# Greater Manchester's Clean Air Plan to tackle Nitrogen Dioxide Exceedances at the Roadside

# Note 16: Sensitivity test: GM-wide CAZ C with revised behavioural response assumptions



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| **Authorised by:**<br>**Date:** | Ian Palmer<br>22nd July 2019 | | |

**COVID-19 Pandemic Statement**

This work has not considered the impact of the COVID-19 pandemic. Whilst we are continuing, where possible, to develop the Greater Manchester Clean Air Plan, the pandemic has already had an impact on our ability to keep to the timescales previously indicated and there may be further impacts on timescales as the impact of the pandemic becomes clearer.

We are also mindful of the significant changes that could result from these exceptional times. We know that the transport sector has already been impacted by the pandemic, and government policies to stem its spread. The sector's ability to recover from revenue loss, whilst also being expected to respond to pre-pandemic clean air policy priorities by upgrading to a cleaner fleet, will clearly require further thought and consideration.

The groups most affected by our Clean Air Plan may require different levels of financial assistance than we had anticipated at the time of writing our previous submission to Government.

More broadly, we anticipate that there may be wider traffic and economic impacts that could significantly change the assumptions that sit behind our plans. We have begun to consider the impacts, and have committed to updating the government as the picture becomes clearer over time.

We remain committed to cleaning up Greater Manchester's air. However, given the extraordinary circumstances that will remain for some time, this piece of work remains unfinished until the impact of the COVID-19 pandemic has been fully considered by the Greater Manchester Authorities.

Modelling contained in Note 16 was indicative modelling carried out at an early stage in the model development process and is superseded by the package modelling presented in Note 29, and Reports T4 and AQ3.

## 1 Introduction

1.1 GM submitted the Clean Air Plan (GM CAP) Outline Business Case (OBC) to JAQU in March 2019. The methodology applied to modelling of conditions with and without action was set out in the supplementary Air Quality reports (AQ1/2/3) and Transport reports T1/2/3/4), and the Economic Appraisal Methodology Report, set alongside a discussion of the limitations, uncertainties and risks of the evidence base in the Analytical Assurance Statement (AAS).

1.2 Following OBC submission, GM is now undertaking further data collection, analysis and modelling to improve the data and tools supporting the GM CAP and reduce the uncertainty of the conclusions reached.

1.3 As a result, a series of potential improvements have been identified to the assumptions about behavioural responses to a Clean Air Zone.

1.4 This Note sets out the results of a sensitivity test carried out of those assumptions using GM's strategic modelling suite.

## 2 Background to Updates

2.1 This Note describes the result of a sensitivity test applying revised behavioural response assumptions to a test of a GM-wide CAZ C in 2023. The purpose of this test is to determine the possible impact of these changes on traffic, NOx emissions and NO2 concentrations. 2023 has been used as it provides the best insight into conditions close to the current modelled year of compliance with-action of 2024.

2.2 The sensitivity test described here will inform decision-making about next steps in the modelling and appraisal of the GM CAP, and help identify what further action is required to achieve compliance in the shortest possible time.

2.3 Evidence is still emerging and additional refinement is expected in advance of the FBC submission to further enhance these assumptions, though the updates discussed within this note present a significant improvement in the behavioural responses since the submission of the OBC and tackle some of the key issues identified in the AAS and by the TIRP and DIRP review. This is discussed further in accompanying Note 1: GM CAP Data, Evidence and Modelling: post-OBC approach.

2.4 Further sensitivity testing will be carried out in support of GM's FBC submission.

## 3 Updates to Behavioural Responses & application within the Demand Sifting Tool

### 3.1 Updated Behavioural Responses

3.1.1 A series of potential improvements have been identified and applied in this test. The analysis carried out to develop these improved assumptions is set out in supporting Notes 8 to 10, covering Behavioural Responses for HGVs, LGVs and Taxis respectively. In this test, the behavioural responses for Taxis (Private Hire Vehicles (PHVs) & Hackney Cabs), LGVs, and HGVs have been updated to reflect new available data.

### 3.2 Taxis: Hackney Cabs

3.2.1 The OBC assumed that 100% of Hackney Cabs upgraded to a compliant vehicle. This assumption was made in the absence of data regarding the likely behavioural responses of Hackney Cab drivers and operators.

3.2.2 It is not intended that this assumption is replicated in the FBC; instead an evidence-based behavioural response will be applied. Consequently, sensitivity testing has not been carried out of the 100% upgrade response as this assumption is no longer relevant.

3.2.3 The updates to the behavioural responses for Hackney Cabs include:

- Stated Preference (SP) Surveys have been conducted in Sheffield with Hackney Cab drivers, allowing us to identify a possible behavioural response;
- The Sheffield SP Surveys included a Cancel Trip response (i.e. work in a different town or leave the trade). Given the GM scheme is region-wide, the ability for taxi drivers to work in a different town is limited and they would still be required to comply or pay to drive through the region to work elsewhere, and therefore this response is not considered relevant for GM. It is also assumed that the demand for Taxi trips is derived by the passenger and not the driver, and therefore that a significant fall in Taxi trips is unlikely;
- The potential impact of the GM CAP on the loss of livelihoods will be considered in the economic appraisal and impacts assessments.

3.2.4 Taxi behavioural responses are discussed further in Note 10: GM CAP: Taxi Behavioural Responses, which provides further details on the derivation of the revised behavioural response assumptions for Hackney Cabs. Work is continuing and the assumptions applied in this test remain subject to review.

3.3 Taxis: Private Hire Vehicles

3.3.1 The updates to the behavioural responses for PHVs include:

- Previous behavioural responses (based on Bristol SP) have been updated to reflect new more relevant data from the Sheffield SP survey; and
- Behavioural response for Sheffield SP included a separate response for PHV and Hackney Cabs which has been reflected in our updated assessment of the GM-CAP.
- As discussed above, the Cancel Trip response has been removed and responses re-proportioned.

3.3.2 Taxi behavioural responses are discussed further in Note 10: GM CAP: Taxi Behavioural Responses, which provides further details on the derivation of the revised behavioural response assumptions for PHVs. Work is continuing and the assumptions applied in this test remain subject to review.

3.3.3 The change in approach to the hackney and PHV responses necessitated some changes to the way in which the DST was used and that is discussed further in **Section 4**.

3.4 LGV / HGV

3.4.1 HGV behavioural responses are discussed further in Note 8: GM CAP: HGV Behavioural Responses and LGV behavioural responses in Note 9: GM CAP: LGV Behavioural Responses, which provide further details on the derivation of the revised behavioural response assumptions for freight vehicles. Work is continuing and the assumptions applied in this test remain subject to review. In particular, there remains considerable uncertainty in terms of likely LGV responses and more work is required to better understand them.

3.4.2 The new approach utilises an operating cost model approach to help estimate the response from freight users (LGV and HGV) to a potential charge.

3.4.3 This included a detailed review of the LGV fleet serving GM, which was split into a series of commodity types based on the types of vehicles used, including age of vehicles kept, and typical mileage travelled for that commodity type. This identified key commodity types which would be most highly impacted by the CAZ (such as the construction sector, which typically operates older LGVs which are more likely to be non-compliant).

3.4.4 Behavioural responses and operational costs for commodity types were amalgamated to derive a total LGV weighted behavioural response for the GM LGV fleet. In addition to 'pay charge' and 'upgrade vehicle' The response model also identified a change mode response which allows for the downgrade of vehicle to a compliant vehicle, e.g. the purchase of an estate car instead of an LGV in response to the CAZ which would have a different impact on air quality.

3.4.5 The DST does not currently enable the transfer of demand from one mode to another (this is an enhancement that is planned for the FBC submission). As a result, the change mode response was renewed and other responses re-proportioned to ensure no loss of overall demand. This results in a 100% upgrade response in the current version of the DST. This also reflects the significant cost impact on HGV users of a £100 daily charge.

## 3.5 Behavioural Responses Applied

3.5.1 Following the updates to the behavioural responses, the values used at OBC have been replaced in this sensitivity test by those shown in **Table 3-1**.

3.5.2 It has been assumed that 100% of buses upgrade, as per the OBC assumption. This assumption is made in the absence of information about alternative upgrade responses, but it is reasonable to assume that in reality this represents a response that could be achieved only by a CAZ supported by funding for bus upgrades. Sensitivity testing analysis has been carried out investigating the theoretical minimum response required for bus in order to achieve compliance in the shortest possible time. The results of this analysis are set out in Note 11: Analysis of Bus Upgrade Options to Deliver Air Quality Compliance.

**Table 3-1. Behavioural Responses Applied**

| Response | Hackney Cab | PHV | HGV | LGV |
|---|---|---|---|---|
| Pay Charge | 26% | 12% | 0% | 56% |
| Change Mode | 0% | 0% | 0% | 0% |
| Cancel Trip | 0% | 0% | 0% | 0% |
| Upgrade | 74% | 88% | 100% | 44% |

*Source: Values based on updated behavioural responses, Taxis based on Sheffield SP Survey, LGV/HGV based on new Operating cost model*

## 3.6 Further work

3.6.1 Analysis continues to determine the behavioural response assumptions to be applied in the updated evidence base to be submitted with the Initial Full Business Case of the GM CAP. The assumptions applied in this test are therefore subject to change.

## 4 Demand Sifting Tool Updates

4.1 Following the inclusion of the revised behavioural response assumptions within the Demand Sifting Tool (DST), the model was run to determine the changes to the compliant and non-compliant vehicle mix. The outputs of this update are presented in

| 4.2 | Taxi | | HGV | | LGV | |
|---|---|---|---|---|---|---|
| Scenario | Do Minimum | GM CAZ C test | Do Minimum | GM CAZ C test | Do Minimum | GM CAZ C test |
| AM Peak | | | | | | |
| Complaint | 22,400 | 24,500 | 26,600 | 30,300 | 36,300 | 43,700 |
| Non-Compliant | 2,600 | 600 | 5,800 | 2,200 | 17,900 | 10,500 |
| Total | 25,000 | 25,100 | 32,400 | 32,500 | 54,200 | 54,200 |
| Interpeak | | | | | | |
| Complaint | 18,500 | 20,300 | 29,000 | 32,900 | 35,400 | 42,600 |
| Non-Compliant | 2,300 | 500 | 6,400 | 2,400 | 17,500 | 10,300 |
| Total | 20,800 | 20,800 | 35,400 | 35,300 | 52,900 | 52,900 |
| PM Peak | | | | | | |
| Complaint | 22,700 | 25,000 | 14,000 | 15,800 | 30,800 | 36,900 |
| Non-Compliant | 2,900 | 700 | 3,100 | 1,300 | 15,100 | 9,000 |
| Total | 25,600 | 25,700 | 17,100 | 17,100 | 45,900 | 45,900 |

4.3 **. Note:** No changes to the car matrices were identified within the CAZ only model run

4.4 Table 4-2 has also been included to allow comparison with the OBC assumptions. Note that the total Taxi number includes Hackney Cabs and PHVs.

4.5 The previous version of modelling had assumed there would be 100% compliance for Hackneys and therefore the structure of the DST did not allow for a behavioural response for this vehicle type. In order to respond to one of the concerns raised by JAQU, this test amended this assumption (see **Table 3-1** above).

4.6 In order to incorporate this change in approach within the DST, it was necessary to first combine the Hackney and PSV into a single group and then split according to the combined proportion of compliant / non-compliant in the two fleets (Hackney and PHV). This is an approximation but allows us to include the behavioural response required without a fundamental restructuring of the DST which was not possible within the timeframe being worked to.

4.7 This required changes to be made to the do minimum (within the DST) for comparative purposes for this test.

**Table 4-1. Updates to Compliant / Non-Compliant Vehicle splits by mode (July 2019)**

| | Taxi | | HGV | | LGV | |
|---|---|---|---|---|---|---|
| Scenario | Do Minimum | GM CAZ C test | Do Minimum | GM CAZ C test | Do Minimum | GM CAZ C test |
| AM Peak | | | | | | |
| Complaint | 22,400 | 24,500 | 26,600 | 30,300 | 36,300 | 43,700 |
| Non-Compliant | 2,600 | 600 | 5,800 | 2,200 | 17,900 | 10,500 |
| Total | 25,000 | 25,100 | 32,400 | 32,500 | 54,200 | 54,200 |
| Interpeak | | | | | | |
| Complaint | 18,500 | 20,300 | 29,000 | 32,900 | 35,400 | 42,600 |
| Non-Compliant | 2,300 | 500 | 6,400 | 2,400 | 17,500 | 10,300 |
| Total | 20,800 | 20,800 | 35,400 | 35,300 | 52,900 | 52,900 |
| PM Peak | | | | | | |
| Complaint | 22,700 | 25,000 | 14,000 | 15,800 | 30,800 | 36,900 |
| Non-Compliant | 2,900 | 700 | 3,100 | 1,300 | 15,100 | 9,000 |
| Total | 25,600 | 25,700 | 17,100 | 17,100 | 45,900 | 45,900 |

*Note: No changes to the car matrices were identified within the CAZ only model run*

**Table 4-2. OBC Compliant / Non-Compliant splits by mode (March 2019)**

| | Taxi | | HGV | | LGV | |
|---|---|---|---|---|---|---|
| Scenario | Do Minimum | GM CAZ C test | Do Minimum | GM CAZ C test | Do Minimum | GM CAZ C test |
| **AM Peak** | | | | | | |
| Complaint | 24,100 | 24,800 | 26,600 | 30,100 | 36,300 | 49,000 |
| Non-Compliant | 1,000 | 300 | 5,800 | 2,200 | 17,900 | 2,700 |
| **Total** | **25,100** | **25,100** | **32,400** | **32,300** | **54,200** | **51,700** |
| **Interpeak** | | | | | | |
| Complaint | 19,900 | 20,600 | 29,000 | 32,800 | 35,400 | 47,700 |
| Non-Compliant | 900 | 200 | 6,400 | 2,400 | 17,500 | 2,800 |
| **Total** | **20,800** | **20,800** | **35,400** | **35,200** | **52,900** | **50,500** |

| PM Peak | | | | | | |
|---|---|---|---|---|---|---|
| Complaint | 24,500 | 25,400 | 14,000 | 15,700 | 30,800 | 41,400 |
| Non-Compliant | 1,100 | 300 | 3,100 | 1,300 | 15,100 | 2,500 |
| **Total** | **25,600** | **25,700** | **17,100** | **17,000** | **45,900** | **43,900** |

4.8 The most significant changes in the outputs from this sensitivity test, relative to that reported in the OBC, are associated with LGVs. There is a net increase in LGV numbers in each time period of around 2,000 vehicles, and a drop in the number of compliant LGVs of around 5,000 vehicles per hour.

4.9 This reflects the changes in behavioural response assumed in this sensitivity test whereby:

- Likelihood of paying charge has increased from 10% in the OBC to over 50% in this test; and
- A reduction in the number cancelling or changing mode from 15% in the OBC to 4% in this test.

4.10 The response of LGVs to the CAZ remains an area of considerable uncertainty and the focus of additional research and analysis in the programme of work to complete the FBC.

## 5 Post Demand Sifting Tool Matrices Processing

5.1 The response matrices from the demand sifting tool were used to adjust the do-minimum demands from the Saturn model at a sector level to create do-something forecasts. The updated do-something matrices were then assigned to the highway networks to assess the demand changes on specific links in the modelled area and the impact on mass emissions using TfGM's EMIGMA software.

## 6 Highway Model

6.1 **Table 6-1** shows annual vehicle kilometre totals from the do-minimum and updated do-something Saturn model runs for roads inside Greater Manchester, for compliant and non-compliant vehicle types. (The terms 'compliant' and 'non-compliant' relate to the user classes represented in the Saturn model and the minimum emission standards for charging clean air zones. Cars are not, however, included in a Category C CAZ, and all cars would therefore comply with the OBC scheme).

6.2 Note that cars are unaffected by the proposals and are therefore excluded from the table below. Buses are assumed to upgrade to a compliant vehicle with no loss in mileage and are thus also excluded below. In total, the model assumes 13,000 million car kms and 118 million bus kms in 2023.

**Table 6-1 2023 Vehicle KM Totals for Compliant and Non-Compliant**

| Vehicle Type | Do Minimum | GM CAZ C test | % Change |
|---|---|---|---|
| Compliant Car | 11,525 | 11,529 | 0.0% |
| Non-Compliant Car | 1,971 | 1,971 | 0.0% |
| All Car | 13,496 | 13,500 | 0.0% |
| Compliant LGV | 1,911 | 2,274 | 19.0% |
| Non-Compliant LGV | 903 | 556 | -38.4% |
| All LGV | 2,814 | 2,830 | 0.5% |
| Compliant OGV | 848 | 987 | 16.4% |
| Non-Compliant OGV | 185 | 47 | -74.8% |
| All OGV | 1,032 | 1,034 | 0.1% |
| Compliant Taxi | 677 | 744 | 9.8% |
| Non-Compliant Taxi | 189 | 42 | -77.7% |
| All Taxi | 866 | 786 | -9.3% |
| Bus | 118 | 118 | 0.0% |
| **Total** | **18,327** | **18,267** | **-0.3%** |

6.3 The results in **Table 6-1** show that there has been a small reduction in total vehicle kilometres of approximately 0.3% relative to the do-minimum, mainly due to a reduction in Taxi travel. Vehicle kilometres for compliant LGVs, HGVs and Taxis have all increased relative to the do-minimum, with reductions in non-compliant travel for these vehicle types. Total vehicle kilometres for car and HGV trips have only changed marginally relative to the do-minimum. There is, however, a small increase in total LGV vehicle kilometres, possibly caused by re-assignment effects, or small rounding 'errors' when applying the demand changes from the Option Sifting tool to the do-minimum Saturn matrices.

## 7 Road Transport Emissions – EMIGMA

7.1 **Table 7-1** shows mass NOx emission totals for the sensitivity test EMIGMA run and percentage changes relative to the 2023 do-minimum. Totals are presented separately for the Regional Centre and the whole of Greater Manchester, as illustrated in **Figure 7-1**.

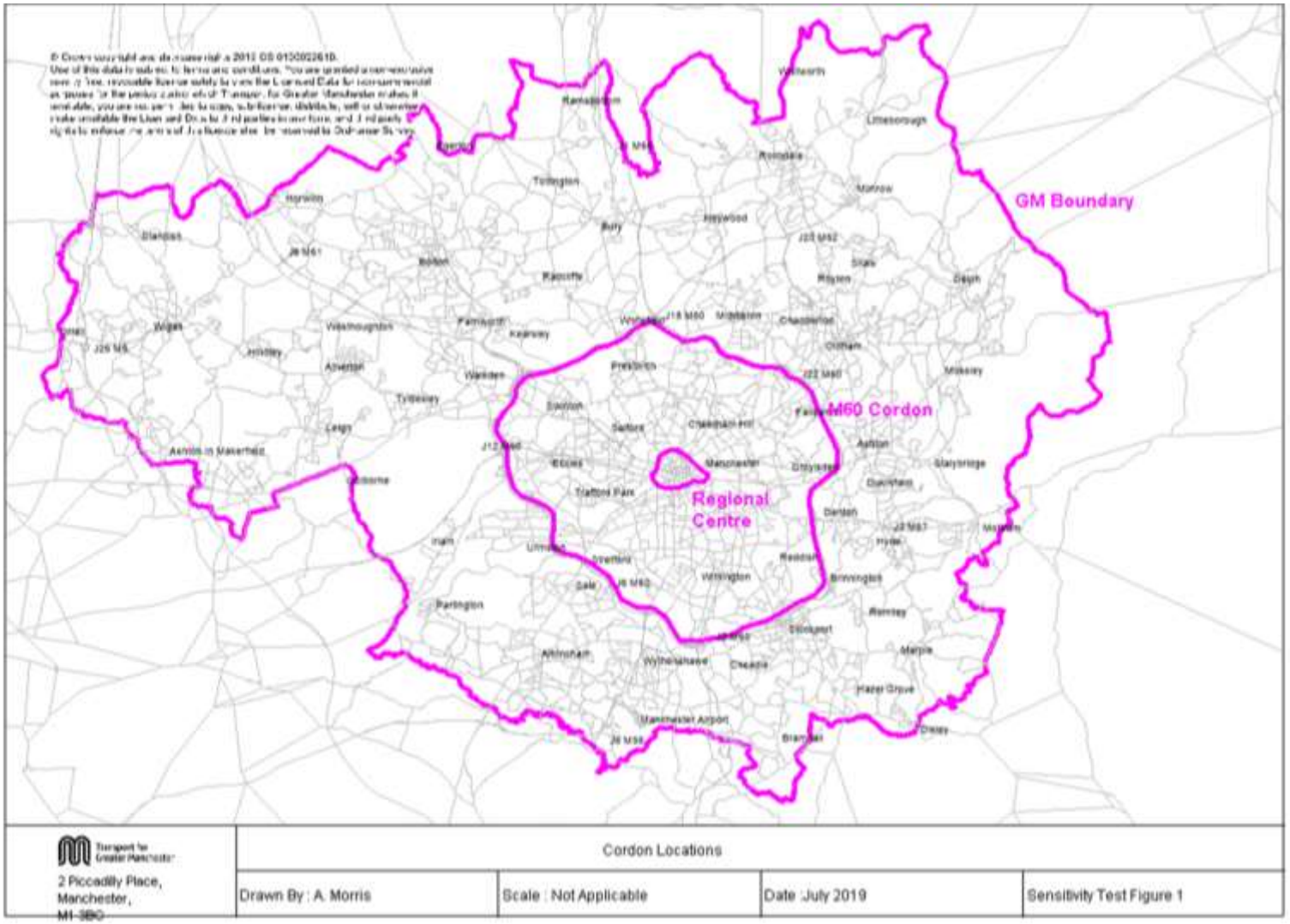
**Table 7-1 Forecast Mass NOx Road Traffic Emissions with Percentage**

| Vehicle Type | Do Minimum | GM CAZ C test | % Change |
|---|---|---|---|
| Regional Centre | 55 | 41 | -26% |
| GM | 6,385 | 5,432 | -15% |

*Values shown in tonnes*

7.2 The results for the test show a reduction in road traffic NOx emissions relative to the do-minimum forecast of approximately 15% for the whole of Greater Manchester. NOx emissions in the Regional Centre, which is more congested and has higher bus flows, are forecast to fall by approximately 26%.

**Figure 7-1 EMIGMA Reporting Areas**



# 8 Air Quality Summary and Impact on Compliance

8.1 The revised vehicle emissions for GM wide CAZ C in 2023 were then used in the dispersion modelling process to produce NO2 concentrations. The AQ modelling process is identical to that used in the OBC modelling, as set out in AQ2 and AQ3.

8.2 However, as a result of the analysis carried out for the Local Exceedances project, there have been amendments to two of the worst case exceedances. The maximum exceedance in Tameside has been reclassified as being associated with the Highways England, so is excluded. The road network representation at the maximum exceedance in Oldham, beside the A62, has been improved in the dispersion modelling, which has reduced the predicted NO2 concentrations. This refinement in Oldham has been included in the model run for the GM CAZ C sensitivity test, but the Do Minimum modelling has not yet been updated, so the results for this scenario remain as per the OBC.

8.3 This sensitivity test focusses on providing an understanding of the impacts of the revised behavioural responses to a charging CAZ. Other measures included in the preferred option from the OBC, such incentivisation funds for freight and investment in electric vehicles, are not included in this test. Therefore, direct comparison with any of the Options developed in the OBC is not relevant, as all of these included the full suite of non-charging measures.

8.4 A summary of the results of this GM CAZ C sensitivity test are presented in **Table 8-1**, alongside the Do Minimum results. The table provides the number of sites remaining in exceedance of legal limits by local authority.

**Table 8-1 Proportion of sites remaining in exceedance of legal limits for NO2 concentrations, by local authority**

| Local Authority | Do Minimum 2023 | Local Authority |
|---|---|---|
| Bolton | 4% | 0% |
| Bury | 18% | 25% |
| Manchester | 43% | 63% |
| Oldham | 4% | 0% |
| Rochdale | 3% | 0% |
| Salford | 15% | 13% |
| Stockport | 6% | 0% |
| Tameside | 6% | 0% |
| Trafford | 0% | 0% |
| Wigan | 0% | 0% |
| **GM Total** | **100%** | **100%** |

8.5 The results show that the updated GM CAZ C test substantially reduces the number of predicted exceedances in 2023 compared with the Do Minimum scenario. The updates to assumed behavioural responses have overall reduced the predicted rates of vehicles upgrading, when compared with the OBC, and therefore the effectiveness of a GM CAZ C would be expected to be decreased.

**Table 8-2 Number of modelled sites by scale of NO2 exceedance**

| **Test Scenario** | **Compliant sites** | | **Non-compliant sites** | | | |
|---|---|---|---|---|---|---|
| | Very compliant (below 35 µg/m$^3$) | Compliant but close (35 to 40 µg/m$^3$) | Non-compliant (40 to 45 µg/m$^3$) | Very non-compliant (45 to 50 µg/m$^3$) | Extremely non-compliant (> 50 µg/m$^3$) | **Total non-compliant (> 40 µg/m$^3$)** |
| Do minimum 2023 | 16,856 | 210 | 58 | 10 | 0 | **68** |
| GM CAZ C test 2023 | 17,020 | 97 | 17 | 0 | 0 | **17** |

8.6 Greater Manchester aims to deliver compliance in the shortest possible time in a way that takes into account the need to minimise human exposure. **Table 8-2** demonstrates the benefits being delivered in each year in terms of reduced concentrations even at sites remaining in exceedance in that year. This also shows that the number of sites close to exceedance reduces considerably in the updated GM CAZ C scenario.

8.7

8.9 Table 8-3 shows the concentrations at the maximum concentration point by local authority. This shows that, in 2023, the highest exceedances are in Manchester, but other exceedances are predicted to remain in Bury and Salford. The GM CAZ C has reduced concentrations significantly in all authorities across GM.

**Table 8-3 Maximum predicted NO2 concentration, by local authority (ug/m3)**

| Vehicle Type | Do Minimum 2023 | GM CAZ C test 2023 |
|---|---|---|
| Bolton | 40.5 | 38.2 |
| Bury | 49.0 | 43.1 |
| Manchester | 46.6 | 44.2 |
| Oldham | 46.4 | 37.1 |
| Rochdale | 44.0 | 39.8 |
| Salford | 46.9 | 42.9 |
| Stockport | 42.6 | 39.7 |
| Tameside | 42.7 | 39.5 |
| Trafford | 39.1 | 35.3 |
| Wigan | 38.4 | 33.5 |

8.10

8.11

8.12



8.13 Figure 8-1 and

8.14

8.15 **Figure** 8-2 provide maps of the exceedances across GM and focussed on the city centre. Overall, the exceedances in this test are located in sites where the OBC Option 7 contained persistent hot spots, and Local Measures are already being reviewed and developed where feasible in these locations.

8.16 There are three new sites (circled in red), which have been reviewed in further detail. One is considered to be associated with the M56 motorway, and therefore not a valid location. The other two (King St, central Manchester; and the access road at Manchester Airport) are where the transport model is poorly validated and not considered to be reliable. King St is located next to centroid connector link which feeds flows on the network for this demand zone.

**Figure 8-1 Map of exceedances identified in the with-GM CAZ C test**

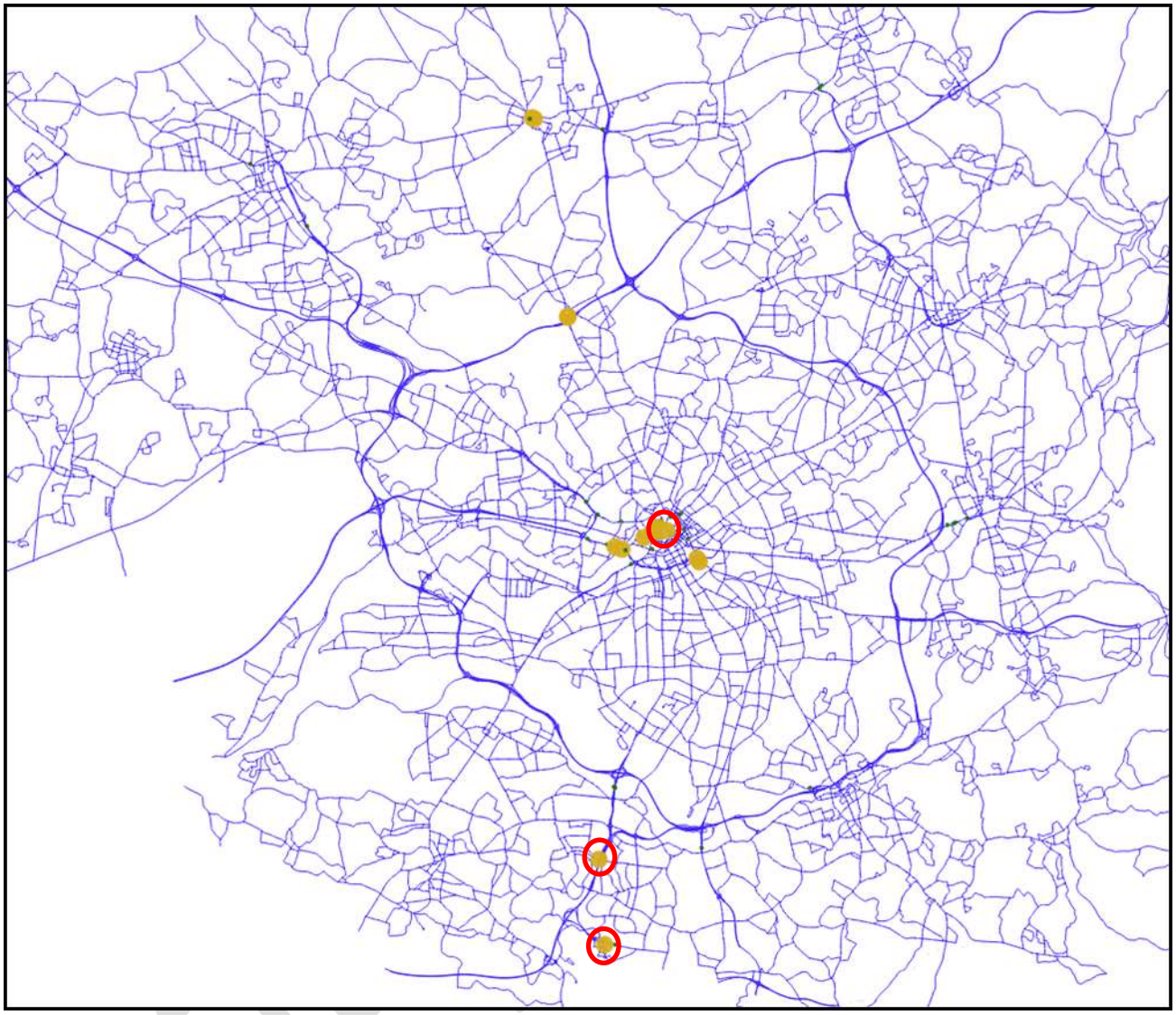
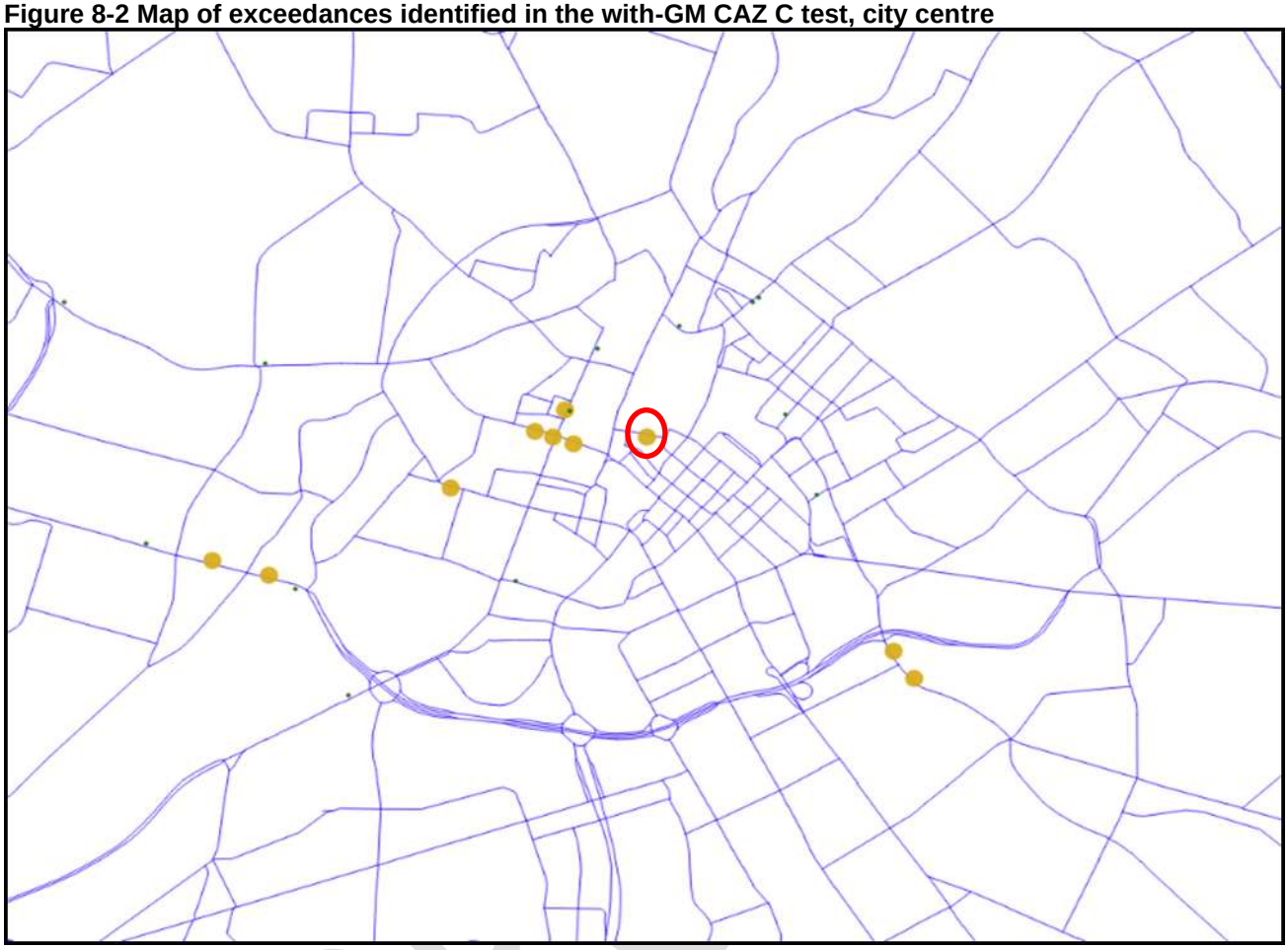


**Figure 8-2 Map of exceedances identified in the with-GM CAZ C test, city centre**



8.17 The air quality and source reduction apportionment data at key sites of exceedance for the GM wide CAZ C sensitivity test in 2023 are provided in **Table 8-4**, whilst the impacts on the traffic flows are provided in **Table 8-5**. The locations of these points are shown in **Figure 4**.

8.18 The analysis in the OBC showed that there are very diverse factors affecting vehicle emissions across Greater Manchester, with emissions from each vehicle type often differing between roads in close proximity to each other. This sensitivity test imposes a penalty charge on all vehicle types except private cars, and therefore reduces the emissions contribution from these vehicles compared to the Do Minimum scenario.

8.19 The results show that the modelled GM wide CAZ C leads to reductions in NO2 concentrations at typical worst case locations of between -2 to -6 ug/m3. The scale of the reduction is dependant on a variety of factors, including the baseline level of bus Euro Class compliance on a given link, the flows of each vehicle type, and the background pollutant concentrations. Therefore, there are very different causes to the reductions on each of the exceedance points presented, most notably from buses which is logical as this is dependant on the more variable frequency of services.

8.20 Across these points, the greatest reductions in NOx emissions are primarily from HGVs and buses, despite their relatively low flows, compared with LGVs and taxi/PHVs. This is in part because the NOx emissions reduction of Euro VI compared with non-compliant pre-Euro VI vehicles for heavy duty vehicles, is much greater than for lighter vehicles i.e. LGVs and cars.

8.21 The CAZ test has the effect of almost all heavy vehicles upgrading, either due to the bus assumption of full compliance, and because of the responsiveness to the modelled charge on HGVs which is shown in **Table 8-5**.

8.22 The alterations to the DST to enable representation of the revised behavioural responses for Hackney Cabs means there is a small loss of overall taxi flow, with the reduction of the of non-compliant flow being greater than the increase in the compliant flow. This will marginally over-estimate the reported emissions reductions from taxi/PHVs, although total taxi (Hackney Cabs /PHV) emissions only contribute to 7% of total vehicle NOx emissions in the Do Minimum scenario.

8.23 The behavioural responses for LGVs indicate that 44% of drivers pay the charge. Combined with the lower emission rate reduction per vehicle for an upgrade to compliant Euro 6 compared with buses or HGVs, the effectiveness of the penalty charges on LGVs emissions is lower.

8.24 The average contribution to the total NOx emissions reduction due to the CAZ test, is 55% from HGVs and 19% from bus (although with the greatest deviation). LGVs typically represent 8% of the vehicle flow, compared with 2% for HGVs, and have lower proportions of compliant fleet in 2023. Despite this, the average contribution to the total NOx emissions reduction by LGVs is only 21%.

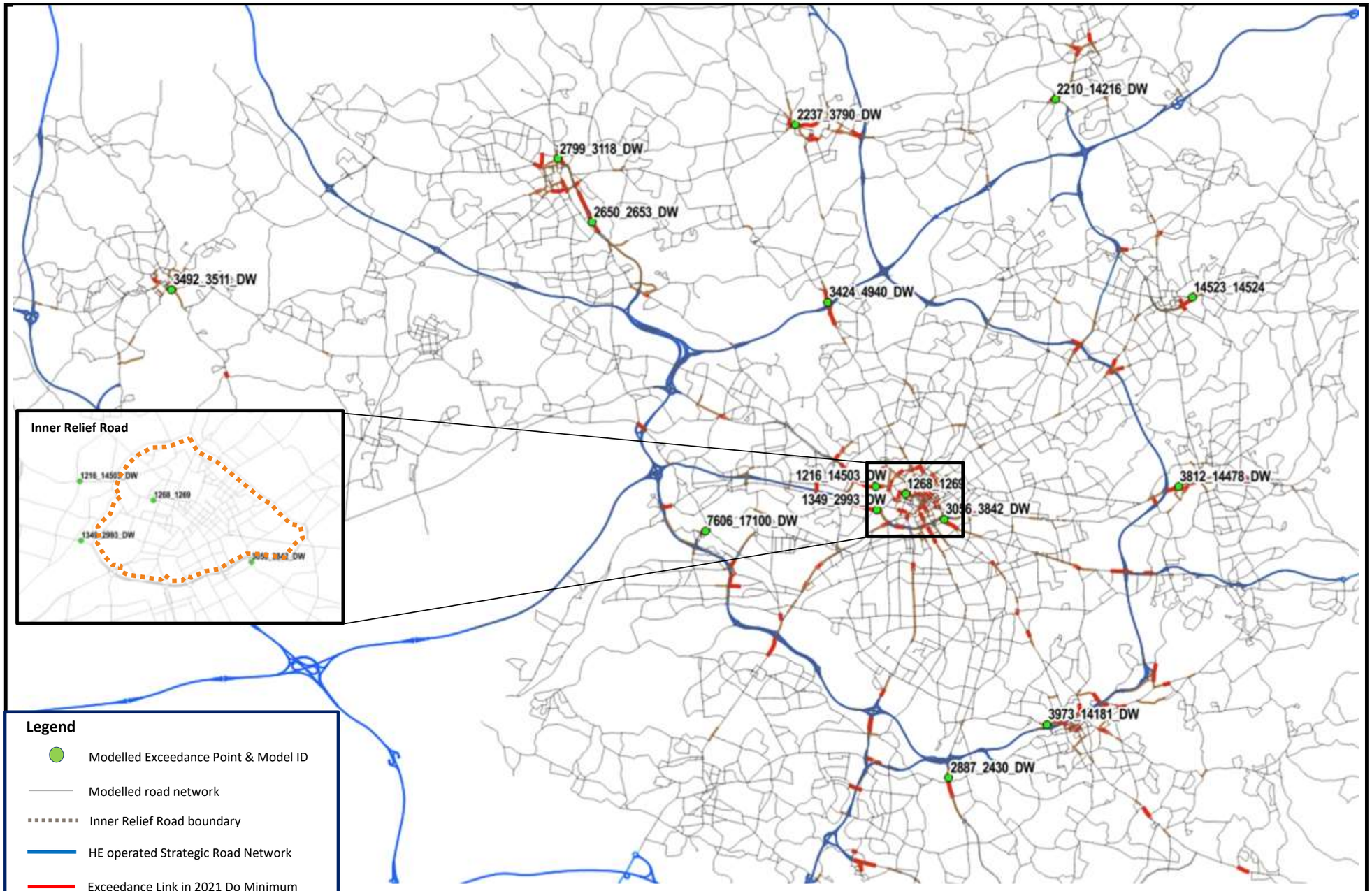
**Table 8-4 Maximum Predicted annual mean NO2 concentrations and source reduction apportionment at key compliance points on the Greater Manchester road network – GM wide CAZ C sensitivity test 2023**

| Point ID | Census ID | Road name | Local Authority | Annual mean $NO_2$ conc (µg/m$^3$) | BG NOx conc (µg/m$^3$) | BG $NO_2$ conc (µg/m$^3$) | Road NOx contribution (µg/m$^3$) | Road $NO_2$ contribution (µg/m$^3$) | AADT | NOx reduction contribution by vehicle type (%) | | | | | Change in Annual mean $NO_2$ conc (µg/m$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Bus | Taxi | HGV | LGV | Car | |
| 2799_3118_DW | 58048 | A673 | Bolton | 37.3 | 26.0 | 18.1 | 41.2 | 19.2 | 27,820 | 0% | 6% | 72% | 22% | 0% | -3.2 |
| 2650_2653_DW | 7431 | A666 | Bolton | 38.2 | 24.8 | 17.3 | 42.1 | 20.8 | 69,895 | 0% | 10% | 41% | 49% | 0% | -2.2 |
| 2237_3790_DW | 38354 | A58 | Bury | 43.1 | 21.4 | 15.2 | 62.4 | 27.9 | 79,499 | 59% | 4% | 25% | 13% | 0% | -5.9 |
| 3424_4940_DW | 17924 | A56 | Bury | 40.5 | 17.0 | 12.4 | 60.4 | 28.1 | 19,939 | 24% | 3% | 63% | 10% | 0% | -5.4 |
| 3056_3842_DW | 26157 | A6 | Manchester | 44.2 | 32.2 | 21.6 | 52.0 | 22.7 | 38,857 | 14% | 7% | 45% | 34% | 0% | -2.4 |
| 1268_1269 | 27974 | A34 | Manchester | 42.3 | 35.6 | 23.4 | 54.8 | 18.8 | 9,320 | 75% | 3% | 15% | 7% | 0% | -2.6 |
| 7556_14523_DW | 36632 | A62 | Oldham | 37.1 | 24.5 | 17.1 | 41.0 | 20.0 | 24,933 | 1% | 7% | 68% | 24% | 0% | -2.7 |
| 2210_14216_DW | 17322 | A664 | Rochdale | 39.8 | 17.9 | 13.0 | 61.2 | 26.8 | 34,464 | 0% | 4% | 77% | 19% | 0% | -4.2 |
| 1349_2993_DW | 73792 | A57 | Salford | 42.9 | 24.7 | 17.2 | 54.7 | 25.7 | 57,604 | 11% | 4% | 65% | 20% | 0% | -4.0 |
| 1216_14503_DW | 17926 | A6 | Salford | 39.8 | 25.2 | 17.6 | 53.0 | 22.3 | 31,601 | 32% | 4% | 48% | 16% | 0% | -3.4 |
| 3973_14181_DW | 58034 | A5145 | Stockport | 39.7 | 20.9 | 14.9 | 53.4 | 24.8 | 26,336 | 2% | 8% | 60% | 31% | 0% | -2.9 |
| 2887_2430_DW | 26352 | A34 | Stockport | 39.7 | 19.0 | 13.8 | 53.4 | 26.0 | 40,340 | 1% | 9% | 66% | 24% | 0% | -2.6 |
| 3812_14478_DW | 99618 | A635 | Tameside | 39.5 | 25.5 | 17.7 | 46.3 | 21.8 | 41,270 | 2% | 5% | 71% | 22% | 0% | -3.2 |
| 7606_17100_DW | N/A | B5214 | Trafford | 34.6 | 19.6 | 14.1 | 45.6 | 20.5 | 28,960 | 29% | 3% | 62% | 6% | 0% | -4.5 |
| 3492_3511_DW | 8566 | A577 | Wigan | 33.3 | 29.1 | 19.7 | 27.8 | 13.6 | 22,508 | 32% | 4% | 50% | 15% | 0% | -3.3 |
| **Average contribution to total NOx emission reduction** | | | | | | | | | | **19%** | **5%** | **55%** | **21%** | **0%** | |

**Table 8-5 Predicted impact on traffic flows at key compliance points on the Greater Manchester road network - GM wide CAZ C sensitivity test 2023**

| Point ID | Local Authority | Do Min ; Total AADT Flows (no. veh per day) | | | | | | | | | GM wide CAZ C sensitivity test : Change in AADT Flows (no. veh per day) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | All Vehicles | Taxi (comp) | Taxi (non-comp) | HGV (comp) | HGV (non-comp) | LGV (comp) | LGV (non-comp) | Car (comp) | Car (non-comp) | All Vehicles | Taxi (comp) | Taxi (non-comp) | HGV (comp) | HGV (non-comp) | LGV (comp) | LGV (non-comp) | Car (comp) | Car (non-comp) |
| 2799_3118_DW | Bolton | 27,875 | 1,187 | 331 | 763 | 166 | 3,169 | 1,497 | 17,597 | 3,008 | -55 | 108 | -258 | 168 | -166 | 655 | -637 | 65 | 11 |
| 2650_2653_DW | Bolton | 70,119 | 2,712 | 753 | 2,075 | 452 | 9,138 | 4,315 | 42,950 | 7,338 | -225 | 267 | -585 | 416 | -410 | 1,875 | -1,789 | 4 | 1 |
| 2237_3790_DW | Bury | 79,714 | 3,526 | 987 | 1,495 | 326 | 8,173 | 3,863 | 51,186 | 8,750 | -214 | 389 | -767 | 327 | -323 | 1,794 | -1,675 | 35 | 6 |
| 3424_4940_DW | Bury | 19,993 | 824 | 230 | 1,020 | 222 | 2,068 | 977 | 12,323 | 2,106 | -54 | 73 | -178 | 224 | -222 | 423 | -405 | 27 | 5 |
| 3056_3842_DW | Manchester | 38,937 | 1,666 | 465 | 553 | 120 | 4,532 | 2,141 | 24,145 | 4,127 | -80 | 245 | -362 | 105 | -103 | 937 | -908 | 5 | 1 |
| 1268_1269 | Manchester | 9,347 | 372 | 104 | 122 | 27 | 847 | 401 | 5,275 | 902 | -27 | 53 | -81 | 28 | -27 | 186 | -170 | -14 | -2 |
| 7556_14523_DW | Oldham | 53,611 | 2,208 | 617 | 1,320 | 288 | 6,647 | 3,142 | 33,376 | 5,705 | -34 | 131 | -227 | 131 | -129 | 595 | -546 | 8 | 1 |
| 2210_14216_DW | Rochdale | 34,521 | 1,387 | 386 | 1,930 | 420 | 4,384 | 2,071 | 20,292 | 3,467 | -56 | 159 | -301 | 435 | -418 | 919 | -878 | 24 | 4 |
| 1349_2993_DW | Salford | 57,674 | 2,306 | 642 | 2,203 | 480 | 7,178 | 3,390 | 35,108 | 5,999 | -70 | 329 | -499 | 469 | -462 | 1,448 | -1,401 | 39 | 7 |
| 1216_14503_DW | Salford | 31,661 | 1,378 | 386 | 889 | 194 | 3,181 | 1,504 | 19,246 | 3,290 | -60 | 191 | -300 | 216 | -194 | 679 | -660 | 6 | 1 |
| 3973_14181_DW | Stockport | 26,401 | 1,076 | 301 | 485 | 106 | 3,123 | 1,476 | 16,504 | 2,821 | -65 | 95 | -234 | 107 | -106 | 687 | -638 | 21 | 4 |
| 2887_2430_DW | Stockport | 40,455 | 1,534 | 427 | 927 | 202 | 4,107 | 1,941 | 26,544 | 4,537 | -115 | 158 | -332 | 194 | -192 | 746 | -725 | 31 | 6 |
| 3812_14478_DW | Tameside | 41,293 | 1,674 | 466 | 1,753 | 382 | 5,627 | 2,658 | 24,195 | 4,134 | -23 | 200 | -361 | 333 | -330 | 1,193 | -1,113 | 48 | 8 |
| 7606_17100_DW | Trafford | 29,051 | 1,209 | 338 | 1,788 | 390 | 2,293 | 1,084 | 17,905 | 3,061 | -90 | 114 | -262 | 397 | -390 | 519 | -463 | -3 | -1 |
| 3492_3511_DW | Wigan | 22,629 | 897 | 251 | 939 | 205 | 2,716 | 1,284 | 13,666 | 2,336 | -121 | 84 | -195 | 182 | -182 | 524 | -566 | 28 | 5 |

**Figure 8-3 Map of key exceedances points across Greater Manchester**




| Transport for Greater Manchester | Key Exceedance Points across GM | | | |
|---|---|---|---|---|
| | Drawn by: NB | Scale: NTS | Date: 17-7-19 | Figure 8-3 |

## 9 Summary and Conclusion

9.1 This note presents the results of sensitivity testing carried out to investigate the impact of revised behavioural responses on the performance of a CAZ C in 2023.

9.2 It has been possible to derive behavioural response assumptions for Hackney Cabs from surveys carried out in Sheffield, not available at OBC. This will allow GM to move away from the assumption that 100% of Hackney Cabs upgrade, applied at OBC in the absence of evidence supporting any alternative assumptions.

9.3 Revised behavioural response assumptions for PHVs have been derived from the same surveys. GM is also investigating the development of an Operational Cost Model for Hackney Cabs and PHVs to provide an alternative view of possible behavioural responses, and to facilitate the analysis of other measures such as upgrade funds.

9.4 GM has developed an Operational Cost Model for HGVs, based on market segmentation and industry data about costs. This provides a better evidenced response assumption for HGVs. Work is continuing to better represent the choice to switch vehicle types or consolidate activity as a response to a CAZ. GM is also carrying out on-street Specialised Goods Vehicle Surveys at key local exceedance locations with high freight traffic volumes to better understand the segmentation of freight by type and activity.

9.5 Finally, GM has tested two alternative methods for improving the representation of behavioural responses for LGVs. Survey data from Sheffield has been applied, alongside the development of an Operational Cost Model for LGVs. Both suggest a much lower upgrade response for LGVs than assumed in the OBC, but differ in other aspects. GM considers that an Operational Cost Model is a more appropriate approach given the scale of the GM CAZ scheme proposed, and the unique nature of the behavioural responses that this is likely to generate. To reduce uncertainty, GM is carrying out further surveys to better understand behavioural responses in the local context, and is further developing the modelling suite to better represent the choice to switch van-to-car and to consolidate activity as a possible response.

9.6 The sensitivity test described in this note applied revised behavioural responses for taxis, HGVs and LGVs to a CAZ C in 2023. The key findings of this test are detailed below:

- The removal of cancel trip/change destination responses for most vehicles (likely to be extended to all vehicle types) means there is minimal change in traffic volumes. This is considered a cautious approach as it does not seem appropriate to base delivery of clean air on a suppression of economic activity. The risk that the costs imposed by the CAP do suppress economic activity, and the mitigations that may be required to prevent this, will be tackled as part of the economic appraisal and impacts assessments.
- In total, the CAZ C in 2023 (without supporting measures) delivered a 15% reduction in mass NOx emissions GM-wide and a 26% reduction within the city centre, inside the Inner Ring Road (IRR).
- Seven districts are fully compliant in this test: Bolton, Oldham, Rochdale, Stockport, Tameside, Trafford and Wigan.
- The number of non-compliant sites falls from 67 in the Do Minimum to 16 in this with-CAZ C test, falling in three districts (Bury, Manchester and Salford):
  - Ten of these sites are those sites already identified as the last remaining exceedances under Option 7 (a GM-wide CAZ B with supporting measures) and are included in the current Local Exceedances project, which seeks to identify local interventions that could be effective in bringing forward compliance at the last points of exceedance.
  - 
  - Three of the additional sites are at the same location as one of these ten sites, with an additional exceedance location found at Regent Road in Salford, near the motorway in Bury, and on the A6 just outside the IRR in Manchester.
  - 
  - Three new locations have been predicted – on King Street in the city centre, on the approach to Manchester Airport, and on Hollyhedge Road crossing the M56. There are some concerns as to the validity of these exceedances and analysis indicates that these are likely to be overestimates and not representative of exceedance.
- Overall, maximum concentrations are lower in all districts than the Do Minimum.
- The CAZ test shows that the emissions reductions on a per vehicle basis, are more effective for heavy duty vehicles. This is due to the greater rate of upgrade, rather than paying, and because of the greater gain in emissions performance between non-compliant and compliant vehicles.

- Further work is required to refine the behavioural response assumptions to be applied to the testing of a GM CAZ. Nevertheless, the results of this test suggest that a CAZ C as defined here and implemented without supporting measures will not be sufficient to achieve compliance in the shortest possible time and that further interventions will be necessary to tackle exceedances in Bury, Manchester and Salford.