
The Cambridge South East Transport Order

Transport And Works Act 1992

Transport And Works (Applications And Objections Procedure) (England And Wales) Rules 2006

Appendix 6.2 – Air Quality Model Verification

Document Reference	CSET-10-14
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Applicant	Cambridgeshire County Council
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Overview

- 6.2.1 Model verification is a process by which checks are carried out to determine the performance of a dispersion model at a local level, primarily by comparison of modelled results with monitoring data. The verification process benefits an assessment by investigating uncertainties and minimising them through informed refinement of model input parameters.
- 6.2.2 Defra TG22 guidance provides a method for model verification including calculation methods and directions on the suitability of monitoring data.
- 6.2.3 Verification of modelled 2019 annual mean NO₂ concentrations has been undertaken utilising monitoring results from Cambridgeshire County Council, South Cambridgeshire District Council and Proposed Development specific monitoring surveys.
- 6.2.4 The Proposed Development monitoring results were annualised to 2019 and bias adjusted in accordance with Defra TG22 guidance.

Monitoring Sites

- 6.2.5 Table A6.2.1 presents the ambient air quality monitoring locations and 2019 annual mean NO₂ concentrations of all sites included within the model verification.

Table A6.2.1 Monitoring sites used in verification

Monitoring Site	X	Y	Z	Site Type	Monitored NO ₂	Local Authority/ Proposed Development Specific
CM1	545507	257828	2	Roadside	27.9	Cambridge
CM2	546055	259486	2	Roadside	21.7	Cambridge
CM4	545367	258391	2.5	Roadside	32.5	Cambridge
CM5	545291	258119	5	Roadside	27	Cambridge
DT01	545295	258421	2.5	Roadside	35	Cambridge
DT03	544677	258994	2.5	Roadside	20	Cambridge
DT04	544491	259022	2.5	Roadside	31	Cambridge
DT05	544783	258116	2.5	Roadside	24	Cambridge
DT06	544867	255709	2	Kerbside	34	Cambridge
DT11	544784	256746	2	Background	11	Cambridge
DT13	545910	258437	2.5	Roadside	22	Cambridge
DT14	546082	257947	2	Roadside	21	Cambridge

Monitoring Site	X	Y	Z	Site Type	Monitored NO ₂	Local Authority/ Proposed Development Specific
DT16	545291	258119	5.5	Roadside	26	Cambridge
DT18	544884	258098	2	Roadside	30	Cambridge
DT20	546061	259260	2.5	Roadside	26	Cambridge
DT25	544100	257470	2	Roadside	18	Cambridge
DT26	544943	257566	2	Roadside	18	Cambridge
DT27	544576	255307	2	Roadside	18	Cambridge
DT28	546948	255169	2	Roadside	33	Cambridge
DT29	548331	256242	2.5	Kerbside	19	Cambridge
DT31	544530	257729	2	Roadside	29	Cambridge
DT32	546187	256530	2.5	Roadside	22	Cambridge
DT33	545333	259438	2	Roadside	31	Cambridge
DT34	545371	258400	2.5	Roadside	31	Cambridge
DT36	546596	257594	2	Urban Background	15	Cambridge
DT38	545566	259578	2	Roadside	23	Cambridge
DT39	545710	258783	2	Kerbside	27	Cambridge
DT40	545405	258521	2	Roadside	31	Cambridge
DT41	545161	258241	2	Roadside	27	Cambridge
DT42	544999	257871	2	Roadside	20	Cambridge
DT43	545271	257675	2	Roadside	27	Cambridge
DT44	545429	258271	2.5	Roadside	21	Cambridge
DT45	545144	258366	2.5	Urban Centre	32	Cambridge
DT46	545538	258294	2	Kerbside	19	Cambridge

Monitoring Site	X	Y	Z	Site Type	Monitored NO ₂	Local Authority/ Proposed Development Specific
DT47	545508	257828	2	Roadside	29	Cambridge
DT50	545896	257154	2	Roadside	23	Cambridge
DT51	544962	254221	2	Roadside	25	Cambridge
DT54	546029	257662	2.5	Kerbside	20	Cambridge
DT58	546096	257124	2.5	Kerbside	30	Cambridge
DTS1	545894	257026	2.5	Roadside	22	Cambridge
DTS2	544616	254648	2.5	Roadside	28	Cambridge
DTS3	544664	254600	2.5	Kerbside	19	Cambridge
DTS4	545241	254216	2.5	Roadside	16	Cambridge
DTS5	546832	255345	2.5	Kerbside	21	Cambridge
DTS6	546700	255374	2.5	Roadside	21	Cambridge
DTS7	545248	256859	2.5	Kerbside	25	Cambridge
DT64	544956	258850	2.5	Roadside	23	Cambridge
SC4	548601	249135	2	Urban Background	23	South Cambridgeshire
SC17	548545	249366	2	Roadside	13.8	South Cambridgeshire
CSET_DT_1	547277	253004	2	Roadside	16.6	Scheme Specific (South Cambridgeshire)
CSET_DT_2	546015	254762	2	Roadside	16.7	Scheme Specific (Cambridge)
CSET_DT_3	547759	252054	2	Roadside	14.6	Scheme Specific (South Cambridgeshire)
CSET_DT_4	549371	249956	2	Roadside	12.9	Scheme Specific (South Cambridgeshire)

Monitoring Site	X	Y	Z	Site Type	Monitored NO ₂	Local Authority/ Proposed Development Specific
CSET_DT_5	552040	249427	2	Roadside	12.9	Scheme Specific (South Cambridgeshire)
CSET_DT_6	552834	249632	2	Roadside	17.5	Scheme Specific (South Cambridgeshire)
CSET_DT_8	547985	254048	2	Roadside	12.6	Scheme Specific (South Cambridgeshire)
CSET_DT_9	551284	250331	2	Roadside	12.2	Scheme Specific (South Cambridgeshire)
CSET_DT_10	552935	252009	2	Roadside	18.1	Scheme Specific (South Cambridgeshire)
CSET_DT_11	550358	251903	1.5	Roadside	14.7	Scheme Specific (South Cambridgeshire)
CSET_DT_12	551981	249748	3	Roadside	21.4	Scheme Specific (South Cambridgeshire)
CSET_DT_13	552012	249731	3	Roadside	19.2	Scheme Specific (South Cambridgeshire)
CSET_DT_14	546714	251848	2	Roadside	18	Scheme Specific (South Cambridgeshire)

Comparison

6.2.6 Table A6.2.2 presents a comparison of the monitored and modelled concentrations of NO₂ at the monitoring sites for the year 2019.

Table A6.2.2 Model verification results NO₂, µg/m³

Monitoring Site	Site Type	Monitored NO ₂	Modelled NO ₂	Difference	% Difference
CM1	Roadside	27.9	28.0	0.1	0%
CM2	Roadside	21.7	20.4	-1.2	-6%
CM4	Roadside	32.5	44.3	11.7	36%
CM5	Roadside	27	24.9	-2.1	-8%
DT01	Roadside	35	26.9	-8.1	-23%
DT03	Roadside	20	20.1	0.1	1%
DT04	Roadside	31	36.1	5.1	16%
DT05	Roadside	24	26.1	2.1	9%
DT06	Kerbside	34	22.7	-11.3	-33%
DT11	Background	11	15.6	4.6	42%
DT13	Roadside	22	34.6	12.6	57%
DT14	Roadside	21	20.4	-0.6	-3%
DT16	Roadside	26	24.8	-1.2	-5%
DT18	Roadside	30	23.0	-7.0	-23%
DT20	Roadside	26	25.7	-0.3	-1%
DT25	Roadside	18	21.1	3.1	17%
DT26	Roadside	18	23.6	5.6	31%
DT27	Roadside	18	17.8	-0.2	-1%
DT28	Roadside	33	22.0	-11.0	-33%
DT29	Kerbside	19	21.2	2.2	12%
DT31	Roadside	29	30.0	1.0	3%

Monitoring Site	Site Type	Monitored NO ₂	Modelled NO ₂	Difference	% Difference
DT32	Roadside	22	21.2	-0.8	-3%
DT33	Roadside	31	32.8	1.8	6%
DT34	Roadside	31	38.0	7.0	23%
DT36	Urban Background	15	18.0	3.0	20%
DT38	Roadside	23	21.1	-1.9	-8%
DT39	Kerbside	27	27.5	0.5	2%
DT40	Roadside	31	27.7	-3.3	-11%
DT41	Roadside	27	24.1	-2.9	-11%
DT42	Roadside	20	22.4	2.4	12%
DT43	Roadside	27	29.6	2.6	10%
DT44	Roadside	21	23.7	2.7	13%
DT45	Urban Centre	32	26.8	-5.2	-16%
DT46	Kerbside	19	27.9	8.9	47%
DT47	Roadside	29	27.7	-1.3	-4%
DT50	Roadside	23	25.0	2.0	9%
DT51	Roadside	25	21.0	-4.0	-16%
DT54	Kerbside	20	27.3	7.3	37%
DT58	Kerbside	30	29.6	-0.4	-1%
DTS1	Roadside	22	25.0	3.0	14%
DTS2	Roadside	28	19.3	-8.7	-31%
DTS3	Kerbside	19	18.8	-0.2	-1%
DTS4	Roadside	16	17.3	1.3	8%
DTS5	Kerbside	21	23.4	2.4	12%

Monitoring Site	Site Type	Monitored NO ₂	Modelled NO ₂	Difference	% Difference
DTS6	Roadside	21	22.7	1.7	8%
DTS7	Kerbside	25	23.8	-1.2	-5%
DT64	Roadside	23	21.3	-1.7	-7%
SC4	Urban Background	23	17.0	-6.0	-26%
SC17	Roadside	13.8	13.3	-0.5	-3%
CSET_DT_1	Roadside	16.6	15.7	-0.9	-6%
CSET_DT_2	Roadside	16.7	19.1	2.4	15%
CSET_DT_3	Roadside	14.6	14.3	-0.3	-2%
CSET_DT_4	Roadside	12.9	13.0	0.1	1%
CSET_DT_5	Roadside	12.9	16.5	3.6	28%
CSET_DT_6	Roadside	17.5	20.8	3.3	19%
CSET_DT_8	Roadside	12.6	18.7	6.1	48%
CSET_DT_9	Roadside	12.2	14.5	2.3	19%
CSET_DT_10	Roadside	18.1	18.0	-0.1	-1%
CSET_DT_11	Roadside	14.7	17.9	3.2	22%
CSET_DT_12	Roadside	21.4	17.2	-4.2	-20%
CSET_DT_13	Roadside	19.2	18.6	-0.6	-3%
CSET_DT_14	Roadside	18	18.9	0.9	5%

6.2.7 Table A6.2.3 summarises the monitored and modelled annual average NO₂ concentrations for 2019 for all modelled sites. The modelled annual mean NO₂ concentration is within 10% of the monitored value at 48% of the monitoring sites and within 25% at 81% of the sites.

Table A6.2.3 Comparison of monitored and modelled NO₂ concentrations at all monitoring sites

Parameter	Number of Sites	Percent
Modelled within 25% of monitored	50	81%
Modelled within 10% of monitored	30	48%
Modelled overestimating by more than 25% of monitored	8	13%
Modelled underestimating by more than 25% of monitored	4	6%
Total number of sites	62	100%

6.2.8 Figure A6.2.1 presents the comparison between monitored and modelled NO₂ concentrations at all locations.

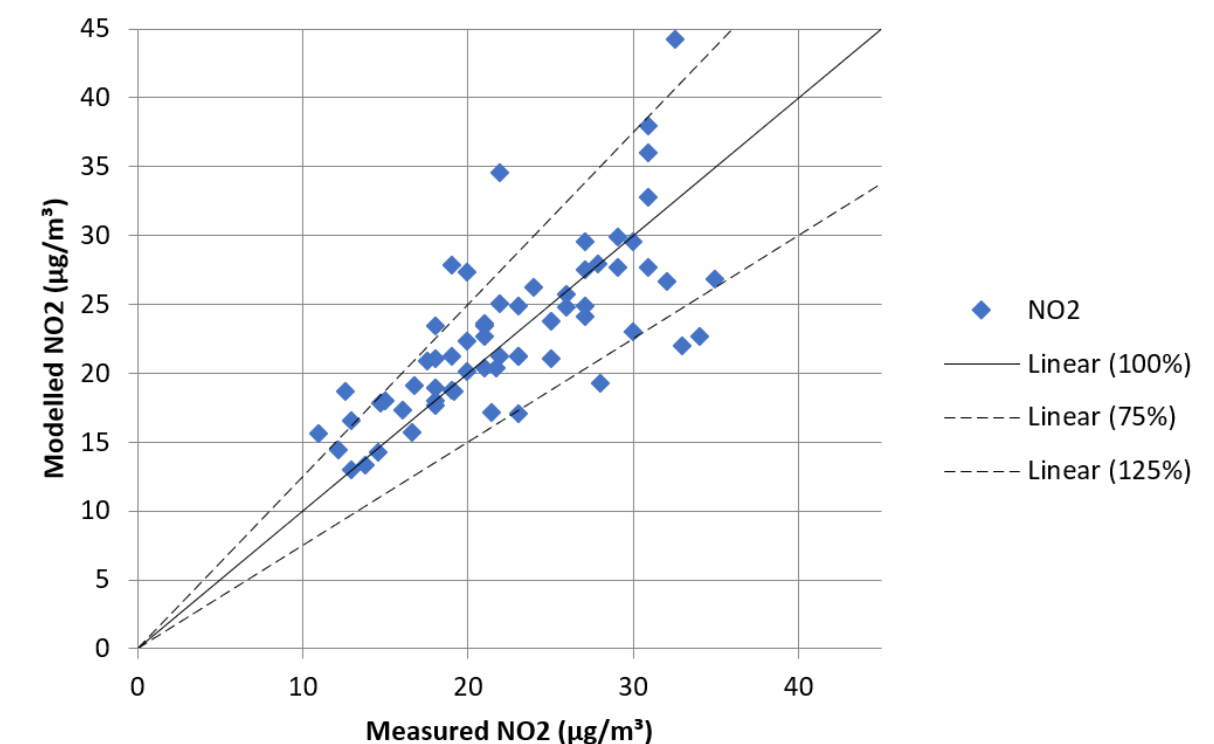


Figure A6.2.1 Model verification results

6.2.9 Table A6.2.4 presents further statistical parameters for describing model uncertainty. The Root Mean Square Error (RMSE) is used to define the average error or uncertainty of the model. The results of the RMSE calculation in this case are concentrations of NO₂ measured in units of micrograms per metre cubed.

6.2.10 Fractional Bias (FB) is used to identify if the model shows a tendency to over or under predict and values can vary between +2 and -2 and have an ideal value of 0. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.

Table A6.2.4 Description of model uncertainty

Statistical parameter	Value	Ideal value
RMSE (All sites)	4.6	0
FB (All sites)	-0.02	0

- 6.2.11

The RMSE value shows that the entire model is predicting with an error of 4.6 µg/m³ or 11.5% of the annual mean air quality objective of 40 µg/m³. This demonstrates that the model uncertainty is well within Defra TG22 recommended value of 25% and marginally above the desired value of 10%.
- 6.2.12

The FB value shows that the entire model has a very slight tendency to overpredict. Care should be exercised when using this parameter as it demonstrates the model's performance as a whole and not at discrete locations.
- 6.2.13

Overall, the modelled concentrations show a generally good agreement with the monitored concentrations at locations representative of the modelled human health and ecological receptors. On this basis, the modelled results are considered appropriate to allow a robust professional judgement of significance to be determined.

Comparison for PM₁₀ and PM_{2.5}

- 6.2.14

Table A6.2.5 presents a comparison of the monitored and modelled concentrations of PM₁₀ at three continuous monitoring sites for the year 2019. The modelled concentrations are all within 25% of the monitored concentrations, and within 10% at two of the three sites.

Table A6.2.5 Model verification results PM₁₀, µg/m³

Monitoring site	Site type	Monitored PM ₁₀	Modelled PM ₁₀	Difference	% Difference
CM1	Roadside	19.5	19.0	-0.5	-2.3%
CM2	Roadside	22.1	18.9	-3.2	-14.5%
CM4	Roadside	20.7	20.8	+0.1	+0.5%

- 6.2.15

Table A6.2.6 presents a comparison of the monitored and modelled concentrations of PM_{2.5} at CM1 for the year 2019. The modelled concentration was within 10% of the monitored concentration.

Table A6.2.6 Model verification results PM_{2.5}, µg/m³

Monitoring Site	Site Type	Monitored PM ₁₀	Modelled PM ₁₀	Difference	% Difference
CM1	Roadside	14.3	13.2	-1.1	-7.7%