Bristol City Council Clean Air Plan

Economic Case

FBC-5 | 6

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Bristol City Council

Contents

Acronyms and Abbreviations

ANPR	Automatic Number Plate Recognition
AQMA	Air Quality Management Area
B&NES	Bath and North East Somerset
BCC	Bristol City Council
CAZ	Clean Air Zone
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
EU	European Union
EV	Electric Vehicle
FBC	Full Business Case
GBATS4M	Greater Bristol Area Transport Study v4M
GVA	Gross Value Added
HGV	Heavy Goods Vehicle
IMD	Indices of Multiple Deprivation
JAQU	Joint Air Quality Unit
LGV	Light Goods Vehicle
NOx	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NSC	North Somerset Council
OBC	Outline Business Case
PCM	Pollution Climate Mapping
PHV	Private Hire Vehicle
PM	Particulate Matter
SOC	Strategic Outline Case
SGC	South Gloucestershire Council
WECA	West of England Combined Authority

3. Introduction

3.1 Introduction

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). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its 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 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2] , to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. 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 originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), an Outline Business Case (November 2019 and updated between April and June 2020) and a Full Business Case (February 2021).

In line with Government guidance BCC is considering implementation of the 'Small CAZ D Option' which includes a charging scheme for non-compliant buses, taxis, HGVs and LGVs and cars alongside a number of other measures.

This chapter sets out the economic case and forms part of the BCC CAP Full Business Case. This economic case will have the following supporting documents:

- Appendix D Air Quality Assessment Reports
- Appendix E Transport Modelling Reports
- Appendix F Stated Preference Survey Report
- Appendix G Economics Methodology Report

[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] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

- Appendix H Distributional and Equalities Impacts Report
- Appendix P Sensitivity Test Report
- Appendix T Environmental Assessment Report

Draft versions of this report were published in January 2019, October 2019 and June 2020. Since these reports, further work has been undertaken to develop the scheme options, and this work is reported in Option Assessment Report, Appendix C to the Full Business Case.

3.2 Option assessment

3.2.1 The Option Assessment Report sets out the details of option development work, including Long List and Shortlist sifting. Update since October 2019 OBC

The OBC submitted in October 2019 identified the Hybrid option as the preferred option. However, the Hybrid Option has a number of legislative risks associated with the implementation of a diesel car ban, which could have significant impacts on scheme delivery. Therefore, work was undertaken to explore alternative options, which could produce similar levels of benefits as the Hybrid Option but with lower delivery risks. This work resulted in the development of a scheme option consisting of a CAZ C across the medium zone and a CAZ D across the small zone. This medium CAZ C/Small CAZ D Option is more closely aligned to the CAZ Framework than the Hybrid option, and does not include a diesel car ban, thereby reducing delivery risks.

This option includes the following measures:

- A charging scheme for non-compliant buses, taxis, HGVS and LGVs (CAZ C) across the medium zone
- A charging scheme for non-compliant buses, taxis, HGVs, LGVs and cars (CAZ D) across the small zone
- Close 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.

During the COVID-19 Pandemic, a number of Street Space Schemes were implemented or planned around Bristol in order to facilitate social distancing and improve air quality. These schemes have significantly improved air quality in the centre of Bristol. It was hoped that these schemes alongside other measures would enable the council to meet its air quality aims without a charging zone. Due in part to the COVID-19 pandemic, it was not possible to demonstrate sufficient behavioural change on key corridors, such as Upper Maudlin St/Marlborough St to avoid having a charging zone. Further work was therefore carried out to assess what impact the street space schemes would have on the charging zone options and the baseline model was updated to include Street Space schemes.

In addition to this, assessment of the Medium CAZ C/Small CAZ D zone previously indicated that the majority of air quality receptors driving compliance are situated within the Small CAZ D zone. An option comprising the Small CAZ D was developed, including the following measures:

- Small Area Class D (charging non-compliant cars, buses, coaches, taxis, HGVs and LGVs);
- Fast Track Measures:
  - Closure of Cumberland Road inbound to general traffic; and
  - Holding back traffic to the city centre through the use of existing signals.

This option was modelled and indicated a compliance year of 2023. This scheme therefore achieves the same compliance year as the Medium CAZ C/Small CAZ D Option, without the wider economic impacts associated with a Medium CAZ C zone.

As a result of the option assessment work, the Small CAZ D Option has been taken forward for further assessment within this FBC.

In addition to the items listed above, the Fast Track Measures include the proposed Old Market Gap project which will facilitate and support the delivery of a CAZ D by completing a missing gap in active mode infrastructure on a key strategic route into the city centre. Provision of active mode infrastructure will help reduce reliance on private car for short journeys, particularly for those commuting from the north east fringe of the city centre and lower income groups. The project will help encourage all forms of movement that impact positively on the health and of the local community.

3.2.2 Preferred Option

The option being considered for analysis within this FBC is the Small CAZ D.

This chapter reports the economic case for the Small CAZ D Option.

The transport and air quality forecasting work in this chapter assumes that the scheme will be implemented in October 2021. It is likely that this will move to summer 2022 resulting in the exemptions being in operation in the first part of 2023. Mitigation measures will be offered in advance of the go live date, reducing the likelihood of compliance being impacted. The economic assessment presented in section 3.6 reflects the change in opening date.

3.3 Transport Modelling Approach

3.3.1 Modelling methodology

This modelling methodology section summarises the detailed methodology found in the Local Plan Transport Modelling Methodology Report (T3), and its appended technical notes, bringing together an overview of all the components of how the baseline and option testing has been carried out using the GBATS4M Transport Model.

3.3.2 Base and Baseline

3.3.2.1 Model Development

The Local Plan Transport Modelling Methodology Report (T3), chapters 3, 4 and 7, outlines the modelling methodology for the Base and Baseline models. It states that the GBATS4M variable demand model has been used to develop the 2023 baseline models, based on the inputs from the updated Uncertainty Log.

The Uncertainty Log was originally developed in 2015 therefore details for an up-to-date Uncertainty Log have been collated. This covers both development and scheme assumptions. The baseline model (2023) has the most recent scheme assumptions for the assessment year modelled within it based on the Near Certain and More than Likely entries in the Uncertainty Log, in accordance with WebTAG.

In addition to the schemes mentioned in the uncertainty log, the Street Space schemes have also been included in the Baseline scenario.

The Street Space schemes have been/are being implemented to open up road space usually reserved for parking and movement of general traffic to cyclists and pedestrians to:

- Enable better social distancing, especially in local shopping areas;
- Encourage people to travel by bike or walk; and
- Reduce air pollution.

A growth model has been developed within the Demand Model which creates highway and public transport future year demand matrices using the production and attraction trip end totals for the new development, a gravity model to distribute these new developments using base year travel costs and then converting to origin and destination format. These new trips are then added to the base year matrices. Three-dimensional matrix balancing to build full reference case matrices is undertaken, retaining the base year trip length distribution and control to the National Trip End model (NTEM, Tempro V7.2) growth for West of England and external zones.

These matrices are then run through the variable demand model until convergence is achieved within the limits specified by the DfT.

Light and heavy goods vehicle growth is based on forecasts produced by the National Transport Model (NTM) as advised by WebTAG. Goods vehicles are not subject to change via the demand model.

Joint Spatial Plan growth has not been included in the development of the 2023 baseline models as it is not sufficiently certain, in terms of the WebTAG criteria, to be included.

The 2023 Baseline highway model developed has been adapted to be able to model the implementation of a charging CAZ. The matrices have been split by compliance for each user class using the surveyed Automatic Number Plate Recognition (ANPR) data.

3.3.2.2 ANPR Data

The 2017 Automatic Number Plate Recognition (ANPR) surveys were undertaken in July and the analysis (including tabulated data) and use is discussed fully in the ANPR Data Analysis and Application technical note which is appended to T3. A summary is provided here.

The ANPR data has been used to determine the compliance splits of the current fleet when compared to the CAZ framework criteria relating to Euro Standards. The registration data from the ANPR surveys have been cross referenced with data purchased from Carweb to gain information on vehicle type, fuel type and Euro standard. The ANPR data has also been used to split the taxi fleet from the car matrices and the coaches from the HGV matrices, by applying global factors, by time period.

The base year compliance splits by vehicle type (Car, Taxi, LGVs, Coaches and HGVs) have been determined from the 2017 ANPR data worked back to 2015 using the Emission Factor Toolkit national euro standard splits. The baseline has been adjusted to 2023 using the fleet projection tool within the Emission Factor Toolkit.

3.3.2.3 Matrix Compliance Splits

The base year highway model has 6 user classes: Car Non-business (Low Income), Car Non-business (Medium Income), Car Non-business (High Income), Car Business, LGV and HGV. These have been split into 16 user classes using the following methodology:

- Split the Car user classes into Car and Taxi user classes;
- Split the HGV user class into HGV and Coach user classes; and
- Split Car, Taxi, LGV, HGV and Coach matrices into compliant and non-compliant using the time period splits.

3.3.2.4 Post-Processing

The ANPR data collected has also been used to determine the HGV rigid/artic split by compliance. The EFT v9.1b has been used for the fuel splits. This has been used to add more detail, where needed, to the modelled outputs via post processing, to produce inputs into the EFT. An additional adjustment has been made to car fuel splits due to identification by BCC of an increase in petrol taxis replacing diesel. These were applied to the traffic link data extracted from the model runs via post-processing before input to the EFT.

First Bus provided information regarding the 2023 fleet composition by service. Non-First bus compliance splits have been derived from ANPR data adjusted to 2023 using the EFT tool. The bus fleet composition has been handled outside the transport model, before input to the EFT. This has enabled vehicle details for particular routes to be accounted for in both the current and future fleet.

Adjustments have been made to traffic flows to improve the accuracy of the Air Quality Modelling along Church Road near St George's Park prior to inputting the data into the EFT. Additional adjustments have also been made to traffic flows and speeds at three locations on the network which critical to Air Quality compliance. These locations are:

- Marlborough St (B4051)
- Rupert St (A38)
- Baldwin St (B4053)

3.3.2.5 Euro Standard Splits

The EFT has national Euro Standard splits within it. These have been overwritten with splits calculated from the 2017 ANPR data, projected forward to 2023 using the EFT.

3.3.2.6 2015 Base Compliance Splits

The base year compliance splits have been determined from the 2017 ANPR data worked back to 2015 using the EFT national euro standard splits. The ANPR Data Analysis and Application technical note (appended to T3), Chapter 3, details this process and the outputs. Table 3-1 shows the projected 2015 compliance data by time period – AM peak, IP (Interpeak) and PM peak.

Table 3-1: 2015 Compliance Splits by Time Period

Vehicle Category	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	36.1%	63.9%	34.7%	65.3%	35.3%	64.7%
LGV	0.2%	99.8%	0.2%	99.8%	0.2%	99.8%
HGV rigid	20.2%	79.8%	19.0%	81.0%	15.2%	84.8%
HGV artic	35.0%	65.0%	36.3%	63.7%	34.0%	66.0%
HGV	22.7%	77.3%	21.7%	78.3%	19.2%	80.8%
Taxi	11.5%	88.5%	9.1%	90.9%	10.7%	89.3%
Bus	7.6%	92.4%	7.9%	92.1%	7.7%	92.3%
Coach	14.7%	85.3%	15.1%	84.9%	15.8%	84.2%
Total	28.4%	74.8%	27.1%	76.6%	30.0%	71.3%

3.3.2.7 2023 Baseline Compliance Splits

The fleet projection tool within the EFT v9.1b has been used to project the euro standard splits from the 2017 ANPR data to the Baseline year of 2023. The ANPR Data Analysis and Application technical note (appended to T3), Chapter 4, details this process and the outputs. A summary of the projected 2023 compliance data by time period is provided in Table 3-2.

Table 3-2: 2023 Compliance Splits by Time Period

Vehicle Category	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	82.9%	17.1%	82.1%	17.9%	82.5%	17.5%
LGV	73.3%	26.7%	77.3%	22.7%	73.5%	26.5%
HGV rigid	85.1%	14.9%	84.1%	15.9%	80.1%	19.9%
HGV artic	92.4%	7.6%	92.8%	7.2%	92.0%	8.0%

Vehicle Category	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
HGV	86.8%	13.2%	86.2%	13.8%	84.2%	15.8%
Taxi	74.5%	25.5%	74.5%	25.5%	74.5%	25.5%
Bus	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%
Coach	81.1%	18.9%	81.7%	18.3%	82.4%	17.6%
Total	81.5%	18.5%	81.6%	18.4%	81.6%	18.4%

3.3.2.8 Fuel Type Splits

The 2017 ANPR fuel splits for cars and LGVs have been adjusted to 2015 using the change over time in the TAG databook (May 2019) fuel split table. These were applied to the traffic link data extracted from the model runs during post-processing. Table 3-3 shows the fuel type splits obtained from the 2015 calculations.

Table 3-3: Fuel Type Splits (2015)

Vehicle Category	2015		
	Petrol	Diesel	Electric
Cars	55.21%	44.74%	0.04%
LGVs	0.80%	99.15%	0.05%

The EFT v9.1b has been used for the fuel splits for 2023. An additional adjustment has been made to car fuel splits due to identification by BCC of an increase in petrol taxis replacing diesel. These were applied to the traffic link data extracted from the model runs via post-processing before input to the EFT. Table 3-4 shows the fuel type splits from 2023 EFT v9.1b with taxi adjustment.

Table 3-4: Fuel Type Splits (2023)

Vehicle Category	2023		
	Petrol	Diesel	Electric
Cars	61.42%	37.18%	1.40%
LGVs	0.44%	99.21%	0.35%

3.3.3 Clean Air Zone Option Testing

3.3.3.1 Primary Behavioural Responses

The primary responses have been modelled using the G-BATS4M highway model using the following methodology, as described in the Local Plan Transport Modelling Methodology Report (T3), Chapter 5:

- Pay Charge – no change to the highway model;
- Avoid Zone – a charge is applied to each inbound link to replicate the percentage change of non-compliant cars, LGVs and HGV's within the CAZ;
- Cancel journey / change mode – modelled by reducing the number of trips made by non-compliant vehicles to/from and within the CAZ area, to replicate the required percentage change from the baseline case; and
- Replace Vehicle – an adjustment to the link flows by extracting select cordon link flows for the non-compliant trips and switching the required proportion of replace vehicles from the non-compliant matrices to the compliant link flows.

3.3.3.2 Secondary Behavioural Responses

In addition to the primary behavioural responses, JAQU have set out some further assumptions on secondary responses for a charging CAZ for cars in paragraph 3.3 of the Evidence Package guidance. These have been used due to lack of any available local data.

These secondary responses have been applied during the calculation of the upgrade costs and post-processing of the extracted link-based flow data from the Transport Model for the 'replace vehicle' response.

3.3.3.3 Stated Preference Surveys

Stated preference survey of BCC / South Gloucestershire Council (SGC) / North Somerset Council (NSC)/ Bath and North East Somerset (B&NES) residents were undertaken in 2018. The work targeted owners of non-compliant cars / LGVs who drive in central Bristol, and 1100 online surveys completed Feb / March 2018.

The questionnaires asked how owners would respond to a small and medium size charging CAZ using structured 'multiple choice' exercises and then the results were analysed using logistical regression statistical techniques.

3.3.3.4 Upgrade Costs

In order to determine the primary response rates over a range of CAZ charges from the stated preference surveys, an upgrade cost is required for cars. The LGVs methodology for determining response rates also requires an estimation of an upgrade cost. The upgrade costs of other vehicle types (HGVs, Taxi, Bus and Coaches) were not used to calculate the primary response rates; rather, the primary response rates for these vehicle types were determined by other information collated.

3.3.3.5 Proposed Charge Rates

Table 3-5 shows the proposed charges. These are selected as the minimum charges required to address the air quality exceedances within Bristol and are in line with charges being considered by other local authorities.

The methodology for determining the proposed charge rates for all vehicle type is discussed fully in FBC-26 Primary Behavioural Response Calculation Methodology in Appendix E of the FBC and Table 3-5 shows the final proposed charges for the small sized charging zone. The charges were initially set for Cars, Taxis and LGVs so that the responses, from the Stated Preference survey, of avoid zone, change mode / cancel journey and replace vehicle combined roughly equated to the combined JAQU CAZ responses. These charges were found to be insufficient to bring about compliance during early model testing and so testing with higher charges was undertaken. Above a certain level there are diminishing returns to further increases and so the final proposed charges arrived at were at this point. Modelling also suggests that lowering the charges would lead to diminished air quality benefits.

Table 3-5: **Bristol CAZ Proposed Charges**

Charge Class	Daily Charge
Cars*	£9.00
Taxis	£9.00
LGVs	£9.00
HGVs	£100.00
Buses	£100.00
Coaches	£100.00

3.3.4 Calculated Response Rates for Small CAZ D

The methodology for calculating the primary response rates for Small CAZ D is discussed fully in FBC-26 Bristol Clean Air Plan: Primary Behavioural Response Calculation Methodology in Appendix E of the FBC and is summarised as follows:

- Cars – The upgrade cost has been used to determine a range of primary responses for different charge rates using the stated preference survey responses for non-compliant cars from the Small zone area;
- LGVs – The primary response rates are calculated from the stated preference survey responses which were identified as a 'van'. Again, the upgrade cost is used to determine a range of primary responses for different charge rates from the Small zone area;
- HGVs – The primary behavioural responses rates for HGVs were taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU.;
- Taxis – The taxi response rate is based on Bristol enforcing compliance for Taxis through their licensing agreements with taxi operators;
- Coaches – The initial response rates for coaches were taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU; and
- Buses – The response rates for buses were determined through discussions between Bristol and bus operators.

An adjustment for foreign vehicles has been applied to the responses rates calculated from the methodology set out above, as foreign vehicles cannot be reliably charged (their details are not captured in the Driver and Vehicle Licensing Agency (DVLA) database in order to determine if the vehicle is compliant and so enforcement can only occur through a manual process with limited powers). The final response rates will assume a 'worst case', i.e. that these vehicles continue to drive within the zone but do not pay the charge. In reality it is unlikely that this will be the case for all foreign vehicles.

Table 3-6 shows the final primary behavioural response rates by vehicle type produced using the methodology set out above and the charge rates in Table 3-5.

Table 3-6: Final Primary Behavioural Response Rates for Small CAZ D

Response	Cars Low Income	Cars Medium Income	Cars High Income	Cars Employers Business	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	4.3%	10.4%	5.4%	6.8%	4.1%	15.9%	8.8%	0.0%	17.8%
Avoid Zone	15.6%	19.0%	15.7%	7.7%	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	39.8%	20.4%	14.2%	30.7%	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	40.4%	50.3%	64.6%	54.8%	95.9%	62.2%	82.6%	93.6%	70.8%

3.3.5 Traffic Management Measures

The identified traffic management measures to improve air quality have been modelled where included within Small CAZ D. This section discusses the methodology used to model these, which are covered by the Fast Track measures.

3.3.5.1 Cumberland Road

The closure of Cumberland Road inbound to general traffic was modelled within the SATURN highway model and run through the VDM to allow the demand model to determine the traffic response to this physical measure of removing highway capacity. This scheme component is a Fast Track measure.

3.3.5.2 Holding Back Traffic from City Centre

The modelling of holding back traffic to the city centre was achieved through the use of adjusting existing signal timings to reduce the capacity to that of the baseline flows at each entry point. This restricted the re-routing of trips from Cumberland Road, therefore ensuring overall trips into the city centre remain at the reduced level.

3.4 Air Quality Modelling Approach

3.4.1 Overview of approach

Pollution dispersion modelling was undertaken using the Cambridge Environmental Research Consultants (CERC) ADMS-Roads modelling suite (versions 4.1 and 4.2). 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. ADMS v4.1 is one of the "standard" models recommended in JAQU's 'Transport and Air Quality' guidance. 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. The model is approved by Defra and used extensively in the United Kingdom.

Traffic data were provided as detailed in T3 (Local Plan Transport Modelling Methodology Report) for the years 2015, 2021, 2023 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.

Whilst undertaking post OBC analysis of the Small CAZ D+FTMs for the FBC phase it became apparent that compliance at all reportable receptors was being achieved in 2023 (according to interpolation) across all scenarios under consideration. Under these circumstances' scenarios continued to be tested at 2021 and 2031 but in addition it was felt more robust to add dedicated 2023 traffic model outputs to the air quality assessment.

Do Minimum (DM) and several Do Something (DS) scenarios were modelled for 2021, 2023 and 2031. The DS included:

- Small Area Class D CAZ – (charging non-compliant cars, buses, coaches, taxis, HGVs and LGVs) + RB4 boundary configuration;
- Fast Track Measures (FTMs):
  - Closure of Cumberland Road inbound to general traffic; and
  - Holding back traffic to the city centre through the use of existing signals.

The modelling domain includes all potential displacement routes which may be affected by mitigation measures, identified from the traffic model. It 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). It's worth noting that the level of uncertainty in the traffic data in central Bristol was lower than areas outside of the authority boundary. Whilst the approach included modelling of receptors outside of the BCC boundary, for other reporting aspects the results provided in AQ3 represent BCC only.

As part of the assurance process Air Quality Consultants (AQC) reviewed modelling results produced by Jacobs for the OBC found there to be no specific bias evident in the approach. Recommendations provided by AQC were responded to by Jacobs, the outcome of which are reported in April 2020 AQ2 report.

3.4.2 Summary of results

A detailed assessment of the impacts of the Small CAZ D scenario on air quality was undertaken for the FBC using the approach summarised in Section 3.4.1. The number of non-compliant receptors per year, per scenario are summarised in Table 3-7. The results indicated that the Small CAZ D would provide total compliance in 2023, compared to the reference case's natural compliance year of 2027.

Table 3-76: Number of Non-Compliant Receptors Per Year, Per Scenario

Year	Number of Non-Compliant Reportable Receptors with BCC in Each Scenario	
	Reference	Small CAZ D
2021	77	15
2022	41	8
2023	22	0
2024	16	0
2025	7	0
2026	2	0
2027	0	0

Further detail is provided on the assessment and associated compliance years in the following sections and in Table 3-8 and Figure 3-1.

3.4.2.1 Small CAZ D

It is evident looking at the 2021 model results that the Small Area CAZ D scenario has a very large impact on annual mean NO_2 concentrations at the majority of the critical locations presented in Table 3-8. Marlborough St, where the highest reportable concentrations were modelled, had a decrease of 14.9 µg/m^3 at receptor 12549, bringing compliance forwards to 2023. On Upper Maudlin Street, Park Row, College Green, Cheltenham Road and Newfoundland Way, the implementation of the Small CAZ D and fast track measures reduced the annual mean NO_2 concentrations sufficiently so that they were compliant with the EU Limit Value. Despite the large impact of the scheme however, Rupert Street, Marlborough Street and Church Road remained non-compliant with the EU limit value in 2021.

With regards to change in annual mean NO_2 concentrations across BCC, the Small Area CAZ D and fast track measures scenario led to decreases (change in concentrations of -0.4 µg/m^3 or less) at 1,153 reportable receptors within BCC in the 2021 scenario. As above, the largest decrease was at receptor 12649 on Marlborough Street. In this scenario there were just 9 increases (of 0.4 µg/m^3 or greater) in annual mean NO_2 concentrations, which is likely attributable to redistribution of traffic across the network. The largest increase was 1.5 µg/m^3 on Lower Ashley Road, which caused this receptor to be non-compliant in 2021. Given the high modelled concentrations elsewhere though, this does not influence the overall anticipated compliance year for BCC.

The 2023 model scenario indicated broadly similar improvements to those seen in the 2021 scenario. The main difference is that in 2023 the changes are generally of smaller magnitudes to those in 2021 as a result of the natural improvements to the vehicle fleet over this two-year period. Even so, Marlborough Street still had a decrease in annual mean NO_2 concentrations of 9.1 µg/m^3 with the Small Area CAZ D in place. The proposals reduced concentrations at all remaining locations with non-compliance (i.e. Marlborough Street, Rupert Street, Upper Maudlin Street and Newfoundland Way) sufficiently to make these locations compliant with the EU limit values (see Table 3-8).

The Small Area CAZ D resulted in a decrease of 0.4 µg/m^3 or greater at 1,059 reportable receptors within BCC authority boundary and no change (change of -0.3 to 0.3 µg/m^3) at 333 reportable receptors (see Figure 3-1). It also resulted in an increase (change greater than 0.4 μg/m^3) in annual mean NO_2 concentrations at 7 receptors, which is again likely attributable to redistribution of traffic across the network. The largest change was 3.2 μg/m^3, which occurred on the A37 Wells Road near the junction with the A4174 Callington Road.

By 2031 all reportable receptors within BCC authority boundary were estimated to be compliant with the EU Limit Value for at least 4 years (see Table 3-8). The high proportions of compliant vehicles on the network by this point also means that the Small CAZ D will have little to no effect on air quality by 2031 (assuming that CAZ emissions compliance criteria remains the same). Changes estimated for this scenario compared to the updated baseline are likely attributable to the fast track measures. There were decreases (less than or equal to -0.4 μg/m^3) in annual mean NO_2 concentrations at 63 reportable receptors, and no change at 1,260 receptors. There were also increases of 0.4 μg/m^3 or more at 76 receptors, the largest of which was 2.0 μg/m^3 on Upper Maudlin Street. None of the increases caused non-compliance with the EU Limit Values.

Table 3-8: 2021, 2023 and 2031 Street Space Scheme Baseline and Small Area CAZ D (including Fast Track measures) modelled annual mean NO_2 results and compliance years at critical locations

	Rupert Street (nr Bridewell St)	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (μg/m^3)											
Reference	51.4	57.7	48.3	44.7	37.8	34.7	40.7	41.4	49.9	43.5	26.5
Small Area CAZ D	43.1	42.8	37.4	35.3	29.3	28.5	32.8	38.9	39.8	41.6	24.5
Difference	-8.3	-14.9	-10.8	-9.4	-8.5	-6.1	-7.8	-2.5	-10.1	-1.9	-2.0
2023 Results (μg/m^3)											
Reference	46.0	49.4	42.1	38.9	32.4	30.1	35.2	37.0	43.9	37.9	23.7
Small Area CAZ D	39.8	40.3	34.6	32.7	26.5	25.8	29.7	35.5	36.3	36.5	22.2
Difference	-6.2	-9.1	-7.5	-6.1	-5.9	-4.3	-5.4	-1.6	-7.5	-1.4	-1.5
2031 Results (μg/m^3)											
Reference	33.3	33.3	28.2	26.3	22.9	21.5	24.2	26.8	29.4	25.2	18.8
Small Area CAZ D	32.9	35.3	28.1	26.6	22.1	21.4	23.9	27.3	29.0	25.6	18.8
Difference	-0.3	2.0	-0.1	0.3	-0.8	-0.1	-0.3	0.5	-0.4	0.4	-0.1
Compliance Year											
Reference	2026	2027	2024	2023	2021	2021	2022	2022	2025	2022	2021
Small Area CAZ D	2023	2023	2021	2021	2021	2021	2021	2021	2021	2022	2021
Difference	-3	-4	-3	-2	0	0	-1	-1	-4	0	0

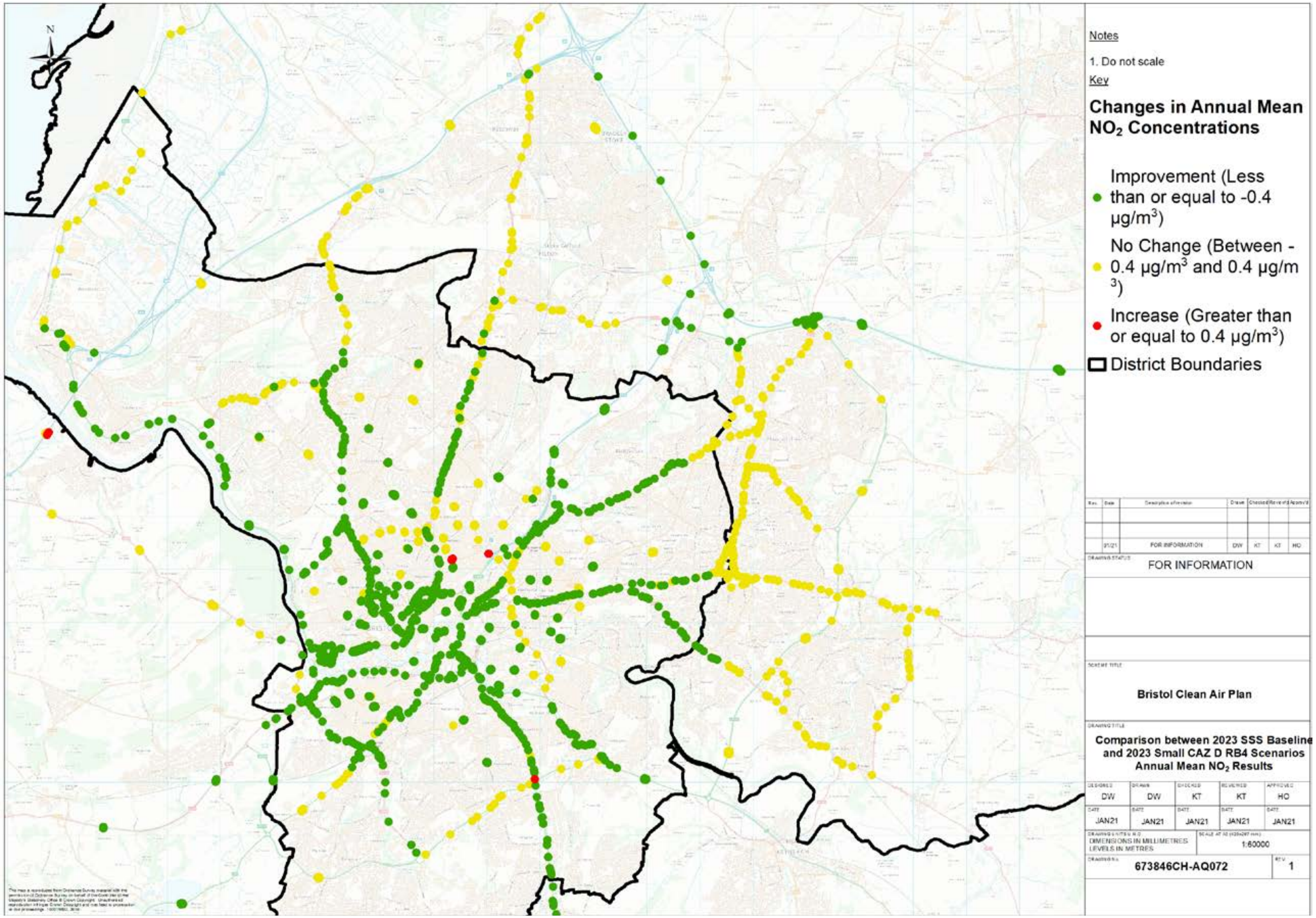


Figure 3-1: Change in 2023 annual mean NO_2 concentrations between the Reference Case and Small CAZ D Scenario at reportable receptors

3.4.3 Conclusion

The main focus areas preventing earlier compliance were Marlborough Street, Upper Maudlin Street and Baldwin Street. The Small Area CAZ D achieves compliance on Marlborough Street in 2023. Compliance on Upper Maudlin Street is estimated to be 2021. Street space schemes in place on Baldwin street alone achieve compliance at this location by 2021. Overall, this scenario achieves compliance by 2023 across the whole of BCC authority area.

3.5 Economic Modelling Approach

JAQU's Option Appraisal Guidance states that each shortlisted option identified at SOC stage should be subject to detailed assessment of their overall costs and benefits and their distributional impacts. The results from these assessments are intended to allow local authorities to identify the preferred option for a scheme based on its value to society, distributional impacts and achieving compliance in the shortest possible time. However, the Options Appraisal Guidance is also clear that only option packages that are likely to lead to compliance as quickly as possible will be accepted, using some pass/fail criteria as part of the Primary Critical Success Factors.

The economic analysis presents information on the Small CAZ D option.

The economic modelling approach is aligned with JAQU's Option Appraisal Guidance and gives full consideration to all of the economic impact types specified in that document. The results of the analysis are outlined in the following section; the overall framework and methodology applied to the analysis is presented in FBC-18 'Economic Methodology Report' in Appendix F of this FBC.

All the work in this section is based on the transport and air quality modelling work undertaken for 2021, 2023 and 2031. Note that the analysis is predicated on interpolation of outputs between these modelled years; this is a fundamental change in approach to previous analyses for which other modelled years were available (e.g. 2021 and 2031 only got OBC stage and 2021, 2025 and 2031 for interim FBC stage.). Further, also note that given the opening year for the scheme is now likely to be 2022, the analysis is predicated on a ten year period 2022 to 2031, rather than 2021-2030 as before. More information on the interpolation and other assumption changes driven by this change in opening year are documented in FBC-18 'Economic Methodology Report' in Appendix F of this FBC.

3.6 Economic Impacts

3.6.1 Health and Environmental Impacts

3.6.1.1 Greenhouse Gas Emissions

By changing travel behaviours (including number of trips, trip mode and vehicle type), the intervention option may influence the quantum of Greenhouse Gas (GHG) emissions generated by road transport. A change in GHG emissions, and CO_2 emissions in particular, could generate variable effects on climate change processes.

Based on air quality modelling outputs, the intervention option will marginally increase the quantum of GHG. This is linked to changes to vehicle speeds, vehicle redistribution, and fleet composition induced by the intervention. The economic impact of the change in GHG emissions is outlined in Table 3-9, based on monetisation through application of Department for Business, Energy and Industrial Strategy (BEIS) carbon prices. In present value terms, there is a marginal negative impact associated with the overall marginal increase in GHG emissions. This is indicative of a GHG emissions being lower under the intervention scenario than the baseline in early years of the appraisal period, followed by being higher later on in the appraisal period.

Table 3-9: GHG impacts

Impact	Small CAZ D
Cumulative Difference in CO_2 Emissions, 2021-30 (tonnes)	+1,227
BEIS Carbon Prices, 2021-2030(£/tonne)	71.59-88.33
Undiscounted Impact (£s)	-337,042
Present Value (PV) of GHG Impact (£'s 2018 Prices and Values)	**-15,882**

3.6.1.2 Air Quality (PM/NO2) Emissions

Based on air quality modelling outputs, the intervention option is forecast to reduce the level of PM and NO_2 emissions in the early stages of the appraisal period, contributing to an improvement in air quality. Improvements in air quality can lead to a range of public health, natural and built environment benefits. These benefits can be monetised through the application of JAQU's Damage Cost estimates.

The economic impact of the change in NOx and PM2.5 emissions is outlined in Table 3-10.

Table 3-10: Air quality impacts

Impact	Small CAZ D
Cumulative Difference in NO_2 Emissions 2021-2030 (tonnes)	-202
NO_2 Damage Costs 2021-2030 (£/tonne)	17,353-20,738
Undiscounted Impact (£s)	3,670,725
PV of NO_2 Change (£'s 2018 Prices and Values)	**2,945,889**
Cumulative Difference in PM Emissions 2021-2030 (tonnes)	-4
PM Damage Costs 2021-2030 (£/tonne)	330,990-395,564
Undiscounted Impact (£s)	1,290,602
PV of PM Change (£'s 2018 Prices and Values)	**1,019,143**
Aggregate PV of Air Quality Changes (£'s 2018 Prices and Values)	**3,965,041**

3.6.2 Impacts on Transport Users

3.6.2.1 Fuel Switch Impacts

The transport analysis assumes that some car drivers will switch fuel type from diesel to petrol, when upgrading their vehicle in response to the intervention option. The change in fuel switch costs is reflected in the change in vehicle operating costs to the user, captured as part of the DfT's Transport User Benefits Assessment (TUBA). No additional or separate analysis is provided here.

3.6.2.2 Transaction Costs

Based on the traffic forecasting analysis, the intervention option will accelerate the rate at which vehicle owners' purchase or upgrade to compliant vehicles. Each upgrading transaction incurs time costs for vehicle owners relating to identifying and buying a compliant vehicle. By applying JAQU's recommended transaction cost data (provided as part of the National Data Inputs for Local Economic Models) to the number of vehicles anticipated to upgrade, Table 3-11 suggests that the scheme will impose a transaction cost of c. £63,000 over the ten-year appraisal period.

Table 3-11: Transaction cost impacts

Impact	Small CAZ D
Number of Vehicles Upgrading	10,398
Undiscounted Impact (£)	72,813
PV of Transaction Costs (£'s 2018 Prices and Values)	**62,855**

3.6.2.3 Consumer Welfare Impacts

The intervention option will affect consumer behaviour by inducing a change in travel behaviour for non-compliant vehicle trips (for example through upgrading vehicles, using alternative modes, cancelling journeys etc, as suggested by the stated preference survey and reflecting in traffic model forecasts). However, because consumers would have preferred their original action in the baseline, this change in behaviour leads to a consumer welfare impact. Two elements of analysis were identified to estimate aggregate consumer welfare loss as a result of intervention:

- Welfare loss associated with vehicles upgrading earlier
- Welfare loss associated with changing travel patterns or behaviours (i.e. mode shift, cancelled journeys, diverted journeys)

The cost of upgrading was estimated by establishing the average cost differential for upgrading a vehicle in the intervention scenario, compared to the baseline scenario. The cost differential was driven by the change in depreciation rates over time and therefore, the change in residual vehicle value between replacement and replaced vehicles, at the time of upgrading in the intervention scenario, relative to the baseline scenario. As vehicles were expected to upgrade earlier in the intervention scenario, the cost of upgrading is expected to be higher as the difference in value between replacement and replaced vehicles is also expected to be higher.

By applying the average cost differential for upgrading to the number of vehicles, upgrading (split by vehicle type [i.e. cars, LGVs, buses etc) and upgrade type [i.e. to new or used vehicles]) the consumer welfare loss associated with upgrading earlier is estimated to cost £8 million, as shown in Table 3-12. Note that the figure reflect use of the 'rule of half' to estimate the average loss to each upgrader.

Table 3-12: Consumer welfare: cost of upgrading impacts

Impact	Small CAZ D
Number of Vehicles Upgrading	10,398
Undiscounted Impact (£)	9,622,389
PV of Consumer Welfare Loss due to upgrading (£'s 2018 Prices and Values)	**8,309,181**

The cost of changing travel behaviour was estimated by establishing the number of vehicle trips in the baseline that would be fundamentally changed in the intervention scenario. The cost of each individual trip cancelled, changed or switched to a new mode was assumed to be equal to half the cost of the charge. This approach, in line with JAQU's Options Appraisal Guidance, was adopted to reflect that only those trips that were valued at less than the cost of the charge were cancelled; any trips valued more than the charge were assumed to pay the charge. However, as it is not possible to value every trip that induced a behavioural response, each cancelled, changed or mode shifted trip was assumed to be valued at half the price of the charge.

Following these approaches Table 3-13 indicates that the consumer welfare loss associated with changing travel patterns or behaviour could induce a consumer welfare loss of £37 million over the ten-year appraisal period.

Table 3-13: Consumer welfare: cost of changing travel pattern or behaviour impacts

Impact	Small CAZ D
Number of Vehicles Trips Cancelled/Changed Mode/Avoiding Zone	33,358,983
Undiscounted Impact (£)	47,265,648
PV of Consumer Welfare Loss due to changing travel behaviour (£'s 2018 Prices and Values)	**37,042,257**

3.6.2.4 Vehicle Scrappage Costs

As part of the upgrading process, it is assumed that the overall size of the vehicle fleet remains fixed. Therefore, for every new vehicle purchased, an older vehicle is scrapped. The differential in lost asset value associated with scrapping a vehicle earlier in the intervention case relative to the baseline case allows monetisation of this impact. By combining the number of vehicles expected to be scrapped in the intervention scenario by the average differential in lost asset value between the intervention and baseline scenarios, Table 3-14 demonstrates that vehicle scrappage costs could amount to £0.9 million across the ten-year appraisal period.

Table 3-14: Vehicle scrappage cost impacts

Impact	Small CAZ D
Number of Vehicles Scrapped	1,813
Undiscounted Impact (£)	1,020,480
PV of Vehicle Scrappage Costs (£'s 2018 Prices and Values)	**881,942**

3.6.2.5 Journey Time/Vehicle Operating Costs

By influencing travel patterns and behaviours, the intervention option could also have an impact on transport economic efficiency (TEE), measured in terms of changes to journey time savings and vehicle operating costs. By reducing vehicle flows, increasing vehicle speeds and reducing congestion, travel time could be reduced alongside reduced running costs. Using DfT's TUBA software, the change in vehicle movements induced by the intervention option could contribute to benefits in the region of £11 million, based on journey time and vehicle operating cost benefits for road users in Bristol.

Table 3-15: Journey timetable/vehicle operating cost impacts

TUBA Impact Category	Small CAZ D
Undiscounted Impact (£)	11,331,967
PV of TEE Impacts (£'s 2018 Prices and Values)	**10,541,659**

3.6.2.6 Accident Impacts

By influencing travel patterns and behaviours, the intervention option could also have an impact on frequency and severity of accidents. The DfT's COBALT (Cost and Benefit to Accidents – Light Touch) software was utilised to monetise the economic impact of changes in accident patterns within the economic appraisal. Table 3-16 demonstrates that the intervention will reduce the monetisable impacts of accidents by c. £5.9 million.

Table 3-16: Monetised accident impacts

Accident Impact	Small CAZ D
Undiscounted (£)	£7,678,177
PV Total (£'s 2018 Prices and Values)	**£5,916,152**

3.6.2.7 Walking/Cycling Impacts

By inducing mode shift, the intervention option will increase the number of individuals making walking and cycling trips. This has a positive economic impact, primarily by improving general health of people, through inducing increasingly active lifestyles and reducing absenteeism from work. Using the DfT's Active Mode Appraisal Toolkit, the forecast growth in the number of walking and cycling trips is expected to lead to a benefit of £1.0 million.

Table 3-17: Walking/cycling impacts

Impact	Small CAZ D
Number of Trips Changing Mode	7,550,459
Number of New Cycling Trips	566,284
Number of New Walking Trips	1,038,188
Undiscounted Impact (£)	1,634,840
PV Total (£'s 2018 Prices and Values)	**1,046,232**

3.6.3 Costs to Central and Local Government

3.6.3.1 Scheme costs

Table 3-18 provides a summary of the scheme costs for the intervention option; further details are provided in the financial case. Optimism bias is included at the prevailing rate defined by HM Treasury Green Book and referenced in FBC-18 'Economic Methodology Report' in Appendix F of this FBC.

Table 3-18: Estimated Scheme Costs for Small CAZ D (including optimism bias)

Item	Costs (£)
Enforcement System	£808,499
Highway Works	£1,914,337
CAZ Project Delivery and Ongoing Operational Management Team	£1,532,036
CAZ Publicity and Advertising	£483,100
Other CAPEX	£19,720
Non-Charging Measures - Implementation Fund	£656,801
Non-Charging Measures - Clean Air Fund	£45,636,227
Risk	£1,163,994
Undiscounted Total Capital Cost (£)	£52,214,716
PV of Capital Costs (£'s 2018 Prices and Values)	**£46,292,399**
System Operations and Maintenance	£14,921,001
Camera, Comms, Signage and Building m	£2,888,125
Monitoring and Evaluation	£392,223
Decommissioning at Scheme End	£575,192
PCN Production	£598,311
Undiscounted Total Revenue Cost (£)	£19,374,852
PV of Revenue Costs (£'s 2018 Prices and Values)	**£14,777,090**

3.6.4 Summary

By combining the economic impacts discussed in the previous sections, the intervention option is forecast to generate an NPV of -£85.9 million as shown in Table 3-19.

Table 3-19: Economic impacts (2018 prices and values £)

Impact (£m, 2018 Prices and Values)	Small CAZ D
Present Value of Benefits	
Air Quality: Changes in NOx	2.95
Air Quality: Particulate Matter	1.02
Journey Time Savings/Vehicle Operating Costs	10.54
Active Mode Appraisal Toolkit	1.07
Accident Analysis	5.92
Present Value of Benefits (PVB)	**21.49**
Present Value of Costs	
Consumer Welfare: Behavioural Response – Replace Vehicle	8.31
Consumer Welfare: Behavioural Response – Cancel Trip/Avoid Zone/Re-mode	37.04

Impact (£m, 2018 Prices and Values)	Small CAZ D
Vehicle Scrappage	0.88
Transactions	0.06
GHGs	0.02
Capital Expenditure: Set Up Costs	46.29
Operational Expenditure: Running Costs	14.78
Present Value of Costs (PVC)	**107.38**
Net Present Value (NPV)	**-85.89**

To provide scale context, this NPV has been compared to the forecast GVA in Bristol (forecast at £137 billion in present value terms [2018 prices and values] between 2021-30). Across the 10-year period assessed, the NPV of the intervention option represents -0.06% of present value GVA in Bristol over the same period.

3.7 Qualitative Assessment of Economic Impacts

Allied to the economic modelling impacts monetised above, a qualitative assessment of the impact of the scheme on a range of other economic indicators was also undertaken. This included employment markets, income deprivation, businesses and economic sectors (e.g. retail/leisure). It also incorporates a review of some of the JAQU-prescribed economic impacts considered within the economic modelling above (e.g. consumer welfare loss, vehicle scrappage costs and transaction costs).

3.7.1 Introduction

The qualitative economic analysis of the intervention option follows a two-step approach:

- Step One –outlines the baseline position for Bristol's economy, covering a range of key economic indicators, in order to establish an economic narrative
- Step Two – assessment of the potential impact of the scheme on key economic indicators

The economic narrative established in Step One provides the context within which the assessment of the impact of the intervention option on key economic indicators is considered as part of Step Two.

3.7.2 Step One: Economic Narrative

This section presents a brief economic narrative for the City of Bristol. It outlines key baseline economic indicators at both local authority level as well as for the small area CAZ boundary pertaining to the preferred Clean Air Plan option (where possible). The analysis contains a summary of the following indicators:

- Business count
- Employment data/labour market characteristics
- Deprivation analysis
- Vehicle compliance patterns

This analysis helps to establish the function and form of Bristol's economy in the context of the forthcoming Clean Air Plan. However, note that the latest available data is utilised in the below assessment, some of which may pre-date the onset of the COVID19 pandemic and therefore may not provide a real-time insight into the current position of Bristol's economy.

3.7.2.1 Business Count

Business count data from National Online Manpower Information System (NOMIS) provides an insight into the number and size of businesses in a given context area. Businesses are classified into various sizes based on the number of employees within that business. The data illustrates that the Bristol economy consist of 22,170 businesses, with 18,025 of these classified as micro-businesses. Micro-businesses make up a significant proportion (81%) of the market structure within the local authority, whilst SMEs account for 18% of all businesses within Bristol. Overall, micro and small businesses account for 96.3% of the business within Bristol. Table 3-20 below presents the distribution of businesses by type across Bristol.

Table 3-20: Business types within Bristol

	Business Type				
Context Area	Micro (0 to 9)	Small (10 to 49)	Medium-sized (50 to 249)	Large (250+)	Total
Bristol LA	18,025	3,320	700	125	22,170
Small CAZ	2,210	675	145	35	3,065

Table 3-20 summarises the business count data pertaining to the small area CAZ, which will be directly affected by the intervention option. More than 3,000 businesses are located within the small boundary, amounting to 13% of all Bristol businesses. It is evident that micro businesses make up the largest proportion of businesses. Further, combining micro and SME businesses reveals that around 99% of all businesses located across the local authority and 94% within the small area CAZ boundary employ fewer than 50 employees. Smaller businesses are particularly vulnerable to economic shocks and the potential burden of additional overhead costs imposed by schemes such as a CAZ.

Business count data was also considered for two key sectors within the Bristol economy: tourism[3] and retail[4]. Table 3-20 reveals that as per the economy-wide analysis, micro businesses in the retail sector comprise a majority of the market structure at local authority and small area CAZ level. Within the small area CAZ boundary, micro-businesses make up 71% of the businesses, this increases to 79% for Bristol as a whole. It should be noted that there is also a large presence of small retail businesses in the small area CAZ (27%), this drops to 19% at the Bristol local authority scale. In total, all retail businesses at all geographic scales are defined as micro or SMEs. At a spatially disaggregated level, only 13% of all retail businesses are located within the small CAZ area.

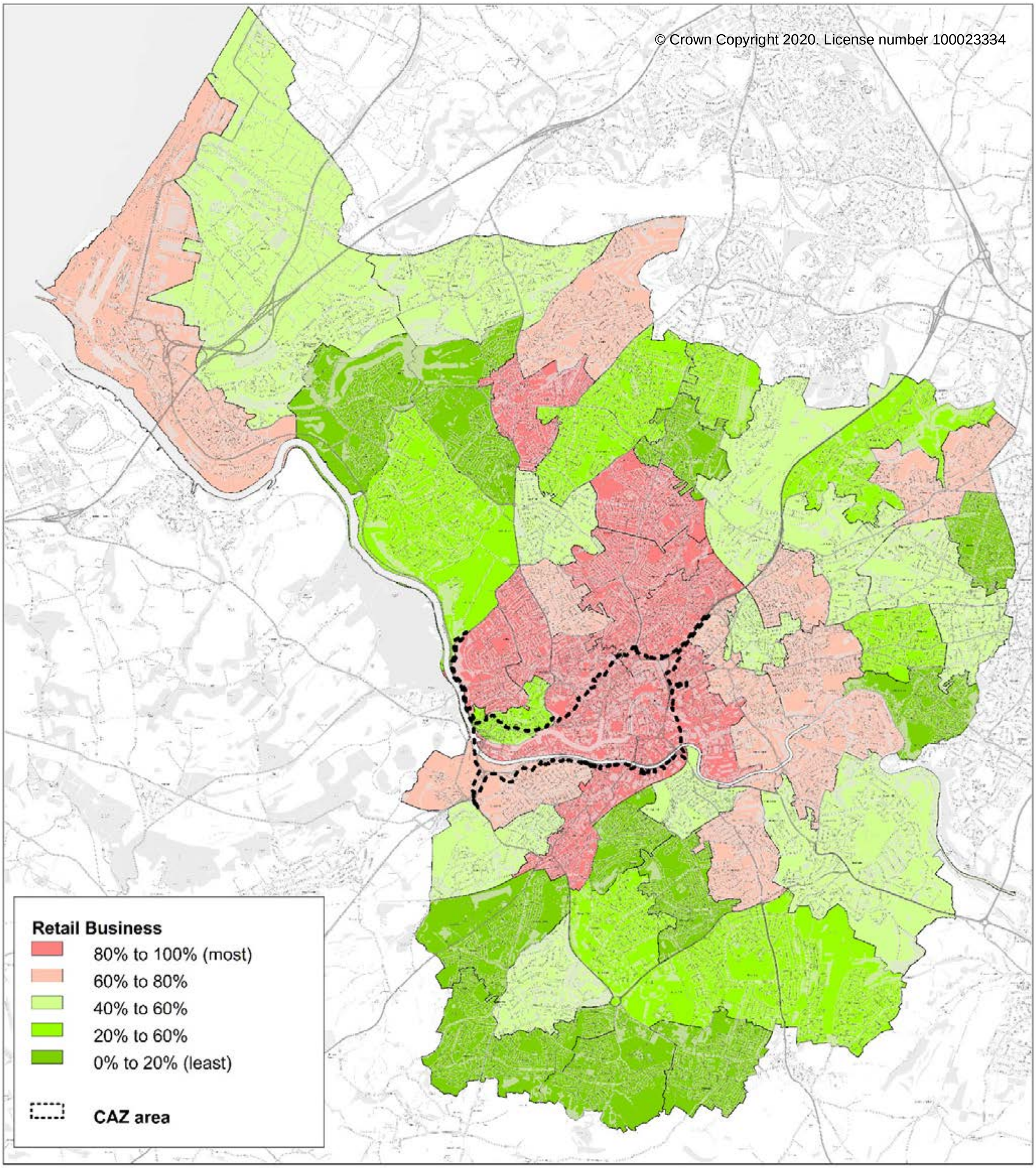
Table 3-21: Retail businesses by type

Industry	Business Type				
Retail	Micro (0 to 9)	Small (10 to 49)	Medium-sized (50 to 249)	Large (250+)	Total
Small Area CAZ	180	70	5	0	255
Bristol	1,565	375	30	0	1,970

The high concentration of retail businesses in the small area CAZ is highlighted in the figure below. Such businesses are reliant on vehicles to service them:

[3] The definition of tourism is based on ONS' 'workers in the tourism sector' report
[4] The definition of retail is based on the SIC category 47

Figure 3-2: Retail businesses across Bristol



Similar patterns are evident within the tourism sector. Micro businesses make up majority of the market share, with 61% of tourism related business in the small area CAZ being micro. This increases to 75% for Bristol local authority area. Small businesses in the small CAZ make up 36% of the market share, this is higher than the 24% in Bristol. In total, all tourism businesses at all geographic scales are defined as micro or SMEs. At a spatially disaggregated level, around 30% of Bristol's tourism businesses are located within the small area CAZ boundary. This suggests a disproportionate number of tourism businesses are located within the small area CAZ boundary; this is understandable given that Bristol City Centre falls within this zone.

Table 3-22: Tourism businesses by type

Industry	Business Type				
Tourism	Micro (0 to 9)	Small (10 to 49)	Medium-sized (50 to 249)	Large (250+)	Total
Small Area CAZ	295	175	15	0	485
Bristol	1,270	405	15	0	1,690

3.7.2.2 Labour Market Characteristics

Employment density outlines the distribution of jobs across Lower Super Output Areas (LSOAs) that make up Bristol, as per data from the Business Register and Employment Survey (BRES). This data has been mapped and is presented as Figure 3-1. The analysis demonstrates that LSOAs that predominantly lie within the small CAZ boundary have the highest jobs density, with more than 2,000 employees per LSOA. Whilst the work illustrates that LSOAs outside the city centre generally have a lower jobs density. Overall, there is a clear concentration of employment within Bristol City Centre, which lies within the small area CAZ boundary.

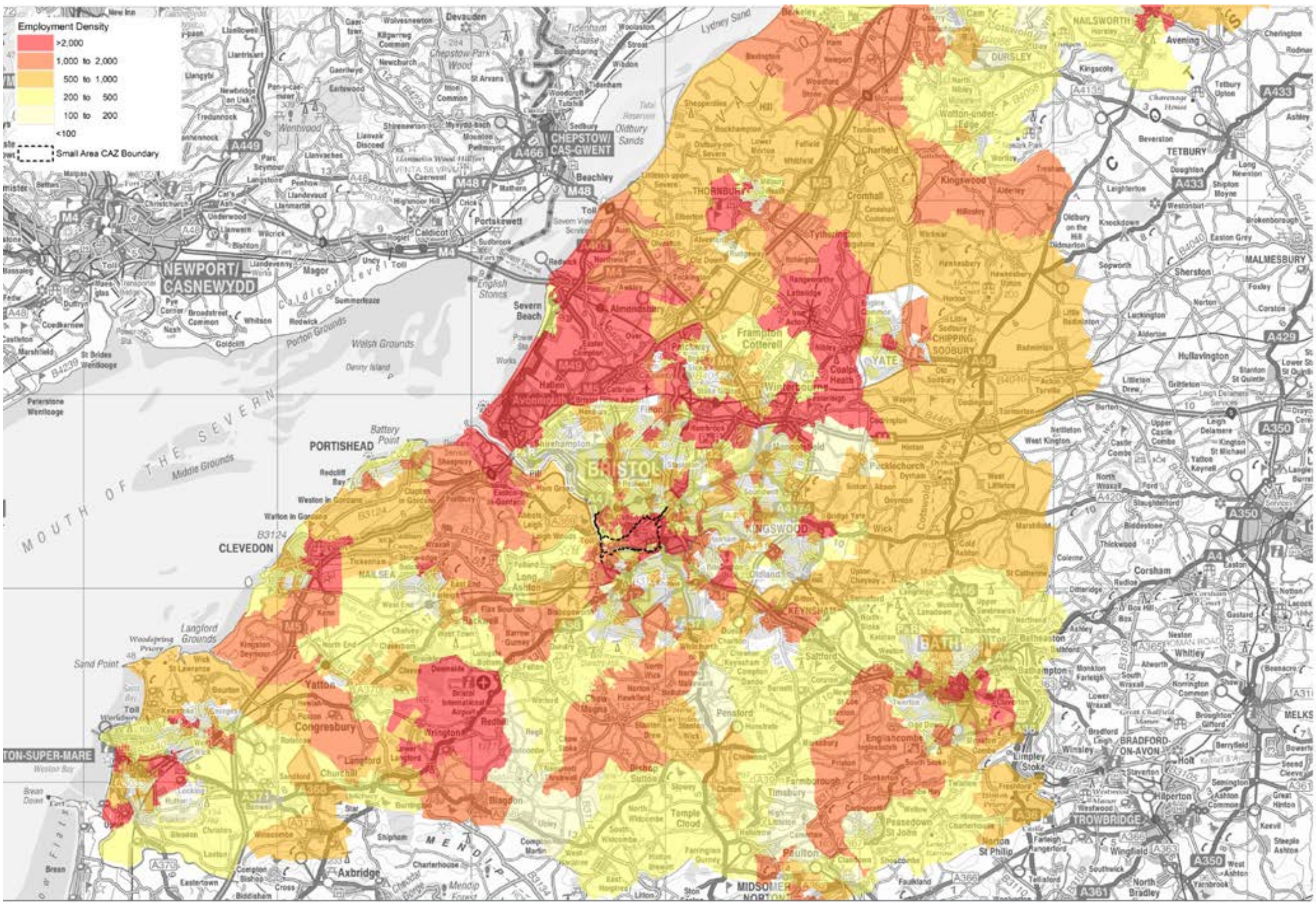


Figure 3.3: Employment Density in Bristol

The trends presented in Figure 3.3 are reflected in Table 3-23 which illustrates the sectoral profile of employment for Bristol and the small area CAZ, compared to national benchmarks. The analysis reveals that within the small area CAZ boundary the main industries of employment are business services (industrial sectors: J, K, L, M, and N). A larger proportion of individuals (63%) are employed within these industries in the small area CAZ boundary relative to Bristol local authority area (35%) and nationally (28%). These sectors tend to make a significant contribution to economic output and value added, as well as offering competitive salaries. As has been mentioned previously, the small CAZ boundary includes Bristol City Centre which is where the majority of business services jobs are located.

Table 3-23: Proportion of individuals in industrial sectors by context area

Industrial Sectors	Small Area CAZ	Bristol	England
Agriculture, forestry & fishing (A)	0%	0%	1%
Mining, quarrying & utilities (B, D and E)	1%	1%	1%
Manufacturing (C)	1%	4%	8%
Construction (F)	1%	4%	5%
Motor trades (Part G)	0%	2%	2%
Wholesale (Part G)	0%	4%	4%
Retail (Part G)	7%	8%	9%
Transport & storage (inc postal) (H)	1%	4%	5%
Accommodation & food services (I)	9%	7%	7%
Information & communication (J)	10%	6%	4%
Financial & insurance (K)	14%	7%	4%
Property (L)	1%	1%	2%
Professional, scientific & technical (M)	19%	11%	9%
Business administration & support services (N)	17%	10%	9%
Public administration & defence (O)	10%	4%	4%
Education (P)	2%	9%	9%
Health (Q)	3%	15%	13%
Arts, entertainment, recreation & other services (R, S, T and U)	4%	4%	5%

Focussing specifically on the previously defined retail and tourism sectors, over 4,400 and 4,600 individuals are employed within the tourism and retail sectors respectively within the small area CAZ boundary. At a spatially disaggregated level, less than 25% of all retail employment in Bristol is located within the small area CAZ boundary. Around 10% of all tourism jobs in Bristol are also located within the small area CAZ boundary).

Table 3-24: Number of individuals employed across different sectors

Context Area	Retail	Tourism
Small Area CAZ	4,620	4,380
Bristol	20,050	45,695

3.7.2.3 Deprivation Analysis

Employment deprivation data from the Indices of Multiple Deprivation reveals that the majority of the LSOAs that lie within the small area CAZ are amongst the least deprived nationally, in terms of employment deprivation. This indicates the strong economic performance of the city centre which is encompassed by the small area CAZ. However, there is a pocket of LSOAs towards the east of the small area CAZ that suffers from acute employment deprivation.

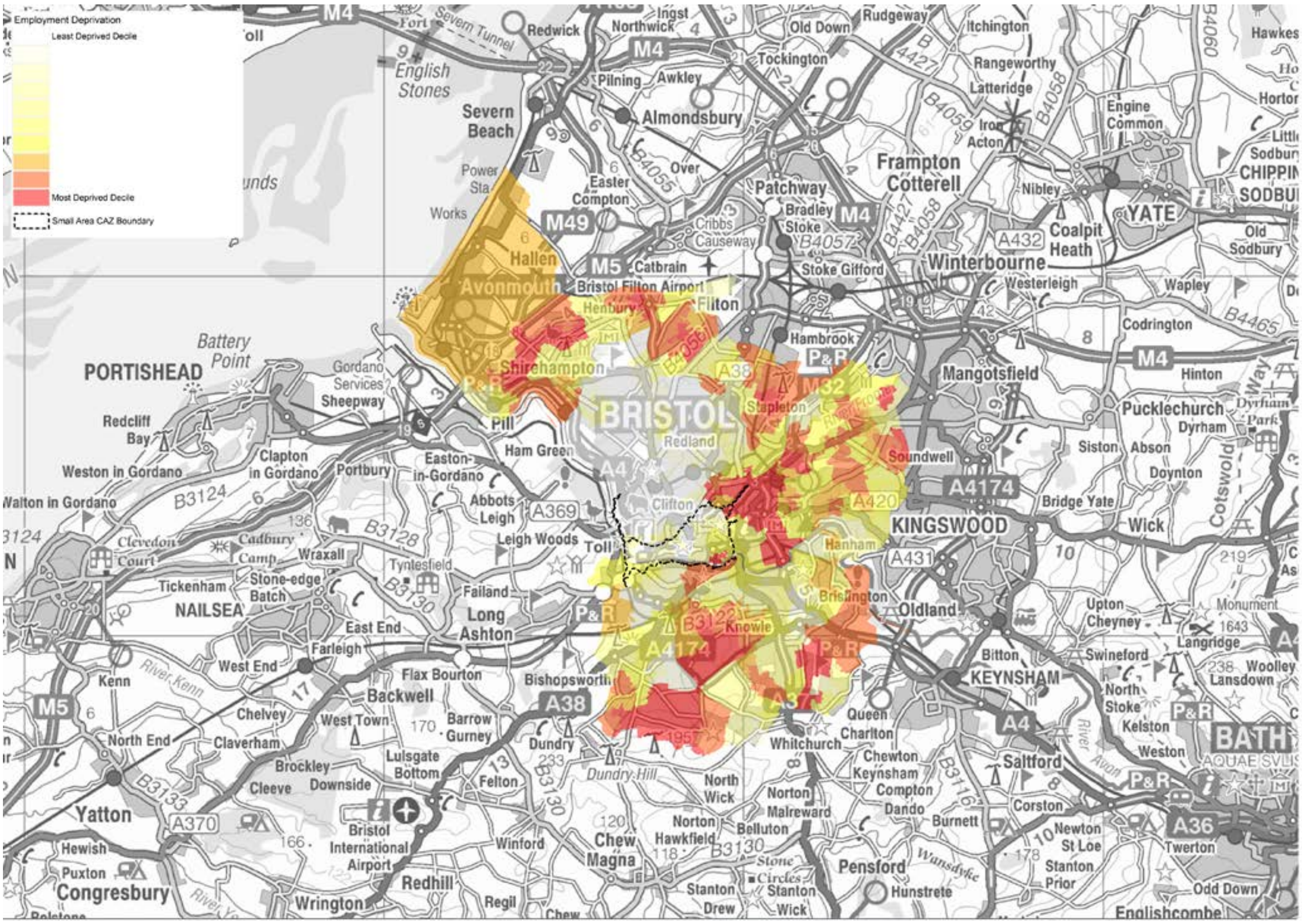


Figure 3.4: Employment Deprivation

Income deprivation data from the Indices of Multiple Deprivation reveals that overarching trends are consistent with employment deprivation patterns. Communities within the small area CAZ boundary are amongst the least income deprived in comparison to the communities nationally. However, there are few pockets of income deprivation of varying degrees on the east side of the zone.

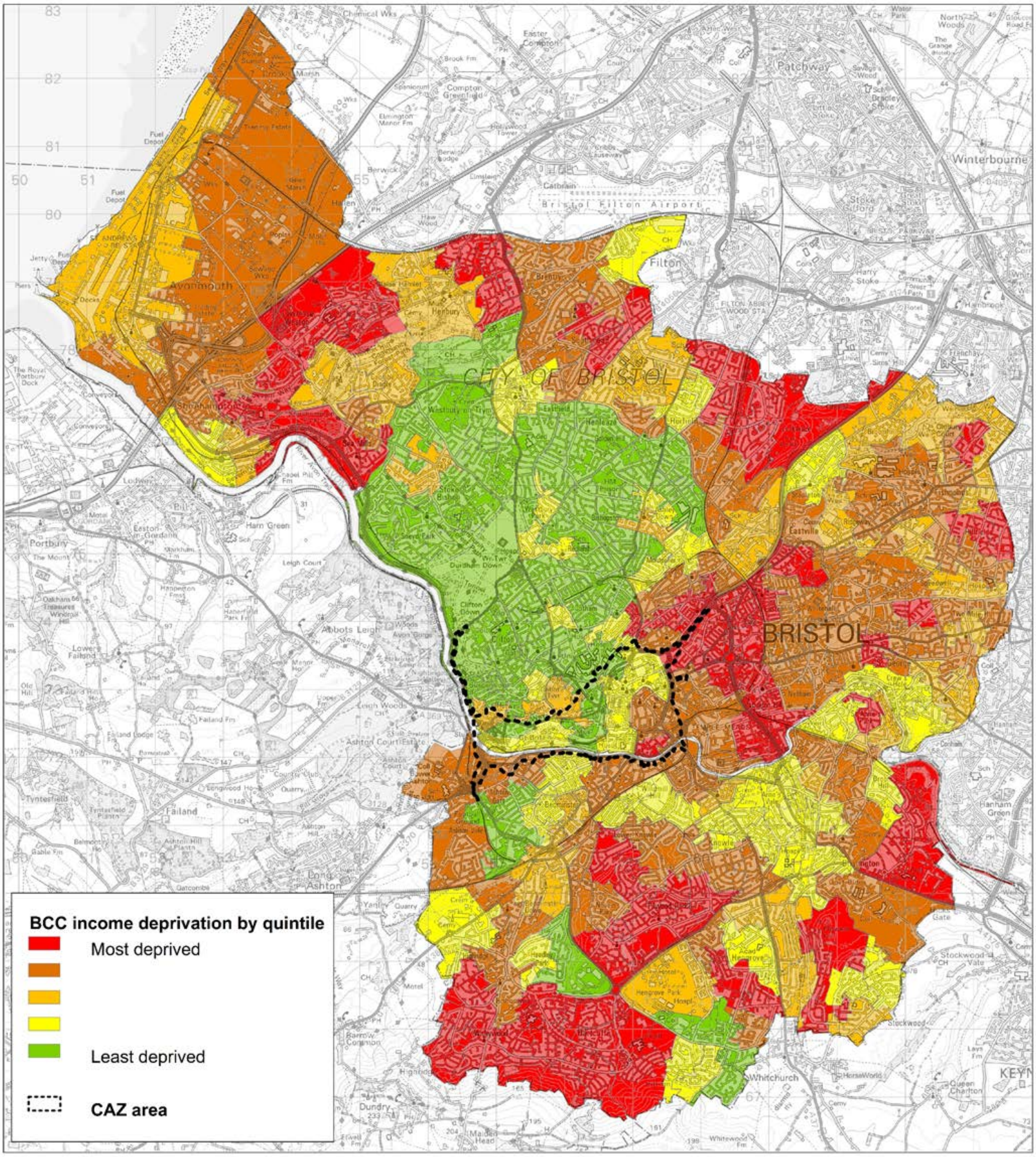


Figure 3.5: Income Deprivation

3.7.2.4 Vehicle Compliance Patterns

Cross-referencing those communities that fall within the two most income deprived quintiles with vehicle registration data reveals that there are large numbers of vehicles registered to properties in low-income areas that fail to meet current air quality standards within the small area CAZ boundary. Table 3-25 reveals that there are more than 350 non-compliant cars and LGVs registered in low-income areas within the small area CAZ boundary. These could be vulnerable to any future charge or punitive action against non-compliant vehicles within the small area CAZ boundary.

Table 3-25: Number of Vehicles Registered to Communities within the Two Most Income Deprived Quintiles

Vehicles Registered in Two Most Income Deprived Quintiles	Small CAZ Area
Non-Compliant Cars	282
Non-Compliant LGVs	72

Overall, Figure 3.6 indicates that non-compliant vehicles and diesel vehicles are concentrated in the most deprived communities in Bristol.

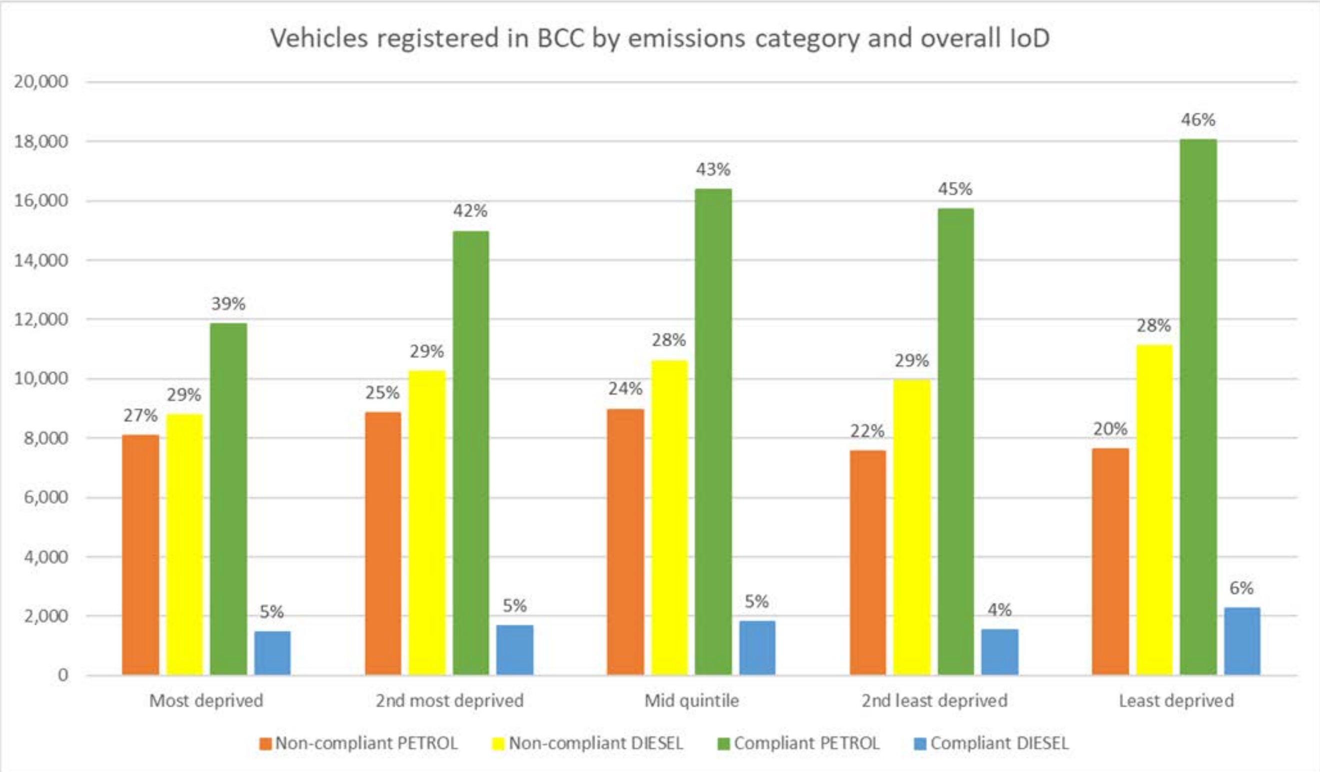


Figure 3.6: Vehicles Registered in Bristol LA by Category, Deprivation and Zone

The number of LGVs registered within an LSOA is reflective of certain types of business activity occurring within it (e.g. tradespeople, courier services, sole-proprietors). LGV registration data reveals that 86% of LGVs that are registered within the small area CAZ boundary are non-compliant with regulations. Ninety per cent of those registered in Bristol are non-compliant.

Table 3-26: Proportion of compliant and non-compliant LGVs[5]

	Compliant		Non-Compliant	
Context area	Petrol	Diesel	Petrol	Diesel
Small area CAZ	0	58	0	361
Bristol	10	2,562	341	22,048

[5] For this analysis the LSOA E01014623 has been excluded as its deemed to be an outlier.

Whilst vehicle registration is not a sound proxy for the business activities and patterns of LGV users, the data gives an indication of the number of LGV users that are based in certain areas. The analysis suggests that only a small proportion of the non-compliant LGV owners within Bristol are based in the small area CAZ boundary.

3.7.3 Step Two: Qualitative Impact Assessment

3.7.3.1 Assessment Methodology

Based on the key issues identified in the economic narrative above, combined with key transport impacts anticipated as a result of intervention, this section presents a qualitative assessment of the preferred Clean Air Plan option. The assessment provides qualitative information about the potential impact of the preferred option on various key economic indicators:

- Deprivation / income
- Businesses - SMEs
- Businesses – LGVs/HGVs
- Businesses – Taxis
- Consumer Welfare costs
- Vehicle Scrappage costs
- Transaction costs
- Effects to the employment market
- Retail/tourism

Qualitative judgements are informed by the baseline data presented in Section 3.6.2, alongside transport modelling data which provides an indication of the scale of any changes to travel patterns and behaviours induced by the scheme.

Table 3-27: Assessment Criteria

Economic Indicator	Analytical Criteria	Small Area CAZ D Impact
Deprivation / income	The Indices of Multiple Deprivation ranks lower super output areas according to the extent of income deprivation within that area..	Non-compliant vehicles registered to households in low-income areas are affected under this option. This includes, as a minimum, almost 300 cars and 100 LGVs registered to low-income households in the small area CAZ itself, as well as potentially thousands of non-compliant vehicles registered to low-income households elsewhere in Bristol and the West of England but travelling into the small area CAZ. That said, imposition of a CAZ does not preclude travel into the small area CAZ; instead households have options for altering their travel patterns/behaviours.
Businesses - SMEs	SMEs are considered to be particularly vulnerable to changes in economic conditions and the potential additional burden of CAZ charges.	This option will extend across and therefore directly affect some 2,900 micro businesses and SMEs. Employees and customers for SMEs may be affected as well as suppliers.

Table 3-27: Assessment Criteria

Economic Indicator	Analytical Criteria	Small Area CAZ D Impact
Businesses – LGVs/HGVs	LGVs/HGVs act as the main mode of transport and servicing for many economic activities, providing distribution of inputs to business and outputs from business.	Almost 400 non-compliant LGVs are registered within the small area CAZ and are therefore directly affected by CAZ designation. As above, around 3,000 businesses are located within the small area CAZ boundary; their operations (in terms of suppliers/deliveries made by LGVs/HGVs) could be affected.
Businesses – Taxis	Taxis are typically older and fail to meet current air quality standards. Taxis are therefore vulnerable to introduction of a small CAZ D.	Non-compliant taxis will be charged for entering the small area CAZ boundary. A significant number of taxi trips within Bristol are likely to be affected, given the small area CAZ boundary incorporates major retail, work and tourist destinations at Bristol City Centre. Hence, a large portion of the (non-compliant) taxi fleet could be affected.
Consumer Welfare costs	Consumer welfare loss is associated with two elements: 1) the additional cost of upgrading sooner rather later, relating to reduced impact of depreciation on vehicle values. Options resulting in more upgrades will induce a greater welfare loss. 2) the cost of changing travel behaviour to avoid zone, cancel journey, change mode, change destination. This cost is valued at half the cost of the CAZ charge, otherwise individuals would continue to make the same journey using the same behaviours.	PV negative impact of £45.4m, as per Section 3.6.
Vehicle Scrappage costs	Vehicle scrappage costs capture the loss in asset value associated with scrapping a vehicle earlier than would otherwise be the case without intervention. This results in vehicles being scrapped when they have greater residual value. JAQU assumes that 25% of all upgrades will result in a new vehicle being purchased. For every new vehicle purchased, JAQU's working assumption is that an older vehicle within the fleet will be scrapped. Options resulting in more upgrades will induce more new vehicles being purchased resulting in a greater number of scrapped vehicles and therefore higher vehicle scrappage costs.	PV negative impact of £0.9m, as per Section 3.6.
Transaction costs	Some policies will bring forward vehicle owners' decisions to purchase newer, cleaner vehicles. This will result in a cost to these owners in having to locate a vehicle that is to their taste. This type of expense is termed, in economics, a transaction (or search) cost.	PV negative impact of £0.2k, as per Section 3.6.
Effects to the employment market	By influencing travel patterns and behaviours, the scheme could fundamentally alter the structure of the labour market by encouraging labour supply to look at labour demand in other locations.	This option involves a high number of daily trips avoiding the zone, cancelling journeys/ changing mode/ changing destination, because most modes of travel are affected by imposition of a CAZ. This implies that labour supply patterns are significantly influenced by this option.
Retail/ tourism	The retail and tourism sectors are core activities within Bristol's economy.	The CAZ will impact a high number of retail/tourism jobs and businesses within the small area CAZ boundary (c. 9,000 employees and c.750 businesses).

Table 3-27: Assessment Criteria

Economic Indicator	Analytical Criteria	Small Area CAZ D Impact
		CAZ D designation will impose charges on LGVs/HGVs, thus making supplies/deliveries to retail and tourism businesses more expensive/difficult. Further, some employees, customers and tourists may be deterred from travelling to the CAZ area via private car due to the charge on all non-compliant vehicles.

3.8 Distributional and Equalities Assessment

This assessment relates locations where benefits/disbenefits accrue to the individuals that live in those areas. The analysis represents relative distribution of impacts on socio-economic quintiles compared to the population shares across the Bristol City Council area. The assessment is presented in the distributional and equalities analysis report appended to the FBC (Reference Appendix H FBC-31). The key conclusions from this work are:

- Air quality improves for most residents. Distributional impacts of air quality changes are also broadly even, though exceptions again exist, with impacts for some demographic groups not being evenly distributed.
- Accessibility impacts are likely to be mixed. Trip-making propensity impacts are evenly distributed in comparison with population distributions but are most heavily on the middle and lower quintiles of income deprived areas, areas with the most children and those that have the lowest proportions of females. Impacts are disproportionately felt by the higher quintiles of the concentration of ethnic minorities, middle quintiles for disabled residents and more evenly for elderly residents. TUBA time benefits are also used as a proxy for accessibility; these are largely beneficial and the distributional impact broadly even.
- Affordability impacts are likely to be negative across the socio-economic and business groups that directly interact with CAZ area, especially where there are charges for non-compliant cars or any restrictions on specific movements. Impacts are disproportionately felt by the second most and least income deprived communities. Impacts also fall on businesses operating non-compliant LGVs and HGVs who are either based in the CAZ area or based elsewhere but operate within central Bristol and hence also interact with the CAZ area. Using TUBA vehicle operating cost benefits as a proxy for affordability indicates that the impacts are positive overall across the city as a whole, although impacts are slightly disproportionately felt by the least income deprived communities, which see a slight disbenefit in vehicle operating costs.
- There will be direct impacts on the costs of operation for LGV/HGV reliant businesses, where their operations interact with the CAZ area. Trips by non-compliant LGV/HGV reliant businesses are reasonably spread around the city.
- The extent of impact on non-compliant car owners varies with the extent of users' trip-making requirements associated with the class 'D' charging measures in the CAZ area. Distribution of non-compliant car ownership is slightly skewed to lower income groups. However, the (in)ability of households to react to restrictions is unevenly felt by lower income groups (for instance, there are fewer multi-car households that could potentially using a compliant vehicle).

3.8.1 Summary distributional impacts

3.8.1.1 Small Area CAZ D Option

Table 3-28 show summary results for the Small Area CAZ D option; and Table 3-29 summarises distributional impacts for each social/business group.

Table 3-28: Distributional impacts: Small CAZ D Option

Quintiles >>>	1 (most)	2	3	4	5 (least)	Distribution
Air quality impacts						
Low-income households	✓	✓✓	✓✓	✓✓	✓✓✓	Slightly uneven
Children	✓✓	✓✓	✓✓	✓✓	✓	Reasonably even
Elderly residents	✓✓	✓	✓	✓✓	✓✓	Slightly uneven
Accessibility (time benefit) impacts						
Low-income households	✓	✓✓	✓✓	✓✓✓	✓	Slightly uneven
Children	✓✓	✓✓	✓✓✓	✓✓	✓	Slightly uneven
Elderly residents	✓✓	✓	✓	✓✓	✓✓	Reasonably even
Disabled residents	✓	✓✓✓	✓	✓	✓	Slightly uneven
Women	✓✓	✓✓	✓✓	✓	✓	Reasonably even
Ethnic minorities	✓	✓	✓	✓	✓✓✓	Reasonably even
Affordability (vehicle operating cost) impacts						
Low-income households	✓	✓✓✓	×××	×	×	Uneven

Table 3-29: Summary impact: Small CAZ D Option

Social or Business Group	Air Quality		Accessibility		Affordability	
	Net +ve impact	Distribution	Net +ve impact	Distribution	Net +ve impact	Distribution
Deprivation / low income	✓	Slightly uneven	✓	Slightly uneven	×	Uneven
Children	✓	Reasonably even	✓	Slightly uneven		
Elderly people	✓	Slightly uneven	✓	Reasonably even		
Disabled people			✓	Slightly uneven		
Women			✓	Slightly uneven		
Ethnic minorities			✓	Reasonably even		
Businesses – SMEs					×	Reasonably even
Businesses – LGVs/HGVs					×	Uneven
Businesses – taxis					×	Reasonably even

3.8.2 Summary of distributional impacts

Table 3-30 provides a brief qualitative summary of the distributional impacts of the Small CAZ D option. Table 3-31 indicates some of the potential mitigation target groups that could arise from the Small CAZ D option.

Table 3-30: Summary distributional impacts

Impact group	CAP scheme
Air quality	Improvements across the city. Distribution of impacts is reasonably even across social groups, though slightly uneven compared to distributions of income deprivation and elderly residents.
Accessibility	Time benefit calculations are all positive, and the distributional impact is slightly reasonably for some groups, but would not overall be considered problematic. Trip-making propensity by people with non-compliant cars related to the CAZ area is evenly distributed.
Affordability	Vehicle operating cost impacts are unevenly distributed, being disproportionately felt by the least income deprived communities, which see a slight net disbenefit in vehicle operating costs; others have net benefits.
Businesses	There are potential direct impacts on costs for LGV/HGV reliant businesses. Though trips by non-compliant LGV/HGV reliant businesses are reasonably spread around the city, those making trips related to the CAZ area will be affected; the CAZ area is reasonably small but covers most of the city centre.
Car owners	Impact on all non-compliant car owners. Distribution of non-compliant car ownerships is slightly skewed to lower income groups, but ability to react to charges more so (such as households with more than one vehicle).

Table 3-31: Summary distributional impacts – potential mitigation targets

Potential mitigation target group [a]	CAP scheme
Residents	
Residents of the CAZ area	✓
Specific trip needs	
Disabled people – blue badge	✓ [b]
Disabled people – with specialist vehicle adaptions	✓ [b]
Out-patient access to hospital	✓ [b]
Car owners	
Low income non-compliant car owners	✓
Low-income compliant car owners	✗
1-car households	✗
Businesses	
SMEs located in the CAZ area	✓
LGV/HGV-dependent businesses not specifically located in the CAZ area but that need to travel into it	✓
Taxi owners/drivers – BCC registered	✓
Taxi owners/drivers – other authority registration	✓

Note:

a) Groups that could be potential mitigation targets indicated with; '✓' are those where there is the potential for mitigation to be sought by or on behalf of the group, though not necessarily that it would be granted as part of implementing the CAP; '✗' indicates that it is less likely that any mitigation would applicable to this group. However, both are indicative, and neither a positive nor negative indication in this table is a definitive indicator of future proposals.

b) Could be linked with a destination specifically in the CAZ area and/or owning/using a non-compliant car

3.9 Environmental Appraisal Report

An Environmental Appraisal report has been prepared for the Small CAZ D Option. This work concluded that the implementation of the scheme is anticipated to reduce air pollution across the city centre, the wider SGC administrative area and potentially beyond (see Section 3,4 for more details). However, it is recommended that signage should be designed and installed with viewpoints in mind, particularly near Clifton Suspension Bridge, due to their historic importance and visual amenity value.

The Environmental Appraisal Report is contained in Appendix T to the FBC.

3.10 Sensitivity Analysis

3.10.1 Traffic Modelling and Air Quality Sensitivity Testing

To understand the sensitivity of the assessment to changes in model assumptions, as series of recent sensitivity tests have been undertaken see Table 3-32 for a summary of this work. The Sensitivity Analysis is reported in Appendix P to the FBC. Sensitivity test were undertaken for work presented in earlier versions of the OBC, these tests are also reported in Appendix P and include the following tests include:

- HGV adjustment factors
- Fleet Composition: Splits by Fuel Type
- Uncertainties in the Air Quality Modelling
- Emissions at Low Speeds
- Background Concentrations
- Model Verification
- Gradients
- Age of Transport Model

Table 3-32: Sensitivity tests

Test	Section Number	Summary	Key Results
Behavioural Reponses to Charging	4.2	Defined pessimistic response rates based on confidence intervals of SP survey statistical modelling and adjusted assumptions for other vehicle types. Compared NO_2 concentrations to Small D scenario.	Air quality is likely to be adversely affected with the mean concentration increasing by 0.1 µg/m^3 and the maximum by 1.3 µg/m^3. The compliance year is pushed back beyond 2023. This test illustrates the "breaking point" of the scheme as it shows that adjusting the response rates based on the Stated Preference survey confidence limits will delay the scheme compliance beyond 2023.

Test	Section Number	Summary	Key Results
One Year Fleet Delay Test	4.3	One-year fleet renewal delay undertaken as a sensitivity test due to the potential effects of COVID-19 on the natural fleet turnover through time.	Air quality is likely to be adversely affected across the whole model domain, with the mean concentration increasing by 0.8 μg/m^3 and the maximum by 1.2 μg/m^3. The compliance year is pushed back beyond 2023.
Uncertainties in the Air Quality Modelling			
Euro 6 Vehicles	3.1.1	The EFT is based on COPERT 5 which predicts different NOx emissions from Euro 6 diesel vehicles registered in different years (based on the expectation that Euro 6 emissions will reduce over time). Sensitivity test outlined in JAQU's 'Supplementary Note on Sensitivity Testing' has been run.	The Low Emission Euro 6 scenario was predicted to reduce the maximum concentration by 3.6 μg/m^3, whereas the Euro 6 High Emission scenario predicted a 2.7 μg/m^3 increase. In terms of the compliance year, the High Emission scenario pushed the compliance year back beyond 2023 at the Marlborough Street critical location. The Low Emission scenario may have brought the compliance year forward from 2023, although without other modelled years for this scenario, it is not possible to tell. The results indicate that the central case results are sensitive to changes in Euro 6, 6c and 6d proportions and the associated NOx emissions standards expected from diesel light duty vehicles.

3.10.2 Economic Modelling Sensitivity Testing

A number of isolated sensitivity tests were assessed within the economic model. This involved changing some of the key input assumptions to the economic model as outlined below.

- Implementation costs: assuming a 10% increase or decrease in implementation costs around the core estimate
- Damage costs: assuming 'Inner London' or 'Transport Average' values apply, rather than 'Urban Big'
- Carbon prices: assuming BEIS low or high values apply instead of the central values
- Vehicle non-compliance: assuming a 10% increase or decrease in vehicle non-compliance around the core estimate
- Upgrading rate: assuming no vehicles upgrade (in line with JAQU guidance[6]) or all vehicles interacting with the CAZ upgrade, instead of using the upgrade rate derived from the stated preference surveys
- Charge rate: assuming a 50% increase or decrease in charge rates around the core values
- TUBA: assuming use of DfT TAG Databook sensitivity test values rather than core Databook inputs.
- COBALT: assuming use of DfT TAG Databook sensitivity test values rather than core Databook inputs.

Note that these tests were undertaken independently and in isolation from any other modelling. Hence, the outcomes of the sensitivities are neither informed by or inform the traffic modelling or air quality workstreams. They are intended to demonstrate the potential impact of changing key input assumptions within the framework of the economic model only.

[6] JAQU (Summer 2020) 'Accounting for local Covid-19 economic impacts'

The results of the sensitivity tests are outlined in Table 3-33, which highlights the following NPV variation resulting from changes to key assumptions:

- The scale of NPV could range between -£67.4 million and -£111.9 million, around a core assessment of -£85.9 million.
- NPV is most sensitive to assumptions around changing the charge rate and changing the criteria for determining which vehicles will upgrade:
  - A higher charge rate will substantially increase the negative NPV
  - Assuming all vehicles interacting with the CAZ will upgrade (rather than just those vehicles who travel into the CAZ most frequently) will substantially increase the negative NPV
- The NPV is less sensitive to changes in carbon prices, damage costs and DfT's TAG sensitivity testing data book assumptions

Table 3-33: Small CAZ D - Sensitivity Analysis Summary NPV (2018 prices and values, £'millions)

Key Assumption Changed	Low/Pessimistic	Core	High/Optimistic
Implementation Costs	-81.3	-85.9	-90.5
Damage Costs	-75.2	-85.9	-87.2
Carbon Prices	-85.9	-85.9	-85.9
Vehicle Non-Compliance Scenario	-81.3	-85.9	-90.5
Charge Rate	-76.6	-85.9	-111.9
Upgrading Rate	-67.4	-85.9	-104.4
TUBA	n/a	-85.9	-86.2
COBALT	n/a	-85.9	-86.1