modelling assessment (Savage and Turpin, 2014). These results show that the modelled concentrations using the data from the roadside meteorological site are much closer to the measured road NO_x values. The model still under-predicted measured concentrations overall but not to the same extent as the original assessment (it is noted that concentrations were over-estimated a site WBG22). Comparing the modelled and measured outputs, an adjustment factor of 1.3106 (i.e. under predicting by 31%) was applied to the modelled values before converting the values to modelled NO_2 concentrations. This magnitude of adjustment is considered to reasonable according to Defra's technical guidance (Defra, 2009). The final adjusted modelled annual mean NO_2 concentrations using the roadside meteorological data are given in Table 3 compared to the measured concentrations at the monitoring sites.

Table 2: Modelled road NO_x concentrations compared to measured

Site	x	y	Annual mean road NO_x concentrations			
			Measured (calculated)	Original (Wattisham) met	Roadside met	9m met
WBG1	627595	249260	66.4	8.6	42.5	11.7
WBG5	627604	249243	22.4	7.0	23.0	23.5
WBG6	627591	249252	55.7	6.9	22.9	12.1
WBG8	627601	249281	63.6	12.5	57.5	18.4
WBG10	627566	249245	33.6	8.2	31.2	28.5
WBG13	627586	249239	45.5	7.1	18.6	19.8
WBG15	627589	249248	60.9	5.9	18.1	13.5
WBG17	627616	249272	26.8	6.8	10.8	26.4
WBG18	627627	249339	40.7	11.2	22.0	43.8
WBG22	627631	249234	13.9	6.4	26.7	20.3
WBG23	627554	249242	22.4	3.5	4.7	6.1
Auto	627595	249260	66.4	8.0	39.6	11

Table 3: Modelled annual mean NO_2 concentrations compared to measured concentrations using the roadside met data, 2012.

Site	x	y	Annual mean NO_2 concentrations		Difference (%)
			Modelled	Measured	
WBG1	627595	249260	**42.3**	**44**	-4%
WBG5	627604	249243	30.9	26	16%
WBG6	627591	249252	30.9	**40**	-30%
WBG8	627601	249281	**49.9**	**43**	14%
WBG10	627566	249245	35.9	31	14%
WBG13	627586	249239	28.1	36	-28%
WBG15	627589	249248	27.8	42	-51%
WBG17	627616	249272	22.9	28	-22%
WBG18	627627	249339	30.3	34	-12%
WBG22	627631	249234	33.2	22	34%
WBG23	627554	249242	18.5	26	-40%
Auto	627595	249260	**40.7**	**44**	-8%

*Exceedances of the annual mean objective in bold

Overall, the modelling results showed that the model over-estimated concentrations at a number of sites (e.g. WBG8, WBG10, WBG22 and the automatic monitor) and under predicted at other sites, with the largest difference of 50% seen at WBG15. This site is located on Melton Hill close to the junction which was represented by an area source in the model rather than an individual link. It is therefore likely that emissions were under-estimated at this site. Modelled concentrations at the automatic monitoring site on Melton Hill were found to exceed the objective, in line with the measured concentrations.

4 Discussion and conclusions

The concentration of any pollutant at any given receptor point is dependent upon a number of factors, namely the magnitude of emission sources, weather conditions, topography and finally any mechanical influences on dispersion generated by vehicle movement (i.e. where traffic is the predominant source of emissions). With respect to minimising the impact of road traffic emissions the only effective mitigation strategy is to affect the source of emission or in some cases affect the physical topography.

The modelling work conducted at the Woodbridge junction to date suggests that local topography has an effect on the regional weather profile. In other words, the very nature of the built form and natural geography surrounding the junction has an influence on localised weather patterns. This has culminated in an elevation of emissions and hence concentrations at this road junction in Woodbridge. One of the main effects would appear to be the entrainment of vehicle emissions from the junction up Melton Hill. It would also appear that the lower wind speeds recorded at the temporary meteorological monitors would allow emissions to remain resident for longer periods. Emissions would therefore tend to accumulate rather than disperse.

Given that modifying the topography around this junction will not be possible the only practical solution to improve air quality in the Woodbridge AQMA and meet the annual mean NO_2 objective at this location is to somehow reduce the emission source.

Since the original assessment, concentrations at the automatic monitoring site have declined slightly and were just below the objective in 2014. However, concentrations fluctuate from year to year, so these sites may exceed the objective in future years and traffic data has shown that flows across the junction remain similar year-on-year. However, year on year emissions from the traffic will reduce as vehicles are renewed which means that it is highly likely that air quality over time will start to improve. However, the time horizon upon which benefits begin to show up at the monitoring sites is difficult to predict. Under these circumstances and the fact that localised weather patterns are tending to entrain the emission source onto sensitive locations within the AQMA it is necessary to consider a solution to deal with the concentrations now.

From the original assessment, it was noted that the traffic flow would need to be reduced by approximately 25% to reduce annual average road NO_2 concentrations by 1 $\mu g/m^3$ at the automatic monitoring site (assuming the same split between heavy and light duty vehicles). What this means in practical terms is that a measure would be needed to reduce the traffic that is directly affecting concentrations at the AQMA (the "resident" traffic) by 25%, rather than reducing overall throughput across the junction by 25%. This distinction is fundamentally important because it would be politically impossible to reduce the throughput by this amount without a comprehensive transport strategy which effectively encouraged modal shift. Nonetheless, reductions in the order of this magnitude will be required to meet the air quality objective.

It may be possible to do this by holding the traffic back at the traffic lights, in both directions on Melton Hill (southbound) and Lime Kiln Quay Road (westbound). To test the impact of this on the AQMA as part of their action plan development, the Council could install temporary traffic lights approximately 30 metres back on Lime Kiln Quay Road and 40 metres back on Melton Hill for a six month period of time (e.g. starting in January and ending in June to account for seasonal variation). This would allow the traffic to be pulsed through the junction in either direction under free flow conditions with low positive acceleration events. In other words, only one direction is active at any one time. There would also be occasions under light traffic conditions where the traffic sources will have even a lesser impact on the AQMA when the traffic is further away from the AQMA.

A further measure that could also be considered as part of options for a revised action plan could be to consider a single carriageway layout. In this situation, traffic would be taken further away from the sensitive receptors in the AQMA. It is also possible that this centralised layout would improve dispersion on Melton Hill. This would also have other benefits including slight reductions in road traffic noise and vibration at the sensitive properties and improve overall well-being of pedestrians having pathways tripling in width. In fact the whole area around the junction would benefit from this type of measure. The impact of this type of measure could be monitored over time by analysing long term changes in measured concentrations at the Woodbridge monitoring sites.

References

Defra (2009). Local Air Quality Management Technical Guidance LAQM.TG(09).

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Suffolk Coastal District Council (2011). Air Quality Action Plan for the Woodbridge Junction, February 2011.