# Appendix 9.4 - Model Verification

Due to the size of the study area, a number of model verification studies will be undertaken. For this PEIR, a model verification study for the borough of South Northamptonshire only has been undertaken.

## South Northamptonshire

The approach to model verification that LAQM.TG16 recommends for local authorities when they carry out their LAQM duties is summarised in the Uncertainty section of Chapter 9. For the verification and adjustment of $NO_x/NO_2$ concentrations, the guidance recommends that the comparison considers a broad spread of automatic and diffusion monitoring. SNC monitors roadside $NO_2$ concentrations passively using diffusion tubes at a number of locations. To ensure that the model verification is representative of the local area, two model verification studies have been undertaken for receptors in South Northamptonshire. One verification study compares modelled concentrations with monitored concentrations close to the M1. The other verification study compares modelled and monitored concentrations at locations away from the influence of the M1.

## Verification for Receptors close to Motorway

The most recent concentrations monitored are provided in Table 9.3.1.

**Table 9.3.1 Measured Annual-mean $NO_2$ Concentrations ($\mu g.m^{-3}$)**

| | Monitoring Site | Measured Annual-mean $NO_2$ Concentrations ($\mu g.m^{-3}$) |
|---|---|---|
| | | 2015 |
| Site Specific Monitoring | 1 – Crematorium | 40 |
| | 2 – Depot | 19 |
| | 3 – Collingtree Road | 20 |
| | 4 – Collingtree Court | 38 |
| SNC Monitoring | K1 | 26.4 |
| | K2 | 26.9 |
| | K3 | 35.0 |
| | H1 | 21.3 |

The monitored annual-mean $NO_x$ road contributions have been derived from the monitored annual-mean $NO_2$ concentrations using the LAQM.TG16 calculator. The monitored annual-mean $NO_X$ road contributions have then been compared with the modelled annual-mean $NO_X$ road contributions. This comparison is provided in Table 9.3.2 below.

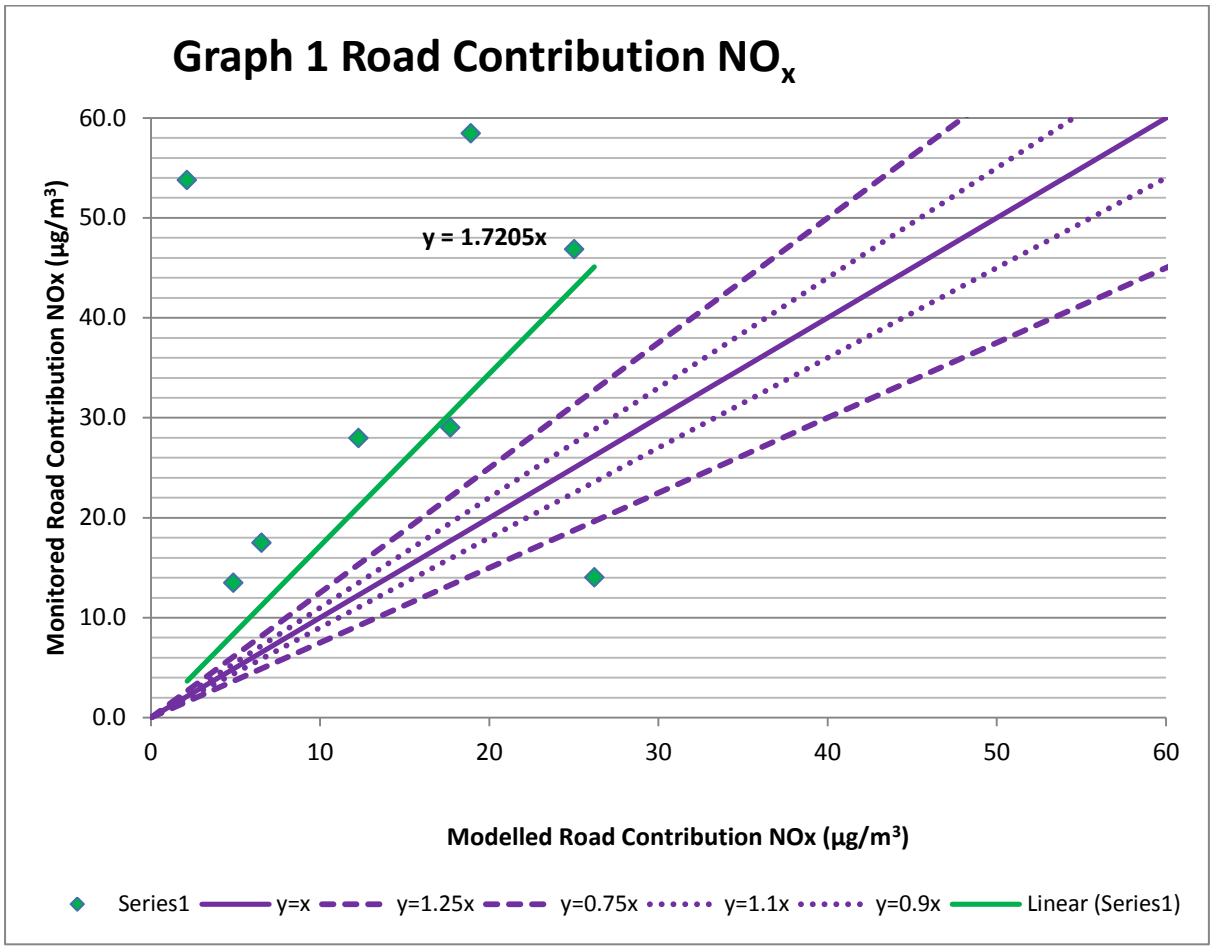
**Table 9.3.2 Comparison of Monitored and Modelled Annual-mean Road $NO_X$ Contribution ($\mu g.m^{-3}$)**

| Monitoring Site | Annual-mean Road $NO_x$ Contribution ($\mu g.m^{-3}$) | |
|---|---|---|
| | Modelled | Monitored |

| | | |
|---|---|---|
| 1 – Crematorium | 22.0 | 39.9 |
| 2 – Depot | 14.8 | 19.3 |
| 3 – Collingtree Road | 25.6 | 19.6 |
| 4 – Collingtree Court | 13.4 | 38.0 |
| K1 | 18.7 | 26.4 |
| K2 | 21.4 | 26.9 |
| K3 | 25.0 | 35.0 |
| H1 | 15.7 | 21.3 |

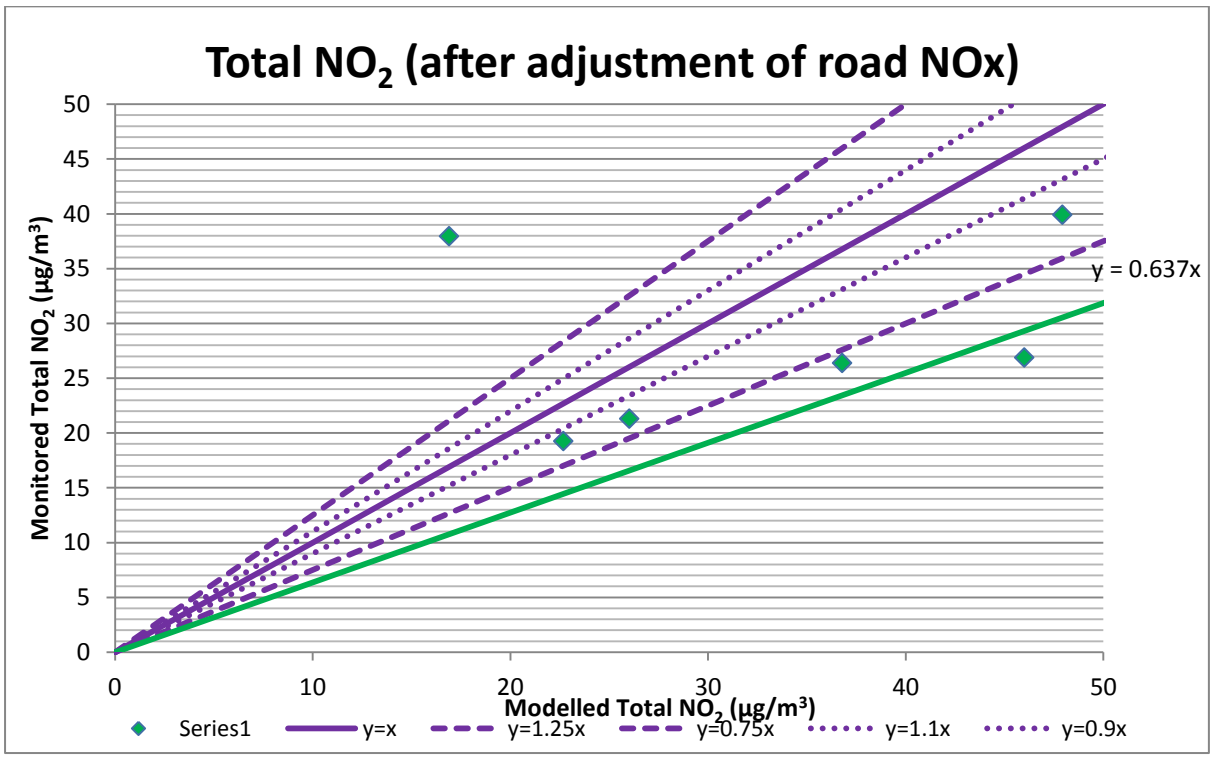
It should be borne in mind that the monitored concentrations are themselves only estimates to the true concentrations at each point; the EU Directive on air quality designates passive $NO_2$ samplers indicative measures with a potential uncertainty of +/-30 %. Table A1.2 above indicates that the model is under-predicting at seven of the eight monitoring locations.

The modelled annual-mean NOx road contributions for the concentrations have been plotted against the monitored annual-mean NOx road contributions in Graph 1.




The modelled $NO_X$ contributions have been multiplied by the gradient of the trend line (1.7205) to determine the corrected $NO_X$ contributions. Modelled annual-mean $NO_2$ concentrations have been

derived from the corrected modelled annual-mean $NO_X$ road contributions. The modelled annual-mean $NO_2$ concentrations have been plotted against the monitored annual-mean $NO_2$ concentrations in Graph 2.




The corrected modelled annual-mean $NO_2$ concentrations are almost all within 25% or greater than the monitored annual-mean $NO_2$ concentrations.

The fractional bias can also be used to determine whether the corrected model has a tendency to over or under-predict. The fractional bias is calculated as:

(Average Monitored $NO_X$ Concentration – Average Predicted NOx Concentration) / 0.5 x (Average Monitored $NO_X$ + Average Predicted NOx Concentration)

Fractional bias values vary between +2 and -2 and has an ideal value of zero. A negative value suggests a model over-prediction and a positive value suggests a model under-prediction.

Table 9.3.3 sets out the average monitored concentration and the average predicted concentration.

**Table 9.3.3 Comparison of Monitored and Modelled Annual-mean Road $NO_X$ Contribution ($\mu g.m^{-3}$)**

| Monitoring Site | Annual-mean Road $NO_x$ Contribution ($\mu g.m^{-3}$) | |
|---|---|---|
| | Modelled | Monitored |
| 1 – Crematorium | 31.6 | 58.4 |
| 2 – Depot | 8.2 | 13.5 |

| | | |
|---|---|---|
| 3 – Collingtree Road | 43.8 | 14.0 |
| 4 – Collingtree Court | 3.6 | 53.8 |
| K1 | 20.5 | 27.9 |
| K2 | 29.6 | 29.0 |
| K3 | 41.9 | 46.9 |
| H1 | 10.9 | 17.5 |
| **Average** | **23.8** | **32.6** |

The fractional bias for this study is therefore (23.8 – 32.6) / (0.5 x (23.8 + 32.6)) = 0.31. As the fractional bias is close to zero, the adjusted model is neither systematically over-predicting or systematically under-predicting.

## Verification for Receptors away from Motorway

The most recent concentrations monitored are provided in Table 9.3.4.

**Table 9.3.4 Measured Annual-mean $NO_2$ Concentrations ($\mu g.m^{-3}$)**

| | Monitoring Site | Measured Annual-mean $NO_2$ Concentrations ($\mu g.m^{-3}$) |
|---|---|---|
| | | 2015 |
| Site Specific Monitoring | 5 – Marina | 23.4 |
| | 6 – Fairfield Road/Station Road | 21.2 |
| | 10 – St Johns Road | 20.0 |
| | 11 – Blisworth Village | 30.4 |
| | 12 – Milton Malsor Village | 27.0 |
| SNC Monitoring | TC1 2 3 | 33.4 (average of triplicate tubes) |
| | TK1 | 47.2 |
| | TK2 | 39.5* |
| | TK3 | 29.6 |
| | TK4 | 39.9 |
| | TK5 | 23.7 |
| | TK6 | 26.6 |
| | TK7 | 22.1 |
| | TK8 | 28.7 |
| | TK9 | 31.8 |
| | TK43 | 28.6 |

| | | |
|---|---|---|
| | T1 | 26.5* |
| | T2 | 24.7 |
| | TN1 | 28.5 |
| | TN2 | 41.9 |
| | OS1 | 19.4 |
| | OS2 | 24.5 |
| | GPKa | 23.8 |
| | RO1 | 28.2 |
| | RO2 | 31.1 |
| | RO3 | 26.6 |
| | RO4 | 16.4 |
| | RO6 | 31.3 |
| | BR2 | 24.4 |
| | BR4 | 24.3 |
| | S1 | 15.3 |

*Results for 2014 as no available data for 2015

The monitored annual-mean $NO_x$ road contributions have been derived from the monitored annual-mean $NO_2$ concentrations using the LAQM.TG16 calculator. The monitored annual-mean $NO_X$ road contributions have then been compared with the modelled annual-mean $NO_X$ road contributions. This comparison is provided in Table 9.3.5 below.

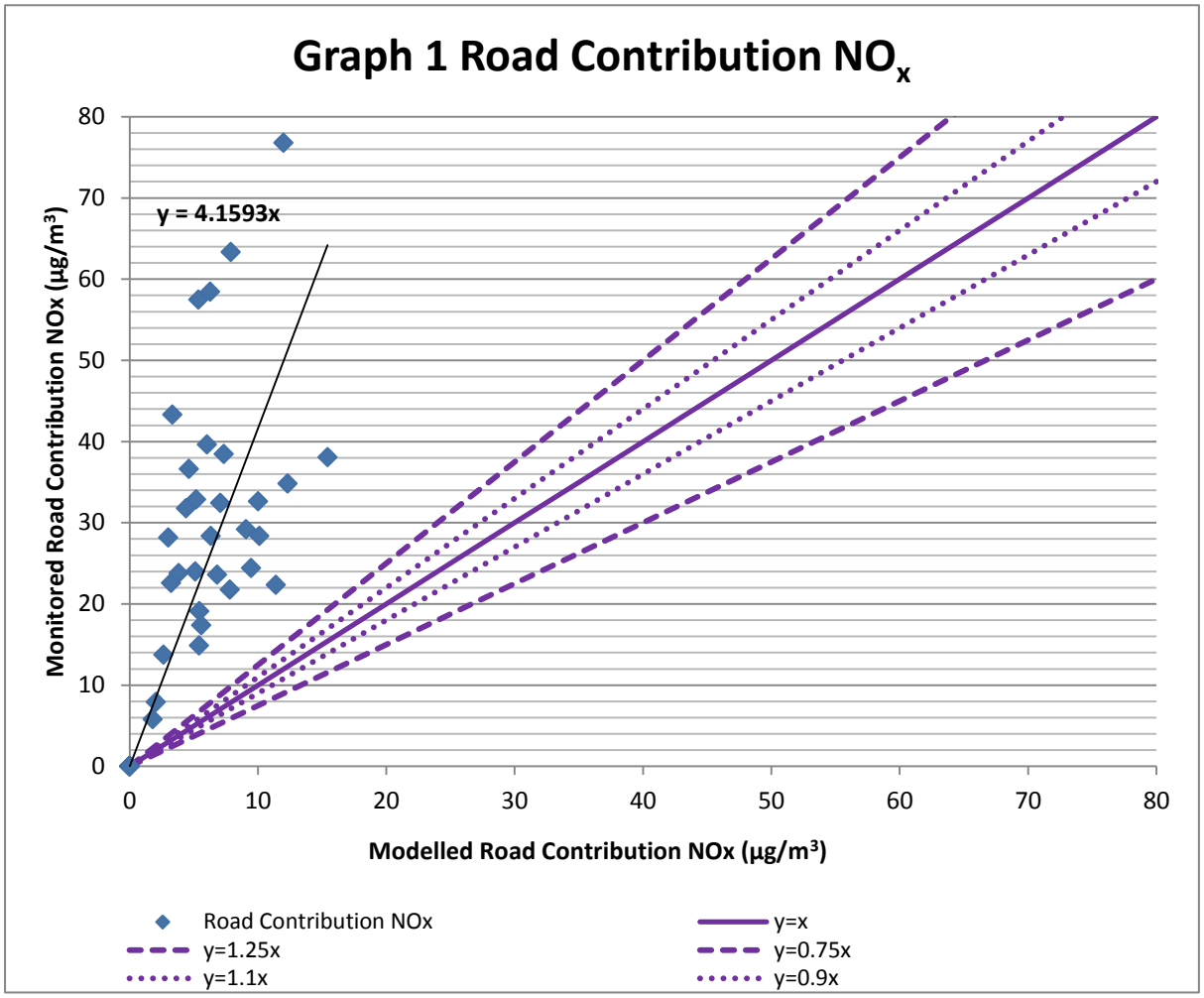
**Table 9.3.5 Comparison of Monitored and Modelled Annual-mean Road $NO_X$ Contribution ($\mu g.m^{-3}$)**

| Monitoring Site | Annual-mean Road $NO_x$ Contribution ($\mu g.m^{-3}$) | |
|---|---|---|
| | Modelled | Monitored |
| 5 – Marina | 7.8 | 21.7 |
| 6 – Fairfield Road/Station Road | 5.6 | 17.4 |
| 10 – St Johns Road | 5.4 | 14.9 |
| 11 – Blisworth Village | 4.6 | 36.6 |
| 12 – Milton Malsor Village | 9.1 | 29.2 |
| TC1 2 3 | 3.3 | 43.3 |
| TK1 | 12.0 | 76.8 |
| TK2 | 5.4 | 57.5 |
| TK3 | 12.3 | 34.8 |
| TK4 | 6.3 | 58.4 |

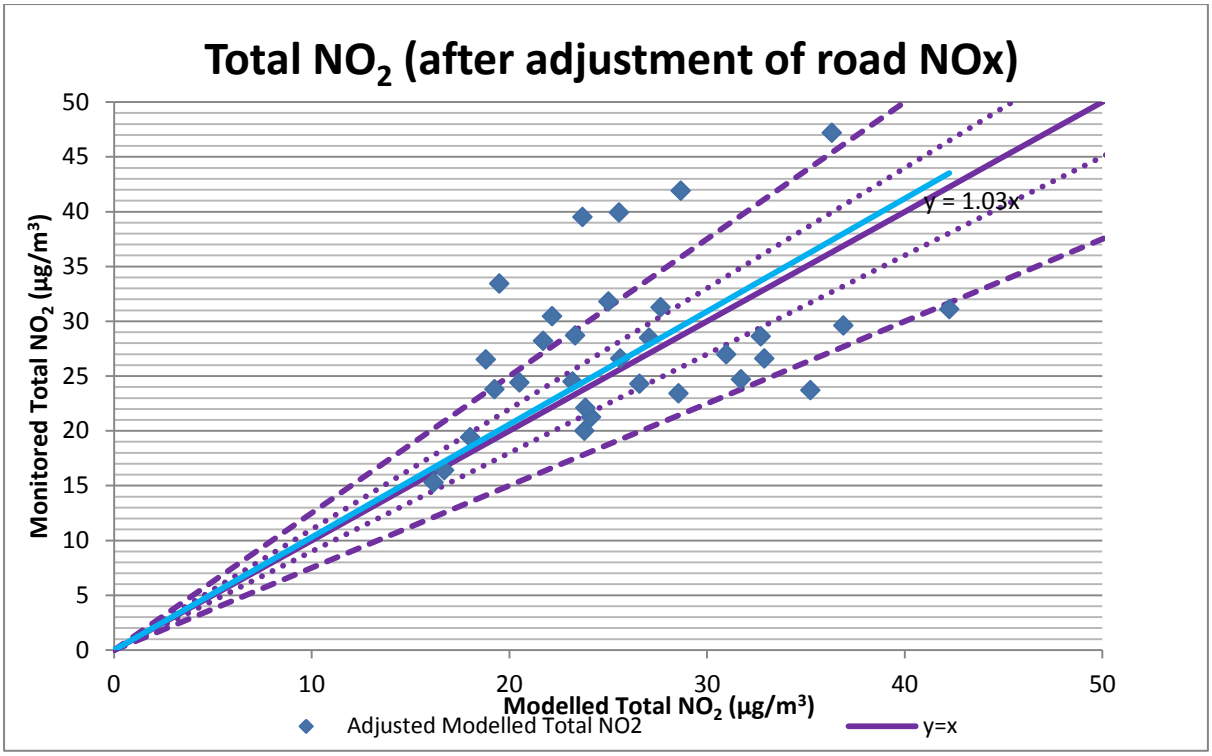
| | | |
|---|---|---|
| TK5 | 11.4 | 22.3 |
| TK6 | 10.1 | 28.4 |
| TK7 | 5.5 | 19.1 |
| TK8 | 5.2 | 32.8 |
| TK9 | 6.0 | 39.6 |
| TK43 | 10.0 | 32.6 |
| T1 | 3.0 | 28.2 |
| T2 | 9.5 | 24.4 |
| TN1 | 7.1 | 32.4 |
| TN2 | 7.9 | 63.3 |
| OS1 | 2.6 | 13.7 |
| OS2 | 5.1 | 24.0 |
| GPKa | 3.2 | 22.6 |
| RO1 | 4.4 | 31.8 |
| RO2 | 15.4 | 38.1 |
| RO3 | 6.3 | 28.4 |
| RO4 | 2.0 | 7.9 |
| RO6 | 7.4 | 38.5 |
| BR2 | 3.8 | 23.8 |
| BR4 | 6.8 | 23.6 |
| S1 | 1.8 | 5.8 |

It should be borne in mind that the monitored concentrations are themselves only estimates to the true concentrations at each point; the EU Directive on air quality designates passive $NO_2$ samplers indicative measures with a potential uncertainty of +/-30 %.

The modelled annual-mean NOx road contributions for the concentrations have been plotted against the monitored annual-mean NOx road contributions in Graph 1.




The modelled $NO_X$ contributions have been multiplied by the gradient of the trend line (4.1593) to determine the corrected $NO_X$ contributions. Modelled annual-mean $NO_2$ concentrations have been derived from the corrected modelled annual-mean $NO_X$ road contributions. The modelled annual-mean $NO_2$ concentrations have been plotted against the monitored annual-mean $NO_2$ concentrations in Graph 2.




The majority of the corrected modelled annual-mean $NO_2$ concentrations are within 25% or are greater than the monitored annual-mean $NO_2$ concentrations. The correction factor therefore improves the modelled concentrations and has been applied to all predictions (away from the motorways) used within the assessment.

The fractional bias can also be used to determine whether the corrected model has a tendency to over or under-predict. The fractional bias is calculated as:

(Average Monitored $NO_X$ Concentration – Average Predicted NOx Concentration) / 0.5 x (Average Monitored $NO_X$ + Average Predicted NOx Concentration)

Fractional bias values vary between +2 and -2 and has an ideal value of zero. A negative value suggests a model over-prediction and a positive value suggests a model under-prediction.

Table 9.3.3 sets out the average monitored concentration and the average predicted concentration.

**Table 9.3.3 Comparison of Monitored and Modelled Annual-mean Road $NO_X$ Contribution (µg.m$^{-3}$)**

| Monitoring Site | Annual-mean Road $NO_x$ Contribution (µg.m$^{-3}$) | |
|---|---|---|
| | Modelled | Monitored |
| 5 | 32.5 | 21.7 |
| 6 | 23.3 | 17.4 |
| 10 | 22.5 | 14.9 |

| | | |
|---|---|---|
| 11 | 19.2 | 36.6 |
| 12 | 37.8 | 29.2 |
| TC1 2 3 | 13.9 | 43.3 |
| TK1 | 49.9 | 76.8 |
| TK2 | 22.3 | 57.5 |
| TK3 | 51.3 | 34.8 |
| TK4 | 26.2 | 58.4 |
| TK5 | 47.4 | 22.3 |
| TK6 | 42.1 | 28.4 |
| TK7 | 22.7 | 19.1 |
| TK8 | 21.6 | 32.8 |
| TK9 | 25.1 | 39.6 |
| TK43 | 41.7 | 32.6 |
| T1 | 12.6 | 28.2 |
| T2 | 39.4 | 24.4 |
| TN1 | 29.4 | 32.4 |
| TN2 | 32.8 | 63.3 |
| OS1 | 11.0 | 13.7 |
| OS2 | 21.3 | 24.0 |
| GPKa | 13.4 | 22.6 |
| RO1 | 18.3 | 31.8 |
| RO2 | 64.2 | 38.1 |
| RO3 | 26.3 | 28.4 |
| RO4 | 8.5 | 7.9 |
| RO6 | 30.6 | 38.5 |
| BR2 | 15.9 | 23.8 |
| BR4 | 28.3 | 23.6 |
| S1 | 7.5 | 5.8 |
| **Average** | **27.7** | **31.3** |

The fractional bias for this study is therefore (31.3 – 27.7) / (0.5 x (27.7 + 31.3)) = 0.12. As the fractional bias is close to zero, the adjusted model is neither systematically over-predicting nor systematically under-predicting.