Bristol City Council Clean Air Plan

Outline Business Case

Local Air Quality Modelling Methodology Report (AQ2)

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Bristol City Council

Bristol Clean Air Plan

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Contents

Acronyms and Abbreviations

ADMS	Atmospheric Dispersion Modelling System
ANPR	Automatic Number Plate Recognition
ATC	Automatic Traffic Counters
AQMA	Air Quality Management Area
BCC	Bristol City Council
CAZ	Clean Air Zone
COPERT	Computer Programme to calculate Emissions from Road Transport
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
GBATS	Greater Bristol Area Transport Model
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit (Defra and the Department for Transport)
LDV	Light Duty Vehicle
LSOA	Lower Super Output Area
$\mu g/m^3$	micrograms per cubic metre
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
PCM	Pollution Climate Mapping
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 micrometres
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 micrometres
SGC	South Gloucestershire Council

1. Introduction

1.1 Background

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). BCC has monitored and endeavoured to address air quality in Bristol for decade and declared their first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2029 without intervention.

The UK has in place legislation transposing requirements in European Union law, to ensure that certain standards of air quality are met, by setting Limit Values on the concentrations of specific air pollutants. In common with many EU member states, the EU limit value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the government has published a UK Air Quality Plan and a Clean Air Zone Framework, both published in 2017. The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ).

Due to forecast air quality exceedances, in 2017 Bristol City Council has been directed by the Minister Therese Coffey (Defra) and Minister Jesse Norman (DfT) to produce a Clean Air Plan to achieve air quality improvements in the shortest possible time. In line with Government guidance, as part of the Plan, Bristol City Council has considered a range of options for the implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality and public health and in line with legal requirements as set out below. This process requires the production of a Strategic Outline Case, an Outline Business Case (this report) and a Full business Case, that will be prepared following the Outline Business Case.

The PCM model predicted several exceedances of the nitrogen dioxide (NO_2) EU Limit Value at various locations (i.e. receptor locations alongside roads on the PCM network) across Bristol, as shown in Figure 1-1. Note that it was agreed with the JAQU and reported in the Strategic Outline Case that 2021 as opposed to 2020 was the earliest year compliance of the EU Limit Value for NO_2 might be achieved. The PCM predicted exceedance of the EU Limit Value on Newfoundland Way and M32. The CAP must set out how BCC will achieve sufficient air quality improvements in the shortest possible time. In line with Government guidance BCC is considering implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality and public health.

Jacobs has been commissioned to support BCC produce an Outline Business Case (OBC) for the delivery of the CAP; a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in Bristol. The OBC assesses the shortlist of options set out in the Strategic Outline Case[2], and proposes a preferred option including details of delivery. The OBC forms a bid to central government for funding to implement the CAP.

This document is written to support the OBC and provides details of the air quality modelling methodology used to reach the conclusions of the OBC.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
[2] Bristol Council Clean Air Plan: Strategic Outline Case, March 2018 (https://democracy.bristol.gov.uk/documents/s19804/Clean%20Air%20Plan%20-%20Cabinet%20Report%20and%20Appendices%20-%20Final%20with%20Early%20Measures%20Fund%20included%20-with%20legal.pdf)

1.2 Purpose of this Report

This report sets out the air quality modelling methodology and outlines the approach taken to model the air quality impacts, including a description of the modelling methods used, details of monitoring data for calibration of the model and a description of how transport model outputs have been fed into the air quality modelling. It also sets out how the emissions from vehicles of different Euro standards have been derived and projected, together with how changes in primary NO_2 emission fraction, f-NO_2, have been taken into account.

The air quality modelling methodology is described in detail, in order that a full understanding and approval of the approach can be made by the JAQU. This report should be read alongside AQ1 (Air Quality Tracking Table), which is included in Appendix A. The tracking table maps out the initial approach considered by the modelling assessment team in light of the guidance issued by the JAQU. The approach described in AQ2 should therefore replicate the tracking table.

A draft version of this report was published in January 2019, which supported the draft economic case that was also published at this time. Since this report, further work has been undertaken to develop the scheme options, and this work is reported in the Option Assessment Report, appended to the OBC.

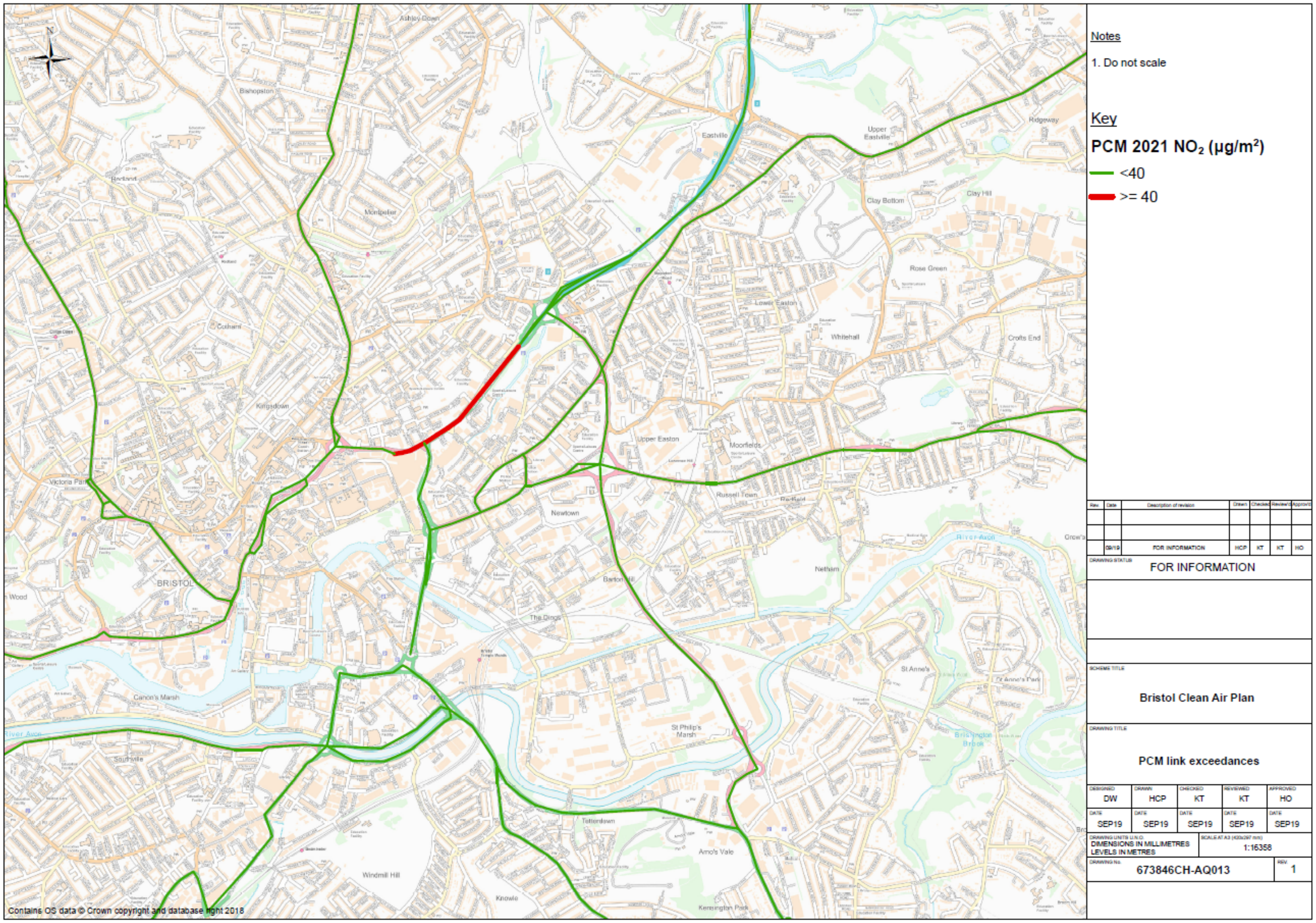


Figure 1-1. Predicted NO_2 concentrations in 2021 at PCM-equivalent receptor locations based on the PCM model 2015

2. Air Quality Modelling

The Evidence Package issued by the Joint Air Quality Unit explains the approach to be undertaken by Local Authorities to provide robust evidence on the impact of measures, informed by local traffic and air quality models and it contains the minimum technical criteria as described in Defra's Local Air Quality Management (LAQM) Technical Guidance (TG(16)(2018)[3]. These primarily cover:

- Air quality monitoring;
- Emission estimation; and
- Dispersion modelling.

Each of these are discussed in the following sections. The study area is shown in *Figure **2**-**1*** in relation to both the district boundaries, the modelled highway network and the PCM network.

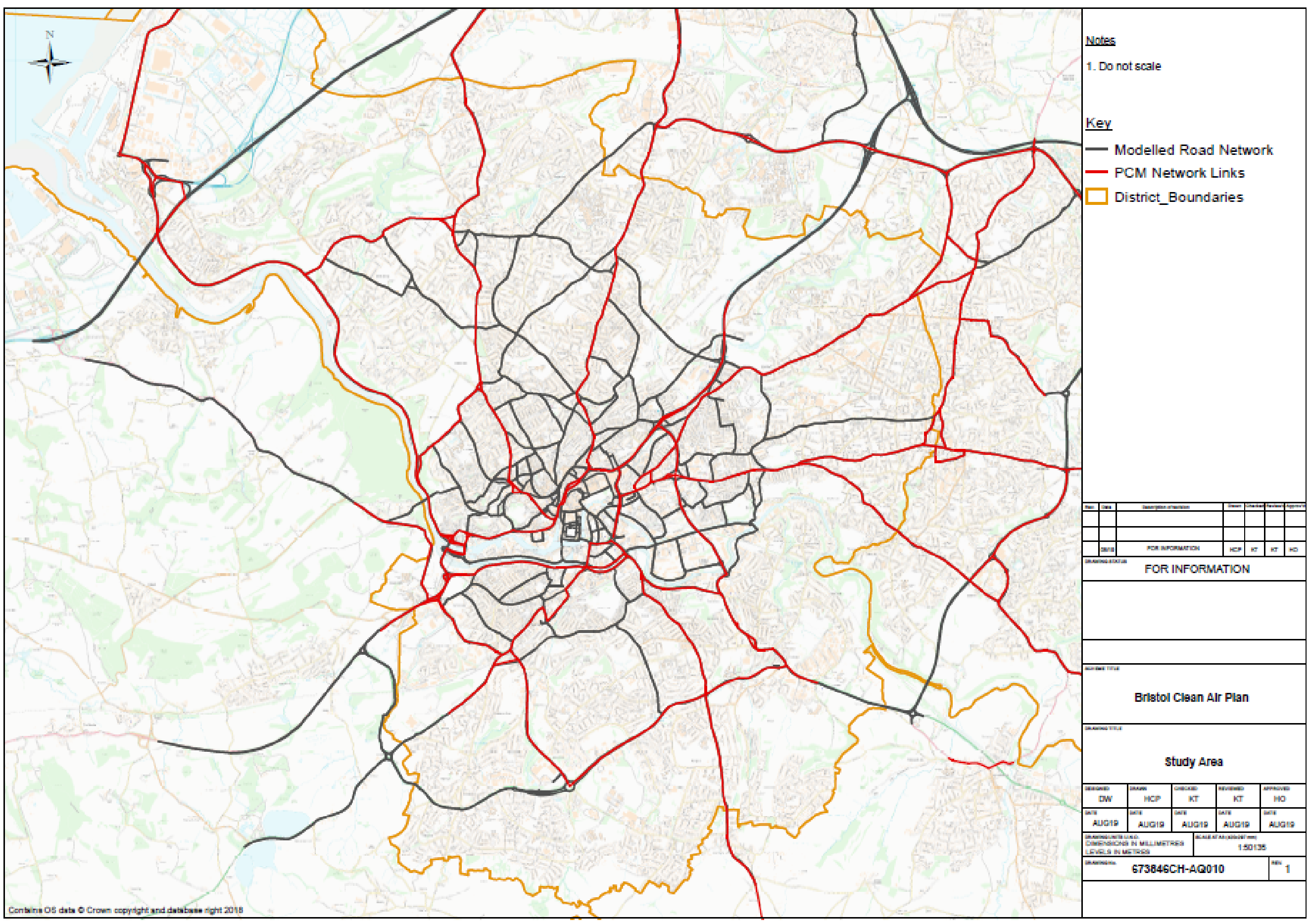


Figure 2-1. AQ study area, PCM network links and district boundaries

[3] https://laqm.defra.gov.uk/documents/LAQM-TG16-February-18-v1.pdf

2.1 Modelling Runs and Scenarios

Traffic data were provided as detailed in T3 (Local Plan Transport Modelling Methodology Report) for the years 2015, 2021 and 2031. The traffic model base year was 2015, with monitoring data for this year used to verify and adjust the modelled concentrations. The use of a later base year was not possible due to a number of locations where road works, relating to new MetroBus routes, caused temporary, significant disruptions to traffic flows, which would not therefore have been representative of typical traffic conditions.

As mentioned in Section 1.1 year 2021 was selected because it was the earliest year for compliance of the EU Limit Value for NO_2, also referred to as the Air Quality Directive (AQD), to be feasible, according to PCM scenario modelling forecasts. Local authorities should calculate expected emissions of the fleet for the baseline ("without measures") conditions for NO_2, particulate matter ($PM_{2.5}$ and PM_{10}) and carbon dioxide (CO_2) for 10 years after the predicted compliance year. This is needed to compare long term costs and benefits of options that are equally effective (i.e. equally able to achieve compliance in the shortest time possible). Interpolation methods can be used. For Bristol, the year 2031 is the future reference year and allows for estimations of results for all years to be made in between, via linear interpolation.

Do Minimum (DM) and a number of Do Something (DS) scenarios were modelled for both 2021 and 2031. The DS scenarios modelled were:

- **Option 1**:
  - Medium Area Class C (charging higher emissions buses, coaches, taxis, HGVs and LGVs);
  - Car diesel scrappage scheme;
  - HGV exclusion on links within the city centre with exceedances;
  - Close of Cumberland Road inbound to general traffic;
  - M32 Park and Ride with bus lane inbound;
  - Holding back traffic to the city centre through the use of existing signals; and
  - 8-hour car diesel exclusion on Park Row/Upper Maudlin Street and Marlborough Street.
- **Medium CAZ D + plus Option 1:** As Option 1 but includes charging higher emission cars.
- **Option 2:** 8-hour small area car diesel exclusion (7am – 3pm)
- **Hybrid Option:** Option 1 + Option 2.

2.2 Air Quality Study Area

The model domain includes all roads that are listed within the PCM model as exceeding the annual mean Limit Value in 2021 for NO_2 at roadside locations (as published by Defra), as well as roadside receptors where annual mean NO_2 concentrations are known to exceed the national air quality objective, based on the most recent review and assessment report published by BCC. Note that local authorities establish monitoring sites to comply with Local Air Quality Management (LAQM) purposes and as such these will comply with public exposure locations. These public exposure locations will not necessarily comply with AQD siting criteria (e.g. a publicly accessible receptor within 4m from the roadside, at 2m in height). The rational for the AQD is that given that most of the emissions in urban areas are road based if compliance is achieved at roadside locations then any sensitive[4] receptors further back from the road are likely to be equally compliant.

[4] "Sensitive receptors "is LAQM terminology describing receptors which have direct human or ecological significance such as a residential home, hospital or a SSSI designated area.

The modelling domain includes all potential displacement routes which may be affected by mitigation measures, identified from the traffic model. The study domain is shown in *Figure **2**-**1***. It also shows that the domain covers the majority of urban areas within Bristol, extending into South Gloucestershire Council (SGC), including the Air Quality Management Areas (AQMAs) (Bristol AQMA, Staple Hill AQMA, Kingswood AQMA and Cribbs Causeway AQMA). The study area extends well beyond the road network that will be affected by changes in traffic in order that the health impacts can be quantified by incorporating all densely populated areas of population (in some cases very small changes in concentrations applied across a large population base can account for significant health impacts).

2.3 Traffic Input Data

Compliant and non-compliant traffic flows by vehicle type have been sourced from the transport model SATURN (GBATS). The following vehicle types were considered: cars which include taxis (diesel and petrol), LGVs, HGVs (rigid and articulated) and buses (including coaches). Motorcycles are not considered given their low contribution to emissions and their subsequently small impact on air quality.

Proportions of vehicle types were estimated from Automatic Traffic Counter (ATC) data and/or Automatic Number Plate Recognition (ANPR) data.

Vehicle speeds were sourced from SATURN and adjusted, where required, based on experience and local knowledge. Traffic master data was used to compare speeds at key locations, but no changes to speeds were included.

Detailed fleet composition such as fuel type, engine size, vehicle weight and Euro emission standard was obtained from the DVLA database using local ANPR data. Emissions were estimated inputting the derived Annual Average Daily Traffic (AADT) flows and fleet compositions into the Emission Factor Toolkit (EFT) using the 'Advanced User Euro Split' tool (more information is provided in Section 2.4).

Road sections included in the traffic model and represented in the air pollution model were manually adjusted to reproduce the actual road geometry making use of Ordnance Survey Master Mapping.

2.4 Emissions Estimation

The latest Emission Factor Toolkit (EFT) version available when the study began was version v8.0.1a, and therefore this was used to model the selected road traffic emissions. Version 9.1a was released in May 2019 via the Huddle, but was not used, to keep the assessment consistent with what had been done previously.

The use of the EFT is specified in JAQU's 'Transport and Air Quality' guidance and this version (v8.0.1a) of the EFT was provided directly by JAQU for use in the study. The EFT is based on the European Environment Agency's COPERT 5 emission tool and allows users to calculate road transport pollutant emission rates for Oxides of Nitrogen (NO_XPrimary Nitrogen Dioxide (f-NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) for a specified year, road type, vehicle speed and vehicle fleet composition.

The EFT was used with appropriate Euro fleet splits set in "Alternative Technologies" mode to derive emission rates in g/km/s for all vehicle types. The outputs were PM, CO_2, NO_x and also the fraction of NO_x made up of primary NO_2, both of which were used in the calculation of annual mean NO_2 concentrations at receptors in the modelling process. Emission rates were calculated for all 2015, 2021 & 2031 DM scenarios, and all variations of the 2021 & 2031 DS scenarios, based on the traffic data provided.

2.5 Dispersion Modelling

Dispersion modelling has been undertaken using ADMS-Roads versions 4.1 and 4.2. ADMS-Roads 4.1 is one of the “standard” models recommended in JAQU’s Evidence Package guidance. The model is approved by Defra and used extensively in the United Kingdom. Typical applications include modelling for review and assessment, quantification of air quality action plan measures (including Low Emission Zones, Clean Air Zones, etc.), and the assessment of new developments through the planning process. ADMS Roads 4.1 was used to produce road NO_x concentrations at receptors for the 2015 baseline scenario (and therefore used in the model verification) and early iterations of both the 2021 and 2031, DM & DS scenarios.

ADMS-Roads v4.2 is a new version and contains a feature which allows a concentration output to be reported from every emissions source (i.e. road section) to every receptor. ADMS Roads v4.2 produces a new output file called Source Long Term or SLT file. This opens an opportunity to model unitary NO_x emission rates for every emission source, and then factor the concentration results using scenario-based emission rates. The use of the SLT allowed for the rapid assessment of scenarios, where previously the method would have required laborious model set up processes and long model runs. Version 4.2 only became available for this project early in 2019 and has been indirectly applied to model all the scenarios from that point onwards. The so called *SLT Processor* approach developed by Jacobs allowed the very challenging BCC air quality programme to be delivered.

A comparison was undertaken between NO_x concentration results of the 2021 DM scenario calculated using ADMS-Roads v4.1 and unitary based concentrations derived using v4.2. Whilst the results were broadly similar, there were some small differences between the two methods, which can be attributed to the default parameter in ADMS which accounts for traffic induced turbulence and secondly, the revised method that v4.2 deals with the dispersion of emissions within street canyons explained in Section 2.6. To counter this, a factor was calculated for each receptor based on the differences in the v4.1 and v4.2 2021 DM scenario results and applied in every modelled scenario where v4.2 was used.

2.6 Representation of Canyons

Representative pollution dispersion modelling in urban areas can be difficult to achieve owing to the presence of obstacles (buildings, trees, walls, etc.) that modify the wind flow locally and therefore can alter dispersion. This is especially the case in what are termed “street canyons”, where buildings on both sides of the road can lead to the formation of vortices and recirculation of air flow that can trap pollutants and restrict dispersion (often termed as the “canyon effect”). Although street canyons were once defined as narrow streets where the height of buildings on both sides of the road is greater than the road width, there are numerous examples whereby broader streets may also be considered as street canyons, where buildings result in reduced dispersion and elevated concentrations (which may be demonstrated by monitoring data).

The ADMS ‘Advanced Canyon Module’ has been used to allow for a more accurate representation of the dispersion patterns within street canyons, including asymmetrical canyons. The dispersion of emissions from traffic is influenced by the presence of tall buildings, or other obstacles such as trees, along roads, which leads to elevated roadside pollutant concentrations. To capture this phenomenon, where necessary, buildings and other obstacles within the study area were represented within ADMS Roads.

Appendix B contains Table B.1 showing an extracted example of the parameters applied to define street canyons for an area within the advanced canyon module of the ADMS-Roads model. Building locations and heights were defined using a combination of OS mapping and Google street view.

2.7 Representation of Gradients

Emissions on roads with gradients have been adjusted following the method outlined in TG(16)(2018) and guidance from the JAQU. The methodology is based on an analysis of the emission factors published for use within the COPERT 4 model methodology. Older vehicles are based on the emission factors published in August 2007, and newer vehicles are based on the September 2014 update. The TG(16)(2018) and JAQU approach is to adjust emissions for pre-2014 HDVs only, with no adjustment for later model vehicles or LDVs.

2.8 Representation of Flyovers

Where major flyovers were identified, though the use of Google street view and local knowledge, roads have been assigned an elevation within the ADMS-Roads model to account for this. In particular the M32 and part of the Brunel Way flyovers were considered and assigned a height of 6m.

2.9 Meteorological Data

An appropriate base year and meteorological site location was used when considering meteorological data, as per Defra Technical Guidance, TG(16)(2018). The meteorological station located at Filton Aerodrome in Bristol was the nearest and most representative meteorological station. Data from this station has been used for the year 2015.

As recommended by Defra's Technical Guidance TG(16)(2018), meteorological, background pollution, monitoring and emissions data have all been derived from the same base year as the model (i.e. 2015). *Table 2-1* provides more detail of the meteorological site location and air dispersion modelled parameters. The weather data, presented as a wind rose, is shown in Figure 2-2. Note that the predominant wind direction is south westerly

Table 2-1. Meteorological Site location and Modelled Parameters

Meteorological Site	Filton Aerodrome
OS Grid reference	360057, 180491
Surface Roughness	Met site: 0.5m; Dispersion Site: 1m
Minimum Monin-Obukhov Length	30

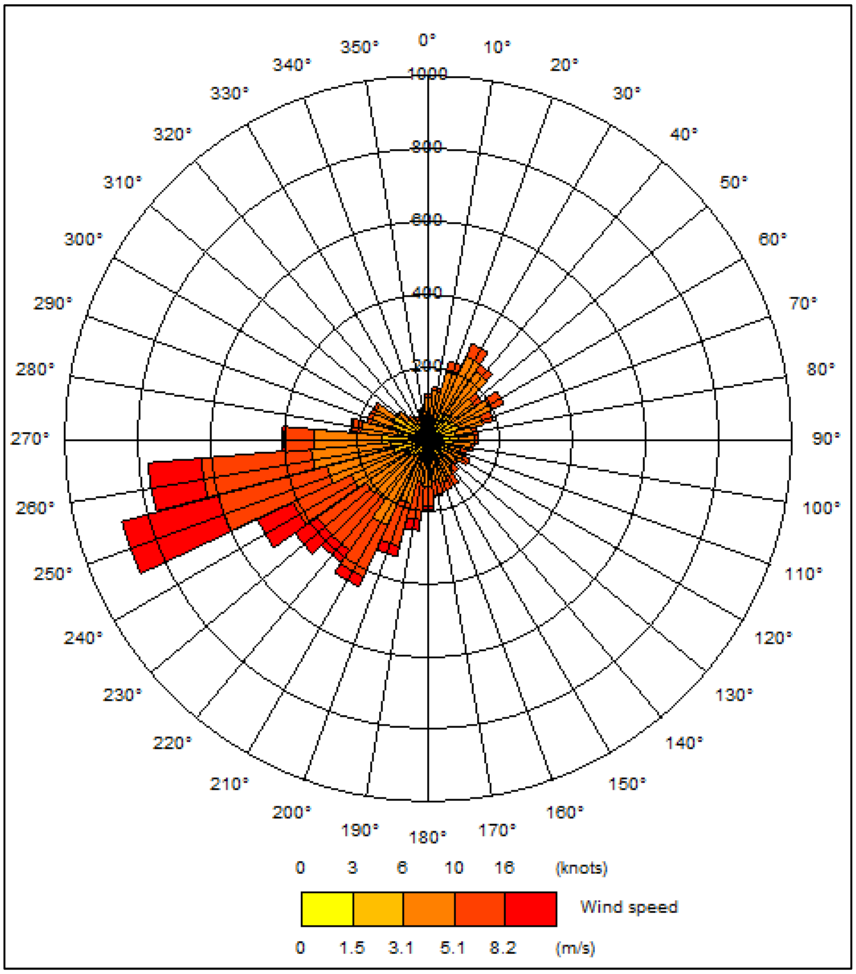


Figure 2-2. Wind Speed and Direction Data for Filton Aerodrome 2015

2.10 Background Concentration Data

Background NO_x, NO_2 and PM_{10} concentrations, for the 2015 base year, have been derived from Defra's background mapped data[5]. A spatial interpolation process was applied to background concentrations, and results extracted for all modelled receptors. A calibration between the extracted interpolated results with the 2015 urban background diffusion tube air quality monitoring sites was undertaken. Measured NO_2 concentrations within the modelling domain were compared to the mapped backgrounds. It was found that mapped background NO_2 concentrations were lower than the monitored values, therefore all mapped background NO_2 concentrations were recalibrated by applying a percentage increase of 3.37%. Mapped background concentrations of PM_{10} and $PM_{2.5}$ have not been adjusted. Whilst the objective of the study is to address NO_2 modelling of PM_{10} and $PM_{2.5}$ was also included. The background concentrations applied for this feasibility study have been included in AQ3.

[5] https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2015

2.11 NOx Chemistry

The conversion of modelled road NO_x to NO_2 was undertaken using the Defra NO_x to NO_2 calculator v6.1. The dispersion model (in the baseline) used link specific NO_x as NO_2 emissions, modelled as NO_x. The modelled annual mean road NO_x and fraction of NO_x as primary NO_2 and background concentrations for each output point were put into the calculator so that a location specific f-NO_2 was applied and total annual mean NO_2 concentrations calculated.

For the DM and DS scenarios the process was slightly different. Here, the primary NO_x as NO_2 fraction, determined by the EFT, was used to calculate the fraction of the total road NO_x concentration from every link to each receptor. These fractions were then summed across all contributing links giving the total primary NO_x as NO_2 contribution. This value was then compared to the total road NO_x concentration contribution at the same receptor. The result was a new NO_x as NO_2 factor which could then be applied to the NO_x to NO_2 calculator for that receptor. This approach is identical in calculation to the baseline but much more efficient in terms of modelling additional scenarios. In each case the primary NO_2 is receptor, rather than source specific.

2.12 Diurnal Profile for Emissions

Figure 2-3 shows the diurnal emissions profiles used in the modelling. These profiles have been derived from a national dataset published by the DfT[6]. These profiles have been assumed to apply to emissions on all links regardless of the diurnal profile of speed or flow occurring locally.

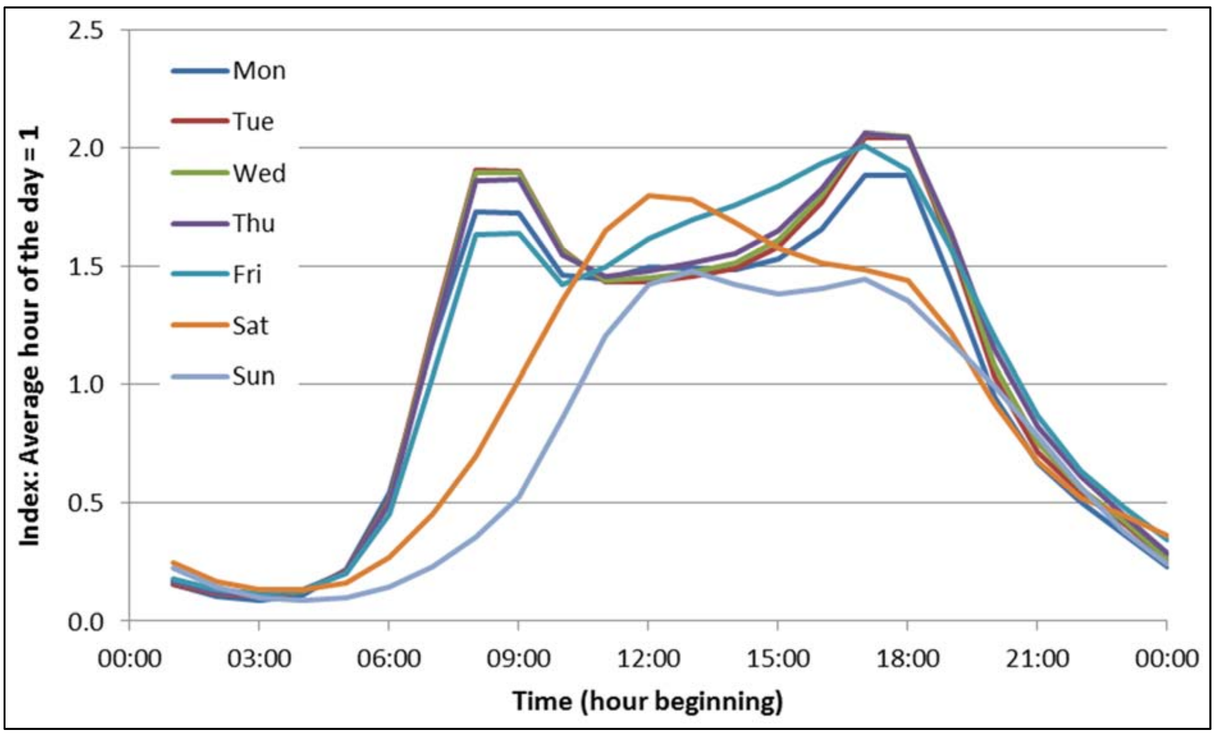


Figure 2-3. Diurnal Profile for Vehicle Emissions Used in the Modelling

[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/801205/tra0307.ods

2.13 Modelled Receptor Locations

The following receptor locations have been included in the model:

- Address base information used to calculate population-weighted mean concentration values for each Lower Super Output Area (LSOA), for input into the distributional analysis. These were modelled at a height of 1.5 m to represent relevant exposure. These receptors have not been included in the Target Determination (TD1/TD2) exercise.
- Selected monitoring site locations were used to verify and calibrate the model. These included automatic and passive (diffusion tube) monitors.
- For each link included in the PCM model, multiple receptors have been included within the model at a height of 2 m and at a distance of 4 m from the kerbside on both sides of the road. For each link, the receptor with the maximum predicted concentration has been used to facilitate a comparison between the local model results and the PCM model. Note that some receptors were non-reportable in line with guidance issued by the JAQU. These receptors where retained in the results for transparent reporting purposes but not included in the Target Determination process.
- A representative set of worst-case receptors for each location identified as either exceeding or likely to exceed the NO_2 annual mean Air Quality Objective. These were modelled at a height of 1.5 m to represent relevant exposure for the Air Quality Objectives.

A subset of receptors listed above (i.e. the third bullet point) were selected to assess compliance with the NO_2 Air Quality Directive via the Target Determination process for the year 2021. The receptors selected for compliance were those at least 25 m from major junctions and are representative of at least a 100 m length of road (as detailed in the Air Quality Directive (Annex III: A, B, and C)). A number of receptors have been modelled along each relevant PCM link and the worst-case concentration reported for the Target Determination exercise.

Initial modelling of the full receptor set noted above was a time-consuming exercise and included several locations with annual mean NO_2 concentrations well below the NO_2 AQD. Following discussions with BCC, the number of modelled receptors was refined to include, predominantly, areas that were either likely to be affected by proposed measures, or areas that were close to exceeding the AQD for NO_2. This made the model runs much more efficient, allowing more scenarios to be assessed.

Figure 2-4 shows reportable and non-reportable PCM related receptors. Note, the non-reportable receptors are retained for comparative purposes.

Figure 2-4a. Modelling receptors included in the study

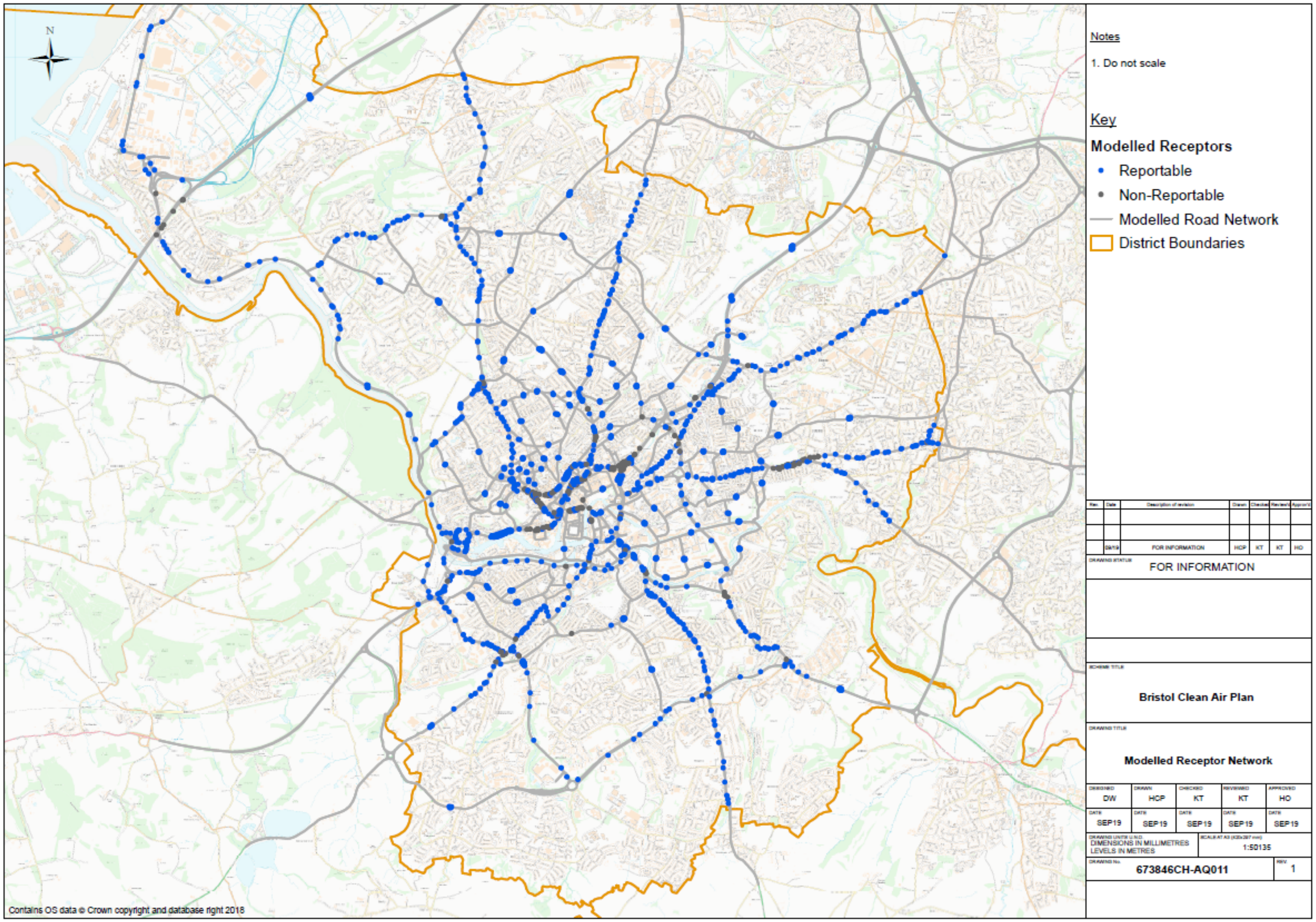
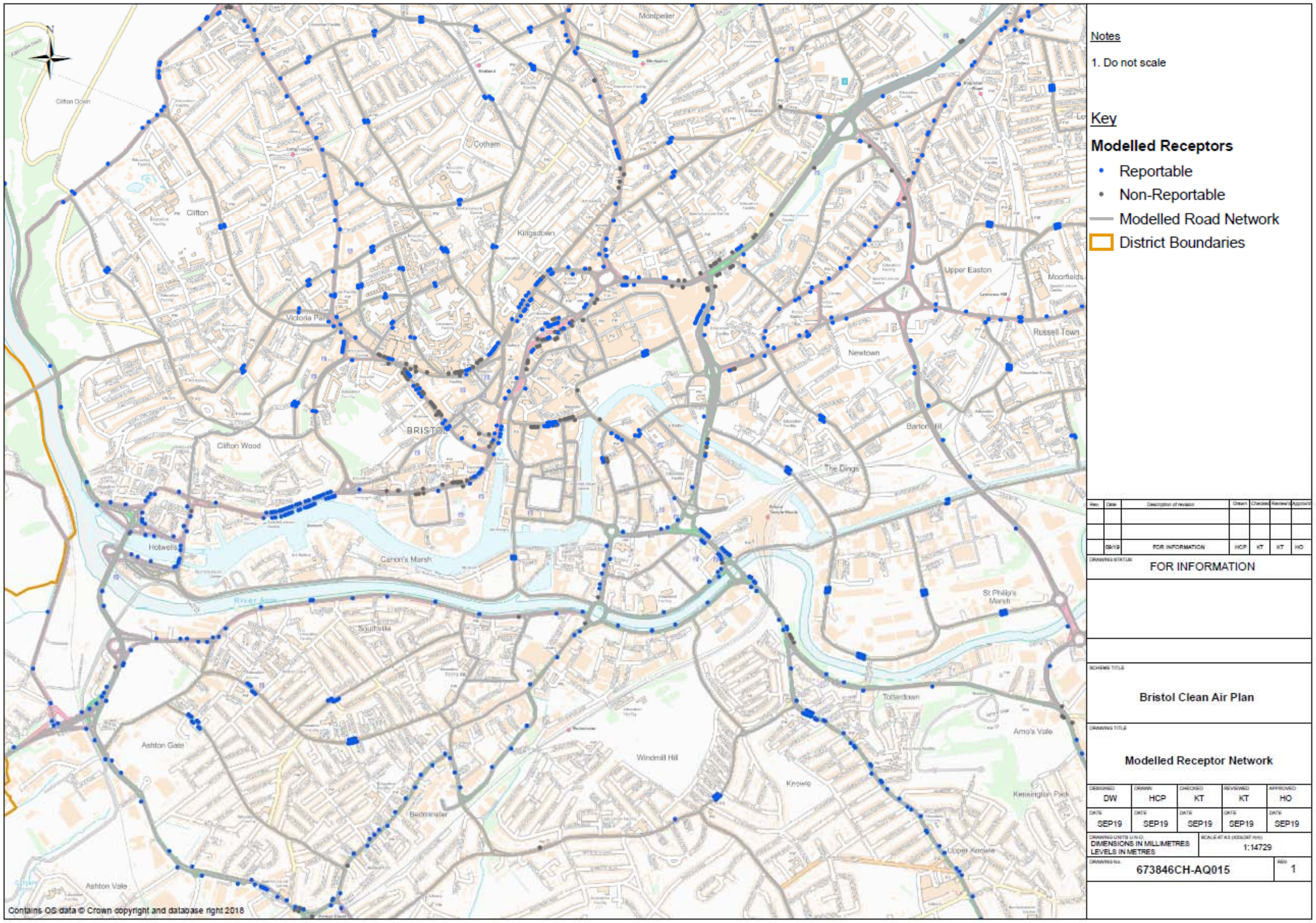


Figure 2-5b. Modelling receptors included in the study (zoomed)



3. Model Verification

3.1 Measurement data for model verification

Modelled NO_x and PM concentrations were verified against the 2015 BCC and South Gloucestershire County (SGC) automatic monitoring stations and, in the case of NO_2, at a selection of diffusion tubes. Data have been collected and verified in accordance with TG16(2018).

All available roadside automatic monitoring stations were initially considered. A screening of diffusion tube data was conducted to ensure that results were not significantly affected by non-road sources. The verification, and subsequent calibration process followed TG16(2018) Guidance. Table 3-1 provides further detail of the monitoring sites used in the verification process. For each monitoring site the measured NO_2 concentrations are compared to the modelled. *Figure **3**-**1*** shows the location of monitors available for 2015 in BCC and SGC.

All monitoring sites have QA procedures in place. Diffusion tube data were bias-adjusted and annualised where necessary. BCC's continuous analysers also followed a QA/QC programme as described below:

- daily checks on the lines, data transfer, analyser operation and data quality to ensure analysers and communications were working and faults reported as soon as possible;
- sites visited once a month by a trained AURN Local Site Operator (LSO) to change the filters and check the analysers;
- analysers were serviced and re-calibrated at six monthly intervals by the equipment suppliers; and
- results of all service, maintenance and calibration checks were held and used for ratification and scaling of the data.

Annual reports on air quality for LAQM purposes for BCC can be found at https://www.bristol.gov.uk/pests-pollution-noise-food/air-quality and for SGC at http://www.southglos.gov.uk/environment-and-planning/pollution/pollution-control-air-quality/air-quality-reports/. Reports include details of QA/QC undertaken for monitoring.

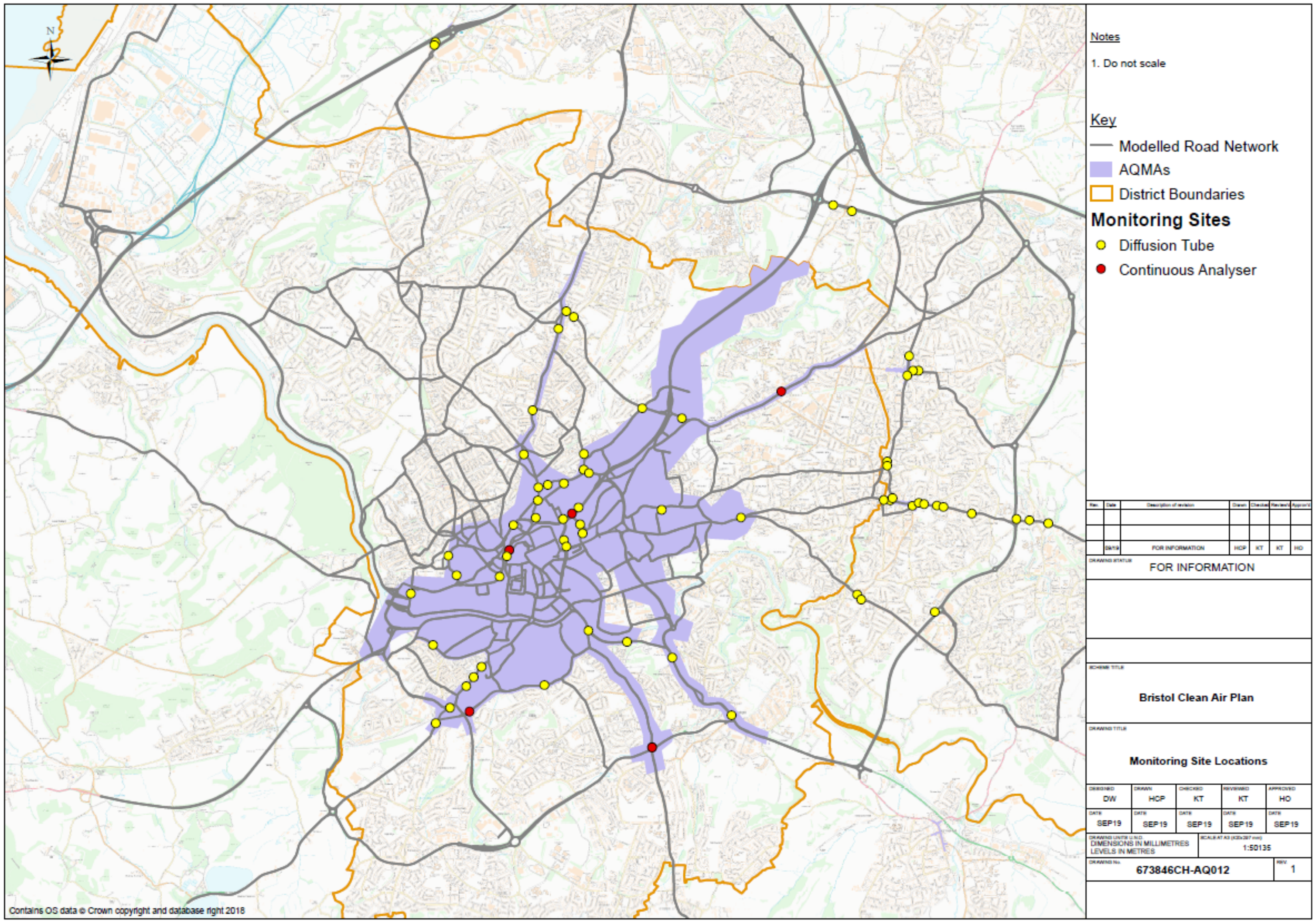


Figure 3-1. Air quality monitoring sites applied for the baseline dispersion model set up

Table 3-1 Details of monitoring sites used in the modelling setup

Monitoring Site ID	Location	Distance from kerb (m) in model domain	In Canyon?	On gradient?	Measured NO_2 Concentration 2015 (µg/m^3)	Adjusted Modelled Concentration 2015 (µg/m^3)
SGC17	364830, 173878	2.5	No	No	24.0	18.1
SGC36	364556, 178856	34	No	No	19.3	28.7
SGC58	365327, 172141	2.5	No	No	20.4	19.0
SGC63	359487, 182479	1.5	No	No	23.1	31.0
SGC68	364631, 173886	1.5	Yes	No	40.5	44.4
SGC69	364597, 173892	2.5	No	No	34.8	45.3
SGC70	364533, 173896	3.7	Yes	No	31.0	32.9
SGC71	365075, 175918	7.4	No	No	23.6	20.6
SGC72	364990, 175920	2.2	No	No	32.2	24.6
SGC74	364885, 175772	0.5	Yes	Yes	28.5	40.6
SGC93	364979, 173801	2.1	Yes	No	29.2	37.6
SGC95	365078, 173846	3.1	Yes	No	34.3	32.9
SGC96	365164, 173832	2.5	Yes	No	34.2	31.5
SGC97	365361, 173804	1.2	Yes	No	32.3	34.3
SGC105	364932, 176147	2.1	No	No	26.7	29.3
SGC129	357508, 181059	1.5	No	No	29.5	31.9
SGC130	357488, 181011	1.5	No	No	26.8	26.9
SGC133	363736, 178507	10.6	Yes	No	28.4	32.1
SGC135	364029, 178413	1.5	Yes	No	26.8	24.3
SGC143	366815, 173574	4.1	Yes	No	25.6	31.8
SGC145	367107, 173531	6.9	Yes	No	25.6	21.2
SGC147A	364586.2, 174495.9	2.2	Yes	No	38.7	40.9
BCC163	359435, 176574	2.7	Yes	No	37.0	49.5
463	362926, 175590	5.1	Yes	No	39.7	47.6
BCC260	361140, 175366	2	Yes	No	45.6	35.0
BCC307	360747, 175328	3.1	Yes	No	36.6	39.9
BCC21	359030.1, 175298.5	0.8	No	No	51.6	52.0
BCC325	361667, 175103	8	No	No	50.8	29.2
BCC407	359829, 174370	1.4	Yes	No	43.1	43.8
BCC426	359517, 174153	0.5	Yes	No	32.5	37.6
BCC157	359119, 174090	2.4	Yes	No	53.3	57.0
BCC497	359268, 174132	1.9	Yes	No	41.8	35.1
BCC373	359747, 173774	14.9	Yes	No	38.3	41.9
375	359645, 173683	6.8	No	No	41.1	36.0
BCC363	359075, 173613	3.2	Yes	No	39.2	46.8
BCC374	359507.4, 173595.2	1.1	Yes	No	47.1	42.6
BCC370	359775.7, 173513.6	0.7	Yes	No	37.7	37.7
BCC15	359294, 173485	1	Yes	No	50.8	39.0
BCC371	359813, 173373	1.6	Yes	No	44.8	45.3
BCC365	359520, 173264	11.1	No	No	36.5	29.5
BCC23	359555, 173166	4.2	Yes	No	45.3	43.6

Monitoring Site ID	Location	Distance from kerb (m) in model domain	In Canyon?	On gradient?	Measured NO_2 Concentration 2015 (µg/m^3)	Adjusted Modelled Concentration 2015 (µg/m^3)
BCC147	358514, 172691	1	Yes	No	60.1	53.8
BCC254	357118, 172429	2.7	Yes	No	54.4	46.7
BCC4	359903, 171850	3.1	Yes	No	53.3	53.2
BCC403	360508, 171676	0.5	Yes	No	41.5	40.6
BCC466	357466, 171622	1.9	Yes	No	34.0	32.2
BCC472	358226, 171284	2.1	Yes	No	40.0	43.1
BCC473	358105, 171124	1.6	Yes	No	49.6	44.1
BCC470	359213, 170997	2.5	Yes	No	38.7	36.8
BCC474	357990.4, 170979.6	2.1	Yes	No	38.5	41.5
BCC418	357737, 170642	2.2	Yes	No	63.7	45.1
215	358042, 170582	5.6	Yes	No	44.2	41.0
SGC22	364116, 172413	2.1	Yes	Yes	28.7	32.5
SGC73	364902, 175843	0.5	Yes	Yes	40.4	33.7
SGC90	364665, 173925	0.8	Yes	Yes	33.2	25.4
SGC98	365463, 173785	2.1	Yes	Yes	37.0	24.0
SGC128	364587, 174431	3.7	Yes	Yes	33.2	27.4
SGC132	364178, 172337	3.2	Yes	Yes	29.2	38.1
SGC142	366613, 173597	2.5	Yes	Yes	29.7	36.8
SGC146	365910.1, 173680.3	0.4	Yes	Yes	41.8	26.7
BCC493	359677, 176758	4.9	Yes	Yes	36.4	34.8
BCC494	359558, 176850	3.1	Yes	Yes	38.4	34.4
BCC492	359445, 176627	3	Yes	Yes	37.8	24.6
BCC303	361368, 175170.1	5.9	Yes	Yes	46.1	46.2
BCC159	358891, 174608	1.2	Yes	Yes	44.1	39.0
BCC312	359832, 174616	1.4	Yes	Yes	36.8	37.4
BCC295	359913.2, 174316.1	0.4	Yes	Yes	63.3	74.1
BCC22	359111.8, 173885.1	5.1	Yes	Yes	49.7	34.4
BCC405	361051, 173743	0.5	Yes	Yes	53.1	52.0
BCC496	362296, 173620	4.7	Yes	Yes	39.3	49.5
BCC9	358729, 173499	0.1	Yes	Yes	48.0	48.4
BCC156	357709, 173018	3.5	Yes	Yes	38.9	34.7
BCC155	357838, 172713	1.4	Yes	Yes	39.9	35.1
BCC413	360043, 171508	3	Yes	Yes	39.3	51.0
BCC467	357568, 171537	2	Yes	Yes	31.6	36.6
BCC10	361218.2, 171429.3	4.8	Yes	Yes	49.3	50.8
BCC175	362147, 170525	0.6	Yes	Yes	52.9	51.4
BCC239	357880, 170506	4	Yes	Yes	69.2	43.4
BCC242	357510, 170401	3.2	Yes	Yes	61.7	53.0
BCC14	360872.3, 170291.5	2	Yes	Yes	40.1	31.5
BCC438	360903, 170024	0.1	Yes	Yes	43.1	36.0
270	360903, 170024	0.1	Yes	Yes	39.3	37.4
BCC318	358667, 173110	4.6	Yes	No	91.2	88.8
206	358667, 173108	5.1	Yes	No	90.9	90.6

Monitoring Site ID	Location	Distance from kerb (m) in model domain	In Canyon?	On gradient?	Measured NO_2 Concentration 2015 (µg/m^3)	Adjusted Modelled Concentration 2015 (µg/m^3)
BCC2	358628, 173011	4.2	Yes	No	69.2	71.1

There are a number of monitoring sites that have **not** been included in the model verification process. All of these sites are included in Table 3-2 with reasons for exclusion from the verification. Some sites are located too far away (>15 m) from the modelled roads, which would not provide a robust verification of the local road contribution to concentrations, with others not located on modelled roads or the sites are affected by other very localised sources, such as bus stops. These sites, along with their distances from the kerb of the nearest modelled road, are presented in Table 3-2.

Table 3-2. Details of monitoring sites not used in model verification

Monitoring Site ID	Location	Distance from kerb (m) of model domain	Reason for exclusion from verification
SGC13	361523, 178732	2.7	Adjacent roads not included in the modelled domain, and gap in building information relevant to canyons
SGC17	364830, 173878	29.9	Located over 15m from the modelled domain
SGC23	364854, 173717	0.1	Located adjacent to a bus stop, not accounted for in model
SGC27	364866, 173835	2.1	Adjacent roads not included in the modelled domain
SGC34	362395, 182544	32.4	Located over 15m from the modelled domain
SGC35	362118, 183031	32.2	Located over 15m from the modelled domain
SGC45	363265, 180539	3	Cannot be located / construction work to expand bus lane
SGC54	365256, 171656	14.7	Located at entrance of retail industrial park - at traffic light where adjacent roads not included in model domain
SGC60	365101, 176688	7.2	Adjacent roads not included in the modelled domain
SGC61	364926, 175926	2.1	Adjacent roads not included in the modelled domain, and gap in building information relevant to canyons
SGC62	364909, 175908	0.4	Adjacent roads not included in the modelled domain
SGC67	364671, 173877	3.4	Located at an intersection - outside of canyon, however likely to be affected in real world
SGC78	364909, 176016	1.5	Adjacent roads not included in the modelled domain, and gap in building information relevant to canyons
SGC79	364913, 176067	1.9	Adjacent roads not included in the modelled domain, and gap in building information relevant to canyons
SGC87A	357739, 181334	24	Located over 15m from the modelled domain
SGC87B	357739, 181334	24	Located over 15m from the modelled domain
SGC87C	357739, 181334	24	Located over 15m from the modelled domain
SGC92	364968, 173836	1.9	Adjacent roads not included in the modelled domain
SGC108	360613, 181680	22.3	Located over 15m from the modelled domain
SGC116	366882, 173562	1.4	Concentrations affected by adjacent gradient road, which is not included in model
SGC117	359874, 178259	4.2	Adjacent roads not included in the modelled domain
SGC118	359875, 178207	2.3	Adjacent roads not included in the modelled domain
SGC119	360263, 179250	3.4	Adjacent roads not included in the modelled domain
SGC124	360918, 178905	47.9	Located over 15m from the modelled domain
SGC125	360891, 179005	10.4	Adjacent roads not included in the modelled domain
SGC137	366984, 173563	2.5	Adjacent roads not included in the modelled domain
SGC138	366941, 173558	1.4	Adjacent roads not included in the modelled domain

Monitoring Site ID	Location	Distance from kerb (m) of model domain	Reason for exclusion from verification
SGC139	366890, 173561	1.6	Adjacent roads (affected by gradients) not included in the modelled domain
SGC140	366879, 173594	22.1	Located over 15m from the modelled domain
SGC141	366705, 173581	8.2	Located adjacent to petrol station exit lane
BCC486	352785, 177858	16.3	Located over 15m from the modelled domain
BCC483	352484, 177735	57.4	Located over 15m from the modelled domain
BCC396	352593, 177673	20.3	Located over 15m from the modelled domain
BCC398	352501, 177698	21.7	Located over 15m from the modelled domain
BCC300	363365, 175883	2.1	Cannot be located (over predicted as coordinates place DT within the road)
BCC161	359152, 175733	0.2	Cannot be located
BCC464	362927, 175592	6.2	Located in same position as 463 (Continuous Monitor)
BCC261	361103, 175059	0	Cannot be located
BCC311	359677, 175057	1.4	Distance from roads included in the modelled domain (i.e. adjacent roads not accounted for in model)
BCC263	360343, 174473	30	Located over 15m from the modelled domain
BCC461	360381, 174405	14.9	Cannot be located
BCC462	360385, 174381	38.5	Located over 15m from the modelled domain
BCC487	360243, 174327	0.5	Adjacent roads not included in the modelled domain
BCC488	360205, 174291	4.4	At junction of an on ramp, and located below the road (on ramp elevation not accounted for in model)
BCC314	357751, 174063	1.8	Located in a taxi waiting area, not accounted for in model
BCC429	360484, 174096	4.9	Located at Bus Stop
BCC406	361576, 173806	0	Cannot be located
BCC441	359645, 173683	6.8	Located in same position as Continuous Monitor 375
BCC20	359567, 173629	6.7	On review, it was noted that this DT was placed upside down, area covered by an automatic monitor (375) and BCC374 DT, therefore excluded as results unreliable
BCC423	358623, 173386	16.4	Located over 15m from the modelled domain, and located at the entrance of parking area at the Children's hospital
BCC6	361262, 173412	4.6	Located at junction, not all roads affected included in modelled area
BCC305	360661, 173373	21.2	Located over 15m from the modelled domain
BCC436	361013, 173352	4.3	Cannot be located
BCC11	358813, 173342	2.8	Located at a parking garage (unable to located DT)
BCC12	359155, 173184	6.1	Cannot be located
BCC113	359254, 172694	4.9	Relocated out of road, to building façade, within parking garage area
BCC154	357601, 172481	3.8	Located adjacent to canal / away from receptors / affected by wind directions
BCC125	359214, 171917	0.1	Adjacent roads not included in the modelled domain
BCC8	359836, 171903	40.1	Located over 15m from the modelled domain
BCC5	358723, 171704	1.2	Located along a building, which the model interprets as a canyon - however building is not solid, therefore excluded
BCC99	357099, 171627	5.6	Located at junction, and adjacent roads not included in the modelled domain
BCC320	361178, 171566	15.5	Located over 15m from the modelled domain
BCC420	358277, 171562	5.1	DT located on a small local traffic circle, was presented as a straight intersection in the model. Therefore, the model under predicts at this location and it has been excluded.
BCC422	358168, 171525	3.3	DT likely to be affected by canyon & DT located on 2 roads - one of which is not accounted for in the model
203	361178, 171566	15.5	Located over 15m from the modelled domain

Monitoring Site ID	Location	Distance from kerb (m) of model domain	Reason for exclusion from verification
BCC417	359635, 171413	3.5	Located at Bus Stop
BCC469	359479, 171114	5.6	Located at junction, and adjacent roads not included in the modelled domain
BCC419	357832, 170686	2.6	Distance from roads included in the modelled domain (i.e. adjacent roads not accounted for in model)
BCC439	358038, 170581	4	Located in same position as Continuous Monitor 215
BCC478	362091, 170447	15.9	Located over 15m from the modelled domain
BCC479	361917, 170442	7	Distance from roads included in the modelled domain (i.e. adjacent roads not accounted for in model)

4. Baseline Projections Modelling (without measures)

4.1 Base Year (2015) – for model verification

The latest available version of the Greater Bristol Area Transport Study model (GBATS) with sufficient coverage to fulfil study requirements, was based on the year 2014. A 2015 transport model was developed using growth factors from 2014 to 2015 (see T3 'Local Plan Transport Modelling Methodology Report' for more details).

4.2 Target Determination Compliance Year (2021) - without measures

In line with achieving compliance in the shortest possible time in accordance with PCM forecasts, the target compliance year of 2021 and the 2021 traffic flows by vehicle type were extracted from the 2021 version of the GBATS traffic model.

Year 2017 ANPR fleet composition data were used as the basis for the forecast of the 2021 fleet, since it accurately reflects the local situation. These data were combined with the anticipated changes in the national fleet set out by the National Atmospheric Emissions Inventory (NAEI) and replicated in the EFT v8.0.1a in order to develop a 2021 fleet composition.

To derive emissions 10 years beyond compliance (2031 Baseline) to inform the options appraisal, projected local fleet proportions were derived by factoring the local ANPR data using NAEI forecasts and used along with the GBATS 2031 model to derive emissions.

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5. Projections Modelling (with measures)

5.1 Target Compliance Year (2021) - with measures

The impact of measures on air quality were evaluated for the target compliance year 2021. The 2021 traffic flows were provided by the GBATS model, which has been used to assess each scenario. Details of the methodology for this assessment are provided in Chapter 5 of T3 ‘Local Plan Transport Modelling Methodology Report’. Changes in the fleet composition were estimated using data provided by JAQU on the rate of replacement of existing vehicles with new/used vehicle combined with local ANPR data.

In order to calculate future fleet emissions 10 years beyond compliance (2031 baseline), to inform the options appraisal, the effect of measures on the traffic flows has been modelled in GBATS 2031 model. The fleet has been estimated using a similar method to 2021, using local ANPR data to reflect the local circumstances and accounting for changes in the national fleet proportions.

Of the 8 DS scenarios considered, as listed in section 2.1, those with the greatest potential to reduce concentrations were taken forward. The four scenarios taken forward are discussed further in this section and are detailed in Table 5-1 below.

Table 5-1. Details of DS options

Option Name	Details
Option 1	• Medium Area Class C (charging higher emissions buses, coaches, taxis, HGVs and LGVs); • Car diesel scrappage scheme; • HGV exclusion on links within the city centre with exceedances; • Close of Cumberland Road inbound to general traffic; • M32 Park and Ride with bus lane inbound; • Holding back traffic to the city centre through the use of existing signals • 8-hour car diesel exclusion on Park Row/Upper Maudlin Street and Marlborough Street.
Option 2	• Diesel car ban in the Bristol central area from 7am – 3pm, 7 days a week
Medium CAZ D+	• As per Option 1, but with inclusion of charges for non-compliant cars as well as all other vehicles
Hybrid	• Combination of all aspects of Option 1 and Option 2

Each scenario was modelled for 2021 and 2031. Linear interpolation was applied to each receptor’s results between these two years to give an estimate of the annual mean NO_2 concentration in each interim year. A “Compliance Year” could then be calculated for each scenario (i.e. an estimate of the earliest that each receptor would be compliant). This formed the basis for comparisons between scenarios to determine which would have the most significant benefit to air quality in Bristol and complies with JAQU’s criteria of achieving compliance in the shortest time possible.

6. Sensitivity Analysis

The Supplementary Note on Sensitivity Testing issued by the JAQU describes which tests would generally apply to both emissions and dispersion modelling. The JAQU Guidance categorises individual tests as being either 'priority' or 'recommended'. Priority tests included the following:

1. The alternative evolution of Euro 6d-temp and Euro 6d light duty diesel vehicles in the preferred DM and DS projected year.
2. Reducing the fraction of primary NO_2 (f-NO2) in the preferred DM and DS projected year.
3. Removing the impact gradients have on HGV emissions in the preferred DM and DS projected year.

Recommended tests include the following:

4. Impact on emissions by reducing the average road speed on links where the speed is already estimated to be <12 km/h.
5. Zonal versus full model domain calibration.
6. Background NO_2 calibration.
7. Fraction of primary NO_2 (f-NO_2) and calibration.
8. Surface roughness length.
9. Meteorology.
10. Canyon effects.

All of the above will be considered for the preferred option including tests associated with stated preferences which will require traffic model inputs and the more recent revision of the detailed fleet profiles published in the Emission Factor Toolkit version 9.1b. This version differs from that applied in the work reported here (i.e. v8.0.1a). The final lists of tests will be compiled in association with the traffic team and discussed with the JAQU.

As an update to discussions with the JAQU in August and September 2019 the following list of sensitivity tests were agreed for the preferred option:

- **HGV adjustment factors:** It was agreed with JAQU that HGV flow adjustments would be made on links with significant differences in modelled flows compared to observed counts. These adjustments would be carried through to future years for both the baseline and options.
- **Splits by Fuel Type: Comparison of NAEI (EFT) fleet projections:** The sensitivity test examines the differences in annual mean NO_2 concentrations between the preferred option modelled using fuel splits derived from the WebTAG Databook and the new information provided in the EFT v9.1a.
- **Behavioural Response to Charging:** To account for uncertainties in the preferred option response rates, alternative scenarios were developed assuming pessimistic and optimistic driver responses in terms of expected air quality impacts.
- **Test 1 above:** The alternative evolution of Euro 6d-temp and Euro 6d light duty diesel vehicles in the preferred DM and DS projected year.
- **Test 2 above:** Reducing the fraction of primary NO_2 (f-NO_2) in the preferred DM and DS projected year.
- **Test 3 above**: Removing the impact gradients have on HGV emissions in the preferred DM and DS projected year.

- **Test 4 above:** Impact on emissions by reducing the average road speed on links where the speed is already estimated to be <12 km/h.
- **Test 6 above**: Background NO_2 calibration.

The results of the sensitivity approach will be reported in the Sensitivity Report issued with the OBC

Appendix A. AQ1 Air Quality Tracking Table

Ref	Requirement	LA Proposal Description
A	**Air quality model specification**	
A.1	**Model selection**	
A.1.1	Details of emissions model based on COPERT 5 emissions to be used.	Emission Factor Toolkit Version 8.0.1a
A.1.2	Gradient effects included?	Yes, for roads with a gradient greater than 2.5% in accordance with TG(16)
A.1.3	Details of air quality dispersion model to be used.	ADMS-Roads 4.1
A.1.4	Canyon effects included?	The ADMS 'Advanced Canyon Module' has been used
A.1.5	Tunnels and flyovers included?	Included (e.g. M32 and part of Brunel Way flyovers considered)
A.2	**Air quality model domain**	
A.2.1	Please provide a map (in report) showing model domain in relation to exceedance locations identified in PCM model.	A map is included in the report AQ2
A.2.2	Locally identified exceedance locations included?	Yes
A.2.3	Domain includes displacement routes?	Yes
A.3	**Air quality model receptor locations**	
A.3.1	Details of receptor grid size and other receptor locations.	Address Base data will be used to calculate population-weighted mean concentration values. We have modelled at monitoring site locations and receptors for each link modelled in the PCM model, at 2 m height and 4 m distance from the kerbside. A receptor for each location identified as either exceeding or likely to exceed the NO_2 limit between the most recent historic assessment and projected years inclusive.
A.3.2	Methods to be used to assign subset of receptors for AQD assessment requirements.	Receptors have been modelled at least 25 m from major junctions and be representative of at least 100m road length. A large number of receptors are modelled on each PCM link at 4 m from the carriageway, 2 m height (at a distance from each other of under 10 m). The worst case receptor on each link (over 25 m from a junction) is reported to JAQU within the TD1 spreadsheet.
		The model has also been used to ascertain public health impacts and has thus included receptors close to junctions, even where these do not necessarily meet the AQD criteria (and have therefore not been used to derive LV compliance).
B	**Air quality base Year modelling**	

Ref	Requirement	LA Proposal Description
B.1	**General**	
B.1.1	Base year to be used	2015
B.1.2	Details of Meteorological data to be used.	Filton Airport, year 2015
B.2	**Traffic input data**	
B.2.1	Source of traffic activity data and vehicle types.	SATURN (GBATS). Vehicle types: cars (including taxis), LGVs, HGVs, coaches and buses. Motorcycles are not considered given their low number and lack of data. Taxis and coach matrices will be separated out from the car and HGV matrices respectively in the traffic model, using the ANPR data to provide global proportions. This has enabled testing of CAZs which include different measures for taxis and coaches. For input into the EFT taxis have been combined with cars, and coaches with buses (since separate Euro class definitions are not available).
B.2.2	Details of representation of road locations (achieved through use of a georeferenced transport model or another approach?).	Road links have been manually adjusted to reproduce the actual geometry using OS Mapping.
B.2.3	Source of vehicle fleet composition information (local/EFT).	Local ANPR data. EFT 'Advanced User Euro Split' has been used to estimate emissions.
B.2.4	Source of vehicle speed information.	
B.3	**NOx/NO2 emissions assumptions**	
B.3.1	Source of primary NO2 emission fractions (f-NO2).	The EFT has been used to calculate location specific f-NO2 values based on the fleet composition for each location for which traffic NOx emissions are calculated.
B.3.2	Details of method used to calculate projections for f-NO2 and to calculate NO2 concentrations from NOx concentrations.	The LAQM NOx to NO_2 calculator v6.1 with user defined f-NO_2
B.4	**Non-road transport modelling**	
B.4.1	Details of modelling for non-road transport sources.	No non-transport measures are assumed. Only Road sources have been modelled. The exceedances of annual mean NO_2 are predominantly associated with roadside emissions and little evidence supports other sources significant enough to be considered within our modelling approach. No other significant sources known, that are deemed significant to be modelled that are not already accounted for in the Defra background mapping.
B.5	**Measurement data for model calibration**	

Ref	Requirement	LA Proposal Description
B.5.1	Details used for the model calibration e.g. dates, locations.	2015 BCC and SGC monitoring data. All available data have been used (with additional QA checks applied). The latest Local Authority air quality reporting, containing details of locations, can be sourced from https://www.bristol.gov.uk/pests-pollution-noise-food/air-quality and http://www.southglos.gov.uk/environment-and-planning/pollution/pollution-control-air-quality/air-quality-reports/ Map of monitoring locations is included in Report AQ2.
B.5.2	Type of monitoring data (automatic and/or diffusion tubes) used for the model calibration.	Automatic and a selection of diffusion tubes (see point B.5.4). Data have been bias adjusted and annualised.
B.5.3	All available automatic (and/or diffusion tube) monitoring data included in the model calibration.	All roadside automatic monitoring data will be used together with a selection of diffusion tube data. All available monitoring locations have been used, unless there was a good reason not to include them – non-roadside location, uncertainty with traffic data (e.g: on a side street), low data capture <75%, other local factors (localised road works, tube close to other sources not explicitly modelled e.g. a bus stop).
B.5.4	Quality assurance of measurement data.	A screening has been performed to ensure the data used are accurate and representative of the actual baseline conditions.
C	**Projections modelling**	
C.1	**Baseline projections modelling**	
C.1.1	Years to be modelled.	Base year: 2015; Reference year (without measures): 2021. All interim years between baseline and baseline +10 years have been modelled using interpolation methods. Straight line interpolation based on concentrations has been included between 2015 and 2021.
C.1.2	Details of method for projected vehicle fleet composition.	Expected rates of new/used vehicles (provided by Defra) have been analysed to project the fleet (EFT 8.0.1a).
C.1.3	Details of method for projected vehicle activity.	SATURN model forecasts which are based on an uncertainty log and constrained to TEMPRO growth. Vehicle splits have been based on ANPR surveys but forecast to baseline year. Further details are provided in 3.1 and 3.6 of the transport tracking table.
C.1.4	Impact of RDE included?	To be determined based on JAQU position on data available at time of assessment.

Ref	Requirement	LA Proposal Description
C.1.5	Details of methods to calculate future fleet emissions 10 years beyond compliance to inform options appraisal (linked with C2.2).	Changes in the national fleet proportions have been applied to the local fleet data established from the ANPR data. Traffic flows have been modelled explicitly in 2031. Fleet composition being determined based on JAQU's fleet projection methodology (using ANPR data for 2015). Interpolation between 2021 and 2031 will be on the basis of concentrations (or emissions in the case of the economic assessment) undertaken using outputs of the EFT.
C.2	**With measures projections modelling**	
C.2.1	Years to be modelled.	Reference year (with measures): 2021. All interim years between baseline and baseline + 10 years will be modelled using interpolation methods.
	Details of method for projected vehicle fleet composition.	The effect of measures on the fleet in specific areas has been taken into account as well as expected rates of new/used vehicles (provided by Defra).
	Details of method for projected vehicle activity.	SATURN (TEMPRO factors)
C.2.2	Details of methods to calculate future fleet emissions 10 years beyond compliance to inform options appraisal.	The effect of measures on the fleet in specific areas has been taken into account as well as changes in the national fleet proportions (that will be applied to the local fleet data established from the ANPR data). Traffic flows have been modelled explicitly in 2031. Fleet composition being determined based on JAQU's fleet projection methodology (using ANPR data for 2015). Straight line interpolation based on concentrations will be included between 2015 and 2021. More complex interpolation based on EFT emissions will be undertaken for the economic assessment.

Appendix B. Canyon Parameters

Details of street canyon parameters used in the model. The extracted example shown in Table B.1.

Table B.1. Extracted example of canyon model parameters applied in the analysis

AdvancedCanyonVersion1																			
ID	Name	X1	Y1	X2	Y2	width_L	avgHeight_L	minHeight_L	maxHeight_L	canyonLength_L	endLength_L	buildLength_L	width_R	avgHeight_R	minHeight_R	maxHeight_R	canyonLength_R	endLength_R	buildLength_R
0	1582_2591	356524	173104	356532	173068	11.1	15.8	13.3	25.3	222.8	259.8	194.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2591_1582	356524	173104	356532	173068	11.1	15.8	13.3	25.3	222.8	259.8	194.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1235_3621	356552	171482	356532	171491	36.1	8.2	6.0	8.6	91.8	17.6	22.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2471_3621	356408	171745	356421	171718	20.3	7.0	3.9	8.3	86.9	2.0	72.4	25.7	7.7	6.0	8.6	196.9	0.0	108.6
4	3621_1235	356500	171570	356508	171529	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.1	8.2	6.0	8.6	91.8	0.0	22.4
5	3621_2471	356500	171570	356485	171613	25.7	7.7	6.0	8.6	196.9	1.6	108.6	20.3	7.0	3.9	8.3	86.9	109.6	72.4
6	1001_2229	355807	177239	355808	177272	24.0	9.9	5.8	11.4	434.6	99.3	220.4	19.7	9.7	7.1	11.1	513.2	20.2	372.9
7	1001_3337	355807	177239	355774	177213	21.1	9.4	4.7	12.4	394.6	15.2	151.0	16.0	6.9	4.5	10.3	100.8	159.0	70.1
8	1001_3592	355807	177239	355812	177228	17.1	8.3	6.9	9.6	123.1	41.8	79.0	17.9	10.1	8.8	12.1	154.8	10.1	78.1
9	1002_1003	356259	176588	356279	176529	13.5	10.4	9.0	12.3	184.4	10.5	123.2	11.8	9.9	4.8	10.9	178.1	0.0	106.5
10	1002_1004	356259	176588	356239	176535	12.7	10.1	9.1	11.2	151.3	0.0	83.7	17.1	5.9	4.5	8.0	160.7	0.0	113.2
11	1002_1883	356259	176588	356248	176627	14.9	8.7	4.8	10.9	371.4	0.0	234.4	16.0	9.3	6.6	11.6	382.0	10.8	242.8
12	1003_1002	356341	176401	356342	176413	11.8	9.9	4.8	10.9	178.1	28.8	106.5	13.5	10.4	9.0	12.3	184.4	12.0	123.2
13	1003_1004	356341	176401	356268	176414	24.6	8.9	7.8	10.1	156.4	0.0	133.5	13.3	10.6	9.9	11.3	120.0	22.4	109.4
14	1003_1616	356341	176401	356356	176390	21.7	9.6	9.0	10.0	18.6	0.0	18.6	22.1	7.9	7.8	8.2	38.1	0.0	34.2
15	1004_1002	356188	176433	356189	176444	17.1	5.9	4.5	8.0	160.7	11.0	113.2	12.7	10.1	9.1	11.2	151.3	20.4	83.7
16	1004_1003	356188	176433	356268	176414	13.3	10.6	9.9	11.3	120.0	13.9	109.4	24.6	8.9	7.8	10.1	156.4	0.0	133.5

Appendix C. External Review of the Air Quality Modelling Methodology

C.1 Preamble

This appendix was inserted in response to feedback from the T-IRP (September 2019). The T-IRP requested that information be provided concerning a third-party review of the modelling methodology undertaken by AQC Ltd and commissioned independently by BCC. The review was commissioned by BCC to provide additional confidence in the approach developed and results obtained by Jacobs which was in turn developed in accordance with guidelines published by the JAQU.

The following information is an Executive Summary extracted from the review entitled Bristol CAZ Air Quality Modelling Review by AQC to BCC and Jacobs dated September 2019.

C.1.1 Introduction

Air Quality Consultants Ltd (AQC) were commissioned by Bristol City Council to undertake a high level review of the work that has been undertaken in relation to air quality modelling for the Bristol Clean Air Zone (CAZ) feasibility work. The work was commissioned partly due to a specific concern about the year of compliance which the modelling was predicting, and therefore elements of the outputs of the model were prioritised for review in order to respond to this concern. At the outset of the process the specification included the following broad topics:

- Review the description of the modelling methodology and Quality Assurance procedures and provide commentary on its appropriateness and any improvements which could be made;
- Review the appropriateness of the dispersion modelling methodology and identify any weaknesses;
- Review the model set up, focusing on the main areas driving compliance to determine what factors are at play, and whether these factors are specific to Bristol, or whether they are caused by model assumptions / setup;
- Consider at a high level, alternative ways in which compliance could be achieved with reference to the findings within bullet point 3; and
- Provide general commentary on the air quality aspect of the work undertaken (through a workshop).

The air quality modelling which has been reviewed has been carried out by Jacobs UK Ltd (Jacobs). Feedback was provided to both Bristol City Council and Jacobs at a workshop hosted by AQC on 12th September 2019. This current note summarises the outcomes of the review and defines specific actions going forward.

It should be noted that this review only covers the air quality modelling. The air quality modelling is highly dependent on the traffic modelling which has not been covered in any detail, as this is outside of AQC's area of expertise.

Prior to any of the other points outlined in this report, it should be noted that the current air quality modelling has reported all relevant annual mean nitrogen dioxide concentrations greater than 39.95 μg/m^3 as exceeding the Limit Value. In practice, the Limit Value allows an annual mean concentration of 40 g/m^3 but not any higher concentration. Defra's approach, when reporting compliance to the European Commission (as confirmed by JAQU at the meeting on 12th September 2019), is to round any concentrations to the nearest integer, and therefore a concentration of 40.49 μg/m3 would not be reported by Defra as an exceedence. JAQU's guidance Bristol CAZ Air Quality Modelling Review Summary Report J3074_ 3 of 16 September 2019 is thus to report annual mean concentrations less than 40.5 g/m3 as compliant with the Limit Value

Action for Jacobs

Adopt a 'cut off' value of 40.5 g/m3 for Limit Value reporting.

Jacobs Response

Whilst it is accepted that 40.5 g/m^3 could be applied the consensus was that the study retains 39.95 g/m^3. To be consistent with all other test results. It's also the case that the existing threshold is conservative and reduces uncertainty of marginal compliance estimated at reportable receptors.

C.1.2 Summary and Conclusions

The assessment of the compliance year for the Bristol CAZ feasibility work appears to be too conservative. This conclusion is based on both an investigation of some of the locations where the model is predicting the highest concentrations (and are thus driving the year of compliance) and by a review of the method for interpolation between 2021 and 2031 which has been used to calculate the year of compliance.

There was no evidence found that there is an overall bias in the modelling, but scatter within the verification process (comparison of modelled versus measured concentrations at monitoring locations) is quite large. Furthermore, imprecision in the model configuration at both receptors used for the verification and those used to assess compliance means that in any one location the model may over-predict or under-predict appreciably. However, because there is no evidence of overall bias (i.e. a tendency to either over-predict or under-predict concentrations) there is no suggestion that the measures being proposed across large parts of the city are inappropriate. This is because, even though the model is likely to predict the highest concentrations in the incorrect locations, these measures will affect large areas and are thus likely to 'catch' the areas where the true maximum concentrations occur.

The same assurance cannot, however, be made regarding location-specific measures (e.g. traffic management measures at particular locations). In these cases, because the model cannot be relied upon to predict the correct locations for the highest concentrations, it should not form the basis for deciding where to apply location-specific measures without considering the location specific model performance in more detail. One example would be Church Road (A420) which is not within the CAZ area, and where the model is predicting high concentrations, which are not supported by long term monitoring in the area.

The interpolation process has been reviewed and re-interpreted based on emissions reductions in the EFT rather than on a linear basis. This brings forward the year of compliance (without any of the other changes suggested in this document) to 2027 in the baseline and 2025 with either of the modelled scenarios. Although this is not judged to be a robust methodology for final determination of the year of compliance, it is a more realistic estimate on which to base the decision on which future year should be modelled in full. It should be noted that this estimate is on the basis that there is a linear change in traffic between 2021 and 2031.

Finally, the feasibility work may choose to round the model outputs to whole integers (for example treating a concentrations of 40.49 µg/m3 as compliant with the Limit Value) since this is the approach which Defra takes when reporting to the European Commission.

Actions for Jacobs

The following are the short-term actions for Jacobs discussed at the meeting on 12th September:

1. Jacobs to run a model for Church Road using different traffic inputs (as a sensitivity test).
2. Canyon parameters could be changed for some receptor locations at the same time.
3. Parson Street – Jacobs to investigate the impacts of the scheme at the monitored locations where the model is under-predicting to see whether the reductions predicted by the model would bring the monitored concentrations into compliance.
4. In order to assess compliance, Jacobs to model 2025 as interim year, with traffic data modelled for that year, rather than 2027 which was going to be undertaken for the OBC.
5. Ascertain what impacts rounding to nearest integer has for the conclusions of the OBC modelling.

Jacobs Response

1. A review of the traffic on Church Road will be undertaken as part of the 2025 modelling task.
2. Canyons have been extensively reviewed and will be reviewed again for some locations as part of the FBC phase.
3. Parson Street receptors and other sensitive locations will be appraised as part of the sensitivity requirements of the FBC.
4. 2025 traffic and air quality modelling had already been anticipated as indicated by existing modelling work, this will be undertaken before the 16th October.
5. See Section C.1.1. The threshold of 30.95μg/m^3 will be retained for consistency.

Actions for the Council

It is recommended that more monitoring is undertaken on Park Street and Church Road. A general review of monitoring across the city would be helpful, particularly in relation to the model outputs – i.e. where high concentrations are predicted, or where the model is under-predicting and it is judged that there is not enough coverage.