N3 HGV Euro 6 Charging Impacts

Document no: 1
Revision no: 3

Bath & North East Somerset Council
674726CH

Bath Clean Air Zone (CAZ)
22 November 2022

N3 HGV Euro 6 Charging Impacts

Client name:	Bath & North East Somerset Council		
Project name:	Bath Clean Air Zone (CAZ)		
Client reference:	674726CH	**Project no:**	674726CH
Document no:	1	**Project manager:**	David Lear
Revision no:	3	**Prepared by:**	Aaron Scardifield
Date:	22 November 2022	**File name:**	N3 HGV Euro 6 Charging Impacts_Consultation Issue_Accessible 22.11.22 with AQC Appendix.pdf

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
1	9.11.22	Draft Report	AS	CB		
2	15.11.22	Final Report	AS	CB	CB	DL
3	22.11.22	Final Report Accessible	AS	CB	CB	DL

Distribution of copies

Revision	Issue approved	Date issued	Issued to	Comments
1	CB	9.11.22	B&NES	
2	DL	15.11.22	B&NES	
3	DL	22.11.22	B&NES	

Jacobs U.K. Limited

The West Wing
1 Glass Wharf
Bristol, BS2 0EL
United Kingdom

T +44 (0)117 457 2500
www.jacobs.com

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Acronyms and Abbreviations

ANPR	Automatic Number Plate Recognition
AQAP	Air Quality Action Plan
AQMA	Air Quality Management Area
AQO	Air Quality Objective
ATC	Automatic Traffic Count
B&NES	Bath and North East Somerset
CAZ	Clean Air Zone
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EU	European Union
EV	Electric Vehicle
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit
LA	Local Authority
LGV	Light Goods Vehicle
NOx	Nitrogen Oxides
NO2	Nitrogen Dioxide
OGV1/2	Other Goods Vehicle (Category 1/2)

1. Introduction

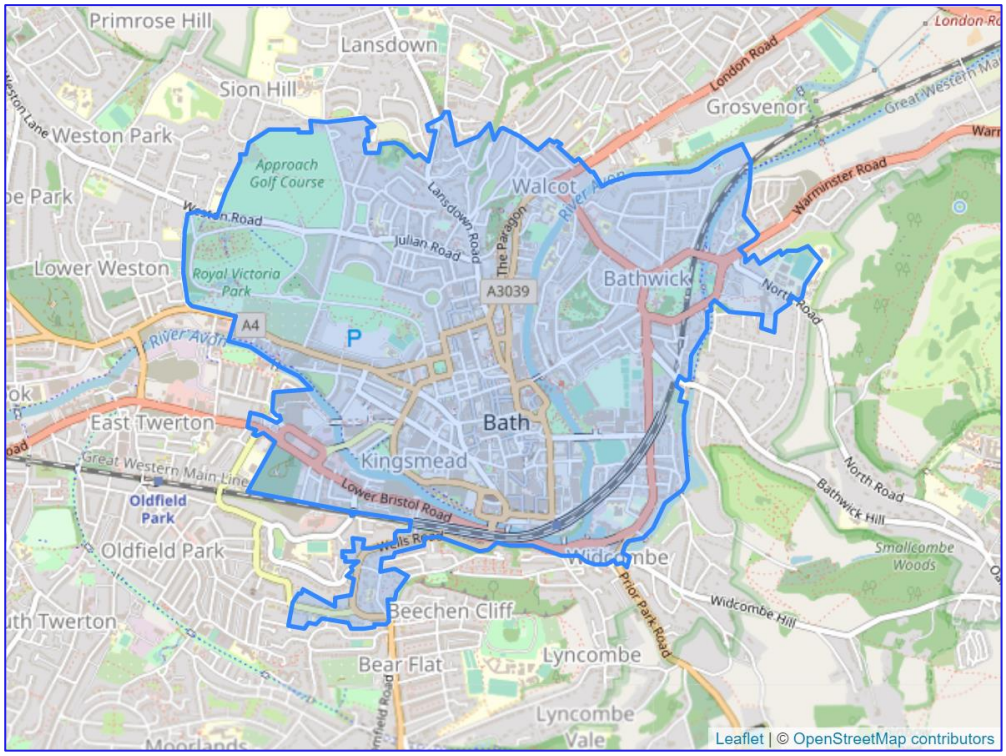
1.1 Background

The Bath Clean Air Zone (CAZ) was introduced in March 2021. This saw the implementation of daily charges to drive within the CAZ area for Euro 1-5/V diesel and Euro 1 to 3 petrol (or earlier) vehicles in the following categories:

- Coaches and buses (M3)
- Trucks and lorries (HGVs)
  - N2 (over 3.5 tonnes); and
  - N3 (over 12 tonnes)
- Taxis and private hire vehicles (M1 and M2)
- Minibuses (M2)
- Vans, light goods vehicles, pick-ups and some campervans and four-by-fours (N1 and PLG)
- Private heavy goods vehicles i.e. horse transporters or motorhomes (PHGV)

There are currently no charges applicable to Euro 6 vehicles.

The boundary of the CAZ area relative to central Bath is shown in Figure 1.1. B&NES are currently considering extending the charging specification to also include Euro 6 N3 HGVs (over 12 tonnes). The current proposals for this change would include a time-limited exemptions area for HGVs operating in the local area. The proposed exemptions area is shown in Figure 1.2, with details of the methodology for defining this area being reported in a separate Technical Note. Hence, only those HGVs travelling through the CAZ, without originating or delivering within the exemptions area, would be subject to the charge. Where this document refers to *entering* or *passing through the CAZ*, this is taken to be synonymous with passing through the charging scheme area for the proposed charge.



Source: www.beta.bathnes.gov.uk

Figure 1.1: CAZ Boundary

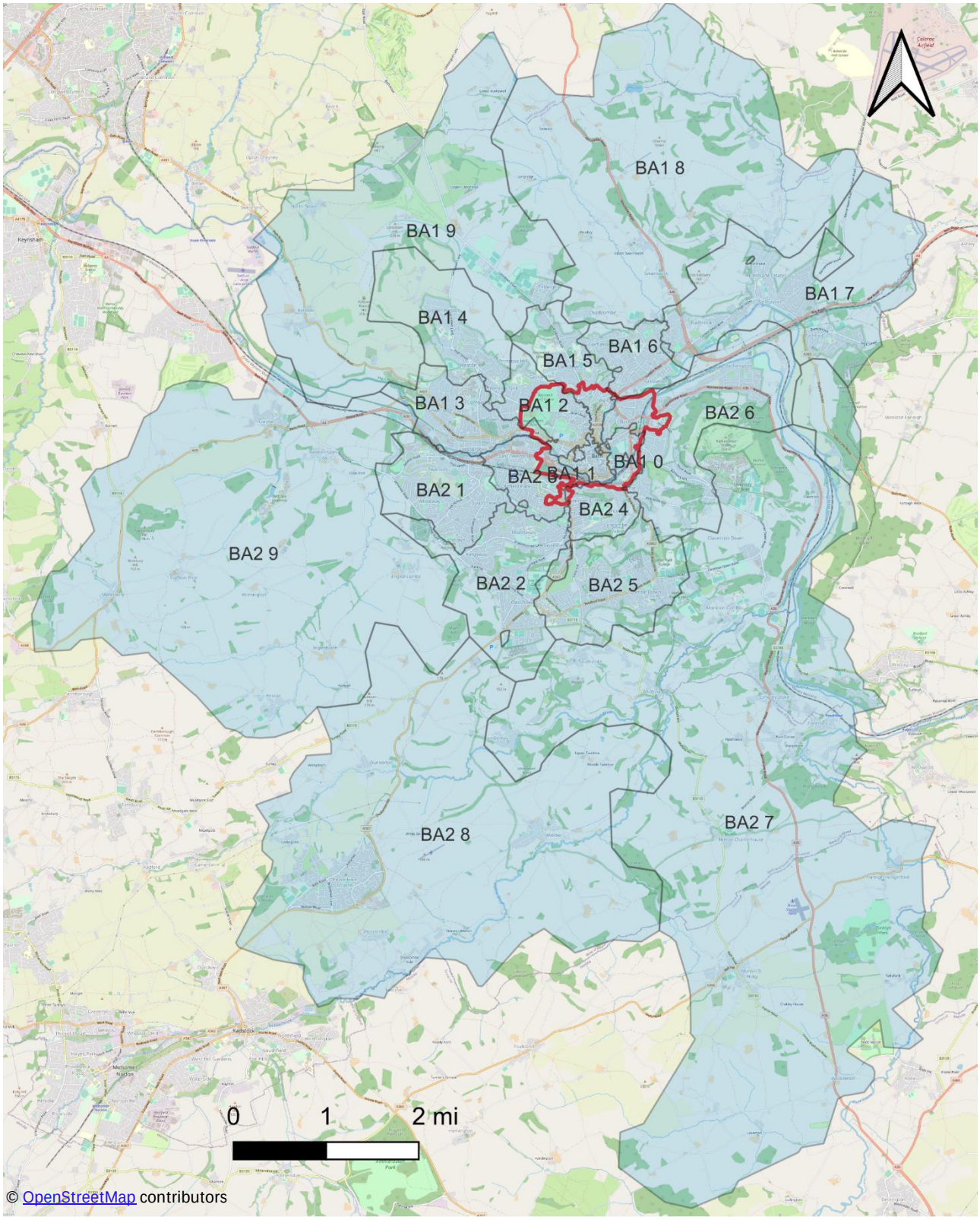


Figure 1.2: Proposed exemption area based on postcode sectors (CAZ boundary shown for reference in red)

The exemptions area covers all addresses in the following postcode sectors:

Table 1.1: Postcode sectors included within the exemption area

Included Postcodes										
BA1 postcodes	BA1 0	BA1 1	BA1 2	BA1 3	BA1 4	BA1 5	BA1 6	BA1 7	BA1 8	BA1 9
BA2 postcodes	BA2 1	BA2 2	BA2 3	BA2 4	BA2 5	BA2 6	BA2 7	BA2 8	BA2 9	

The proposed exemption area has been defined on the basis that for trips originating from or delivering to locations within the exemption area, there are no suitable alternative routes available which would have an additional journey time of less than 20 minutes.

It should be noted that the boundary of the exemptions area shown in Figure 1.2 is indicative, as all postcode polygon boundaries are. The only absolute method for determining whether or not an address is within the exemption area is to compare the target address's postcode with the list of included postcode sectors in Table 1.1.

1.2 Purpose of this Report

The purpose of this report is to document the estimated traffic and air quality impacts of charging Euro 6 N3 HGVs to drive within the CAZ. The remainder of this report is structured as follows:

- Chapter 2: Data Sources
- Chapter 3: Number of Impacted HGVs per Day Across the CAZ
- Chapter 4: Traffic Impacts at Key Locations
- Chapter 5: Alternative Routes
- Chapter 6: Summary of Air Quality Impacts
- Appendix A: Air Quality Impacts of N3 HGV Charging Report

The analysis contained in the report is based on the most relevant data available. However, it also necessarily contains estimates and assumptions as described, some of which limit the accuracy of the calculations. The report has been prepared exclusively for B&NES and no liability is accepted for any use or reliance on the report by third parties.

2. Data Sources

2.1 ANPR Survey 2017

As part of the assessment of the CAZ impacts prior to implementation, Automatic Number Plate Recognition (ANPR) data was collected at various locations within and around Bath. The locations of these are shown in Figure 2.1, and are categorised into three groups, with each group corresponding to a different colour dot on the map. The three groups and colours are as follows:

- Outer cordon (purple)
- Inner cordon (orange)
- Car parks (turquoise)

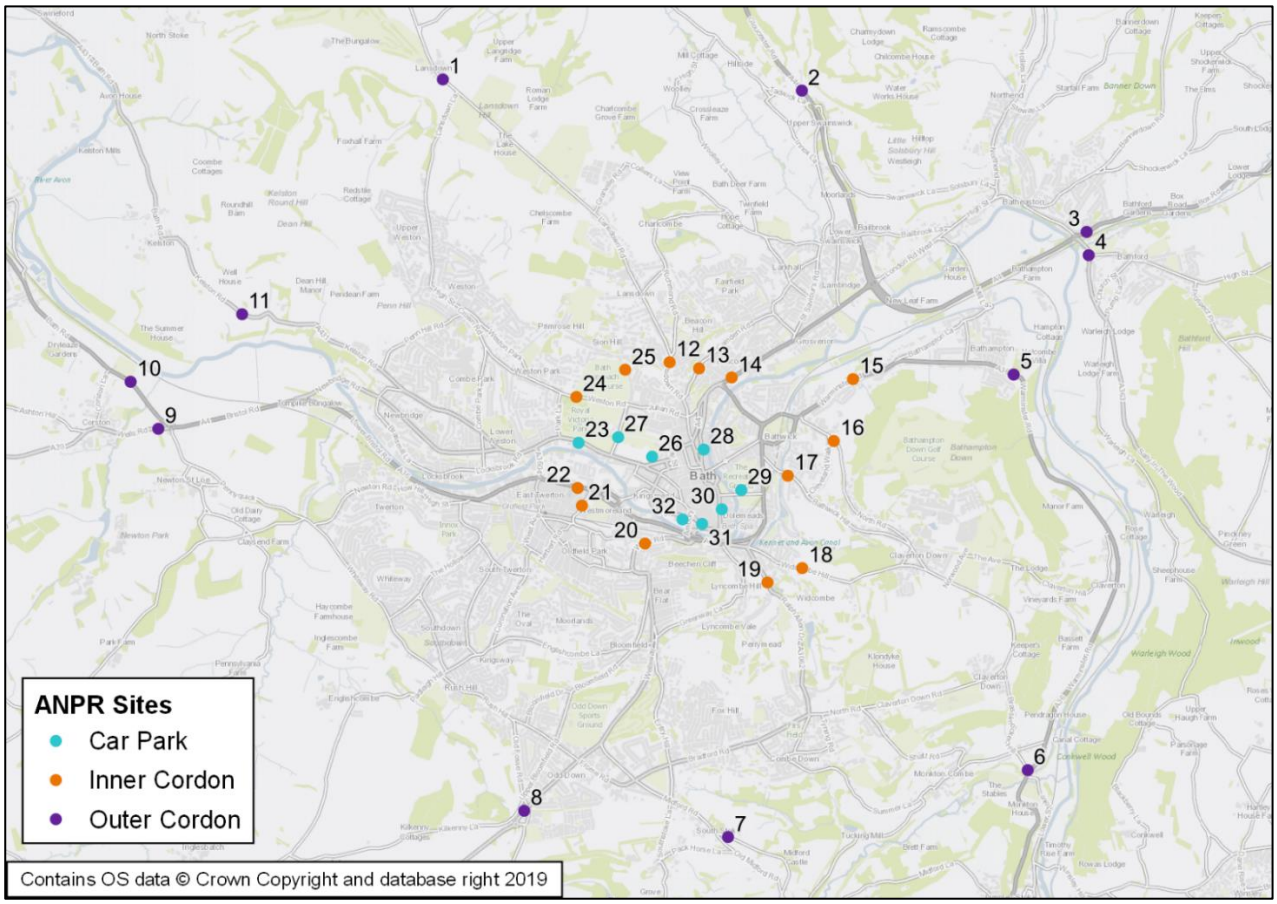


Figure 2.1: ANPR Survey Locations

This data was cross referenced with data purchased from Carweb[a] to gain information on vehicle type, fuel type and Euro Standard and was then used to identify:

- traffic patterns around Bath
- vehicle types
- fuel type
- Euro standards

[a] https://carwebid.carwebuk.com/

2.2 CAZ Monitoring Data

Since the CAZ has been implemented, monitoring data is available from the enforcement cameras, which gives:

- Total numbers of vehicles entering the CAZ per day
- Numbers of vehicles that pay the charge per day
- Vehicle type
- Fuel type
- Euro standard

2.3 Automatic Traffic Count (ATC) Data

Current and historic ATC data is available for a range of locations in and around Bath, which gives traffic volumes by time of day and by vehicle type.

2022 monitoring revealed that there were four locations which either exceeded relevant air quality objectives or were close to exceeding. To assess traffic flows, ATCs were supplied by B&NES for these locations:

- DT020 Wells Road;
- DT060 Victoria Buildings;
- DT222 Walcot Terrace/Anglo Terrace Façade; and
- DT224 Walcot Parade

3. Number of Impacted HGVs per Day Across the CAZ

3.1 Cleveland Bridge Traffic Restrictions

Cleveland Bridge, which is located within the CAZ in Bath, has had several traffic management restrictions placed upon it over the past two years linked to necessary strengthening repairs. These restrictions have been as follows:

- 3rd February 2020 - An 18T weight restriction was introduced;
- 4th May 2021 - under two-way temporary traffic control - 'shuttle working';
- 28th June 2021 - closed to all traffic; and
- 25th October 2021 - returned to two-way temporary traffic control, but with a 7.5T weight limit for HGVs and an additional 2.0m width limit imposed, except for emergency vehicles.
- 2nd October 2022 – present - open to all traffic but with 18T weight limit whilst further monitoring is conducted prior to full opening

When restrictions are fully lifted, weight limits on the bridge will be removed. The full opening is expected to affect the AADT 2022 flows at Walcot Terrace/Anglo Terrace on the A4 London Road, close to Cleveland Bridge and on the A46(T)-A36(T) strategic route. This will in turn affect the number of HGVs entering the CAZ as a whole.

3.2 Estimates with Restrictions on Cleveland Bridge

Previous work had estimated that the number of daily N3 Euro 6 HGVs (unique vehicles) across the CAZ in early 2022 was **272**. This was calculated from monitoring data by taking the daily average between the start of January and the end of March. The compliance split for N3s (proportion of N3s that are Euro 6) over this period was 98%. This figure is during a period when Cleveland Bridge was closed to N3 HGVs.

Using 2017 ANPR data, path routing was used to determine the proportion of N3 Euro 6 trips that were passing through the exemptions area without stopping, meaning HGVs making these trips would be required to pay the charge. These were defined as trips that passed an outer cordon point, at least one inner cordon point, and then another outer cordon point, while spending less than 30 minutes travelling between any two cordon points. 30 minutes was used as a cut-off point to try and limit the number of "stopping" HGVs being included in the calculation, while allowing sufficient time for HGVs to pass through the inner cordon area in periods of heavy congestion. It was estimated that **18%** of trips made by N3 Euro 6 HGVs across the CAZ as a whole were 'through trips', defined in this way.

3.3 Estimate with no Restrictions at Cleveland Bridge

For the purposes of this analysis, the impact of charging Euro 6 N3 HGVs is undertaken assuming no weight restrictions at Cleveland Bridge. In order to estimate the total number of N3 Euro 6 HGVs across the CAZ as a whole with no restrictions at Cleveland Bridge, two approaches were used. Given the estimate of 272 (with Cleveland Bridge closed to HGVs) referenced above, it was sufficient to calculate the number of additional trips expected as a result of Cleveland Bridge being opened to all traffic. This could then be added to the 272, before taking 18% as the proportion of through trips.

The first approach used the estimated absolute increase in N3 Euro 6 HGVs at DT222 Walcot Terrace/Anglo Terrace Façade as a proxy for the number of additional trips over Cleveland Bridge. The other air quality exceedance locations (Walcot Parade, Wells Rd, Victoria Buildings/Lower Bristol Rd) are less likely to be affected by Cleveland Bridge, hence no adjustment was applied to HGV flows at these locations to account for changes in restrictions on the bridge. The increase was based on the reversal of the decrease seen when the bridge was closed to HGVs (from 2019 to 2021), and was then uplifted to 2022 values based on the overall increase in trips at this site between 2021 and the first three months of 2022. This was done for both OGV1 and OGV2, and therefore needed to be converted into HGV weight classes (N2/N3) to determine the increase in terms of N3s. Data from 2017 ANPR analysis was used to determine the proportion of OGV1/2 that are N3 HGVs. This data showed that all OGV2s were N3, while 53% of OGV1s were N3. The compliance split of 98% was then applied to give an additional 324 N3 Euro 6 trips as a result of the bridge being open to all traffic. When added to the 272 vehicles mentioned previously and after taking 18% of this, it was estimated that

there would be approximately **100** N3 Euro 6 non-exempt HGVs across the CAZ once all restrictions at Cleveland Bridge are lifted.

The second method involved calculating uplift factors to the value of 272 to account for the bridge being opened, before applying the compliance split and proportion of through trips. This was done for the total of all four locations (although only DT222 Walcot Terrace/Anglo Terrace Façade was assumed to change) and to OGV1/2 separately, before applying the same N3 proportions mentioned above. The uplift factors were from 2021 (with restrictions in place) to 2022 (assuming no restrictions). Once the proportion of N3 HGVs and compliance split was applied, the value of 272 was uplifted to 391, and after taking 18% of this, it was estimated that there would be approximately **70** N3 Euro 6 non-exempt HGVs across the CAZ once all restrictions at Cleveland Bridge are lifted.

Given these two approaches and two different estimates, an estimated range of **70-100** N3 Euro 6 non-exempt HGVs across the CAZ was estimated. If charging is to be brought in, these HGVs would incur a charge, and are therefore expected to divert away from the CAZ in order to avoid this.

4. Traffic Impacts at Key Locations

4.1 Key Locations

As mentioned above, 2022 monitoring revealed that there were four locations which either exceeded relevant air quality objectives or were close to exceeding. These are as follows:

- DT020 Wells Road;
- DT060 Victoria Buildings;
- DT222 Walcot Terrace/Anglo Terrace Façade; and
- DT224 Walcot Parade

Figure 4.1 shows the location of these four exceedance points relative to central Bath. Cleveland Bridge is also marked for reference.

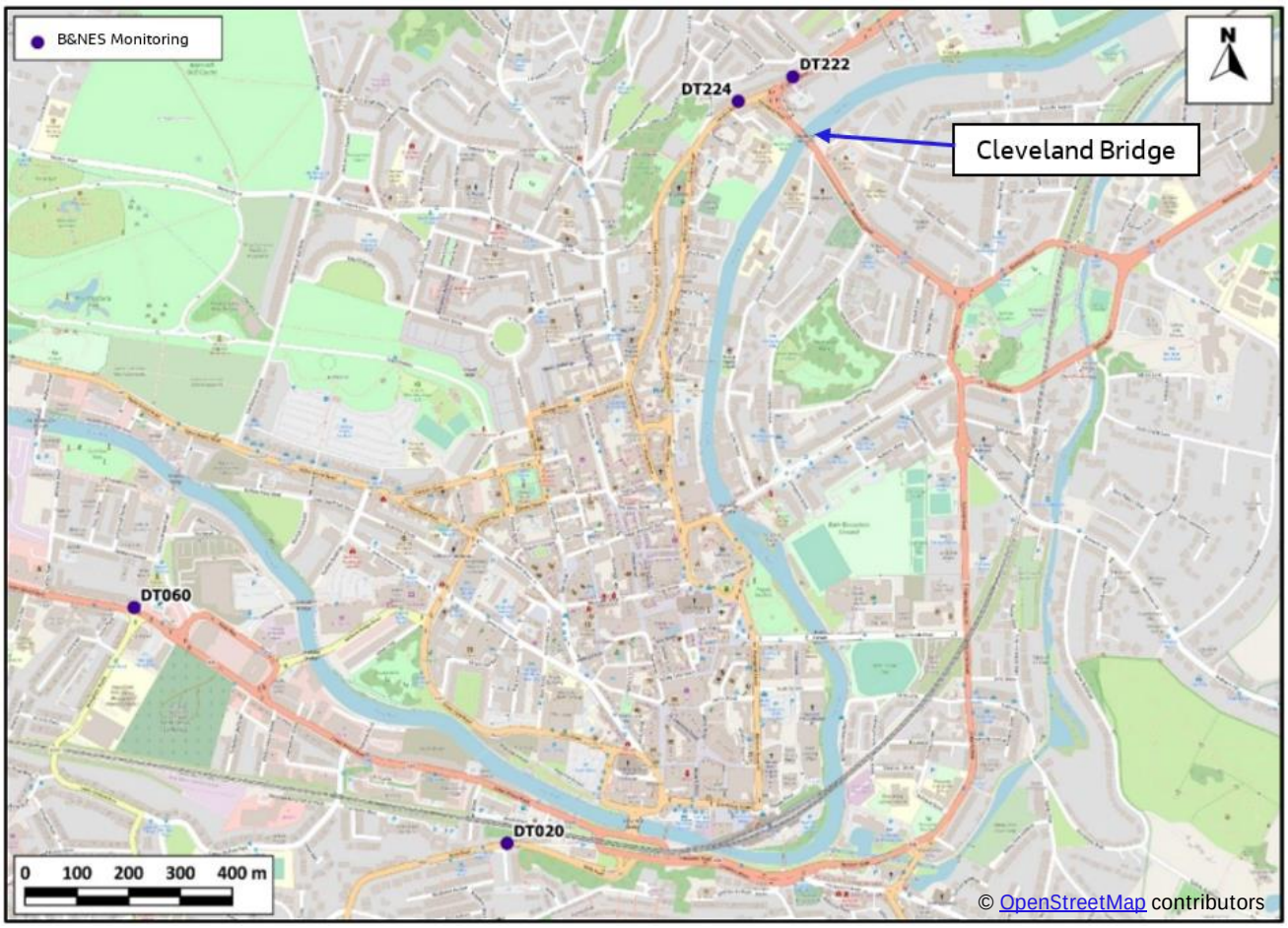


Figure 4.1: Locations of the four exceedance points

To calculate the 2021 and 2022 AADT for each of the exceedance locations, Jacobs used the following ATC data at each location:

- A367 Wells Road – Site 7 - Permanent ATC counter – 7-day average by vehicle type and direction - 2021 and January to March 2022
- Victoria Buildings/ A36 Lower Bristol Road – Site 88 – 2-week ATC counter – Weekly totals by class and by direction – November 2021

- Walcot Terrace/Anglo Terrace – Site 79 – 2-week ATC counter – Weekly totals by class and by direction – November 2021
- Walcot Parade – Site 78 – 2-week ATC counter – Weekly totals by class and by direction – November 2021

In addition to the data above, an additional count was obtained for October 2019 for Walcot Terrace/Anglo Terrace to represent a time before the Cleveland Bridge restrictions.

4.2 Traffic Flow Estimates

Traffic flow estimates (AADTs) at current (2022) levels were estimated for the four locations and are shown in Table 4.1. This is estimated to reflect a situation where Cleveland Bridge is open to all traffic throughout the year. Flows for all locations except Walcot Terrace were assumed to be unchanged regardless of the level of restrictions on Cleveland Bridge. These flows pivot directly from 2021 flows, with an allowance for an annual increase. Flows for Walcot Terrace were calculated by reversing the decrease seen when restrictions on the bridge were brought in (2019 to 2021). This was then uplifted to 2022 values based on the same annual increase mentioned above.

Table 4.1: 2022 AADT Flows - Cleveland Bridge open

Location	Direction	2022 AADT (Bridge open all year)						
		Car	LGV	OGV1	OGV2	Bus/Coach	Total	Speed
Walcot Parade	Northbound	5646	567	623	56	163	7055	21.4
	Southbound	7161	719	348	44	91	8363	20
Walcot Terrace/Anglo Terrace	Eastbound	11021	1106	508	218	250	13103	21.5
	Westbound	9521	956	348	214	236	11274	20.25
Victoria Buildings	Eastbound	5553	558	959	71	250	7391	23.75
	Westbound	8819	885	407	131	106	10347	17.9
A367 Wells Road	Northbound	6516	654	430	16	227	7842	18.8
	Southbound	6137	616	583	24	235	7595	20.3

4.3 HGV Flows at Each Location

The OGV1/2 flows in Table 4.1 were proportioned into N2 and N3 using 2017 ANPR data. OGV1s and PSVs with 2-axles were not included in the analysis of N3 Euro 6 HGVs. Table 4.2 shows the number of HGVs at the four locations for 2022, split by weight category (N2≤12T, N3>12T). As before, these estimates reflect a situation where Cleveland Bridge is assumed to be fully open for the entirety of 2022. The final column shows the number of N3s that are Euro 6 (compliant), and is based on an assumed compliance split of 98%, consistent with previous work.

Table 4.2: 2022 HGV flows - N2 and N3

Location	Direction	2022 HGVs flows		
		N2	N3	N3 (Euro 6)
Walcot Parade	Northbound	34	94	91
	Southbound	13	58	57
Walcot Terrace/Anglo Terrace	Eastbound	39	261	255
	Westbound	46	264	258
Lower Bristol Road	Eastbound	16	89	87
	Westbound	35	170	166
A367 Wells Road	Northbound	26	44	43
	Southbound	34	61	60

4.4 HGVs Affected by New Charge

The next step was to estimate the number of N3 HGVs that would be affected by a charge, namely the number of N3 Euro 6 HGVs that are not delivering to or originating their journeys from the exemption area discussed in Section 1 (i.e. through trips). Proportions of N3 Euro 6 trips that were through trips were calculated from 2017 ANPR data for three of the four locations: Walcot Terrace/Anglo Terrace, Victoria Buildings and Wells Road. These three locations are located very close to ANPR outer cordon points, hence data from these could be used to estimate proportions of through trips at each location. The proportion of through trips at Walcot Parade was estimated based on judgement. Given this location is not on a through route and is close to the city centre, 3% of N3 Euro 6 trips were assumed to be through trips, although in reality this may be even lower. The proportions used are shown in Table 4.3.

Table 4.3: Assumed proportion of through trips by location

Location	Direction	Proportion of N3 Euro 6 trips assumed to be through trips
Walcot Parade	Both	3%
Walcot Terrace/Anglo Terrace	Both	35%
Victoria Buildings	Both	39%
A367 Wells Road	Both	23%

These proportions were applied to the number of Euro 6 N3 HGVs at each location shown in Table 4.2. These were then split back up into OGV1/2 to give the predicted number of affected HGV trips at each location, the results of which are shown in Table 4.4.

Table 4.4: Predicted number of HGVs at key locations subject to an N3 Euro 6 charge

Location	Direction	2022 Predicted Affected HGVs	
		OGV1	OGV2
Walcot Parade	Northbound	1	2
	Southbound	1	1
Walcot Terrace/Anglo Terrace	Eastbound	35	54
	Westbound	35	54
Victoria Buildings	Eastbound	13	21
	Westbound	25	39
A367 Wells Road	Northbound	4	6
	Southbound	5	8

4.5 Predicted HGV Flows

It is assumed that the affected HGV trips shown in Table 4.4 re-route away from the CAZ in order to avoid paying the charge. Therefore, these were then subtracted from the total flows shown in Table 4.1, to give the predicted AADT flows at the four locations with the bridge assumed to be open all year and N3 Euro 6 charging in place. The results of this are shown in Table 4.5.

Table 4.5: 2022 AADT Flows - Cleveland Bridge open, with N3 Euro 6 charging

Location	Direction	2022 AADT (bridge open all year, with N3 Euro 6 charging)						
		Car	LGV	OGV1	OGV2	Bus/Coach	Total	Speed
Walcot Parade	Northbound	5646	567	622	54	163	7052	21.4
	Southbound	7161	719	347	43	91	8361	20
Walcot Terrace/Anglo Terrace	Eastbound	11021	1106	473	164	250	13015	21.5
	Westbound	9521	956	313	159	236	11185	20.25
Victoria Buildings	Eastbound	5553	558	946	50	250	7357	23.75
	Westbound	8819	885	381	92	106	10283	17.9
A367 Wells Road	Northbound	6516	654	426	10	227	7833	18.8
	Southbound	6137	616	578	16	235	7581	20.3

5. Alternative Routes

It has been assumed that all N3 Euro 6 HGVs that are charged will divert onto an alternative route to avoid paying the charge. Therefore, alternative routes have been examined to give an indication of where else on the network may be affected by this re-routing.

ANPR data from 2017 was used to determine the entry and exit points of N3 HGV through trips into and out of the outer cordon. The 11 outer cordon points are shown in Figure 2.1 and cover all key routes into and out of Bath, including all A roads, B roads and one unclassified road. HGVs that entered and exited via the same outer cordon point have not been included as through trips.

Results from this analysis found the most heavily trafficked pairs of outer cordon points. The number of trips from the top three pairs are shown in Table 5.1, with alternative routes for each of these discussed in the next three sub-sections.

Table 5.1: Number of N3 trips between top three pairs, based on review of 2017 ANPR data

Pairs of Outer Cordon Points	Road name/number	Number of through trips (both ways)
2, 5	A46-A36 (Gloucester Road-Warminster Road)	126
5,10	A36-A4 (Warminster Road- Bristol Road)	43
2, 8	A46-A367 (Gloucester Road-Wellsway)	19

5.1 A46-A36 (Gloucester Road-Warminster Road)

The largest through movement by some margin was between Outer Cordon numbers 2 and 5, representing north-south A46-A36 movements, which is classified as a trunk route which crosses Cleveland Bridge. The ANPR data used for this analysis was from 2017 and hence pre-dates any restrictions on the bridge. This route passes the air quality exceedance location at Walcot Terrace.

Two proxy trips-ends to the south were chosen to represent a general point HGVs may be routed to: Frome (close option) and Poole (far option). To the north, four proxy trip-end points were chosen: A420/A46 roundabout (close option), Yate, Newport and M4 J17 (all far options). Alternative route options are shown in Table 5.2.

Table 5.2: A46-A36 Alternative Routes

Trip-end 1	Trip-end 2	Alternative Route 1	Alternative Route 2
A420/A46 r'bout	Frome	A46-A4-A363-Bradford-on-Avon	A46-A4-A363-Trowbridge
A420/A46 r'bout	Poole	A46-A4-A363-Bradford-on-Avon-B3109-A36	A46-A4-A363-Trowbridge-A361-A350-A36
M4 West (Newport)	Frome	M4-A46-A4-A363-Bradford-on-Avon-B3109	M4-A46-A4-Trowbridge
M4 West (Newport)	Poole	M4-A46-A4-A363-Bradford-on-Avon/Trowbridge-A36	M4-M49-M5-A358-A303-A37-A35
Yate	Frome	A432-A46-A4-A363-Bradford-on-Avon-B3109	A432-A46-A4-Trowbridge
Yate	Poole	A432-A46-A4-A363-Bradford-on-Avon-B3109-A36	A432-A46-A4-Trowbridge-A361-A350-A36
M4 East (J17)	Frome	A350-A4-B3109-Bradford-on-Avon	A350-A361-Trowbridge
M4 East (J17)	Poole	A350-A36	-

As seen in Table 5.2, all combinations of trip-end points had suitable alternative routes, including options for N3 HGVs of all weights. It should be noted that routes via Bradford-on-Avon are subject to an 18T weight restriction over Town Bridge, meaning they are only suitable for N3s between 12-18T. However, for each route passing through Bradford-on-Avon, there is an alternative route via Trowbridge which does not have weight restrictions. This route through Trowbridge bypasses Bradford-on-Avon by using the B3105 via Staverton Mill.

5.2 A36-A4 (Warminster Road- Bristol Road)

The second largest through movement was between Outer Cordon numbers 5 and 10, representing northwest-south movements between the A4 (northwest) and A36 (south). This route passes through Bath south of the river, so does not cross over Cleveland Bridge. It does, however, pass an air quality exceedance location at Victoria Buildings. Given the northwest-south orientation of this route, just one southern proxy trip-end has been used, at Beckington. To the northwest, two proxy trip-ends are being used: Keynsham (close option) and Bristol (far option). No option further than Bristol was used as there are suitable alternatives via the M5 or M4 for longer-distance trips in this direction. Alternative Routes for this pair of points are shown in Table 5.3.

Table 5.3: A36-A4 Alternative Routes

Trip-end 1	Trip-end 2	Alternative Route 1	Alternative Route 2
Beckington	Keynsham	Frome-A362-Radstock-A367-Pennyquick-A4	Bradford-on-Avon/Trowbridge-A363-A4-A46-A420-A4174
Beckington	Bristol	Bradford-on-Avon/Trowbridge-A363-A4-A46-M4-M32	A37-Farrington-Temple Cloud-A361
Poole	Keynsham	A4-A39-Farrington-A37-A371-A357-A350	A4174-A420-A46-A363-Bradford-on-Avon/Trowbridge-A350
Poole	Bristol	A37-Temple Cloud-Farrington-A37-A371-A357-A350	M32-M4-A350
Salisbury	Keynsham	A36-Bradford-on-Avon/Trowbridge-A363-A46-A420-A4174	A36-A362-Frome-A367-Pennyquick-A4
Salisbury	Bristol	A36-Bradford-on-Avon/Trowbridge-A363-A46-M4-M32	A36-A362-Frome-Farrington-Temple Cloud-A37

5.3 A46-A367 (Gloucester Road-Wellsway)

The third largest through movement was between Outer Cordon points 2 and 8, representing north-southwest movements between the A36 (north) and A367 (southwest). This route crosses over Cleveland Bridge and passes two air quality exceedance points at Walcot Terrace and Wells Road. The same northern proxy trip-ends were used as for A46-A36 movements, but with the omission of M4 West (Newport). This was omitted as it would not be practical for trips between M4 West and southwest of Bath to travel via the Bath CAZ, with a much more direct route being via Bristol and the M32. Two proxy trip-ends were chosen for the southwest of Bath: Radstock (close option) and Shepton Mallet (far option). Results are shown in Table 5.4.

Table 5.4: A46-A367 Alternative Routes

Trip-end 1	Trip-end 2	Alternative Route 1	Alternative Route 2
A420/A46 r'bout	Radstock	A420-A4174-A4-Pennyquick-A367	A420-A4174-A4-A39-Farrington-A362
A420/A46 r'bout	Shepton Mallet	A46-A363-Bradford-on-Avon or Trowbridge-A361	A420-A4174-A4-A37-Temple Cloud-Farrington-A37
Yate	Radstock	A432-A4174-A4-Pennyquick-A367	A432-A4174-A4-A37-Temple Cloud-Farrington
Yate	Shepton Mallet	A432-A4174-A4-A37-Temple Cloud-Farrington-A37	A432-A4174-A4-A39-Farrington-A37
M4 East (J17)	Radstock	M4-A46-A430-A4174-A4-Pennyquick-A367	A350-A361-Trowbridge-Frome-A362
M4 East (J17)	Shepton Mallet	A350-A361-Trowbridge-A361	A350-A4-B3109-Bradford-on-Avon-A361

5.4 Summary

In summary, there are a number of alternative routes that may be used by N3 Euro 6 HGVs in order to avoid driving through the proposed charging scheme area and subsequently paying a charge. Further work is being done in order to estimate potential additional flows on these routes, but some of the routes most likely to feature are shown below:

- **North-South:** A46 – A4 – A363 – Bradford-on-Avon – B3109 – A361 (for N3s <18T)
- **North-South:** A46 – A4 – A363 – B3105 – Staverton Mill – Trowbridge – A361 (for all N3s)
- **Northwest-South:** A4 – Pennyquick – A367 – A362 – Frome
- **Northwest-South:** A37 – Temple Cloud – A362/A37

Figure 5.1 and Figure 5.2 show these four possible alternative routes on maps.

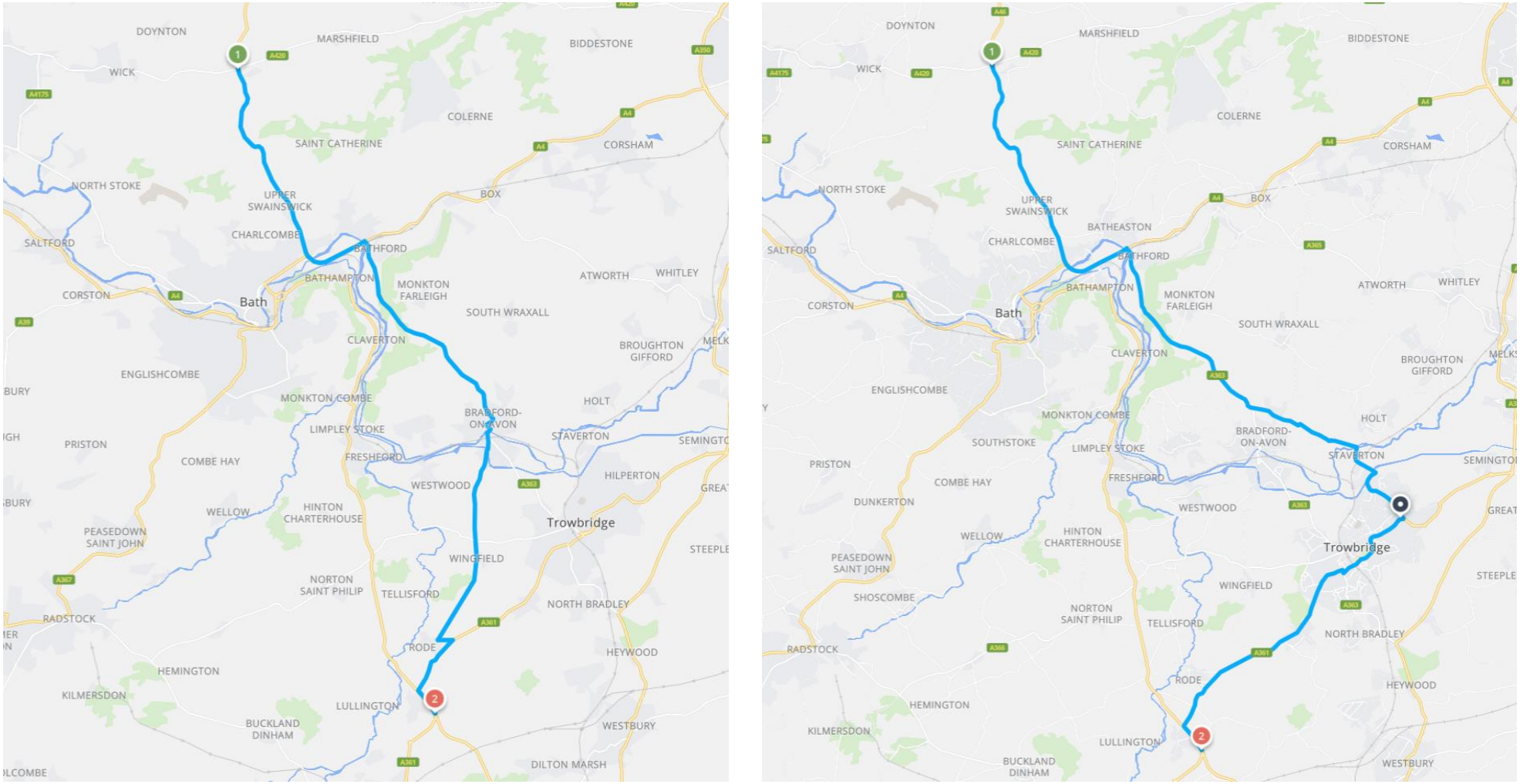


Figure 5.1: North-South alternative routes via Bradford-on-Avon (left) and Trowbridge (right). Source: Road Lords.

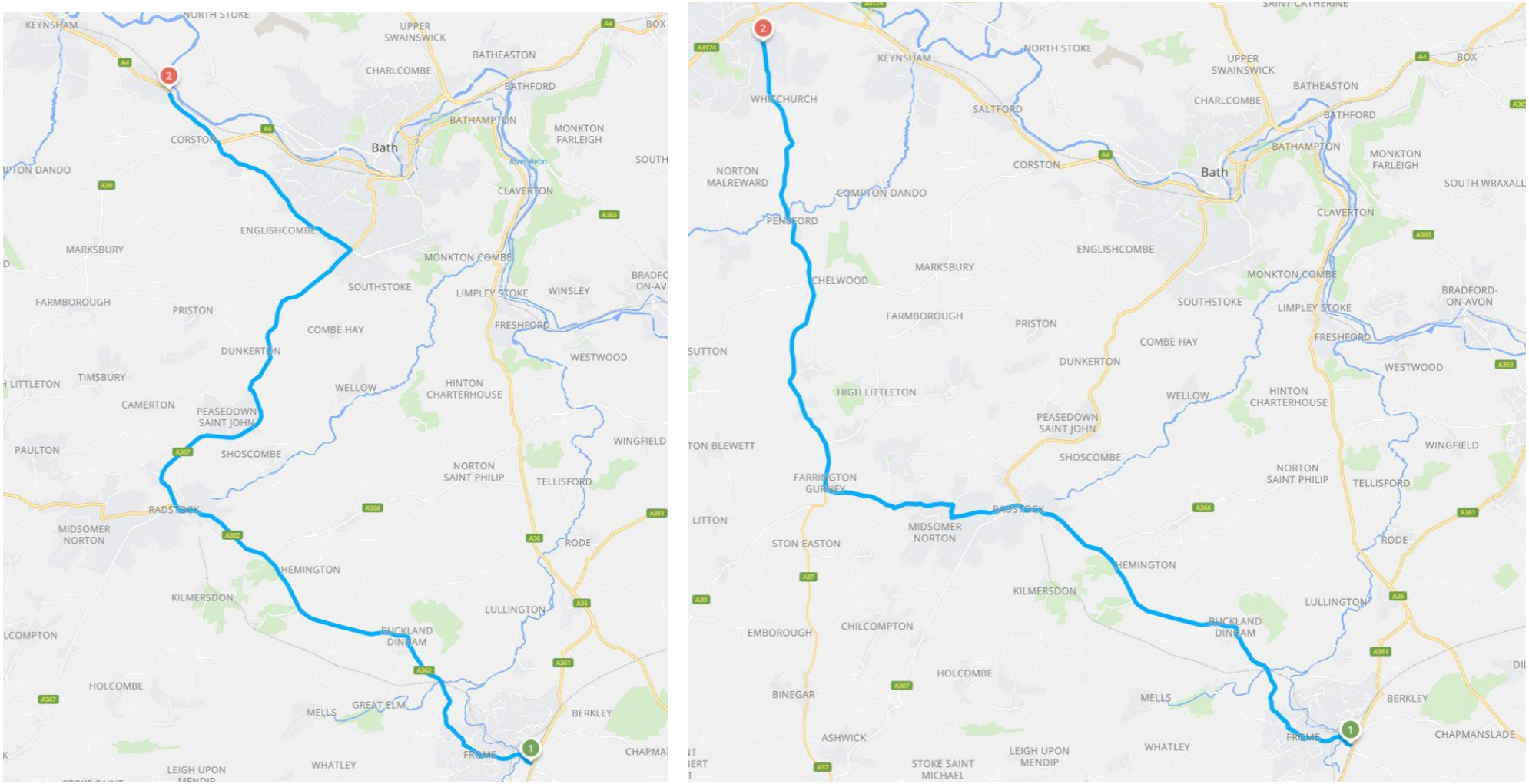


Figure 5.2: Northwest-South alternative routes via Pennyquick (left) and Temple Cloud (right). Source: Road Lords.

6. Summary of Air Quality Impacts

The analysis presented in AQC's Air Quality Report has predicted the effect of charging Euro 6 N3 HGVs within the Bath CAZ on annual mean nitrogen dioxide (NO2) concentrations in 2022 at four worst-case air quality monitors within the CAZ.

Modelling has considered two different scenarios in 2022; one, assuming that the current charging strategy remains in place (which does not charge Euro 6 N3 HGVs) and one assuming that all N3 HGVs are charged. The difference between these two scenarios is the effect that N3 charging is predicted to have on nitrogen dioxide concentrations.

The methodology manipulates the 2021 annual mean measured concentration, through an analysis of the ratio of expected 2022 road emissions with the current charging strategy, and assuming that all N3 HGVs are charged, versus 2021 emissions. The ratio is then applied to the road emissions at each site utilising JAQU-approved tools such as the Emission Factor Toolkit (EFT) and NOx to NO2 calculator. This provides an estimate of the 2022 concentrations with and without the additional N3 charging.

The analysis has demonstrated that the additional charges for N3 HGVs will result in a small reduction in predicted concentrations in 2022, in the range of 0.01- 0.27 µg/m^3 as an annual mean, as shown in Table 6.1. A reduction of this magnitude would not be evident in the monitoring data, which have uncertainties of a larger magnitude (largely because of the accuracy of the monitoring method and fluctuations due to meteorological conditions).

Table 6.1: Summary of Predicted Changes in Annual Mean Concentrations in 2022[b]

Site	Measured 2021 Annual Mean NO_2 Concentration (µg/m^3)	2022 Predicted Annual Mean Concentration (µg/m^3) with Current Charges	2022 Predicted Annual Mean Concentration (µg/m^3) with Additional N3 Charges	Change in Annual Mean Concentrations from Additional N3 Charges
DT020 (Wells Road)	42.6	39.6	39.5	0.05
DT060 (Victoria Buildings)	40.0	36.9	36.7	0.17
DT222 (Anglo Terrace)	38.1	42.3[c]	42.1	0.27
DT224 (Walcot Parade)	43.1	40.1	40.1	0.01

[b] Unrounded values have been used in the calculations, and have been rounded for presentation purposes only.

[c] Anglo Terrace is predicted to increase in concentration between 2021 and 2022 because of the additional predicted traffic flow (with or without the intervention).

Appendix A. Air Quality Impacts of Charging Report

Bath Clean Air Zone:
Air Quality Analysis of N3 HGV Charging

November 2022

Experts in air quality management & assessment

Document Control

Client	Bath and North East Somerset Council	**Principal Contact**	Chris Bushell (Jacobs)

Job Number	J10/12569E/10

Report Prepared By:	Dr Frances Marshall and Dr Clare Beattie

Document Status and Review Schedule

Report No.	Date	Status	Reviewed by
J10/12569E/10/F4	16 November 2022	Final	Dr Ben Marner (Director – Air Quality Modelling & Assessment)

Air Quality Consultants Ltd
23 Coldharbour Road, Bristol BS6 7JT Tel: 0117 974 1086
24 Greville Street, Farringdon, London, EC1N 8SS Tel: 020 3873 4780
aqc@aqconsultants.co.uk

Registered Office: 23 Coldharbour Road, Bristol BS6 7JT
Companies House Registration No: 2814570

1 Introduction

1.1 Air Quality Consultants (AQC) Ltd has been commissioned by Bath and North East Somerset (BANES) Council to undertake an analysis of the effect of charging Heavy Goods Vehicles (HGVs) exceeding 12 tonnes in weight (referred to as 'N3' HGVs) on annual mean nitrogen dioxide (NO_2) concentrations at four key monitoring locations with the greatest risk of non-compliance[1] in the Clean Air Zone (CAZ). The four monitoring sites are:

- DT020, located on Wells Road;
- DT060, located on Victoria Buildings adjacent to Lower Bristol Road;
- DT222, located on Anglo Terrace; and
- DT224, located on Walcot Parade.

Methodology

Scenarios

1.2 The analysis has been completed for two different scenarios in 2022; one, assuming that the current charging strategy remains in place ("2022") and one assuming that all N3 HGVs are charged ("2022 with E6N3 Charging") (the current charging strategy charges N3 HGVs other than Euro VI vehicles).

Background Concentrations

1.3 Background concentrations at each monitoring site in 2021 and 2022 have been defined using Defra's 2018-based background maps[2]; these are provided in Table 1. These cover the whole of the UK on a 1 x 1 km grid.

1.4 The background annual mean nitrogen dioxide maps for 2021 have been calibrated against local measurements made at the background monitoring site in Alexandra Park (DT023). The measured nitrogen dioxide concentration at this site in 2021 was 8.5 µg/m^3, while the mapped background for the grid square within which it lies was 8.0 µg/m^3.

1.5 All mapped background nitrogen dioxide concentrations have therefore been calibrated by applying a factor of 1.06 (i.e. 8.5/8.0). This calibration factor has also been applied to the 2022 concentrations.

[1] These four monitoring sites have previously been identified as locations at the greatest risk of non-compliance in 2022.

[2] Defra (2022), 'Local Air Quality Management Support Website'

Table 1: Annual Mean Background Nitrogen Dioxide Concentrations (µg/m^3) at Each Monitoring Site

Site	2021	2022
DT020 (Wells Road)	14.4	13.9
DT060 (Victoria Buildings)	14.4	13.9
DT222 (Anglo Terrace)	12.9	12.4
DT224 (Walcot Parade)	12.9	12.4

Traffic Data

1.6 Traffic data, in the form of Annual Average Daily Traffic (AADT) flows and vehicle fleet composition, for the roads adjacent to each monitoring site have been provided by Jacobs. AADT flows used in the analysis are provided in Table 2, whilst the fleet compositions are provided in Appendix A1.

Table 2: AADT Flows Used in the Analysis

Location	Direction	Relevant Diffusion Tube	AADT Flow					Speed (kph)
			Car	LGV	HGV	Bus / Coach	Total	
2021								
Walcot Parade	Northbound	DT224	5,509	553	662	159	6,883	21.4
	Southbound		6,987	701	382	88	8,159	20.0
Walcot Terrace / Anglo Terrace	Eastbound	DT222	7,699	773	547	190	9,208	21.5
	Westbound		6,828	685	347	218	8,078	20.3
Victoria Buildings	Eastbound	DT060	5,418	544	1,005	244	7,211	23.8
	Westbound		8,604	864	524	103	10,095	17.9
A367 Wells Road	Northbound	DT020	6,273	630	461	250	7,613	18.8
	Southbound		5,731	575	595	255	7,156	20.3
2022								
Walcot Parade	Northbound	DT224	5,646	567	679	163	7,055	21.4
	Southbound		7,161	719	392	91	8,363	20.0
Walcot Terrace / Anglo Terrace	Eastbound	DT222	11,021	1,106	726	250	13,103	21.5
	Westbound		9,521	956	562	236	11,274	20.3
Victoria Buildings	Eastbound	DT060	5,553	558	1,030	250	7,391	23.8
	Westbound		8,819	885	538	106	10,347	17.9

Location	Direction	Relevant Diffusion Tube	AADT Flow					Speed (kph)
			Car	LGV	HGV	Bus / Coach	Total	
A367 Wells Road	Northbound	DT020	6,516	654	445	227	7,842	18.8
	Southbound		6,137	616	607	235	7,595	20.3
2022 with E6N3 Charging								
Walcot Parade	Northbound	DT224	5,646	567	676	163	7,052	21.4
	Southbound		7,161	719	390	91	8,361	20.0
Walcot Terrace / Anglo Terrace	Eastbound	DT222	11,021	1,106	637	250	13,015	21.5
	Westbound		9,521	956	472	236	11,185	20.3
Victoria Buildings	Eastbound	DT060	5,553	558	996	250	7,357	23.8
	Westbound		8,819	885	473	106	10,283	17.9
A367 Wells Road	Northbound	DT020	6,516	654	436	227	7,833	18.8
	Southbound		6,137	616	594	235	7,581	20.3

Calculations

1.7 The prediction of annual mean concentrations in 2022 follows a series of steps, utilising input data described above. For each site, the approach is as follows:

- Step 1: Total road emissions and primary NO_2 fractions (fNO_2 [3]) in 2021 and 2022 have been calculated from traffic data using the Emission Factor Toolkit (EFT) (v11.0)[2]; then
- Step 2: Using Defra's NOx to NO_2 calculator (v8.1)[2], the road nitrogen oxide (NOx) components of the measured 2021 concentrations have been calculated; then
- Step 3: Based on the ratio between the 2021 and 2022 total road emissions, the projected 2022 road NOx components have been calculated; then
- Step 4: Defra's NOx to NO_2 calculator[2] has been used to calculate total concentrations in 2022, in combination with the predicted background and fNO_2 for 2022.

1.8 The above steps have been undertaken for both 2022 scenarios (i.e., assuming that the current charging strategy remains in place ("2022") and assuming that all N3 HGVs are charged ("2022 with E6N3 Charging")).

[3] fNO_2 is the fraction of NOx emitted as NO_2, which varies with different vehicle types. Increased primary NO_2 emissions are associated with the greater penetration of diesel cars into the vehicle fleet, and the use of catalytically regenerative particle traps on some heavy duty vehicles.

Uncertainty and Limitations

1.9 The available traffic data do not differentiate between different weight categories of HGVs. It has thus not been possible to take account of the different emissions from different sized HGVs.

1.10 Measured concentrations at the diffusion tubes will be affected by the meteorological conditions at the time of those measurements (such as wind directions and speeds and planetary boundary layer heights, amongst others). For obvious reasons, it is not possible to predict the meteorological conditions across the whole of 2022, and thus factor these variations into the projections. As such, the methodology described in Paragraph 1.7 does not account for any variation in meteorology between 2021 and 2022.

1.11 The calculations also rely on trends in traffic volumes and fleet composition based on data collected in 2021, which was, to a certain degree, affected by changes in behaviour brought about by the Covid-19 pandemic.

1.12 Additionally, the projections rely on emissions predicted by the EFT using a fleet provided by Jacobs, both of which will also have inherent uncertainties. There will also be imprecision introduced by using Defra's NOx to NO_2 calculator.

2 Monitoring Analysis

Step 1

2.1 Total road emissions of NOx and fNO_2 in 2021 and 2022 from the EFT for each site are provided in Table 3.

Table 3: Total Road NOx Emissions and Primary NO_2 Fractions [a]

Site	2021		2022		2022 with E6N3 Charging	
	Total NOx Emissions (g/km/s)	fNO_2 (%/100) [b]	Total NOx Emissions (g/km/s)	fNO_2 (%/100) [b]	Total NOx Emissions (g/km/s)	fNO_2 (%/100) [b]
DT020 (Wells Road)	0.112	0.19	0.099	0.20	0.099	0.20
DT060 (Victoria Buildings)	0.117	0.20	0.102	0.21	0.101	0.21
DT222 (Anglo Terrace)	0.110	0.22	0.134	0.22	0.132	0.22
DT224 (Walcot Parade)	0.094	0.22	0.084	0.22	0.084	0.22

[a] Unrounded values have been used in the calculations, and have been rounded for presentation purposes only.

[b] e.g. 0.19 = 19%.

Step 2

2.2 The road NOx component of the measured 2021 concentrations for each site, based on Defra's NOx to NO_2 calculator[2], are presented in Table 4.

Table 4: 2021 Measured Concentrations and Predicted Road NOx Components [a]

Site	2021 Annual Mean NO_2 Concentration ($\mu g/m^3$)	fNO_2 (%/100) [b]	Background NO_2 Concentration ($\mu g/m^3$)	Road NOx ($\mu g/m^3$)
DT020 (Wells Road)	42.6	0.19	14.4	68.8
DT060 (Victoria Buildings)	40.0	0.20	14.4	59.7
DT222 (Anglo Terrace)	38.1	0.22	12.9	57.2
DT224 (Walcot Parade)	43.1	0.22	12.9	71.0

[a] Unrounded values have been used in the calculations, and have been rounded for presentation purposes only.

[b] e.g. 0.19 = 19%.

Step 3

2.3 The projected 2022 road NOx component for each site, based on the ratio between the 2021 and 2022 total road emissions, is presented in Table 5.

Table 5: Predicted Road NOx Components in 2022 [a]

Site	2021 Road NOx (µg/m^3)	Ratio 2022:2021 Road Emission		Predicted Road NOx	
		2022	2022 with E6N3 Charging	2022	2022 with E6N3 Charging
DT020 (Wells Road)	68.8	0.88	0.88	60.7	60.6
DT060 (Victoria Buildings)	59.7	0.88	0.87	52.4	51.8
DT222 (Anglo Terrace)	57.2	1.21	1.19	69.4	68.3
DT224 (Walcot Parade)	71.0	0.89	0.89	63.1	63.1

[a] Unrounded values have been used in the calculations, and have been rounded for presentation purposes only.

Step 4

2.4 Total concentrations in 2022, based on Defra's NOx to NO_2 calculator[2], in combination with the predicted background and fNO_2 for 2022 are presented in Table 6.

Table 6: Predicted Annual Mean Concentrations in 2022 [a]

Site	Predicted 2022 Road NOx (µg/m^3)	2022 Background Concentration (µg/m^3)	fNO_2 (%/100) [b]	Predicted Annual Mean NO_2 Concentration (µg/m^3)
2022				
DT020 (Wells Road)	60.7	13.9	0.20	39.6
DT060 (Victoria Buildings)	52.4	13.9	0.21	36.9
DT222 (Anglo Terrace)	69.4	12.4	0.22	42.3
DT224 (Walcot Parade)	63.1	12.4	0.22	40.1
2022 with E6N3 Charging				
DT020 (Wells Road)	60.6	13.9	0.20	39.5
DT060 (Victoria Buildings)	51.8	13.9	0.21	36.7
DT222 (Anglo Terrace)	68.3	12.4	0.22	42.1
DT224 (Walcot Parade)	63.1	12.4	0.22	40.1

[a] Unrounded values have been used in the calculations, and have been rounded for presentation purposes only.

[b] e.g. 0.19 = 19%.

Table 7: Summary of Predicted Changes in Annual Mean Concentrations in 2022 [a]

Site	Measured 2021 Annual Mean NO_2 Concentration ($\mu g/m^3$)	2022 Predicted Annual Mean Concentration ($\mu g/m^3$) with Current Charges	2022 Predicted Annual Mean Concentration ($\mu g/m^3$) with Additional N3 Charges	Change in Annual Mean Concentrations from Additional N3 Charges
DT020 (Wells Road)	42.6	39.6	39.5	0.05
DT060 (Victoria Buildings)	40.0	36.9	36.7	0.17
DT222 (Anglo Terrace)	38.1	42.3 [b]	42.1	0.27
DT224 (Walcot Parade)	43.1	40.1	40.1	0.01

[a] Unrounded values have been used in the calculations, and have been rounded for presentation purposes only.

[b] Anglo Terrace is predicted to increase in concentration between 2021 and 2022 because of the additional predicted traffic flow (with or without the intervention).

Discussion

2.5 The predicted annual mean NO_2 concentrations in Table 6, which are summarised in Table 7, demonstrate that additional charging of N3 HGVs in the CAZ will have a very small effect.

2.6 The predicted concentrations, assuming the charge for all N3 HGVs is implemented, are slightly lower than those predicted assuming the current charging strategy remains in place. The greatest changes are predicted to occur at sites DT222 on Anglo Terrace (0.27 $\mu g/m^3$) and DT060 on Victoria Buildings (0.17 $\mu g/m^3$). These are the roads where the largest reduction in total HGV numbers is expected due to the change in charging.

3 Summary

3.1 The analysis presented in this report has predicted the effect of charging Euro VI N3 HGVs within the Bath CAZ on annual mean nitrogen dioxide concentrations in 2022 at four worst-case air quality monitors within the CAZ.

3.2 Modelling has considered two different scenarios in 2022; one, assuming that the current charging strategy remains in place (which does not charge Euro VI N3 HGVs) and one assuming that all N3 HGVs are charged. The difference between these two scenarios is the effect that N3 charging is predicted to have on nitrogen dioxide concentrations.

3.3 The methodology manipulates the 2021 annual mean measured concentration, through an analysis of the ratio of expected 2022 road emissions with the current charging strategy, and assuming that all N3 HGVs are charged, versus 2021 emissions. The ratio is then applied to the road emissions at each site utilising JAQU-approved tools such as the Emission Factor Toolkit (EFT) and NOx to NO_2 calculator. This provides an estimate of the 2022 concentrations with and without the additional N3 charging.

3.4 The analysis has demonstrated that the additional charges for N3 HGVs will result in a small reduction in predicted concentrations in 2022, in the range of 0.01- 0.27 µg/m^3 as an annual mean. A reduction of this magnitude would not be evident in the monitoring data, which have uncertainties of a larger magnitude (largely because of the accuracy of the monitoring method and fluctuations due to meteorological conditions).

4 Glossary

AADT	Annual Average Daily Traffic
AQC	Air Quality Consultants
BANES	Bath and North East Somerset
CAZ	Clean Air Zone
Defra	Department for Environment, Food and Rural Affairs
DT	Diffusion Tube
EFT	Emission Factor Toolkit
EGR	Exhaust Gas Recirculation
fNO_2	Primary NO_2 (the fraction of NOx emitted as NO_2)
HGV	Heavy Goods Vehicle
kph	Kilometres Per hour
µg/m^3	Microgrammes per cubic metre
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
SCR	Selective Catalytic Reduction
SCRRF	Selective Catalytic Reduction Retrofit

5 Appendices

A1 Euro Proportions

A1.1 The Euro proportions for each vehicle type in 2021 and 2022, as provided by Jacobs, are detailed in Table A1.1.

Table A1.1: Euro Proportions for 2021 and 2022

Vehicle Type	Euro Classification [a]	Proportion (%/100) [b]	
		2021	2022
Petrol Car	1Pre-Euro 1	0.00	0.00
	2Euro 1	0.00	0.00
	3Euro 2	0.01	0.00
	4Euro 3	0.09	0.06
	5Euro 4	0.22	0.19
	6Euro 5	0.23	0.22
	7Euro 6	0.24	0.25
	7Euro 6c	0.22	0.26
Diesel Car	1Pre-Euro 1	0.00	0.00
	2Euro 1	0.00	0.00
	3Euro 2	0.00	0.00
	4Euro 3	0.05	0.04
	5Euro 4	0.18	0.16
	6Euro 5	0.34	0.33
	7Euro 6	0.29	0.31
	7Euro 6	0.03	0.04
	7Euro 6c	0.10	0.12
Petrol LGV	1Pre-Euro 1	0.04	0.03
	2Euro 1	0.01	-
	3Euro 2	0.00	-
	4Euro 3	0.02	0.02
	5Euro 4	0.17	0.20
	6Euro 5	0.04	0.06
	7Euro 6	0.29	0.30
	7Euro 6c	0.42	0.40
Diesel LGV	1Pre-Euro 1	0.00	0.00
	2Euro 1	0.00	0.00
	3Euro 2	0.00	0.00
	4Euro 3	0.02	0.01
	5Euro 4	0.12	0.04
	6Euro 5	0.23	0.14

	7Euro 6	0.30	0.37
	7Euro 6c	0.04	0.04
	7Euro 6d	0.29	0.40
Rigid HGV	1Pre-Euro I	0.00	0.00
	2Euro I	0.00	-
	3Euro II	0.00	-
	4Euro III	0.02	-
	5Euro IV	0.03	0.01
	6Euro V_EGR	0.02	0.01
	7Euro V_SCR	0.07	0.03
	8Euro VI	0.86	0.95
	9Euro II SCRRF	-	-
	10Euro III SCRRF	-	-
	11Euro IV SCRRF	-	-
	12Euro V EGR + SCRRF	-	-
Articulated HGV	1Pre-Euro I	0.00	0.00
	2Euro I	0.00	-
	3Euro II	0.00	-
	4Euro III	0.02	-
	5Euro IV	0.03	0.01
	6Euro V_EGR	0.02	0.01
	7Euro V_SCR	0.07	0.03
	8Euro VI	0.86	0.95
	9Euro II SCRRF	-	-
	10Euro III SCRRF	-	-
	11Euro IV SCRRF	-	-
	12Euro V EGR + SCRRF	-	-
Bus	1Pre-Euro I	0.00	-
	2Euro I	0.00	0.00
	3Euro II	0.00	0.00
	4Euro III	0.02	-
	5Euro IV	0.12	0.09
	6Euro V_EGR	0.12	0.13
	7Euro V_SCR	0.35	0.39
	8Euro VI	0.38	0.39
	9Euro II SCRRF	-	-
	10Euro III SCRRF	-	-

	11Euro IV SCRRF	-	-
	12Euro V EGR + SCRRF	-	-
Coach	1Pre-Euro I	0.00	-
	2Euro I	0.00	0.00
	3Euro II	0.00	0.00
	4Euro III	0.02	-
	5Euro IV	0.12	0.09
	6Euro V_EGR	0.12	0.13
	7Euro V_SCR	0.35	0.39
	8Euro VI	0.38	0.39
	9Euro II SCRRF	-	-
	10Euro III SCRRF	-	-
	11Euro IV SCRRF	-	-
	12Euro V EGR + SCRRF	-	-

[a] where EGR = Exhaust Gas Recirculation, SCR = Selective Catalytic Reduction and SCRRF = Selective Catalytic Reduction Retrofit.

[b] e.g. 0.19 = 19%