



## **APPENDIX AVAILABLE ON REQUEST**

### **Research Report 155**

#### **The Impact of the Congestion Charging Scheme on Air Quality in London**

#### **Part 1. Emissions Modeling and Analysis of Air Pollution Measurements**

**Frank Kelly et al.**

#### **Appendix I. Results for Weekday Congestion Charging Hours**

Note: Appendices Available on the Web may appear in a different order than in the original Investigators' Report, and some remnants of their original names may appear in Table and Figure numbers. HEI has not changed the content of these documents, only the letter identifier.

Appendix I was originally Appendix F2.

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## APPENDIX I

### RESULTS FOR WEEKDAY CONGESTION CHARGING HOURS

Table I.1 Controlled ratios for changes in NO<sub>x</sub> geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue compared to other roadside locations 8 km+ from zone center - congestion charging hours only

Station Name	Code	%	LCL	UCL
A3 – AURN	A30	-13.3	-20.6	-5.3
Croydon 2 - Purley Way	CR2	8.2	-0.7	18.0
Croydon 4 - George Street	CR4	2.3	-5.7	11.0
Crystal Palace 1 - C Palace Parade	CY1	5.2	-4.8	16.2
Ealing 2 - Acton Town Hall	EA2	-8.1	-16.0	0.4
Enfield 2 - Church Street	EN2	-1.3	-10.0	8.3
Enfield 4 - Derby Road Upper Edmonton	EN4	-3.3	-10.3	4.3
Greenwich Bexley 6 - A2 Falconwood	GB6	14.8	2.2	28.9
Greenwich 5 - Trafalgar Road	GR5	16.9	8.2	26.3
Haringey 1 - Town Hall	HG1	0.4	-7.8	9.5
Hillingdon 1 - South Ruislip	HI1	-1.1	-9.2	7.6
Hounslow 4 - Chiswick High Rd	HS4	-17.3	-23.3	-10.9
Havering 1 - Rainham	HV1	1.1	-7.7	10.8
Havering 3 - Romford	HV3	2.5	-6.0	11.8
Redbridge 4 - Gardner Close	RB4	-10.7	-19.6	-0.7
Richmond 1 - Castlenau	RI1	-1.5	-9.9	7.7
	FE	-1.2	-3.3	1.0
	RE	-0.9	-5.3	3.8

Notes: % - change in NO<sub>x</sub> concentrations at the within-zone site (CD3) before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates.

Table I.2 Controlled ratios for changes in NO<sub>x</sub> geometric mean concentrations before/after introduction of CCS at Bloomsbury, City of London and Westminster compared to other background locations 8 km+ from zone center - congestion charging hours only

Within charging zone background										
Bloomsbury - AURN	BL0									
City of London 1 - Senator House	CT1									
Westminster AURN	WM0									
Outer London background		BL0 %	LCL	UCL	CT1 %	LCL	UCL	WM0 %	LCL	UCL
Barnet 2 - Finchley	BN2	-1.1	-11.6	10.7	-5.3	-16.4	7.3	2.2	-10.1	16.1
Ealing 1 - Ealing Town Hall	EA1	-6.8	-16.1	3.5	-9.2	-18.9	1.6	-5.7	-16.2	6.2
Enfield 3 - Salisbury Sch Ponders End	EN3	-1.5	-11.5	9.6	-0.5	-11.2	11.5	4.3	-7.6	17.7
Harrow 1 - Stanmore Background	HR1	-4.9	-15.3	6.8	-6.8	-17.6	5.4	-1.0	-13.0	12.6
Lewisham 1 - Catford	LW1	-2.7	-12.5	8.1	0.3	-9.7	11.4	3.6	-8.0	16.8
Redbridge 1 - Perth Terrace	RB1	-2.2	-11.3	8.0	-5.0	-14.3	5.3	2.4	-8.4	14.5
Waltham Forest 1 - Dawlish Road	WL1	0.6	-9.5	11.8	-4.9	-14.8	6.1	2.6	-8.7	15.3
	FE	-2.7	-6.5	1.3	-4.4	-8.4	-0.2	1.2	-3.3	5.9
	RE	-2.7	-6.5	1.3	-4.4	-8.4	-0.2	1.2	-3.3	5.9

Notes: % - change in NO<sub>x</sub> concentrations at the within-zone sites before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates.

Table I.3 Controlled ratios for changes in NO geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue compared to other roadside locations 8 km+ from zone center - congestion charging hours only

Station Name	Code	%	LCL	UCL
A3 - AURN	A30	-12.0	-21.9	-0.8
Croydon 2 - Purley Way	CR2	10.3	-1.6	23.7
Croydon 4 - George Street	CR4	3.9	-6.4	15.3
Crystal Palace 1 - C Palace Parade	CY1	3.7	-10.2	19.9
Ealing 2 - Acton Town Hall	EA2	-8.3	-18.2	2.8
Enfield 2 - Church Street	EN2	-2.1	-13.6	10.9
Enfield 4 - Derby Road Upper Edmonton	EN4	-5.3	-14.5	4.8
Greenwich Bexley 6 - A2 Falconwood	GB6	17.8	2.2	35.9
Greenwich 5 - Trafalgar Road	GR5	17.1	6.0	29.2
Haringey 1 - Town Hall	HG1	1.3	-9.5	13.4
Hillingdon 1 - South Ruislip	HI1	0.1	-9.6	10.8
Hounslow 4 - Chiswick High Rd	HS4	-9.5	-17.6	-0.5
Havering 1 - Rainham	HV1	-2.6	-13.8	10.1
Havering 3 - Romford	HV3	1.8	-8.9	13.7
Redbridge 4 - Gardner Close	RB4	-13.4	-25.4	0.5
Richmond 1 - Castlenau	RI1	-2.6	-13.2	9.2
	FE	-0.4	-3.2	2.5
	RE	-0.4	-4.7	4.1

Notes: % - change in NO concentrations at the within-zone site (CD3) before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates

Table I.4 Controlled ratios for changes in NO geometric mean concentrations before/after introduction of CCS at Bloomsbury, City of London and Westminster compared to other background locations 8 km+ from zone center - congestion charging hours only

Within charging zone background										
Bloomsbury - AURN	BL0									
City of London 1 - Senator House	CT1									
Westminster AURN	WM0									
Outer London background		BL0 %	LCL	UCL	CT1 %	LCL	UCL	WM0 %	LCL	UCL
Barnet 2 - Finchley	BN2	-17.5	-32.7	1.2	-9.7	-25.2	9.0	-10.6	-27.0	9.3
Ealing 1 - Ealing Town Hall	EA1	-21.3	-35.2	-4.4	-10.0	-24.0	6.6	-12.8	-27.4	4.8
Enfield 3 - Salisbury Sch Ponders End	EN3	-22.2	-36.5	-4.7	-8.8	-23.2	8.3	-12.5	-27.5	5.6
Harrow 1 - Stanmore Background	HR1	-23.4	-38.0	-5.2	-16.3	-30.0	0.1	-15.5	-30.4	2.7
Lewisham 1 – Catford	LW1	-51.9	-62.6	-38.1	-3.5	-17.1	12.3	-8.1	-23.6	10.5
Redbridge 1 - Perth Terrace	RB1	-17.6	-31.4	-1.0	-8.1	-21.1	7.0	-10.7	-24.9	6.2
Waltham Forest 1 - Dawlish Road	WL1	-19.4	-34.5	-0.8	-18.9	-31.5	-4.0	-15.8	-29.9	1.1
	FE	-23.9	-29.6	-17.7	-10.5	-16.0	-4.7	-12.3	-18.3	-5.9
	RE	-25.0	-34.5	-14.2	-10.5	-16.0	-4.7	-12.3	-18.3	-5.9

Notes: % - change in NO concentrations at the within-zone sites before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates.

Table I.5 Controlled ratios for changes in NO<sub>2</sub> geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue compared to other roadside locations 8 km+ from zone center - congestion charging hours only

Station Name	Code	%	LCL	UCL
A3 - AURN	A30	-18.4	-22.9	-13.7
Croydon 2 - Purley Way	CR2	-2.4	-7.8	3.3
Croydon 4 - George Street	CR4	0.7	-4.9	6.6
Crystal Palace 1 - C Palace Parade	CY1	1.6	-4.3	7.8
Ealing 2 - Acton Town Hall	EA2	-7.6	-12.5	-2.3
Enfield 2 - Church Street	EN2	3.1	-3.3	10.0
Enfield 4 - Derby Road Upper Edmonton	EN4	-0.2	-4.7	4.5
Greenwich Bexley 6 - A2 Falconwood	GB6	8.5	0.0	17.7
Greenwich 5 - Trafalgar Road	GR5	17.9	11.6	24.6
Haringey 1 - Town Hall	HG1	0.7	-4.9	6.7
Hillingdon 1 - South Ruislip	HI1	-4.9	-10.9	1.5
Hounslow 4 - Chiswick High Rd	HS4	-29.3	-32.9	-25.4
Havering 1 - Rainham	HV1	7.4	1.0	14.2
Havering 3 - Romford	HV3	3.1	-2.7	9.3
Redbridge 4 - Gardner Close	RB4	-6.8	-12.7	-0.5
Richmond 1 - Castlenau	RI1	1.4	-5.1	8.3
	FE	-2.9	-4.4	-1.5
	RE	-2.2	-7.8	3.6

Notes: % - change in NO<sub>2</sub> concentrations at the within-zone site (CD3) before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates

Table I.6 Controlled ratios for changes in NO<sub>2</sub> geometric mean concentrations before/after introduction of CCS at Bloomsbury, City of London and Westminster compared to other background locations 8 km+ from zone center - congestion charging hours only

Within charging zone background										
Bloomsbury - AURN	BL0									
City of London 1 - Senator House	CT1									
Westminster AURN	WM0									
Outer London background		BL0 %	LCL	UCL	CT1 %	LCL	UCL	WM0 %	LCL	UCL
Barnet 2 - Finchley	BN2	28.2	17.6	39.8	1.6	-6.6	10.6	9.0	-0.5	19.4
Ealing 1 - Ealing Town Hall	EA1	6.3	-1.7	15.1	-8.0	-14.4	-1.2	-3.2	-10.6	4.9
Enfield 3 - Salisbury Sch Ponders End	EN3	23.7	13.4	35.0	9.5	1.2	18.5	15.1	5.6	25.4
Harrow 1 - Stanmore Background	HR1	16.9	5.2	29.8	3.0	-6.1	13.0	8.9	-1.3	20.1
Lewisham 1 - Catford	LW1	23.0	11.1	36.1	3.0	-4.2	10.7	8.3	-0.3	17.7
Redbridge 1 - Perth Terrace	RB1	15.9	7.2	25.3	0.2	-6.4	7.3	9.1	0.9	17.9
Waltham Forest 1 - Dawlish Road	WL1	30.6	19.8	42.5	7.6	-0.2	15.9	16.2	7.0	26.2
	FE	19.9	16.0	23.9	2.0	-0.9	5.0	8.7	5.3	12.3
	RE	20.2	14.0	26.8	2.1	-2.1	6.6	8.8	4.0	13.8

Notes: % - change in NO<sub>2</sub> concentrations at the within-zone sites before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates.

Table I.7 Controlled ratios for changes in PM<sub>10</sub> geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue compared to other roadside locations 8 km+ from zone center - congestion charging hours only

Station Name	Code	%	LCL	UCL
A3 – AURN	A30	-7.9	-13.7	-1.8
Croydon 4 - George Street	CR4	7.4	1.3	13.8
Crystal Palace 1 - C Palace Parade	CY1	19.0	12.3	26.1
Ealing 2 - Acton Town Hall	EA2	0.9	-5.4	7.7
Enfield 2 - Church Street	EN2b	2.8	-4.5	10.7
Enfield 4 - Derby Road Upper Edmonton	EN4b	1.8	-5.0	9.0
Greenwich Bexley 6 - A2 Falconwood	GB6	-1.2	-7.9	6.1
Greenwich 5 - Trafalgar Road	GR5	5.5	-1.1	12.4
Haringey 1 - Town Hall	HG1	6.1	-0.2	12.9
Hillingdon 1 - South Ruislip	HI1	-2.5	-8.8	4.3
Hounslow 4 - Chiswick High Rd	HS4	3.5	-2.8	10.2
Havering 3 – Romford	HV3	2.9	-3.8	10.0
Redbridge 4 - Gardner Close	RB4b	-2.7	-9.1	4.1
Richmond 1 – Castlenau	RI1	-2.3	-8.3	4.1
	FE	2.5	0.7	4.3
	RE	2.3	-0.9	5.6

Notes: % - change in PM<sub>10</sub> concentrations at the within-zone site (CD3) before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates



Table I.8 Controlled ratios for changes in PM<sub>10</sub> geometric mean concentrations before/after introduction of CCS at Bloomsbury compared to other background locations 8 km+ from zone center - congestion charging hours only

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Within charging zone background				
Bloomsbury - AURN	BL0			
Outer London background		BL0 %	LCL	UCL
Barnet 2 - Finchley	BN2	-15.4	-22.1	-8.1
Enfield 3 - Salisbury Sch Ponders End	EN3b	-5.2	-13.6	4.0
Harrow 1 - Stanmore Background	HR1	-10.0	-17.3	-2.1
Redbridge 1 - Perth Terrace	RB1b	-17.0	-23.5	-9.9
Waltham Forest 1 - Dawlish Road	WL1	-12.8	-20.1	-4.9
	FE	-12.5	-15.8	-9.1
	RE	-12.4	-16.3	-8.4

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Notes: % - change in PM<sub>10</sub> concentrations at the within-zone sites before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals; FE & RE – fixed and random effects summary estimates

Table I.9 Controlled ratios for changes in CO geometric mean concentrations before/after introduction of CCS at Bloomsbury compared to other background locations 8 km+ from zone center - congestion charging hours only

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Within charging zone background							
Bloomsbury - AURN	BL0						
Westminster AURN	WM0						
Outer London background							
		BL0 %	LCL	UCL	WM0 %	LCL	UCL
Enfield 3 - Salisbury Sch Ponders End	EN3	-22.9	-30.0	-15.1	-13.8	-21.5	-5.3

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Notes: % - change in CO concentrations at the within-zone sites before and after the introduction of the CCS as a percentage of the corresponding change measured at individual outer-London sites. LCL & UCL – lower and upper 95% confidence intervals.

Figure I.1 Changes in NO<sub>x</sub> geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue (within zone) compared to changes at sites 8 km+ from zone center - congestion charging hours only

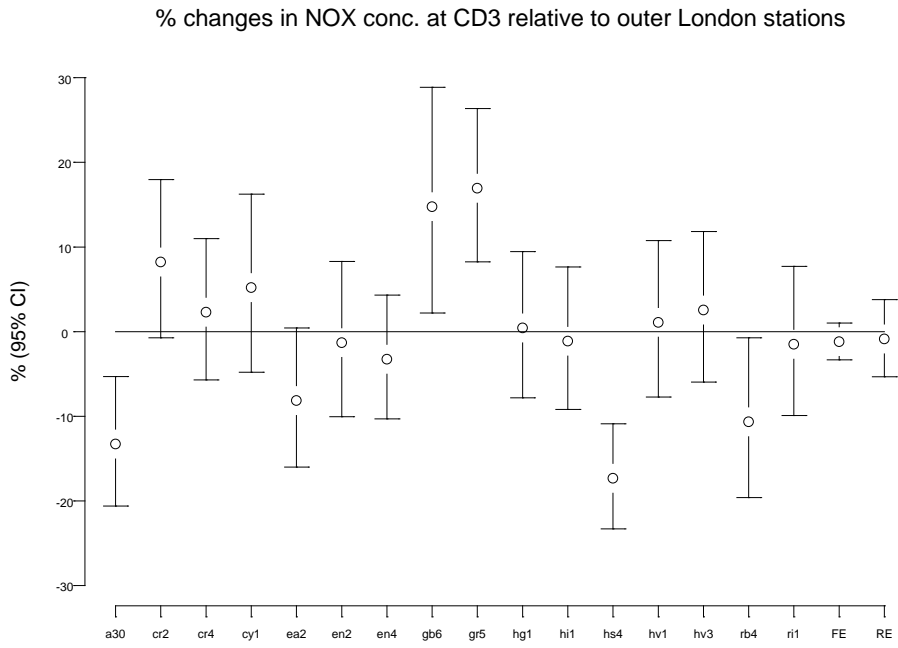
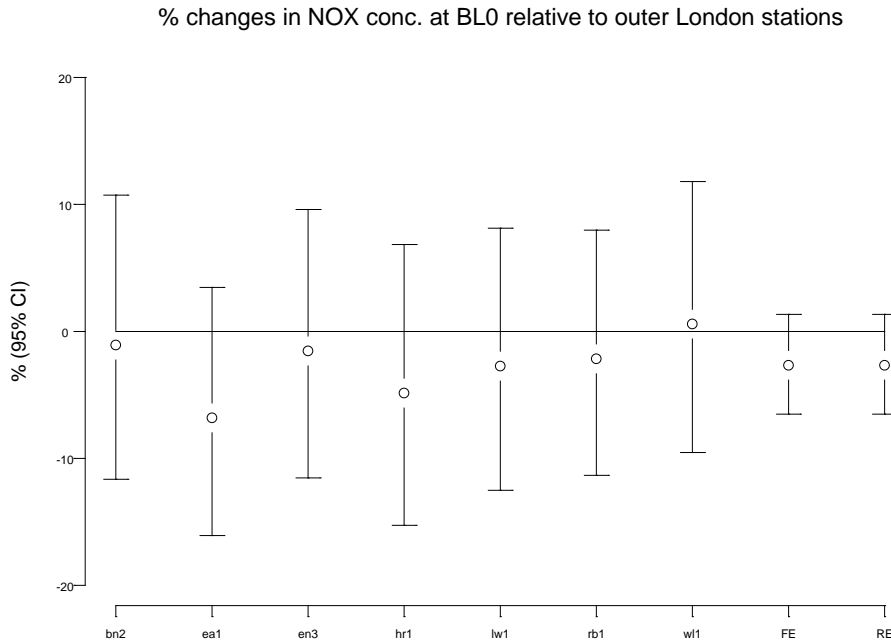
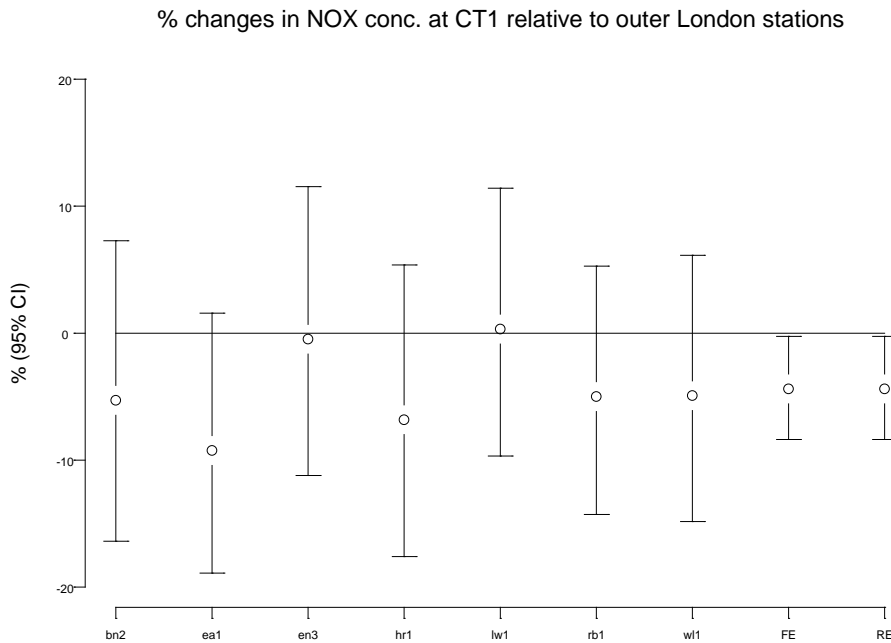


Figure I.2 Changes in NO<sub>x</sub> geometric mean concentrations before/after introduction of CCS at background locations within zone compared to changes at sites 8 km+ from zone center - congestion charging hours only

a) Bloomsbury, BL0



b) City of London, CT1



c) Westminster, WM0

% changes in NOX conc. at WM0 relative to outer London stations

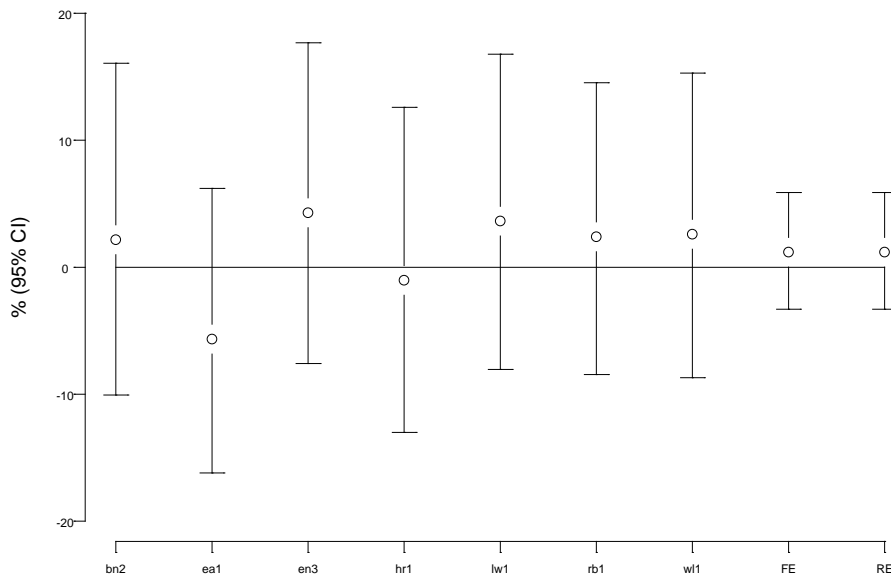


Figure I.3. Changes in NO geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue (within zone) compared to changes at sites 8 km+ from zone center - congestion charging hours only

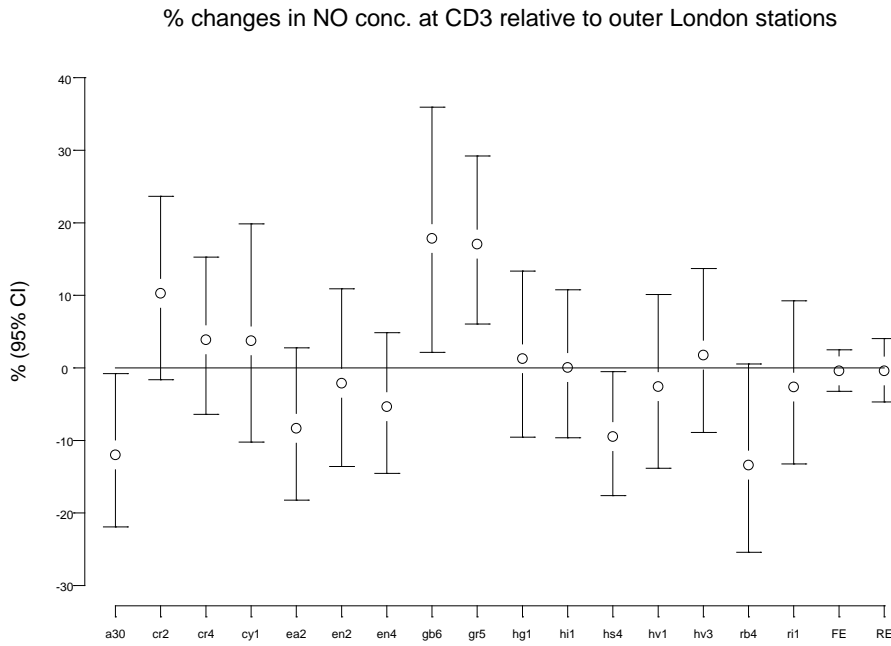
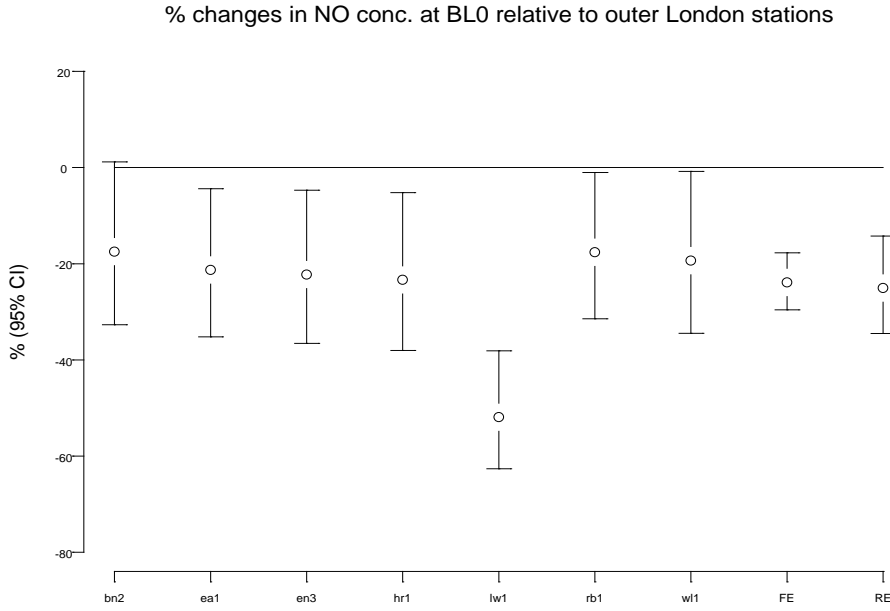
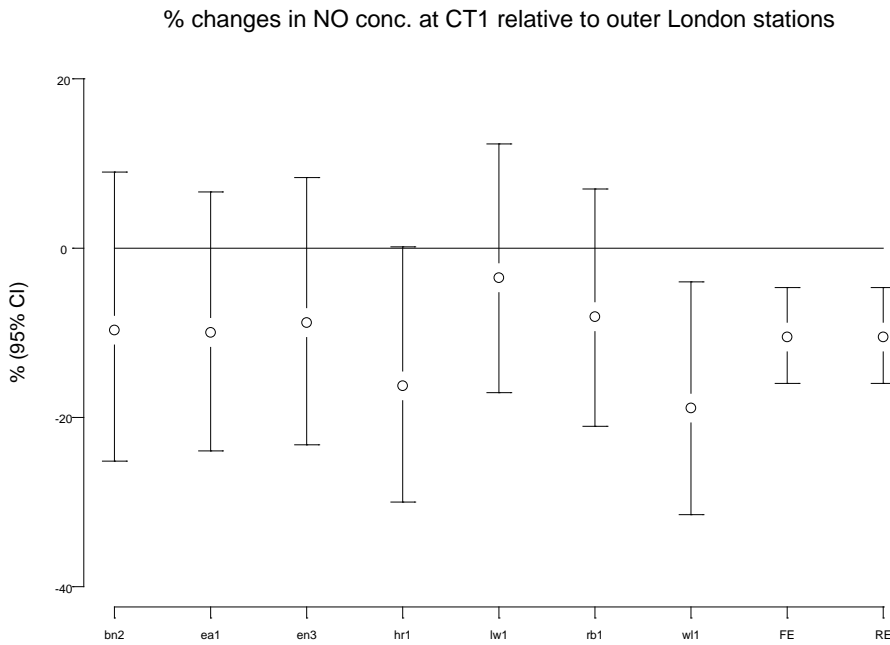


Figure I.4. Changes in NO geometric mean concentrations before/after introduction of CCS at background locations within zone compared to changes at sites 8 km+ from zone center - congestion charging hours only

a) Bloomsbury, BL0



b) City of London, CT1



### c) Westminster, WM0

% changes in NO conc. at WM0 relative to outer London stations

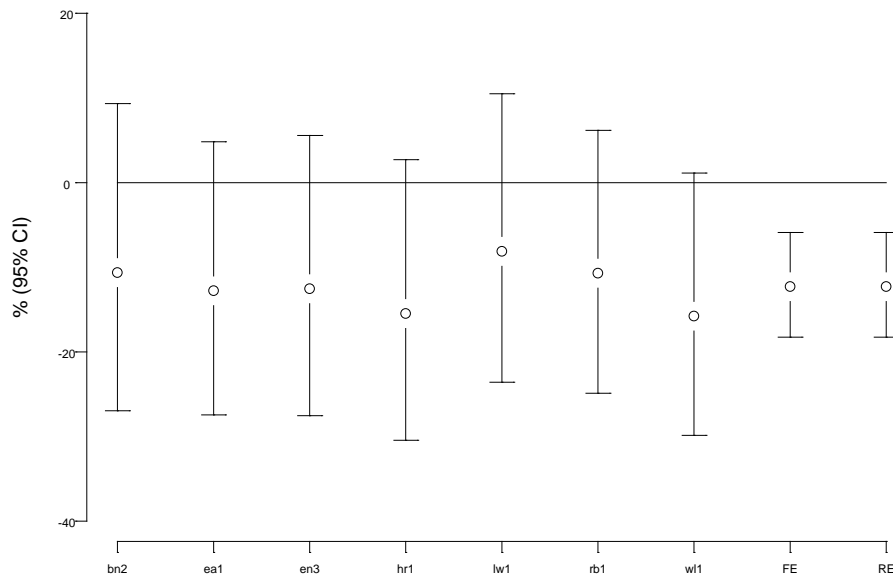




Figure I.5. Changes in NO<sub>2</sub> geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue (within zone) compared to changes at sites 8 km+ from zone center - congestion charging hours only

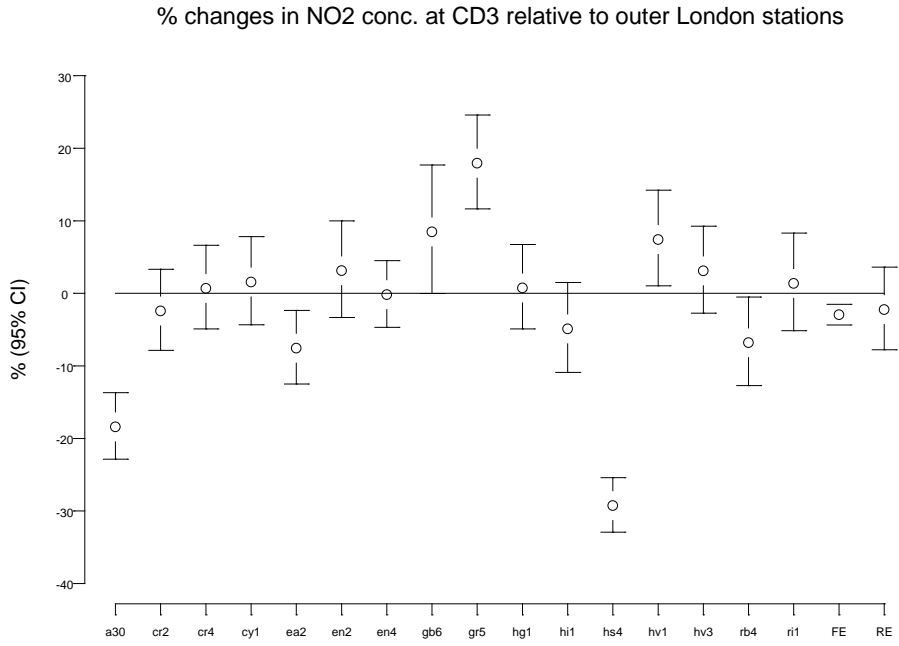
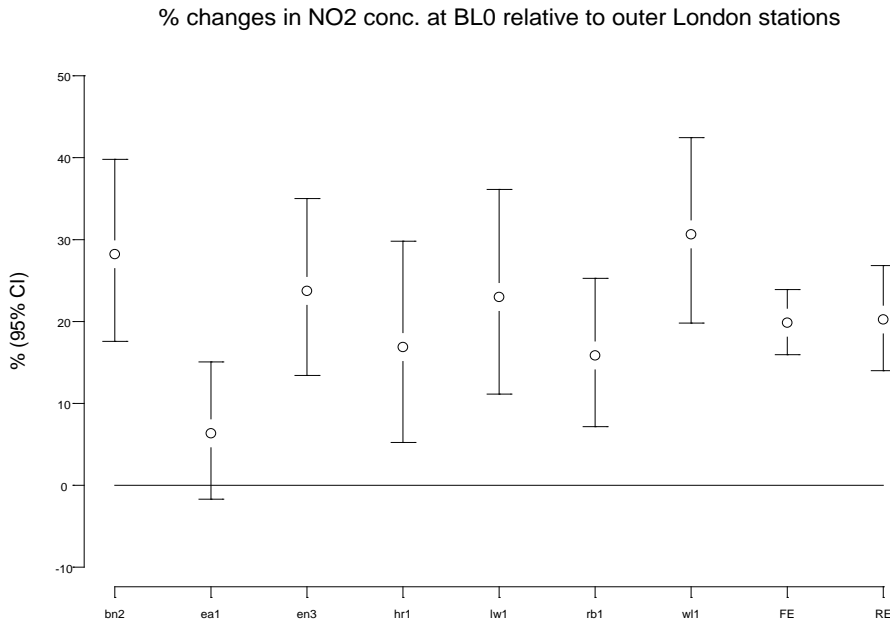
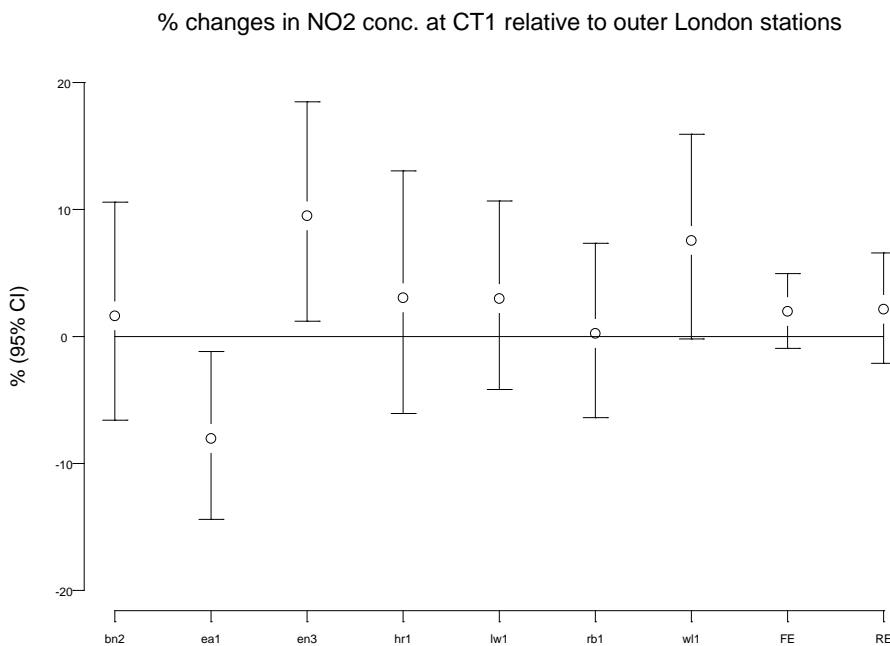


Figure I.6. Changes in NO<sub>2</sub> geometric mean concentrations before/after introduction of CCS at background locations within zone compared to changes at sites 8 km+ from zone center - congestion charging hours only

a) Bloomsbury, BL0



b) City of London, CT1



c) Westminster, WM0

% changes in NO<sub>2</sub> conc. at WM0 relative to outer London stations

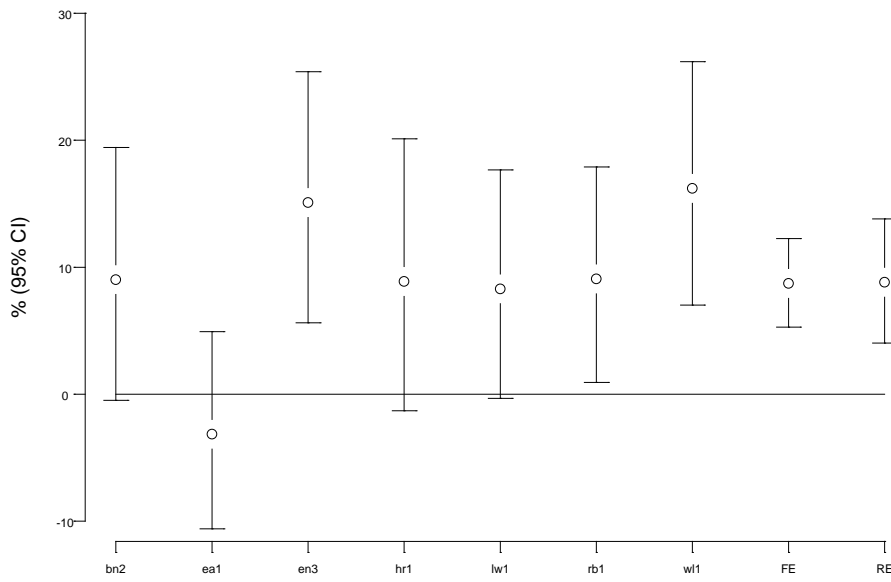


Figure I.7. Changes in PM<sub>10</sub> geometric mean concentrations before/after introduction of CCS at Shaftesbury Avenue (within zone) compared to changes at sites 8 km+ from zone center - congestion charging hours only

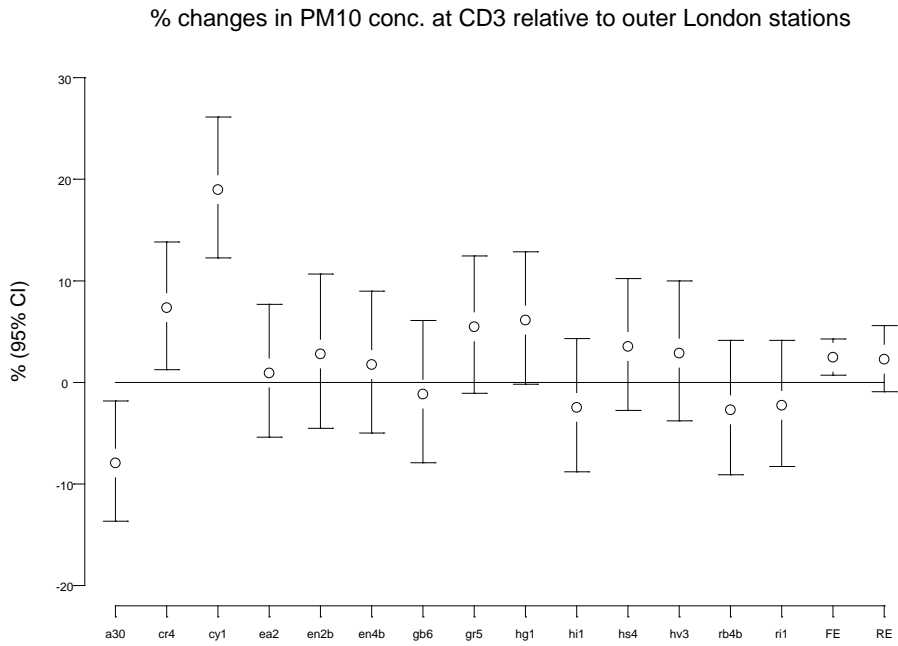


Figure I.8. Changes in PM<sub>10</sub> geometric mean concentrations before/after introduction of CCS at Bloomsbury (within zone) compared to changes at sites 8 km+ from zone center - congestion charging hours only

