Local Plan

Air Quality Modelling Methodology Report (AQ2)

Coventry City Council

10 September 2019

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This document has 38 pages including the cover.

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 2.0	Initial Evidence Submission	SP	JM	PJT	PJT	04/10/2018
Rev 3.0	Outline Business Case	SP	JM	PJT	PJT	15/01/2019
Rev 4.0	Revised Air Quality Modelling	JM	SJP	PJT	PJT	14/06/2019
Rev 5.0	Revised Air Quality Modelling	JM	SJP	PJT	PJT	12/09/2019

Client signoff

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1. Introduction

1.1. Content

This deliverable (AQ2) outlines the methodology for and inputs to the air quality modelling used to inform Coventry Council's Local Air Quality Plan.

The Air Quality Modelling Report (AQ3) reports the results of applying this approach.

The Analytical Assurance Statement provides an overall assessment of the uncertainty associated with the modelling and the results of sensitivity and uncertainty tests undertaken relating to air quality (emissions and dispersion) modelling.

1.2. Air Quality Model Revisions

A number of updates and improvements have been made to the air quality modelling approach compared to that employed prior to the submission of the Outline Business Case (OBC) in January 2019. These revisions have been made in the time available since the OBC was submitted and following receipt of additional monitoring data and comments from the Technical Independent Review Panel (T-IRP). These revisions include:

- the addition of more recent monitoring data for diffusion tubes on Holyhead Road and the Inner Ring Road giving a longer period of monitoring and hence more confidence in the annual mean concentrations derived at these locations and used in model verification;
- refining the modelled geometry of a small number of sections of the A4053 Inner Ring Road so that an individual emission source is now modelled for each carriageway, as opposed to a single emission source for both carriageways. The purpose of these modifications was to better reflect the effect on roadside NO_2 concentrations of differences in traffic flows by direction, particularly in response to proposed measures; and
- Use of the advanced street canyon module in ADMS-Roads (as an enhancement to the standard street canyon modelling included in previous submissions), at the suggestion of the T-IRP (see Section 4.3.4).

These updates and revisions have resulted in improved model performance at the majority of monitoring sites used in the model verification process and consequently a reduction in the model adjustment factors applied across the model domain.

2. Approach

2.1. Chosen Model

The ADMS-Roads (version 4.1.1) dispersion model was used to estimate the contribution from road traffic emission sources to annual mean NOx concentrations at selected receptor locations. This model is widely used and has been validated against measured data[1].

Emissions were calculated outside of ADMS-Roads and were reflected in the model using a diurnal emissions profile (.FAC file). The chemistry module within ADMS-Roads was not used, instead NOx to NO_2 chemistry was reflected using modelled Road-NOx and Road-NO_2 concentrations in Defra's 'NOx to NO_2 Calculator' v6.1 (Nov 17).

The contribution from other sources at modelled receptor locations was estimated using Defra background maps (with the estimated contribution from modelled road sources removed from the background contribution to avoid double counting) using Defra's 'NO_2 Adjustment for NOx Sector Removal Tool' v6.0 (Nov 17).

2.2. Chosen Model Domain

The chosen model domain is shown in Figure A-1 of Appendix A and includes the majority of roads in Coventry. The extent and resolution of the model domain has been informed by the locations of exceedances of the annual mean NO_2 EU limit value identified by Defra's PCM model (see Figure A-2 of Appendix A) and the road links explicitly included within Coventry Area Strategic Model (CASM).

2.3. Years Modelled

The following years were explicitly modelled:

- 2017 (the base year);
- 2021 (the compliance assessment year); and
- 2030 (a future year to aid interpolation beyond 2021 and to inform emissions estimates). This is an enhancement on the approach used in the IES.

Intervening years were interpolated (see Section 4.8).

[1] http://www.cerc.co.uk/environmental-software/model-validation.html

3. Traffic Data

3.1. Traffic Flow Data

The Coventry Area Strategic Model (CASM) estimates flows of buses, cars, light goods vehicles (LGVs) and Heavy Goods Vehicles (HGVs) during the weekday AM peak hour (08:00-09:00), Inter-Peak (1-hour average) and PM peak hour (17:00-18:00).

Vehicle type specific expansion factors have been developed to allow expansion of these modelled hourly vehicle flows so as to be representative of the weekday AM period (07:00 – 10:00), IP period (10:00 – 16:00) and PM period (16:00 – 19:00). These expansion factors are shown in Table 1.

Off-Peak (OP) period flows (19:00 – 07:00) have also been estimated from the weekday 12-hour daytime flow derived by using vehicle type specific expansion factors. These expansion factors are shown in Table 2.

Table 1 – Vehicle Type Expansion Factors (Peak to Period)

Vehicle Class	AM	IP	PM
Car, LGV, HGV	2.634	6.265	2.710
Bus	2.418	4.660	2.052

Table 2 – Vehicle Type Expansion Factors (Off-Peak)

Vehicle Class	Off-peak factor (12hr to 24hr factor)
Car, LGV, HGV	1.117
Bus	1.036

3.2. Vehicle Speed Data

Average vehicle speeds for each modelled road-link were obtained from the CASM traffic model for AM, IP and PM peak hours. The average speeds for the IP hour were also used for modelled OP periods in the absence of modelled data.

Modelled speeds were used as opposed to observed speeds (e.g. those derived from TrafficMaster data) for the following reasons:

- The results of the model verification process (see AQ3) indicated that model performance was acceptable using modelled speeds;
- TrafficMaster data were only available for Coventry for the AM and PM peak periods (i.e. 25% of the day) meaning that modelled speeds would in any case have had to be used for the remaining time periods (i.e. 75% of the day);
- Using modelled speeds allowed the effect of changes in average speeds in future years to be accounted for (e.g. as a result of increased congestion or changes to the modelled road network), which was particularly relevant for a number of road links in the study area; and
- Using modelled speeds allowed the effect of reduced congestion as a result of proposed measures to be taken into account (e.g. measures aimed at reducing congestion and / or flows during peak periods).

3.3. Vehicle Fleet Composition

The traffic flows described in Section 3.1 were further disaggregated into the sub-categories described in Table 3 using the results of a week-long Automatic Number Plate Recognition (ANPR) survey undertaken in November 2017 and/or, where necessary, using ratios derived from the basic fleet projection data included within Defra's Emission Factors Toolkit (EFT). For example, observed proportions of petrol hybrid cars were disaggregated into proportions of full and plug-in hybrids respectively using the corresponding ratio of the proportions of these vehicle types given in the EFT.

An average vehicle fleet composition was estimated for Coventry by averaging the observations over all of the ANPR survey sites. The locations of ANPR survey sites are shown in Figure A-3 of Appendix A.

Table 3 – Vehicle Type Sub-Categories

Vehicle Category	Sub-Categories (ANPR)	Sub-Categories (Basic fleet projection)
Car	Petrol Car	
	Diesel Car	
	Petrol Hybrid Car	Full Petrol Hybrid Car
		Plugin Hybrid Petrol Car
	Full Diesel Hybrid Car	
	Battery EV Car	
	LPG Car	
	Taxis (Black Cabs)	
LGV	Petrol LGV	
	Diesel LGV	
	Petrol Hybrid LGV	Full Petrol Hybrid LGV
		Plugin Hybrid Petrol LGV
	LPG LGV	
HGV	Rigid HGV	
	Artic HGV	
		Coaches
Bus	Bus	

The proportion of vehicles in each sub-category in 2021 was estimated from the observed 2017 data by applying the corresponding ratio between the 2017 and 2021 basic fleet projection data contained within the EFT. This for example, results in a greater proportion of electric vehicles in 2021 than observed in 2017.

The fleet composition data used in the modelling, for 2017, 2021 and 2030, are shown in Table 4.

Table 4 – Average Fleet Composition for Coventry

Vehicle Category	Vehicle Sub-Category	Proportion of Vehicle Fleet		
		2017	2021	2030
Car	Petrol Car	0.50	0.46	0.41
	Diesel Car	0.44	0.46	0.40
	Full Petrol Hybrid Car	0.01	0.02	0.03
	Plugin Hybrid Petrol Car	<0.01	0.01	0.09
	Full Diesel Hybrid Car	<0.01	<0.01	0.01
	Battery EV Car	<0.01	<0.01	0.02
	LPG Car	<0.01	<0.01	<0.01
	Taxis (Black Cabs)	0.04	0.04	0.04
LGV	Petrol LGV	0.01	0.01	<0.01
	Diesel LGV	0.99	0.99	0.95
	Full Petrol Hybrid LGV	<0.01	<0.01	<0.01

Vehicle Category	Vehicle Sub-Category	Proportion of Vehicle Fleet		
		2017	2021	2030
	Plugin Hybrid Petrol LGV	<0.01	<0.01	<0.01
	Battery EV LGV	<0.01	<0.01	0.05
HGV	Rigid HGV	0.47	0.46	0.46
	Artic HGV	0.26	0.26	0.28
	Coaches	0.27	0.28	0.26
Buses	Buses	1.00	1.00	1.00

3.4. Euro Standard Composition

Euro standard composition by vehicle type was also derived from the results of the ANPR survey (for the base year 2017). Again, an average Euro standard composition was estimated for Coventry by averaging the observations over all of the ANPR survey sites so that a single average figure could be used to define the proportions of 'compliant' and 'non-compliant' vehicles in the study area when estimating the impacts of a Clean Air Zone (CAZ) in the CASM traffic model.

Euro standard composition by vehicle type in 2021 and 2030 was estimated using the Fleet Projection tool in the EFT (v 8.0.1a). Option 1 was used, with a base year of 2017, which assumes the future year Euro fleet composition has the same difference in Euro classes as observed between the default base year profile in the EFT and that observed in the ANPR data.

In order to account for the effect on Euro standard composition in 2021 of specific measures aimed at improving the local vehicle fleet within Coventry, which are already planned and funded, the following modifications have also been made:

- To account for the likely impact of Early Measures Funding for taxis (black cabs), it has been assumed that 70 of the 816 taxis (black cabs) in the local taxi fleet will upgrade to Zero Emission Capable (ZEC) taxis (8.6%); and
- The impact of buses being retrofitted to meet the Euro VI emission standard as part of the Clean Bus Technology Fund (CBTF) programme has been accounted for by reducing the projected proportion of buses in each Euro standard below Euro VI in 2021 by the expected change in the Euro standard composition of the local bus fleet as a result of the CBTF programme. The proportion of Euro VI buses was then increased accordingly. A total of 104 out of 303 buses (i.e. 34% of the local bus fleet) will be upgraded to Euro VI as a result of the CBTF programme.

The Euro standard composition data used in the modelling, is shown in Table 5.

It should be noted that no Euro 6d vehicles (which are due to enter the fleet in 2020) are projected to be in the Coventry vehicle fleet in 2021 by the EFT Fleet Projection Tool. According to JAQU, this is most likely because observed Euro standard proportions in Coventry in 2017 are closest to those in the EFT for 2015, which are then projected forward by the tool four years to 2019 (i.e. the difference between the base year 2017 and the forecast year 2021), when there are no Euro 6d vehicles in the fleet.

Table 5 – Average Euro Standard Composition for Coventry

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet		
		2017	2021	2030
Petrol Car	Pre-Euro	<0.01	-	-
	Euro 1	<0.01	-	-
	Euro 2	0.02	<0.01	-
	Euro 3	0.21	0.04	-
	Euro 4	0.30	0.16	<0.01
	Euro 5	0.22	0.23	0.03

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet		
		2017	2021	2030
	Euro 6	0.15	0.13	0.04
	Euro 6c	0.09	0.44	0.92
Diesel Car	Pre-Euro	<0.01	-	-
	Euro 1	<0.01	-	-
	Euro 2	<0.01	<0.01	-
	Euro 3	0.11	0.02	-
	Euro 4	0.26	0.13	<0.01
	Euro 5	0.36	0.30	0.03
	Euro 6	0.16	0.19	0.05
	Euro 6c	0.10	0.36	0.16
	Euro 6d	-	- [a]	0.76
Petrol LGV	Pre-Euro	0.21	-	-
	Euro 1	0.03	<0.01	-
	Euro 2	0.01	-	-
	Euro 3	0.14	0.04	-
	Euro 4	0.39	0.20	<0.01
	Euro 5	0.18	0.29	0.01
	Euro 6	0.04	0.21	0.01
	Euro 6c	-	0.26	0.97
Diesel LGV	Pre-Euro	<0.01	-	-
	Euro 1	<0.01	-	-
	Euro 2	<0.01	-	-
	Euro 3	0.06	0.01	-
	Euro 4	0.33	0.12	<0.01
	Euro 5	0.45	0.25	0.03
	Euro 6	0.16	0.16	0.03
	Euro 6c	-	0.46	0.10
	Euro 6d	-	- [a]	0.84
Rigid HGV	Pre-Euro	<0.01	-	-
	Euro I	<0.01	-	-
	Euro II	0.02	<0.01	-
	Euro III	0.13	0.03	-
	Euro IV	0.19	0.08	<0.01
	Euro V EGR	0.07	0.04	<0.01
	Euro V SCR	0.22	0.12	0.01
	Euro VI	0.36	0.72	0.99
Artic HGV	Pre-Euro	<0.01	-	-

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet		
		2017	2021	2030
	Euro I	<0.01	-	-
	Euro II	0.01	<0.01	-
	Euro III	0.06	0.01	-
	Euro IV	0.07	0.01	<0.01
	Euro V EGR	0.07	0.02	<0.01
	Euro V SCR	0.22	0.07	<0.01
	Euro VI	0.57	0.89	1.00
Buses	Pre Euro	<0.01	-	-
	Euro I	<0.01	-	-
	Euro II	0.01	-	-
	Euro III	0.18	0.05	-
	Euro IV	0.15	0.02	<0.01
	Euro V EGR	0.10	0.03	<0.01
	Euro V SCR	0.31	0.09	0.01
	Euro VI	0.24	0.80	0.98
Coaches	Pre Euro	<0.01	-	-
	Euro I	<0.01	-	-
	Euro II	0.01	-	-
	Euro III	0.18	0.06	-
	Euro IV	0.15	0.07	<0.01
	Euro V EGR	0.10	0.07	0.01
	Euro V SCR	0.31	0.22	0.03
	Euro VI	0.24	0.57	0.96
Taxis (Black Cabs)	Pre-Euro	0.07	0.06	0.06
	Euro 1	0.08	0.07	0.07
	Euro 2	0.01	0.01	0.01
	Euro 3	0.44	0.40	0.40
	Euro 4	0.36	0.33	0.33
	Euro 5	0.04	0.04	0.04
	Euro 6	-	-	-
	Euro 6c	-	-	-
	Euro 6d	-	-	-
	ZEC	-	0.09	0.09

4. Modelling Methodology

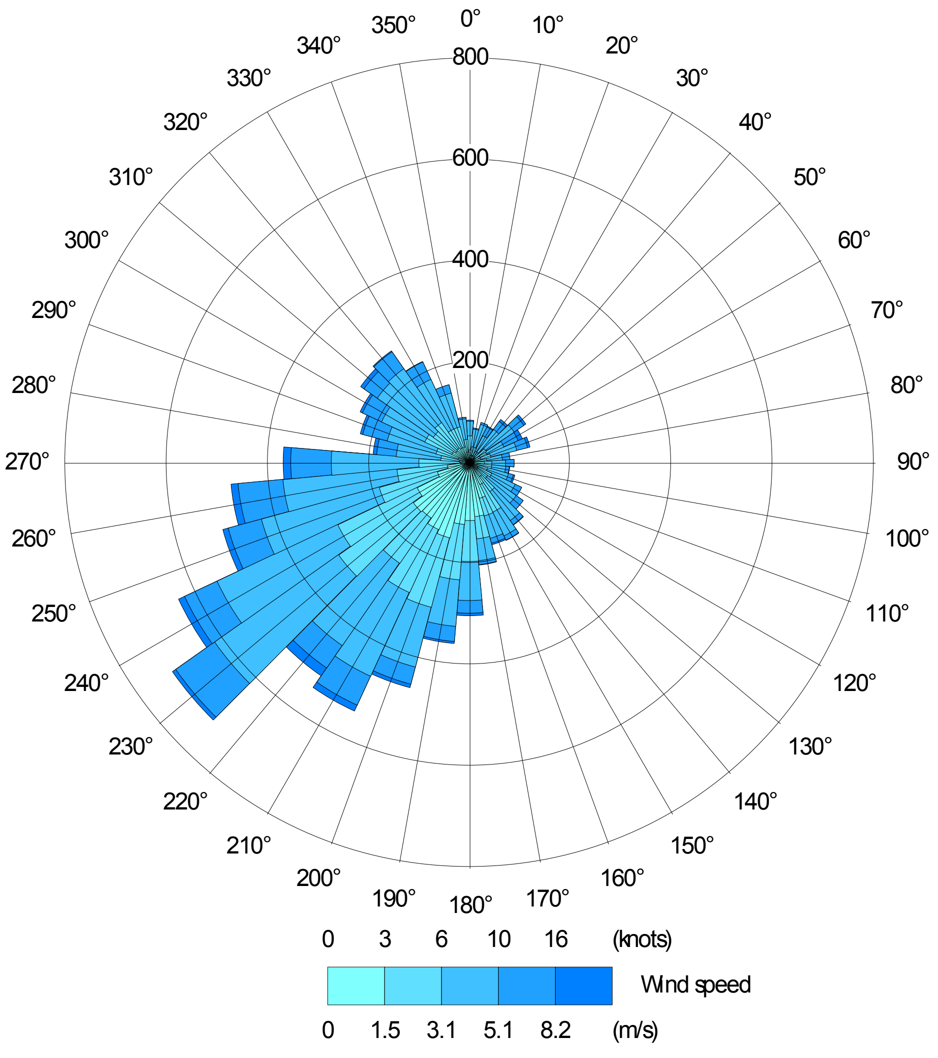
4.1. Meteorological Data

Meteorological data from Coventry Airport for the year 2017 were used in the dispersion modelling, a wind rose for which can be seen in Figure 4-1, with missing data infilled using data from Church Lawford. Data from this site was used as it was considered the most representative of the study area (e.g. this site is the closest to the study area and has similar characteristics).

These data indicate that the prevailing wind is from the southwest.

Data were used in the modelling as ADMS-formatted files representing 8,760 sets of hourly data.

Figure 4-1 - Windrose for Coventry Airport (2017)



4.2. Model Settings

The following model settings were applied within the ADMS dispersion model:

- Surface roughness = 0.3m (at the meteorological measurement site), which represents agricultural areas (max.) and 1.0 m (at the dispersion site), which represents cities (indicative of the Coventry central urban study area); and
- Minimum Monin-Obukhov length = 30m, which represents cities and large towns.

4.3. Specific Model Treatments

4.3.1. Elevated Road Sections

A number of road sections within the modelled study area (including those representing some PCM links) are substantially elevated compared to other nearby roads and sensitive receptors. As such, and in order to account for the influence of this elevation on pollutant dispersion, these sections of road were modelled at a relative height of between 4m and 10m, measured in accordance with JAQU Evidence Guidance on 'Dispersion modelling of flyovers and tunnels'. The locations, extent and modelled heights of these link are shown in Figure A-4.

The majority of these roads are located along the A4053 inner ring road, with the main carriageway of the inner ring road undulating as it passes both over and under key interchanges around the city centre. It has not been possible to model road links that are below ground level (i.e. in cutting), so these road links have been modelled at grade, which would generally provide a worst-case estimate of annual mean NO_2 concentrations.

Aside from the A4053 inner ring road, other elevated sections include:

- A444 where it is elevated above the A4600;
- Southbound flyover where the A4114 meets the A444;
- Cheylesmore interchange on the A444;
- A45 where it is elevated above the A444;
- A45 Dunchurch Highway at Allesley;
- Western section of the M6; and
- The A46 where it becomes the M69 over the M6.

4.3.2. Tunnels

There is a single section of the inner ring road (A4053) that is enclosed within a tunnel to the south of the city centre, immediately north of Coventry railway station. This has been modelled as a volume source in ADMS in accordance with JAQU Evidence Guidance on 'Dispersion modelling of flyovers and tunnels'. The location and extent of this volume source is shown in Figure A-6.

4.3.3. Road Gradients

Gradient effects were included, in accordance with the methodology set out in LAQM.TG16, for a number of key road links within the model where gradients in excess of 2.5% were identified. The locations of these links within the air quality model domain are shown in Figure A-5, coloured by the degree of the modelled road gradient.

Road gradients were estimated for each road link from freely available LIDAR Digital Surface Model data[2] at 1m resolution, based on the relative height of the start and end point of each link. Where gradients in excess of 2.5% were identified using this method, the heights derived were verified manually using height differences measured using GoogleEarth.

4.3.4. Street Canyons

Canyon effects were accounted for across the entire model domain by using the Advanced Canyon Module in ADMS-Roads. The Advanced Canyon Module inputs were automatically generated using the 'Street Canyon Tool' add-in for ArcGIS. Inputs for this tool included geographically correct road polylines and Ordnance Survey (OS) MasterMap building polygons with associated OS height data. The building height used in the canyon tool was the 'eaves height' with minor, manual corrections made in key locations.

The settings within the 'Street Canyon Tool' add-in for ArcGIS were set to the same parameters the model developers (CERC) used whilst verifying the tool in London (i.e. a representative location). Collation of Coventry-specific datasets for these parameters was not possible in the programme. These included:

- Building distance tolerance (proportion) – 0.3;
- Building distance tolerance (metres) – 14;

[2] https://environment.data.gov.uk/ds/survey/#/survey

- Precision mode – ADMS;
- Target minimum proportion of road with buildings – 0.0; and
- Maximum distance to the nearest building (metres) – 40.

The extent of the canyons modelled are presented in Figure A-5.

Of particular relevance to this study is the approach taken along Holyhead Road where the highest annual mean NO_2 concentrations in Coventry are observed. These elevated concentrations are thought to be as a result of a combination of factors including inhibited pollutant dispersion as a result of nearby buildings. The modelled extent of the modelled street canyon for Holyhead Road is shown below in Figure 4-2. The modelled street canyon parameters for the eastbound and westbound carriageways of Holyhead Road respectively are presented in Table 6.

Figure 4-2 – Modelled Extents of Street Canyons for Holyhead Road

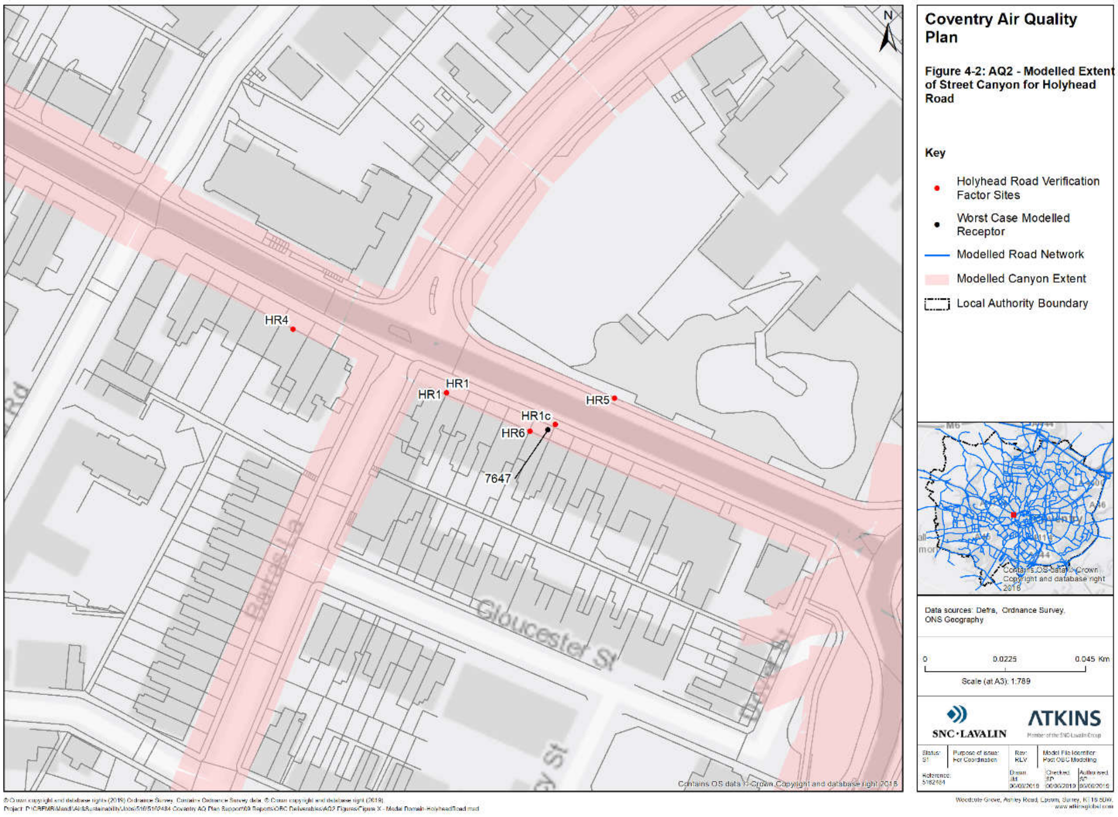


Table 6 – Holyhead Road Advanced Canyon Parameters (m)

Carriageway	Canyon	Width	Average Height	Minimum Height	Maximum Height	Canyon Length	Building Length
Eastbound	Right	14.8	6.4	3.0	8.4	124.7	118.4
	Left	3.8	2.0	2.0	2.0	52.0	52.0
Westbound	Right	8.7	2.0	2.0	2.0	52.0	52.0
	Left	10.4	6.5	3.0	8.4	138.2	125.2

4.4. Road-NOx Emissions

Hourly Road-NOx emissions (in g/km/s) were calculated for weekday AM, IP, PM, OP periods respectively using the traffic flows by vehicle type, sub-category and Euro Standard and average vehicle speed data described in Section 0, together with corresponding NOx emission factors extracted from the EFT (v 8.0.1a) for the relevant year.

Weekend emissions were estimated by factoring the weekday emissions in each period by the ratio of weekday traffic flows to weekend traffic flows during each period derived from an Automatic

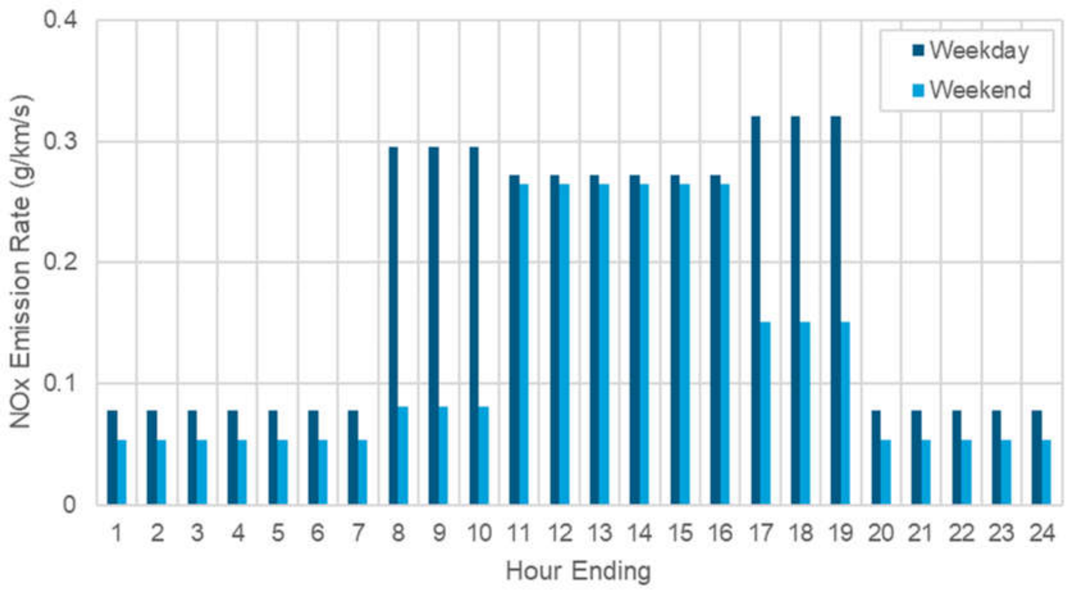
Traffic Count site within the study area. The factors applied to each period are provided in Table 7 below.

Table 7 - Weekday vs Weekend Traffic Count Factors

Period	Weekday Flow	Weekend Flow	Ratio
AM	74,236	20,311	0.27
IP	112,077	109,051	0.97
PM	78,753	36,889	0.47
OP	65,115	44,975	0.69

Estimated hourly NOx emissions for each road-link were input to the dispersion model using a time varying emissions file, an example of which is shown in Figure 4-3.

Figure 4-3 – Example Time Varying Emissions Profile for a Southern Section of the A4053 Inner Ring Road



4.5. Primary NO_2

The fraction of primary NO_2 (f-NO_2) at each modelled receptor was estimated by modelling both Road-NOx and Road-NO_2 emissions for each modelled road-link. Road-NO_2 emissions were estimated for each link by multiplying the estimated Road-NOx emission rate (g/km/s) for each vehicle type / Euro standard by the corresponding f-NO_2 fraction contained within the EFT (v8.0.1a). This process was repeated for each modelled year.

4.6. Background NO_2 Concentrations

No emission sources other than major roads were explicitly modelled. All other sources were reflected in the variable backgrounds used. Defra mapped background NO_2 concentrations (for a 2015 reference year) were used in the modelling, with the "in-square" contribution from Motorways and A-roads removed using Defra's Sector Removal Tool (v 6.0) to avoid double counting.

4.7. NO_2 from NOx Calculations

Annual mean NO_2 concentrations were estimated from modelled Road-NOx concentrations using Defra's 'NOx to NO_2 Calculator' v6.1 (Nov 17) and the modelled fNO_2 at each receptor.

4.8. Intervening years

Annual mean NO_2 concentrations in intervening years (i.e. those between 2017 and 2021, and between 2021 and 2030) were estimated by linearly interpolating modelled Road-NOx and Road-NO_2 concentrations at each modelled receptor and then applying the specific Defra mapped background concentration for that year (with the “in-square” contribution from Motorways and A-roads removed).

An additional future year was modelled (2030) as it was thought that, when interpolating beyond 2021 based solely on the results for 2017 and 2021, future year NO_2 concentrations and the interpolated compliance date for certain links, particularly link 37731, were heavily influenced by changes to the physical road network between the modelled base year (2017 - but derived from a 2013 base year traffic model) and 2021, and the associated impact on traffic flows. Annual mean NO_2 concentrations beyond 2021 were therefore estimated by interpolating between modelled concentrations in 2021 and 2030.

4.9. Model Verification

The outputs of the base year model were verified in accordance with the methodology described within LAQM.TG16 against the results of monitoring undertaken by Coventry City Council. These data are provided in Appendix B and their locations shown in Figure A-7 of Appendix A.

A number of diffusion tubes within close proximity of modelled road links (16 out of 65) were excluded from the model verification process because either:

- the monitored concentration was significantly different to those monitored in the vicinity (i.e. HR2c);
- the geometry of the road network in the 2017 base year model does not correspond with the geometry of the real-world network (i.e. LON8, STL1, QV1 and BL1);
- an adjacent road link is not included in the base traffic model (i.e. GF1);
- low data capture results in insufficient confidence in measured concentrations (i.e. CS3, FGS4, KG1, EB1, SA1, SA2, SA3, HL1 and BS1); or
- the location was too close to a complex junction which is difficult to replicate in the air quality model (i.e. QAV01).

Model verification steps and findings are reported in AQ3.

5. Proposed Measures

The 2021 Do-Minimum scenario accounts for the impact of Early Measures committed to in Coventry (e.g. travel planning focused on the A4600) – details of which are provided in the traffic modelling methodology report (T3).

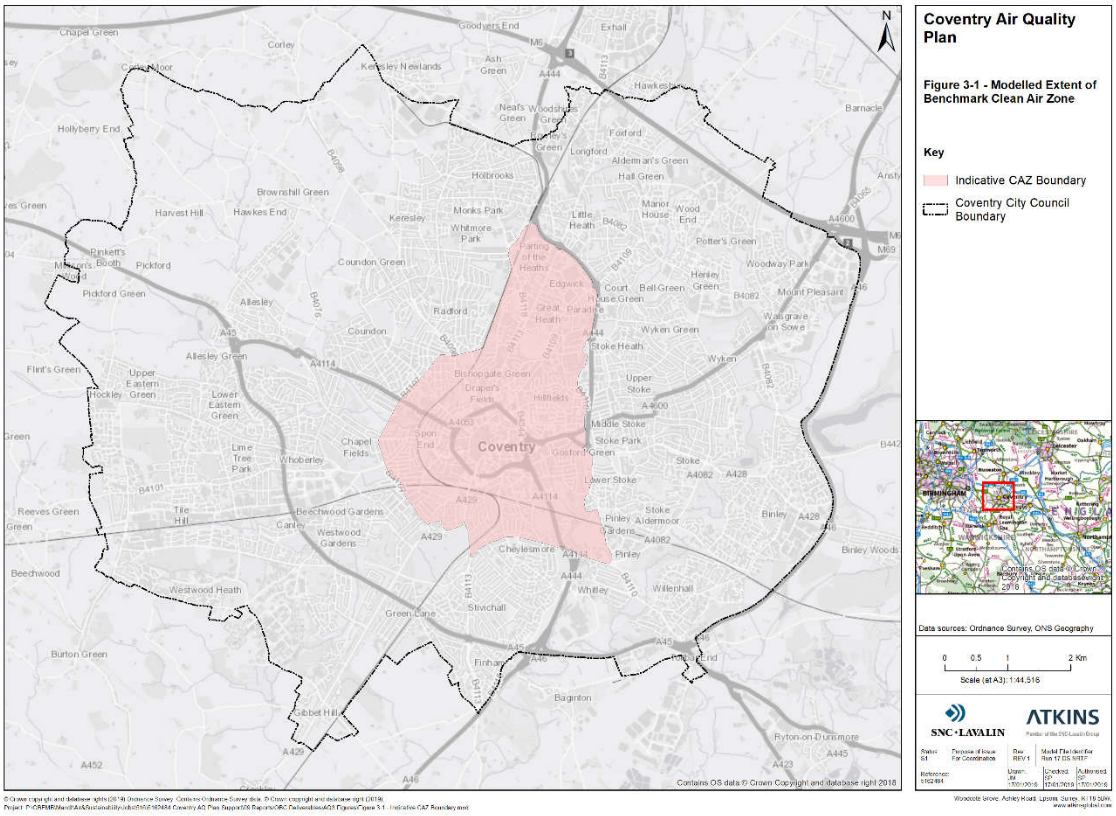
T3 also describes in detail the methodology and sources of data used to estimate the impact of proposed measures on traffic flows and vehicle speeds within the modelled study area. Information on the methodologies used to estimate the effect of individual measures within the air quality modelling process is provided below.

5.1. Benchmark Clean Air Zone (Class D)

The benchmark Clean Air Zone (CAZ) considered consists of Class D CAZ (i.e. affecting buses, coaches, taxis, private hire vehicles, LGVs, HGVs and private cars) with a daily toll of £8.00 for Cars and LGVs and £50 for HGVs and coaches to enter the zone. The extent of the benchmark CAZ is presented in Figure 4-1 below.

A range of upgrade responses to the charge have been considered, as presented within the Analytical Assurance Statement, ranging from 'no upgrade' to the upgrade responses proposed by JAQU.

Figure 5-1 – Modelled Extent of Benchmark Clean Air Zone



5.1.1. Compliant / Non-Compliant Vehicle Proportions

The impact of the benchmark Class D Clean Air Zone (CAZ) was modelled in CASM, which accounted for the Do-Minimum proportions of 'compliant' and 'non-compliant' vehicles shown in Table 8. These proportions were derived from the projected fleet composition data shown in Table 4 and Table 5.

Table 8 – Do-Minimum Complaint / Non-Compliant Proportions

Vehicle Category	Proportion of Vehicle Fleet			
	2021		2030	
	Compliant	Non-Compliant	Compliant	Non-Compliant
Car	73%	27%	95%	5%
LGV	62%	38%	97%	3%
HGV	72%	28%	98%	2%

5.1.2. Behavioural Response

The CASM model provided flows of 'compliant', 'non-compliant' and 'upgraded' cars, LGVs and HGVs on each road link within the study area, together with resulting average speeds, based on the assumed behavioural responses of non-complaint vehicle owners to the CAZ (i.e. pay charge, cancel journey / use alternative mode, re-route or upgrade). The default upgrade assumptions published in 'JAQU Evidence Guidance' are understood to be derived from survey responses given by London residents / businesses to a planned Ultra Low Emission Zone (ULEZ). These upgrade assumptions are considered to be overly optimistic for Coventry given the difference in the geographical scale of the London ULEZ and the benchmark CAZ considered by Coventry and socio-economic differences between London and Coventry. As such, an assumed 'West Midlands' upgrade response has been derived, which has been informed by work undertaken by Birmingham City Council for the Birmingham CAZ study given the relative proximity and similar socio-economic conditions between Birmingham and Coventry. The modelled 'West Midlands' upgrade responses are summarised in Table 9, along with the default JAQU upgrade responses for comparison.

The 'West Midlands' responses have been explicitly modelled within CASM to give a more locally realistic representation of those likely to pay the charge and those that are likely to re-distribute as a result of the benchmark CAZ.

Table 9 – Modelled Upgrade Responses

Scenario	Cars	LGVs	HGVs	Coaches
JAQU (default)	64.3%	63.8%	82.6%	71.9%
West Midlands	32.0%	25.0%	62.0%	62.0%

Note: % is the proportion of that vehicle type that would upgrade under the CAZ scenario

5.1.3. Fleet Composition

Modelled flows of 'non-compliant', 'compliant' and 'upgraded' vehicle classes from CASM were modelled with a different fleet composition based upon:

- normalised projected fleet composition data for 'compliant' and 'non-compliant' vehicles respectively (see Table 4 and Table 5);
- the behavioural responses suggested by JAQU for those vehicles which are 'upgraded' as a result of a CAZ, namely:
  - 75% replace their non-compliant vehicle with a second-hand compliant vehicle, whilst 25% will scrap their vehicle and buy a new one of the same fuel type; and
  - for cars, 75% of those replacing will purchase the cheapest compliant vehicle (so diesel will switch to petrol) while the remainder remain within the same fuel type.

In the benchmark CAZ scenario, it was assumed that all non-compliant buses would be upgraded or retrofitted to a minimum of Euro VI, whilst all taxis (black cabs) would be upgraded (50% to Euro 6 / 50% to ZEC), but that a CAZ in itself would not have a material impact on absolute traffic flows for these vehicle types.

The fleet and Euro composition data used in the modelling for 'compliant', 'non-compliant' and 'upgraded' vehicles are shown in Table 10 and Table 11 respectively.

Table 10 – CAZ Fleet Composition Data

Vehicle Category	Vehicle Sub-Category	Compliant	Non-Compliant	Upgrade
Car	Petrol Car	0.58	0.07	0.57
	Diesel Car	0.33	0.89	0.39
	Full Petrol Hybrid Car	0.03	<0.01	<0.01
	Plugin Hybrid Petrol Car	0.02	-	-
	Full Diesel Hybrid Car	<0.01	<0.01	<0.01
	Battery EV Car	<0.01	-	-
	LPG Car	<0.01	-	-
	Taxis (Black Cabs)	0.04	0.04	0.04
LGV	Petrol LGV	0.01	<0.01	<0.01
	Diesel LGV	0.99	1	1
	Full Petrol Hybrid LGV	0.03	-	-
	Plugin Hybrid Petrol LGV	0.02	-	-
	Battery EV LGV	<0.01	-	-
HGV	Rigid HGV	0.46	0.47	0.47
	Artic HGV	0.32	0.1	0.1
	Coaches	0.22	0.43	0.43
Buses	Buses	1	-	-

Table 11 – CAZ Euro Standard Composition Data (2021)

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet		
		Compliant	Non-Compliant	Upgraded
Petrol Car	Euro 2	-	0.02	-
	Euro 3	-	0.98	-
	Euro 4	0.16	-	0.83
	Euro 5	0.24	-	-
	Euro 6	0.14	-	-
	Euro 6c	0.46	-	0.17
Diesel Car	Euro 2	-	<0.01	-
	Euro 3	-	0.05	-
	Euro 4	-	0.29	-
	Euro 5	-	0.66	-

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet		
		Compliant	Non-Compliant	Upgraded
	Euro 6	0.34	-	0.50
	Euro 6c	0.66	-	-
	Euro 6d	-	-	0.50
Petrol LGV	Euro 1	-	0.04	-
	Euro 2	-	-	-
	Euro 3	-	0.96	-
	Euro 4	0.20	-	0.75
	Euro 5	0.30	-	-
	Euro 6	0.22	-	-
	Euro 6c	0.27	-	0.25
Diesel LGV	Euro 3	-	0.03	-
	Euro 4	-	0.32	-
	Euro 5	-	0.65	-
	Euro 6	0.26	-	0.75
	Euro 6c	0.74	-	-
	Euro 6d	-	-	0.25
Rigid HGV	Euro II	-	<0.01	-
	Euro III	-	0.11	-
	Euro IV	-	0.30	-
	Euro V EGR	-	0.14	-
	Euro V SCR	-	0.43	-
	Euro VI	1.00	-	1.00
Artic HGV	Euro II	-	0.01	-
	Euro III	-	0.10	-
	Euro IV	-	0.10	-
	Euro V EGR	-	0.20	-
	Euro V SCR	-	0.59	-
	Euro VI	1.00	-	1.00
Buses	Euro VI	1.00	-	-
Coaches	Pre Euro	-	-	-
	Euro I	-	-	-
	Euro II	-	-	-
	Euro III	-	0.15	-
	Euro IV	-	0.17	-
	Euro V EGR	-	0.17	-
	Euro V SCR	-	0.52	-

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet		
		Compliant	Non-Compliant	Upgraded
	Euro VI	1.00	-	1.00
Taxis (Black Cabs)	Euro 6	0.50	0.50	0.50
	ZEC	0.50	0.50	0.50

5.2. DS13L

Option DS13L consists of the following package of measures:

- Peak time restrictions on Holyhead Road (inbound AM, outbound PM);
- Interpeak restrictions on Holyhead Road (three hours inbound and three hours outbound);
- High quality cycle infrastructure along Coundon Road;
- Capacity improvements along Spon End;
- Redesign of Ring Road Junction 7;
- Closure of Barras Lane between Coundon Road and Holyhead Road;
- Opening of Upper Hill Street allowing a left in / left out movement with the Inner Ring Road clockwise;
- Replacement of two thirds of the bus movements on Foleshill Road with electric buses; and
- Restricting the right-hand turn movement from Cash's Lane to Foleshill Road southbound.

The effect of the proposed package of measures contained within DS13L, on traffic flows and average vehicle speeds was estimated within CASM (see T4 for further details).

5.2.1. Fleet Composition

It was also assumed in this scenario that all non-compliant buses would be upgraded or retrofitted to a minimum of Euro VI, whilst 50% of the baseline taxi fleet (black cabs) would be upgraded to ZEC.

The fleet and Euro composition data used in the DS13L scenario are shown in Table 12 and Table 13 respectively.

Table 12 – Assumed Average Fleet Composition in DS13L Scenario

Vehicle Category	Vehicle Sub-Category	Proportion of Vehicle Fleet			
		2021		2030	
		Compliant	Non-compliant	Compliant	Non-compliant
Car	Petrol Car	0.58	0.07	0.41	-
	Diesel Car	0.33	0.89	0.39	0.96
	Full Petrol Hybrid Car	0.03	<0.01	0.03	<0.01
	Plugin Hybrid Petrol Car	0.02	-	0.10	<0.01
	Full Diesel Hybrid Car	<0.01	<0.01	0.01	<0.01
	Battery EV Car	<0.01	-	0.02	<0.01
	LPG Car	<0.01	-	<0.01	<0.01

Vehicle Category	Vehicle Sub-Category	Proportion of Vehicle Fleet			
		2021		2030	
		Compliant	Non-compliant	Compliant	Non-compliant
	Taxis (Black Cabs)	0.04	0.04	0.04	0.04
LGV	Petrol LGV	0.01	<0.01	<0.01	<0.01
	Diesel LGV	0.99	1.00	0.95	1.00
	Full Petrol Hybrid LGV	0.03	-	<0.01	<0.01
	Plugin Hybrid Petrol LGV	0.02	-	<0.01	<0.01
	Battery EV LGV	<0.01	-	0.04	<0.01
HGV	Rigid HGV	0.46	0.47	0.47	0.32
	Artic HGV	0.32	0.10	0.28	0.02
	Coaches	0.22	0.43	0.25	0.66
Buses	Buses	1.00	-	1.00	-

Table 13 – Assumed Euro Standard Composition in DS13L Scenario

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet			
		2021		2030	
		Compliant	Non-compliant	Compliant	Non-compliant
Petrol Car	Pre-Euro	-	-	-	-
	Euro 1	-	-	-	-
	Euro 2	-	0.02	-	-
	Euro 3	-	0.98	-	-
	Euro 4	0.16	-	<0.01	-
	Euro 5	0.24	-	0.03	-
	Euro 6	0.14	-	0.04	-
	Euro 6c	0.46	-	0.92	-
Diesel Car	Pre-Euro	-	-	-	-
	Euro 1	-	-	-	-
	Euro 2	-	<0.01	-	-
	Euro 3	-	0.05	-	-
	Euro 4	-	0.29	-	0.09
	Euro 5	-	0.66	-	0.91
	Euro 6	0.34	-	0.05	-
	Euro 6c	0.66	-	0.16	-
	Euro 6d	-[a]	-	0.78	-

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet			
		2021		2030	
		Compliant	Non-compliant	Compliant	Non-compliant
Petrol LGV	Pre-Euro	-	-	-	-
	Euro 1	-	0.04	-	-
	Euro 2	-	-	-	-
	Euro 3	-	0.96	-	-
	Euro 4	0.20	-	<0.01	-
	Euro 5	0.30	-	0.01	-
	Euro 6	0.22	-	0.01	-
	Euro 6c	0.27	-	0.97	-
Diesel LGV	Pre-Euro	-	-	-	-
	Euro 1	-	-	-	-
	Euro 2	-	-	-	-
	Euro 3	-	0.03	-	-
	Euro 4	-	0.32	-	0.14
	Euro 5	-	0.65	-	0.86
	Euro 6	0.26	-	0.03	-
	Euro 6c	0.74	-	0.10	-
	Euro 6d	0.00	-	0.86	-
Rigid HGV	Pre-Euro	-	-	-	-
	Euro I	-	-	-	-
	Euro II	-	<0.01	-	-
	Euro III	-	0.11	-	-
	Euro IV	-	0.30	-	0.32
	Euro V EGR	-	0.14	-	0.17
	Euro V SCR	-	0.43	-	0.51
	Euro VI	1.00	-	1.00	-
Artic HGV	Pre-Euro	-	-	-	-
	Euro I	-	-	-	-
	Euro II	-	0.01	-	-
	Euro III	-	0.10	-	-
	Euro IV	-	0.10	-	0.04
	Euro V EGR	-	0.20	-	0.24
	Euro V SCR	-	0.59	-	0.72
	Euro VI	1.00	-	1.00	-
Buses	Pre Euro	-	-	-	-
	Euro I	-	-	-	-
	Euro II	-	-	-	-

Vehicle Category	Euro Standard	Proportion of Vehicle Fleet			
		2021		2030	
		Compliant	Non-compliant	Compliant	Non-compliant
	Euro III	-	-	-	-
	Euro IV	-	-	-	-
	Euro V EGR	-	-	-	-
	Euro V SCR	-	-	-	-
	Euro VI	1.00	-	1.00	-
Coaches	Pre Euro	-	-	-	-
	Euro I	-	-	-	-
	Euro II	-	-	-	-
	Euro III	-	0.15	-	-
	Euro IV	-	0.17	-	0.08
	Euro V EGR	-	0.17	-	0.23
	Euro V SCR	-	0.52	-	0.69
	Euro VI	1.00	-	1.00	-
Taxis (Black Cabs)	Pre-Euro	0.03	0.03	0.03	0.03
	Euro 1	0.04	0.04	0.04	0.04
	Euro 2	0.01	0.01	0.01	0.01
	Euro 3	0.20	0.20	0.20	0.20
	Euro 4	0.16	0.16	0.16	0.16
	Euro 5	0.02	0.02	0.02	0.02
	Euro 6	-	-	-	-
	Euro 6c	-	-	-	-
	Euro 6d	-	-	-	-
	ZEC	0.54	0.54	0.54	0.54

5.3. DS14 – Benchmark CAZ + Additional Measures

As required by the Ministerial Direction (dated March 2019), an additional scenario including a wider CAZ D along with additional measures has been assessed. The proportion of compliant and non-compliant vehicles, behavioural responses, fleet composition and euro composition were modelled as per the Benchmark CAZ detailed in Section 5.1.

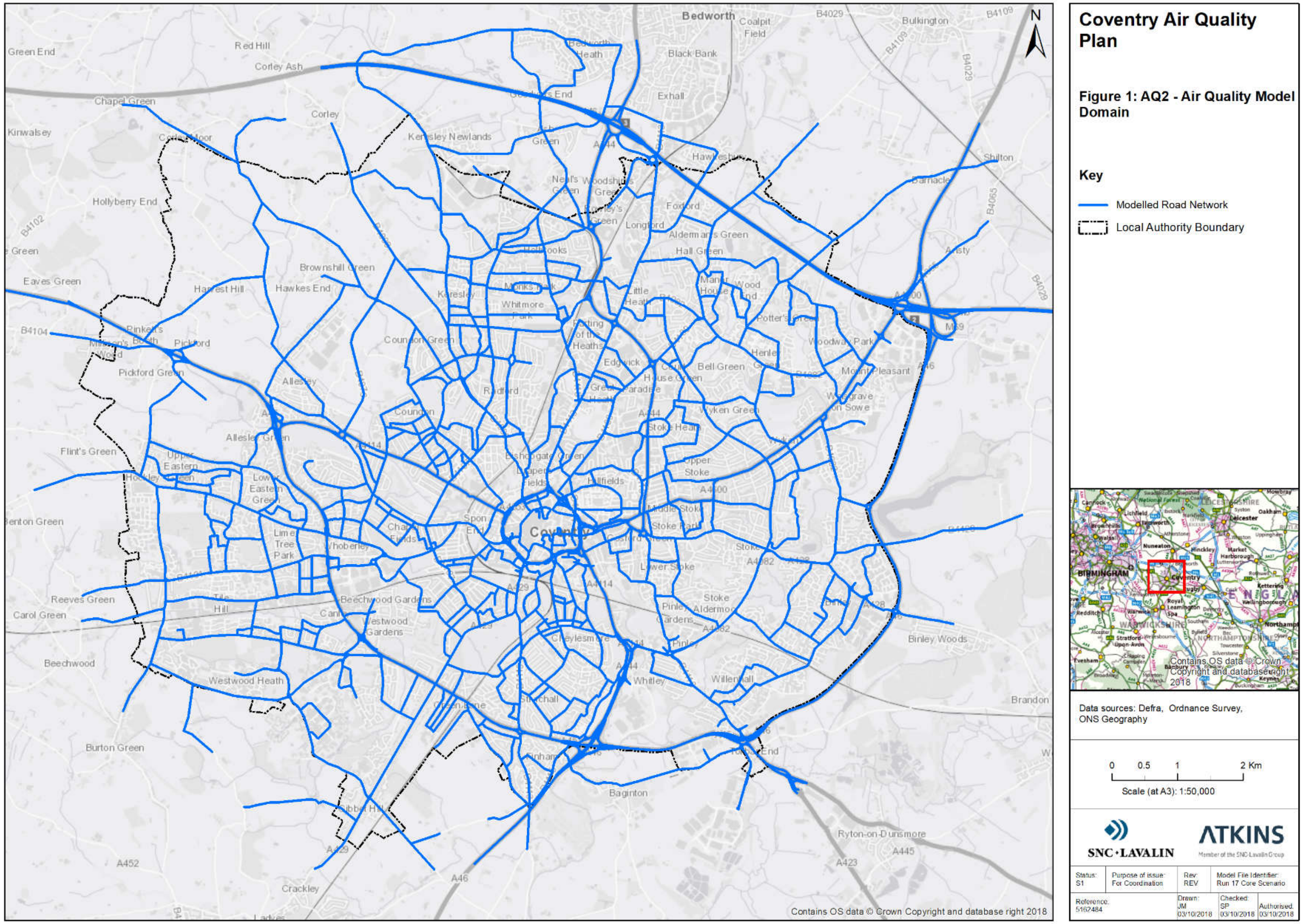
The additional measures included in this scenario, which were also included in DS13L, include:

- High quality cycle infrastructure along Coundon Road;
- Capacity improvements along Spon End;
- Redesign of Ring Road Junction 7;
- Closure of Barras Lane between Coundon Road and Holyhead Road; and
- Opening of Upper Hill Street allowing a left in / left out movement with the Inner Ring Road clockwise.

Appendices

Appendix A. Figures

Figure A-1 - Air Quality Model Domain



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Project: P:\GBEMB\MandI\Air&Sustainability\Jobs\516\5162484 Coventry AQ Plan Support\09 Reports\ES deliverables\AQ2 Figures\Figure 1 - Model Domain.mxd

Woodcote Grove, Ashley Road, Epsom, Surrey, KT18 5BW.
www.atkinsglobal.com

Figure A-2 – Defra PCM Link Locations

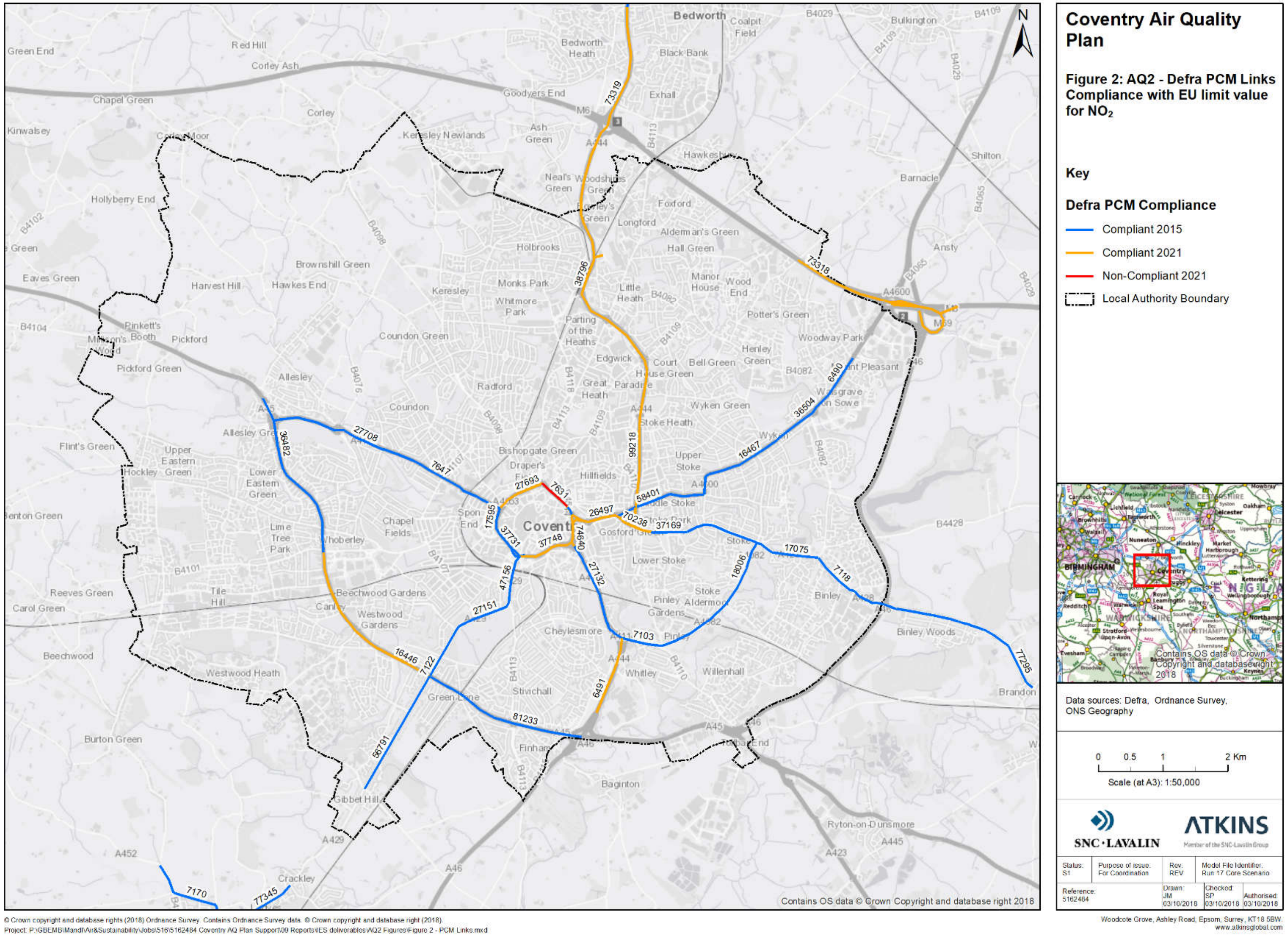
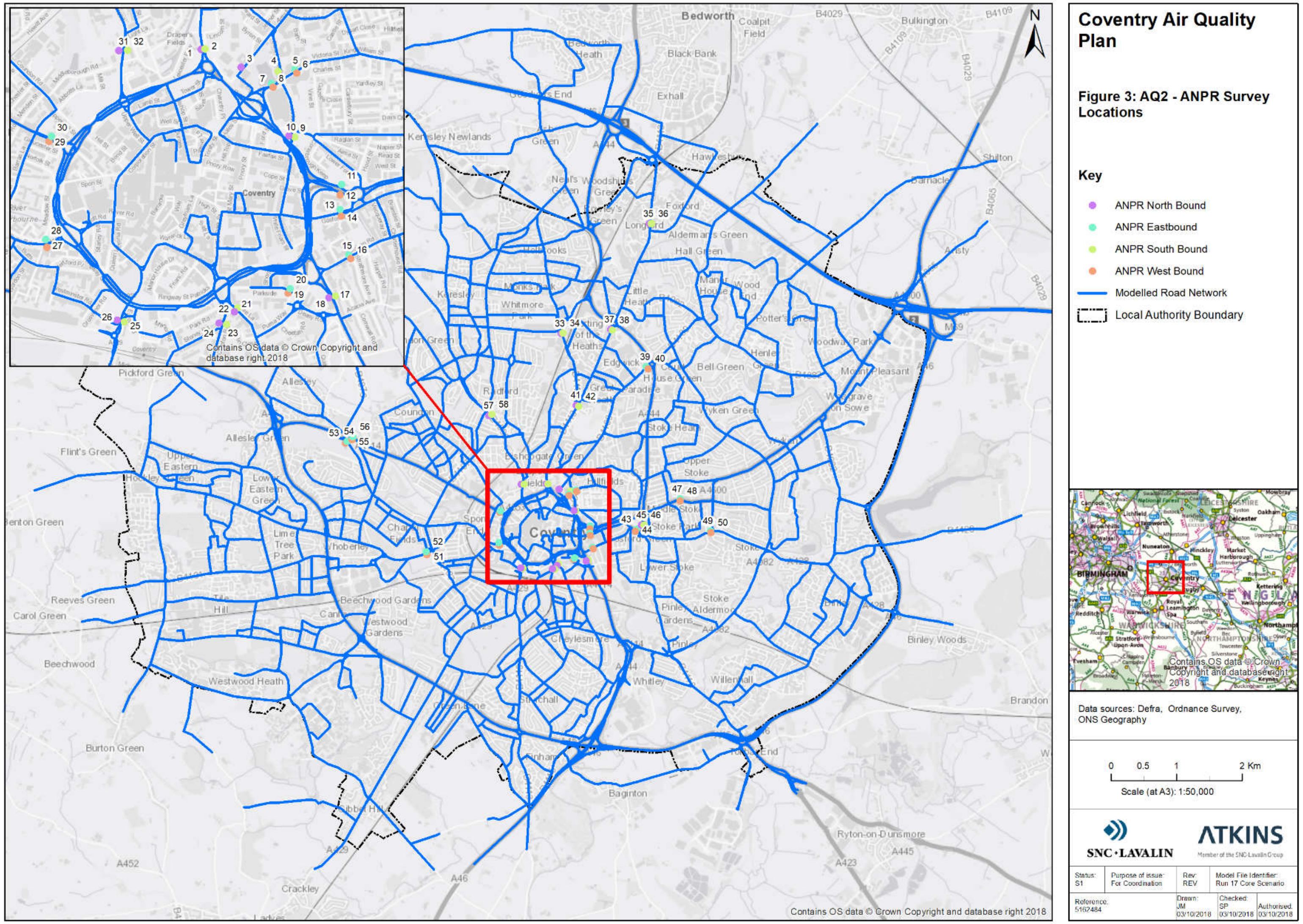


Figure A-3 – ANPR Survey Locations



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Project: P:\GBEMB\Mandl\Air&Sustainability\Jobs\516\5162484 Coventry AQ Plan Support\09 Reports\ES deliverables\AQ2 Figures\Figure 3 - ANPR Locations.mxd

Figure A-4 – Air Quality Model Domain – Elevated Roads

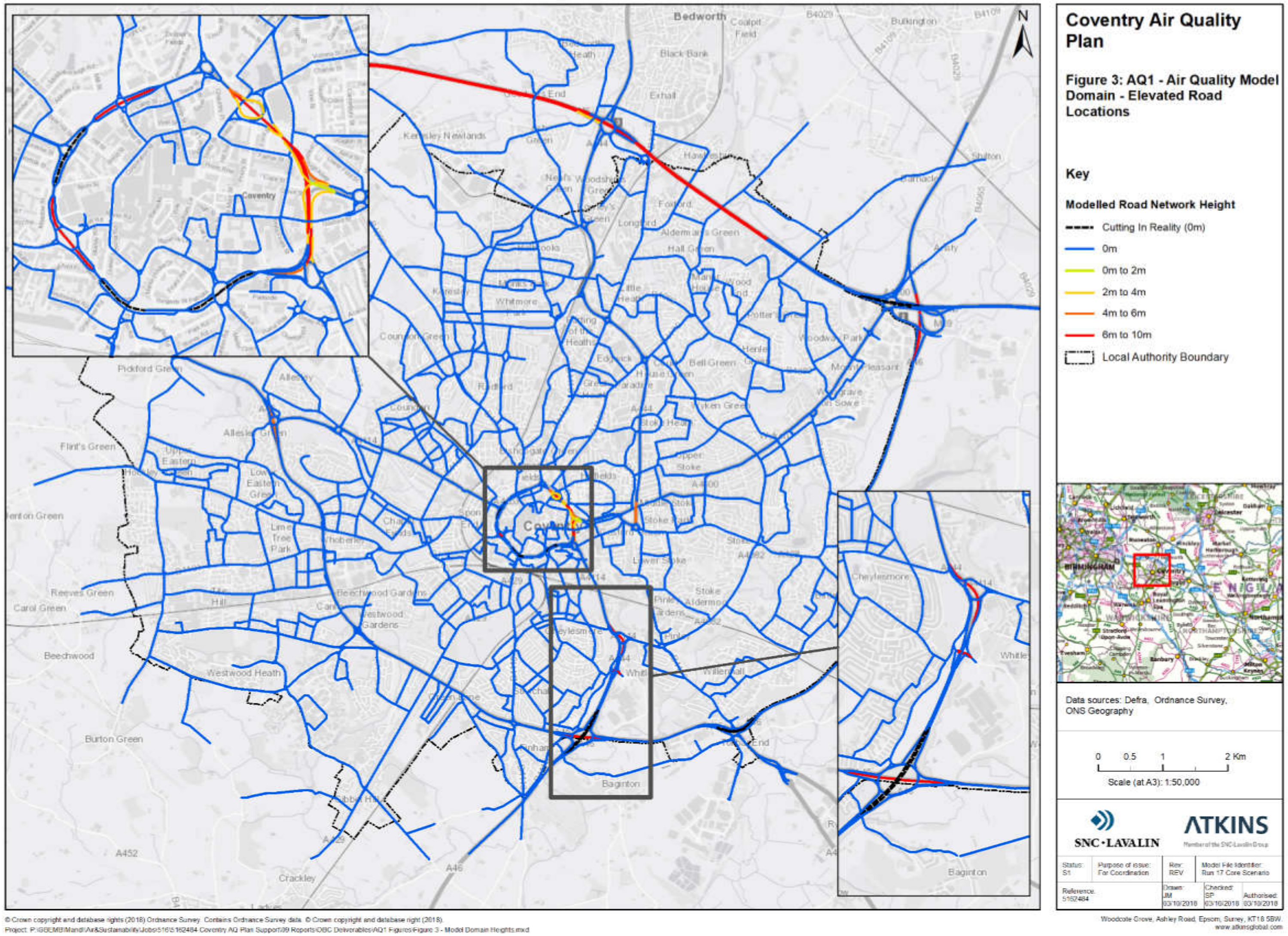


Figure A-5 - Air Quality Model Domain – Links with Modelled Gradient ± 2.5%

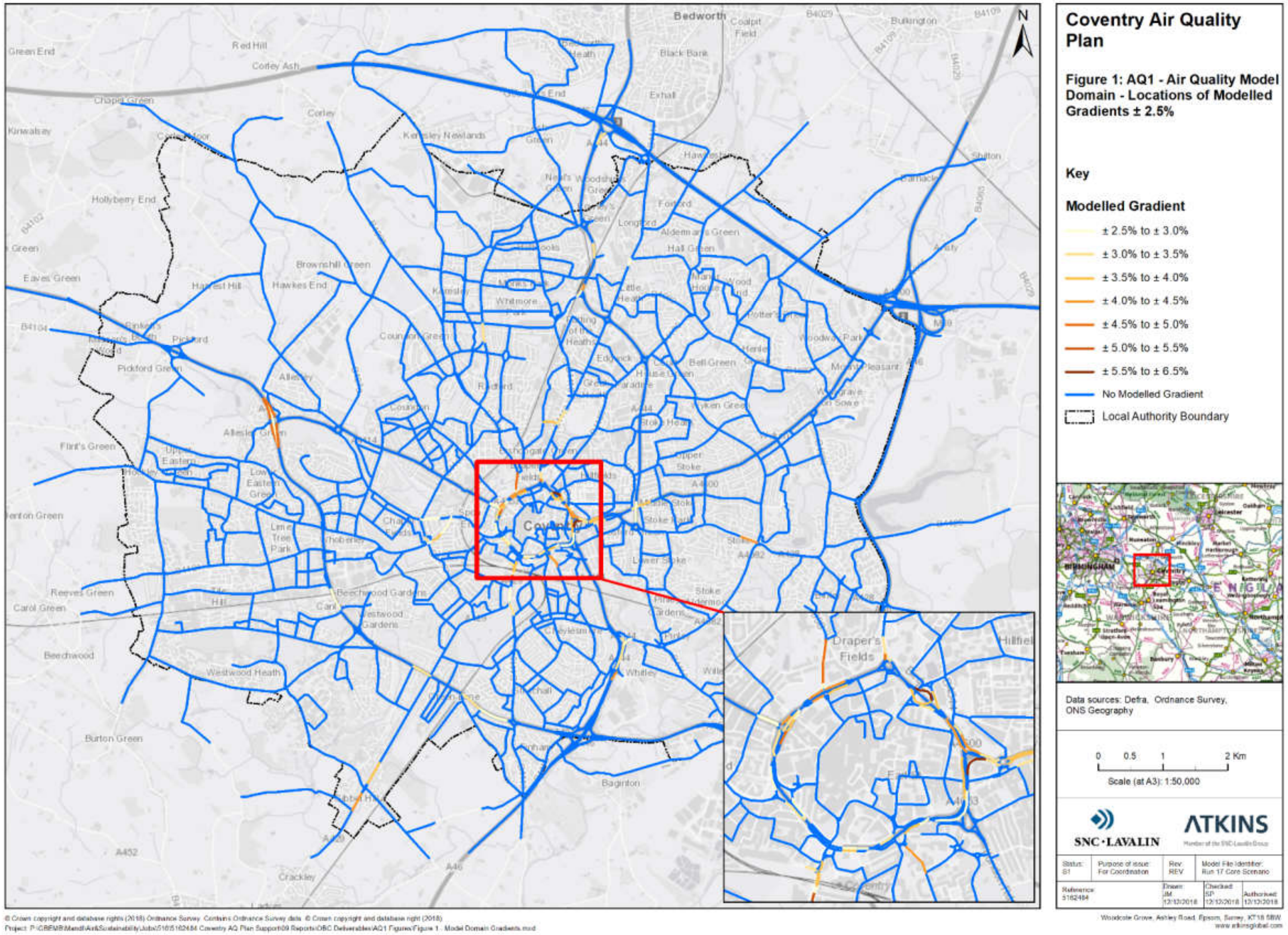


Figure A-6 - Air Quality Model Domain – Links with Modelled Canyon & Tunnel (volume) Sources

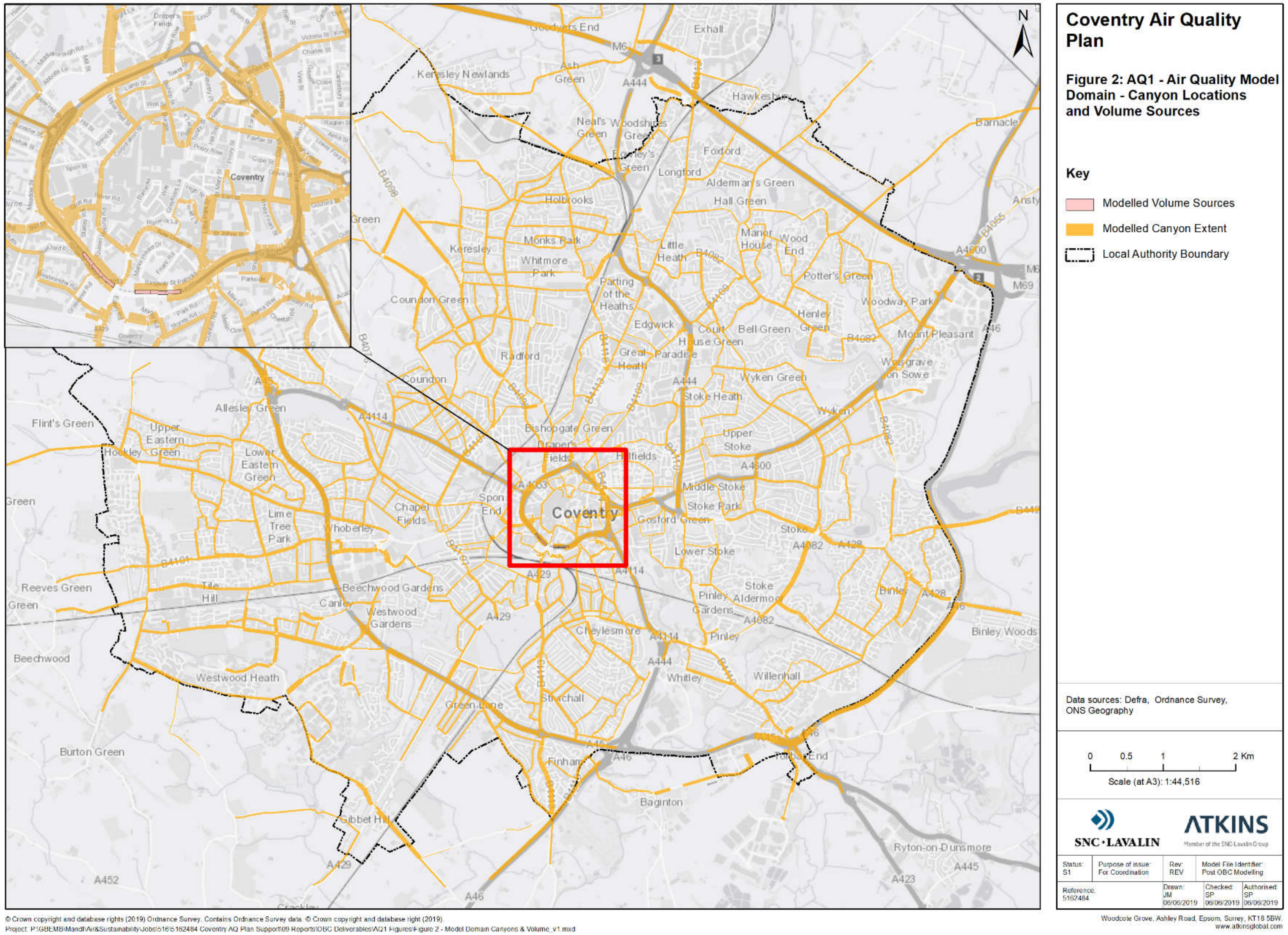
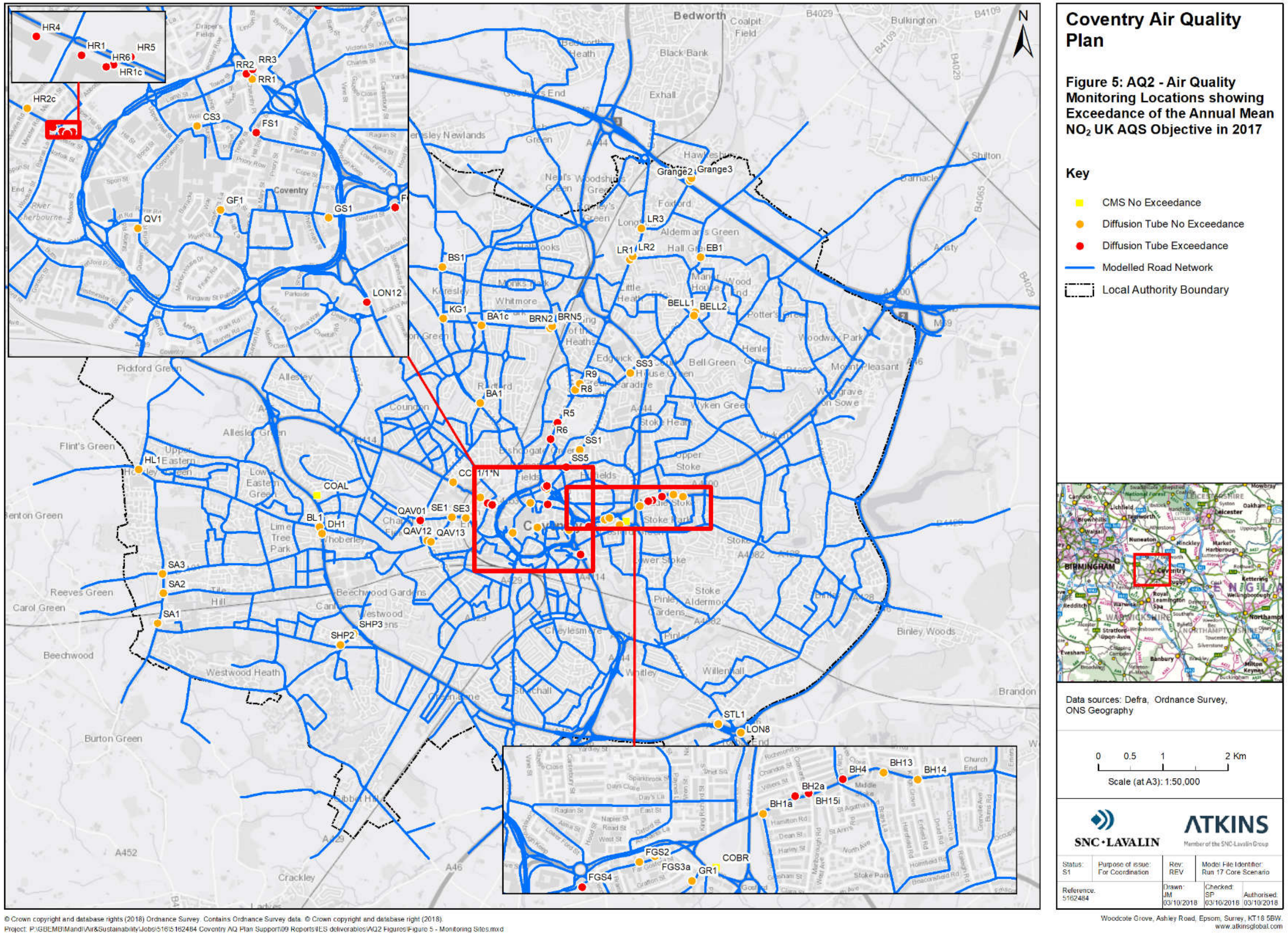


Figure A-7 – Air Quality Monitoring Locations



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Appendix B. Monitoring Data

B.1. Continuous Monitoring Data

Monitoring is undertaken at two continuous monitoring stations (CMS) within the air quality study area, the locations of which are shown in Figure A-3 of Appendix A. The results obtained at these CMS sites are summarised in Table B-1.

Both sites form part of Defra's Automatic Urban and Rural Network (AURN) and are subject to Formal Quality Assurance/Quality Control (QA/QC) provided by Ricardo AEA to ensure the reliability and accuracy of the measurements.

Table B-1 – Continuous Monitoring Results in Air Quality Study Area

Site ID	Site Name	Site Type	X	Y	2017 Annual Mean NO_2 (µg/m^3)	2017 Data Capture (%)
COAL	Coventry Allesley	Urban Background	430011	279376	21.9	97.8
COBR	Coventry Binley Road	Roadside	434785	278978	33.4*	74.7

*COBR began monitoring 01/04/2017, therefore has a reduced data capture for 2017. The annual mean presented is based on the data obtained between 01/04/2017 to 31/03/2018 and was annualised using the procedure detailed in Section B.2.1.

B.2. Diffusion Tube Monitoring Data

B.2.1. Short-term to Long-term Data Adjustment

As shown in Table B-3, additional diffusion tube monitoring was undertaken between August 2017 and December 2018 to provide further information on NO_2 concentrations in the air quality study area. Annualisation was therefore undertaken of the measurement data obtained to provide an estimate of 2017 annual mean NO_2 concentrations at these sites, to inform model verification. Annualisation was also required at two further sites (CS3 and COBR), as data capture in 2017 was below 75%. Annualisation was completed in accordance with Defra Technical Guidance LAQM.TG(16) Box 7.10. Details of the annualisation are provided in Table B-2.

Table B-2 – Short-term to Long-term Monitoring Data Adjustment

Site ID	Annualisation Factor Coventry Allesley (Urban Background)	Annualisation Factor Leamington Spa (Urban Background)	Annualisation Factor Leicester University (Urban Background)	Annualisation Factor Walsall Woodlands (Urban Background)	Average Annualisation Factor
COBR	1.05	1.08	1.03	1.03	1.03
CS3	0.75	0.71	0.82	0.70	0.74
GF1	1.00	1.03	1.00	0.93	0.99
STL1	1.05	1.10	1.05	1.01	1.05
LON8	1.05	1.10	1.05	1.01	1.05
Grange3	1.09	1.18	1.09	1.01	1.09
RR1	1.07	1.17	1.06	1.01	1.08
RR2	1.12	1.26	1.12	1.04	1.14
RR3	1.05	1.20	1.06	1.01	1.08

Site ID	Annualisation Factor Coventry Allesley (Urban Background)	Annualisation Factor Leamington Spa (Urban Background)	Annualisation Factor Leicester University (Urban Background)	Annualisation Factor Walsall Woodlands (Urban Background)	Average Annualisation Factor
HR4	1.11	1.47	1.16	1.01	1.19
HR5	1.14	1.55	1.16	1.06	1.23
HR6	1.14	1.55	1.16	1.06	1.23
FGS4	1.12	1.54	1.18	1.04	1.22
SA1	1.14	1.55	1.16	1.06	1.23
SA2	1.14	1.55	1.16	1.06	1.23
SA3	1.23	1.78	1.36	1.09	1.36
HL1	1.14	1.55	1.16	1.06	1.23
BS1	1.14	1.55	1.16	1.06	1.23
KG1	1.14	1.55	1.16	1.06	1.23
EB1	1.14	1.55	1.16	1.06	1.23

[a] This site was excluded in derivation of the annualisation factor for those diffusion tubes with a monitoring period of May 2018 to July 2018 as the data capture for this period was <85%.

B.2.2. Diffusion Tube Bias Adjustment Factors

Diffusion tubes provided by Gradko (20% TEA in water) were used in the monitoring survey. The diffusion tube data have been corrected using bias adjustment factors, which are an estimate of the difference between measured diffusion tube concentrations and those measured by a continuous analyser, the latter being a more accurate method of monitoring. Defra Technical Guidance LAQM.TG(16) provides guidance with regard to the application of a bias adjustment factor to correct diffusion tube monitoring. Triplicate co-location studies can be used to determine a local bias factor based on the comparison of diffusion tube results with data taken from NOx/NO_2 continuous analysers. Alternatively, the national database of diffusion tube co-location surveys provides bias factors for the relevant laboratory and preparation method.

As per the methodology followed in Coventry City Council's 2017 Local Air Quality Management Annual Status Report, the national bias adjustment factor of 0.87 has been applied to the diffusion tube measurements.

B.2.3. QA/QC of Diffusion Tube Monitoring

Gradko International Ltd is a UKAS accredited laboratory and participates in laboratory performance and proficiency testing schemes. These provide strict performance criteria for participating laboratories to meet, thereby ensuring NO_2 concentrations reported are of a high calibre. The laboratory follows the procedures set out in the Harmonisation Practical Guidance. Gradko International Ltd previously participated in the Workplace Analysis Scheme for Proficiency (WASP) for NO_2 diffusion tube analysis and the Annual Field Inter-Comparison Exercise. In April 2014, a new scheme, AIR PT10, was introduced. This is an independent analytical proficiency-testing (PT) scheme, operated by LGC Standards and supported by the Health and Safety Laboratory (HSL). AIR PT combines two long running PT schemes: LGC Standards STACKS PT scheme and HSL WASP PT scheme.

Defra and the Devolved Administrations advise that diffusion tubes used for Local Air Quality Management should be obtained from laboratories that have demonstrated satisfactory performance in the AIR PT scheme. Laboratory performance in AIR PT is also assessed, by the National Physical Laboratory (NPL), alongside laboratory data from the monthly NPL Field Intercomparison Exercise carried out at Marylebone Road, central London. A laboratory is assessed and given a 'z' score. A score of 2 or less indicates satisfactory laboratory performance.

Gradko International Ltd's performance for Jan 2017 to Mar 2018 was covered by rounds AR018, AR019, AR021, AR022 and AR024 of the AIR-PT scheme, for each round 100% of the laboratory's results were deemed to be satisfactory based upon a z score of ≤ ± 2. In 2017, the tube precision in the NO_2 Annual Field Inter-Comparison for Gradko International using the 20% TEA in water method was 'good' for the results of all participating local authorities.

Table B-3 – NO_2 Diffusion Tube Data

			2017												2018												Period Average	Annualisation Factor	Bias Adjusted [a]
ID	X	Y	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
CC01/1*N	432105	279578	57.7	43.5	50.5	42.3	39.9	42.6	37.0	35.9	37.2	37.2	40.1	43.1	-	-	-	-	-	-	-						42.3	-	36.8
HR1	432683	279240	82.9	61.3	68.8	60.2	70.1	61.8	55.8	47.5	56.4	54.5	59.2	49.3	-	-	-	-	-	-	-						60.6	-	**52.8**
HR2C	432525	279345	52.2	34.7	36.7	32.6	37.3	22.9	27.4	23.4	30.1	27.8	-	-	-	-	-	-	-	-	-						32.5	-	28.3
HR1C	432714	279231	121.4	83.8	99.3	86.3	103.3	89.5	93.1	82.9	88.3	85.6	79.4	79.6	-	-	-	-	-	-	-						91.0	-	**79.2**
BH1a	434987	279209	61.4	43.1	47.9	46.8	40.6	40.1	39.8	37.3	41.2	37.7	41.3	41.0	-	-	-	-	-	-	-						43.2	-	37.6
BH2a	435125	279286	69.1	46.8	56.7	61.7	48.6	45.3	45.4	42.1	43.1	42.7	51.0	47.7	-	-	-	-	-	-	-						50.0	-	**43.5**
BH4	435331	279358	73.2	54.8	60.5	52.7	57.3	43.3	46.0	44.1	44.9	44.3	50.9	52.5	-	-	-	-	-	-	-						52.0	-	**45.3**
BH13	435507	279387	54.8	37.4	42.1	34.8	35.2	36.7	31.3	33.0	48.5	34.9	40.4	41.0	-	-	-	-	-	-	-						39.2	-	34.1
BH14	435655	279356	71.9	41.4	32.2	47.9	38.5	43.4	38.4	37.8	38.3	34.9	48.0	44.6	-	-	-	-	-	-	-						43.1	-	37.5
BH15i	435184	279298	68.2	46.2	51.7	60.6	54.0	46.6	48.8	41.3	7.7	40.7	50.9	-	-	-	-	-	-	-	-						47.0	-	**40.9**
FS1	433569	279234	73.5	50.4	56.5	59.5	53.7	47.7	50.1	42.4	49.0	43.5	58.5	48.5	-	-	-	-	-	-	-						52.8	-	**45.9**
QV1	433029	278798	68.2	44.2	50.4	49.0	37.2	-	37.6	34.6	38.5	41.9	-	42.5	-	-	-	-	-	-	-						44.4	-	38.7
GF1	433407	278882	-	-	-	-	-	22.6	-	-	-	37.1	43.0	42.3	33.1	42.2	37.6	33.2	30.6	25.9	25.9						35.7	0.99	30.8
GS1	433899	278845	58.2	38.9	44.6	41.8	39.2	32.8	41.2	34.8	39.1	39.1	39.5	37.8	-	-	-	-	-	-	-						40.6	-	35.3
CS3	433300	279264	72.8	50.5	52.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						58.6	0.74	37.9
STL1	436203	275841	-	-	-	-	-	39.9	28.2	33.1	37.5	37.4	42.1	42.1	44.2	34.6	33.7	32.6	28.3	20.9	31.9						36.2	1.05	33.2
LON8	436551	275703	-	-	-	-	-	31.1	27.4	28.4	31.8	30.8	40.6	31.7	32.4	31.4	25.9	27.1	25.5	20.2	25.7						30.3	1.05	27.8
LON12	434074	278460	74.5	46.0	57.6	-	-	61.1	55.3	47.8	51.0	48.4	69.4	50.1	-	-	-	-	-	-	-						56.1	-	**48.8**
SE1	432084	279042	62.0	43.3	45.1	39.7	40.4	37.3	33.2	32.8	35.2	39.0	43.1	36.7	-	-	-	-	-	-	-						40.6	-	35.4
SE3	432303	279028	64.0	44.3	49.0	42.1	-	-	32.5	-	35.5	35.0	40.8	35.6	-	-	-	-	-	-	-						42.1	-	36.6
QAV01	431595	278991	76.7	46.0	54.7	50.0	46.6	47.0	41.9	39.2	45.0	41.9	48.0	40.8	-	-	-	-	-	-	-						48.2	-	**41.9**
QAV12	431704	278680	-	-	-	37.8	36.3	35.3	31.1	30.8	37.9	35.8	39.3	37.8	-	-	-	-	-	-	-						35.8	-	31.1
QAV13	431763	278657	62.3	39.0	47.2	42.3	42.6	44.4	38.5	35.3	-	39.8	41.9	38.8	-	-	-	-	-	-	-						42.9	-	37.3
R5	433716	280503	65.1	40.5	49.4	55.2	48.8	43.7	49.5	37.4	42.8	40.4	41.3	39.3	-	-	-	-	-	-	-						46.1	-	**40.1**
R6	433609	280246	78.8	61.0	59.9	71.8	56.5	54.9	57.4	47.4	49.5	52.3	57.5	52.5	-	-	-	-	-	-	-						58.3	-	**50.7**
R8	433992	281008	83.4	39.5	47.5	47.2	38.6	35.9	35.4	34.9	40.2	33.3	39.1	38.9	-	-	-	-	-	-	-						42.8	-	37.3
R9	434059	281105	59.9	46.3	49.2	38.9	43.5	39.3	37.1	33.4	38.7	40.8	-	39.1	-	-	-	-	-	-	-						42.4	-	36.9
LR1	434836	283030	65.5	36.9	46.0	51.2	46.1	37.7	42.5	33.2	40.9	38.4	42.2	40.9	-	-	-	-	-	-	-						43.4	-	37.8
LR2	434880	283077	58.2	39.2	51.2	42.4	51.6	40.8	40.0	33.0	39.8	37.7	40.2	38.7	-	-	-	-	-	-	-						42.7	-	37.2
LR3	435016	283515	62.4	38.7	47.6	52.1	42.3	43.7	41.0	36.6	42.0	38.8	46.3	42.4	-	-	-	-	-	-	-						44.5	-	38.7
BRN2	433605	281965	59.6	38.7	46.6	41.1	40.0	39.4	35.7	32.5	39.2	38.8	43.8	40.8	-	-	-	-	-	-	-						41.4	-	36.0
BRN5	433639	281995	57.4	36.5	40.5	39.1	40.9	30.7	34.4	29.5	35.8	34.4	33.7	36.4	-	-	-	-	-	-	-						37.4	-	32.6
BA1	432526	280806	54.8	38.5	41.3	37.5	37.3	-	36.9	31.9	38.0	36.8	33.5	40.4	-	-	-	-	-	-	-						38.8	-	33.8
BA1c	432544	282004	45.7	28.4	32.9	28.0	27.9	26.5	23.8	22.0	27.0	27.1	-	-	-	-	-	-	-	-	-						28.9	-	25.2
SS1	434062	280082	55.0	39.3	43.9	44.5	40.0	35.4	36.2	30.5	36.1	35.8	39.9	35.9	-	-	-	-	-	-	-						39.4	-	34.3
SS2	433994	279969	55.7	41.0	42.5	33.4	19.1	36.7	32.3	29.3	33.8	34.8	35.7	37.1	-	-	-	-	-	-	-						35.9	-	31.3
SS3	434842	281272	58.6	42.0	45.5	43.0	44.9	40.8	34.2	32.4	41.6	39.4	37.3	38.1	-	-	-	-	-	-	-						41.5	-	36.1

ID	X	Y	2017												2018												Period Average	Annualisation Factor	Bias Adjusted [a]
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
SS5	433852	279814	69.1	48.6	56.1	57.9	51.1	54.2	48.4	41.9	48.6	49.1	59.8	46.9	-	-	-	-	-	-	-						52.6	-	**45.8**
BELL1	435849	282211	62.6	48.2	48.8	42.0	41.5	39.0	39.8	35.2	41.0	41.5	45.3	41.3	-	-	-	-	-	-	-						43.9	-	38.2
BELL2	435826	282158	52.5	38.4	43.7	42.0	38.8	40.8	34.1	33.1	41.0	39.7	42.6	38.8	-	-	-	-	-	-	-						40.5	-	35.2
FGS2	434450	279001	54.8	38.3	43.6	37.5	34.9	33.0	33.0	31.9	37.2	36.6	35.3	34.8	-	-	-	-	-	-	-						37.6	-	32.7
FGS3a	434519	279026	56.0	37.4	39.8	44.2	36.5	32.3	33.5	31.6	35.5	36.8	42.8	39.6	-	-	-	-	-	-	-						38.8	-	33.8
GR1	434679	278920	56.1	34.0	40.2	38.7	27.0	33.5	35.5	30.6	37.9	39.2	48.3	40.5	-	-	-	-	-	-	-						38.5	-	33.5
Grange2	435765	284246	54.1	44.2	47.0	45.3	32.0	39.3	-	-	-	-	-	-	-	-	-	-	-	-	-						43.7	0.96	36.5
Grange3	435791	284285	-	-	-	-	-	-	-	33.3	40.6	39.1	47.0		41.5	38.5	37.5	37.0	29.6	22.9	32.4						36.3	1.09	34.4
SHP2	430364	277059	49.3	37.7	35.5	30.3	32.2	28.6	28.6	25.2	29.7	27.5	36.7	32.9	-	-	-	-	-	-	-						32.8	-	28.6
SHP3	430566	277231	56.6	39.6	40.4		33.7	35.4	35.4	30.0	36.5	38.2	42.7	41.2	-	-	-	-	-	-	-						39.1	-	34.0
BL1	430043	278890	53.2	40.9	42.3	35.2	36.3	35.1	30.3	26.9	32.7	33.1	33.5	-	-	-	-	-	-	-	-						36.3	-	31.6
DH1	430076	278789	52.7	43.4	45.5	32.2	37.8	24.5	25.3	23.1	29.0	30.7	-	-	-	-	-	-	-	-	-						34.4	-	29.9
RR1	433550	279478	-	-	-	-	-	-	-	-	39.7	34.2	46.0	38.2	45.3	47.8	47.7	42.5	45.8	36.5	40.9	27.5	34.6	48.5	50.8	42.4	41.0	1.08	38.4
RR2	433525	279502	-	-	-	-	-	-	-	-	40.2	36.6	-	41.3	43.0	50.2	44.3	44.0	45.9	38.4	38.2	27.9	34.8	49.4	43.7	41.6	40.9	1.14	**40.4**
RR3	433552	279524	-	-	-	-	-	-	-	-	-	57.0	65.9	-	57.1	51.6	48.0	51.5	-	31.1	53.5	48.3	55.3	54.9	56.7	61.7	51.5	1.08	**48.5**
HR4	432640	279258	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48.1	34.1	34.3	-	37.6	45.0	76.0	48.0	46.1	1.19	**47.7**
HR5	432730	279238	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.0	46.6	61.3	43.4	53.7	56.2	52.4	48.8	51.5	1.23	**55.1**
HR6	432706	279229	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48.8	48.2	64.4	47.4	50.5	56.5	56.5	52.6	53.1	1.23	**56.8**
FGS4	434203	278892	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35.6	33.8	41.1	34.0	-	43.5	45.1	42.5	39.4	1.22	**41.7**
SA1	427538	277397	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.9	22.5	24.3	19.3	20.3	28.6	32.8	29.6	25.6	1.23	27.3
SA2	427624	277863	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.9	27.1	29.5	21.7	25.8	32.0	34.3	32.9	28.9	1.23	30.9
SA3	427613	278162	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.2	22.4	24.7	-	-	-	27.2	-	25.7	1.36	30.4
HL1	427249	279780	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.9	23.2	25.3	20.1	25.4	30.0	27.7	24.6	25.3	1.23	27.0
BS1	431940	282916	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.1	13.4	19.7	18.9	22.4	17.9	25.9	27.3	20.3	1.23	21.7
KG1	431956	282113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.3	27.4	30.5	25.0	29.5	36.2	39.0	36.0	32.0	1.23	34.2
EB1	435928	283069	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.6	24.7	29.4	18.8	24.8	33.7	33.3	36.2	28.7	1.23	30.7

[a] National bias-adjustment factor of 0.87 applied for Gradko tubes (20% TEA in water) in 2017.