



Cambridge South East Transport Phase 2

Environmental Statement

Appendix 6.2 Air Quality Model Verification

31st July 2023

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% |

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% |

6.2.7 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.

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

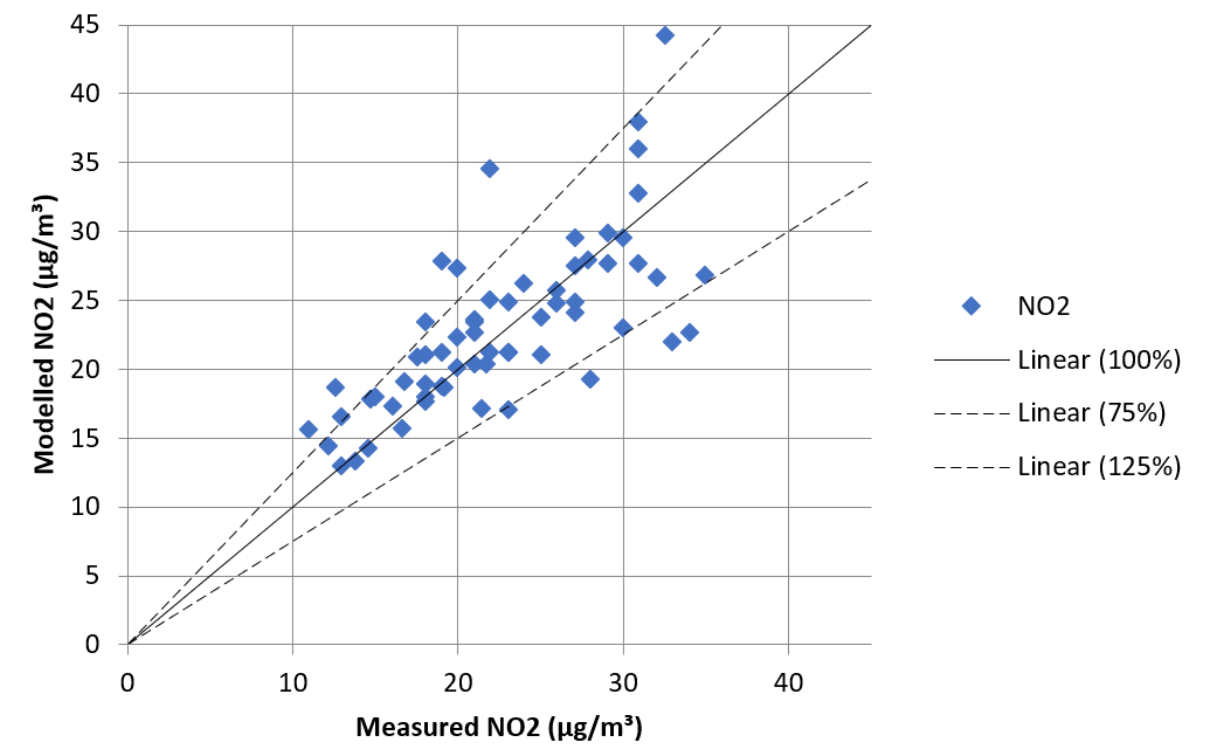


Figure A6.2.1 Model verification results

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 $\mu\text{g}/\text{m}^3$ or 11.5% of the annual mean air quality objective of 40 $\mu\text{g}/\text{m}^3$. 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, $\mu\text{g}/\text{m}^3$

| 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}, $\mu\text{g}/\text{m}^3$

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