Greater Manchester's Outline Business Case to tackle Nitrogen Dioxide Exceedances at the Roadside

Local Plan Transport Model Forecasting Report (T4)

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Version Status:	DRAFT FOR APPROVAL	**Prepared by:**	Transport for Greater Manchester on behalf of the 10 Local Authorities of Greater Manchester
Authorised by: **Date:**	Simon Warburton 28th February 2019		

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1 Introduction

1.1 This report describes the transport modelling process for the Greater Manchester Clean Air Plan Project and presents a series of results. The report is part of a suite of documents that have been produced to describe the transport modelling deliverables for the study. Other documents in the series include:

- Local Plan Transport Modelling Tracking Table (T1), which is a live document, that is intended to demonstrate that the modelling requirements for the study are being met
- Local Plan Transport Model Validation Report (T2), which explains in detail how the road traffic model was validated against real-world data
- Local Plan Transport Modeling Methodology Report (T3), which describes the approach taken to forecast traffic
- Local Plan Transport Model Forecasting Report (T4), this document
- Local Plan Air Quality Modelling Methodology Report (AQ2), which provides an overview of the air quality modelling process
- Local Plan Air Quality Modelling Report (AQ3), which provides details of modelled NOx and NO2 concentrations for the base and forecast years, including comparisons with measured concentrations for the base year.

1.2 The purpose of this report is to present the baseline transport and emissions modelling results for the study and to describe the cumulative impacts of the Clean Air Plan proposals.

1.3 The report is divided into seven sections, as follows:

- Section 2 provides an overview of the CAP project and the scope of the study;
- Section 3 describes the modelling process;
- Section 4 describes the transport modelling methodology;
- Section 5 presents the baseline road traffic and emission forecasts;
- Section 6 presents the scenario forecasts;
- Section 7 provides a summary of the results and the key findings for the study (to follow); and
- Further details of the study are provided in the Appendices, which include information considered too detailed for inclusion in the main body of the text.

1.4 The report should be read in association with the documents described above and alongside the Analytical Assurance statement.

2 Background and scope of the study

Background

2.1 In July 2017 the Government published the UK plan for tackling roadside nitrogen dioxide (NO2) concentrations. This set out how the Government would bring UK concentrations of NO2 within the statutory annual limit of 40 micrograms per cubic metre (µg/m3) in the shortest possible time. The plan sets out a number of national and local measures that need to be taken.

2.2 Transport for Greater Manchester is considering options to reduce emissions from transport sources within the county, to help meet the target values for NO2 concentrations as soon as possible. A variety of measures are being considered in the study, including the introduction of Clean Air Zones, (CAZ), that could include charging as a measure to help achieve compliance. Table 1 shows the measures under consideration, as set out in the Strategic Outline Case.

Table 1: Categorisation of measures

Reference	Measure	Description
	CAZ	
1	Charge-based CAZ - Category B or C; different geographical boundaries / time restrictions	Category B includes non-compliant bus, coach, taxi/PHV and HGV. Category C includes the above plus non-compliant LGV
2	Charge-based CAZ - Category D; different geographical boundaries / time restrictions	Category D includes all of Category C plus non-compliant private cars
	Parking	
3	Differential parking charges	Related to usage/capacity (e.g. different charges for times of day to reduce congestion); vehicle type (e.g. free for electric or reduced for car sharers or for emission standard/engine size); residential parking zones and; workplace parking levy
	Public Transport	
4	Retrofitting or upgrade of public transport fleet and introduction of stringent emissions standard through contracts or partnership	Retrofitting of public transport fleet to cleaner alternatives. Set stretching targets to improve the efficiency of fleet and specify emission standards in bus contracts
5	Increase capacity of public transport on specific routes	

Reference	Measure	Description
	Infrastructure - Alternative Fuels	
6	Switch bus, HGV/LGV depot fuelling stations or GM fleet to GtL	Use of GtL fuel as a diesel alternative. (if Public Transport retrofit is standard measure then would not need GtL for commercial bus but could apply to community transport)
7	LGV – Electric Vehicle (EV) incentivisation	Additional EV charging points; promotion of EVs
8	Improve Local Authority fleet to electric/LPG/low emission through a procurement policy	
	Infrastructure - Traffic Control	
9	Congestion Plan traffic management – increased capacity	Providing more highway capacity – review of existing junction improvement plans. Assess existing schemes to understand potential benefit on specified links; with a view to bringing schemes forward sooner
10	Congestion Plan traffic management – encouraging alternatives	Encouraging alternative travel choices – road space reallocation in order to suppress latent car demand released through implementation of other measures
11	Congestion Plan traffic management – network management	Signal optimisation – changes to traffic signal timing to optimise flows in order to reduce congestion on specified links
	Taxis	
12	Incentives for private hire vehicles to change to EV vehicles. Installation of rapid EV infrastructure for taxi and private hire vehicles.	Incentivise private hire vehicles to changes to EV/ULEV vehicles through reduced licence fees/ free top up at taxi charge points
13	Retrofitting of Hackney Carriages to LPG/Euro 6. Increase LPG refuelling infrastructure	Retrofitting of Hackney Carriages to LPG/Euro 6
	Non-charge-based CAZ awareness activities	
14	Communications campaigns/awareness raising of health and cost benefits of different modes	Communications campaigns/awareness and signage
15	Travel choices programme (businesses & individuals)	Dependent on scale of programme

Reference	Measure	Description
16	Active travel programme – engagement	Encouraging a switch to active travel modes
	Cycling & Walking	
17	Active travel programme – infrastructure	Provision of measures to encourage modal shift to active travel to PT hubs and for short journeys

2.3 Government guidance sets out charging Clean Air Zones (CAZ) as the measure most likely to achieve EU Limit Value for NO2 in towns and cities in the shortest possible time. A charging CAZ places a penalty on the most polluting vehicles if they travel into, within or through a designated area. Government specifies four classes of CAZ that apply penalties to different types of vehicle that are classified as non-compliant because they fall below particular euro emission standards. Cleaner vehicles are unaffected.

- Category A: Buses, coaches, taxis and private hire vehicles (PHVs)
- Category B: Buses, coaches, HGVs, taxis and PHVs.
- Category C: Buses, coaches, HGVs, large vans, minibuses, small vans/ light commercials, taxis and PHVs
- Category D: Buses, coaches, HGVs, large vans, minibuses, small vans/ light commercials, taxis and PHVs, cars, motorcycles/mopeds

2.4 The associated emissions standards are as follows:

- Euro 3 for motorcycles, mopeds, motorised tricycles and quadricycles. Applied since 2007
- Euro 4 for petrol cars, vans, minibuses and other specialist vehicles. Applied since 2006
- Euro 6 for diesel cars, vans and minibuses and other specialist vehicles. Applied since 2015 (for cars) and 2016 (for vans)
- Euro VI for lorries, buses and coaches and other specialist heavy vehicles. Applied since 2013

2.5 A vehicle's Euro emission standard is shown in the vehicle registration document – also known as a V5C.

Scope of the Study

2.6 The CAP study is being undertaken using guidance produced by Defra and the DfT's Joint Air Quality Unit, (JAQU), to help local authorities develop strategies for improving air quality (References 1, and 2). The project is being led by Transport for Greater Manchester (TfGM), the transport delivery arm of the Greater Manchester Combined Authority (GMCA). TfGM is leading the project on behalf of the ten districts of Greater Manchester (Manchester, Salford, Wigan, Bury, Rochdale, Stockport, Oldham, Bolton, Tameside and Trafford) who are the local highway authorities and will represent their interests in delivering the project plan.

2.7 JAQU's initial modelling, Pollution Climate Mapping (PCM) suggested that 11 links in 7 of Greater Manchester's 10 districts would exceed target values of NO2 concentrations by 2020. Subsequent modelling carried out by TfGM has shown this to be a significant under estimation and 250 points are now forecast to be in exceedance across all 10 districts.

2.8 The scope and phasing of the study is set out in Table 2 below. Transport, traffic and air quality modelling has been used to inform each phase. For more information, see the Optioneering Process Report (Appendix X to the Strategic Case of the OBC).

Table 2: Timeline of option development process

Phase	Stage	Process Undertaken	When	Approval
Phase 1: **Strategic Outline Case**	Identification of a long list of nearly 100 measures in 12 categories. With shortlisting to 17 measures.	Brainstorming of all measures – shortlisting using professional judgment against the Critical Success Factors.	Winter / Spring 2018	LA governance and submitted to JAQU in Spring 2018.
Phase 2: **Target Determination**	Identification of the local air quality challenge.	Modelling & analysis to identify the scale of the challenge and points of exceedance of air quality levels in 2021, confirmation of locations of non-compliance to be addressed by the CAP.	Spring / Summer 2018	Submitted to JAQU and approved by them for publication as a GMCA paper in Autumn 2018. Final confirmation that Target Determination has been completed expected from JAQU by end February.

Phase	Stage	Process Undertaken	When	Approval
Phase 3: **High Level assessment**	a. Expansion of shortlisted measures to 95 implementation options.	Detail was added to the shortlisted measures, which were expanded to give multiple variants on how they could be delivered. Subsequently this provided a list of 95 implementation options.	Summer 2018	Steering Group and engagement with Executive Members and Leaders.
	b. Examination of the 95 implementation options and identification of measures	Stakeholder engagement - industry expert feedback -capacity assessments -traffic and air quality modelling – application of bespoke MCA toolkit.	Summer 2018	
	c. Aggregation of measures into 6 Clean Air Plan Options.	Aggregation based on differing measures of incentives, parking and scales/severity of CAZ.	Autumn 2018	
Phase 4a: **Appraisal of 6 options and further shortlisting for full economic analysis**	a. Selection of 3 Clean Air Plan Options to progress to full analysis.	Modelling and appraisal.	Late 2018	Discussed with Steering Group, Executive members and Leaders Concerns were raised and the need for further refinement identified.
Phase 4b: **Re-evaluation**	b. Addition of two further Options, as the risk of unintended socio-economic consequences was not fully understood and other options have not been explored in sufficient depth to be ruled out.	Further analysis on the CAZ D Clean Air Plan Options was undertaken to understand socio-economic implications and further traffic and air quality modelling carried out to consider alternatives.	Early 2019	To be approved via full LA governance and submitted to JAQU in March 2019.

3 The Modelling Process

3.1 At the highest level, the modelling process for producing the GM view on air quality consists of:

- Stage A – Transport Modelling to Estimate Traffic Flows
- Stage B – Converting Traffic Flows to Mass Emissions
- Stage C – Converting Mass Emissions to Air Quality Concentrations

3.2 For future years the forecasts include:

- National changes to the vehicle fleet mix and engine technology, which deliver improvements to air quality over time; and
- Future road and travel demand changes.

Data Sources

3.3 The following data is being used in the study alongside a series of assumptions and values drawn from JAQU, WebTAG and Green Book guidance:

- Traffic speed and flow data from TfGM's county-wide highway model;
- Information about the vehicle fleet composition in Greater Manchester from Automatic Number Plate Recognition surveys (ANPR) undertaken in 2016;
- Road traffic emission factors and national fleet composition data from version 8.0 of DEFRA's Emission Factor Toolkit (EFT); and
- Information about the bus fleet composition in Greater Manchester from TfGM's Punctuality and Reliability Monitoring Survey (PRMS) and the Greater Manchester Bus Route Mapping system for 2015.

Model Specifications

3.4 The modelling system that is being used in the study consists of four components:

- A Demand Sifting Tool, which has been developed to allow the behavioural change of measures to be estimated before passing data on for further assessment using the highway and air quality models
- The highway model, which is used to provide details of traffic flows and speeds for input to the emissions model and forecasts of travel times, distances and flows for input to the economic appraisal

- The emissions model, which uses TfGM's EMIGMA (Emissions Inventory for Greater Manchester) software to combine information about traffic flows and speeds form the highway model with road traffic emission factors and fleet composition data from the EFT to provide estimates of annual mass emissions for a range of pollutants including Oxides of Nitrogen (NOx), Particulate Matter (PM10 and PM2.5) and CO2.
- The dispersion model, which uses ADMS-Urban software to combine information about mass emissions of pollution (from EMIGMA) with emissions from non-traffic sources and other data such as wind speed and direction, topography and atmospheric chemical reactions to predict pollutant concentrations.

3.5 An appropriate variable demand model was not available and it would not have been possible to develop one in the time available.

3.6 The demand sifting tool is an elasticity model, rather than one that represents each different behavioural response separately. It is not a full variable demand model and does not represent, for example, the impact of suppressed trips being released.

3.7 We did consider modelling the impacts of the CAP schemes on suppressed traffic using the elastic assignment procedures available within the Saturn model. Tests suggested, however, that this would not be necessary as the schemes that were being considered would not have a significant impact on highway congestion. Tests showed, for example, that the implementation of a CAZ D for the Regional Centre with a CAZ B for GM as-a-whole would result in an approximate 2% reduction in total vehicle kilometres on roads within the County in 2021 and a 3% reduction in total PCU hours, which is was not thought would have a significant impact on suppressed traffic.

Model Availability

3.8 An appropriate variable demand model was not available. Therefore, a bespoke tool has been developed to assess the possible behavioural responses to a CAZ and/or the introduction of incentives to upgrade (referred to the as the Demand Sifting Tool).

3.9 A detailed description of the methodology applied is included as Appendix A.

3.10 The highway modelling is being undertaken using TfGM's county-wide Saturn model.

3.11 Several versions of the Saturn model were available for use in the project, which had been previously developed for the appraisal of different transport schemes for different future year forecasts and development assumptions. It was decided, however, to use the do-minimum model that had been developed for the appraisal of the planned extension of the Greater Manchester Metrolink system through Trafford Park. This model was considered to be the most appropriate given its base year of 2013, (which was close to the 2016 base year required for the CAP project), and its forecast year of 2020, which was close to the opening year for the CAP proposal.

3.12 For a detailed discussion of the traffic modelling validation and methodology, see associated reports T2 and T3.

Modelled Years

3.13 Separate versions of the Demand Sifting tool and Saturn model have been developed for three years comprising: 2021, which represents the assumed opening year of the CAP scheme, 2023 and 2025.

3.14 The 2023 and 2025 models were developed to assist in confirming the year of compliance and to help with modelling the phased introduction of a GM-wide CAZ C.

Time Periods

3.15 The Saturn model represents 3 time periods comprising:

- a weekday morning peak hour 0800-0900
- an evening peak hour 1700-1800
- an average inter-peak hour for the 1000-1530 time period

3.16 As the Demand Sifting Tool uses the outputs of the SATURN modelling this also uses the same 3 modelled periods.

User Classes

3.17 The assignment matrices that are used with the Demand Sifting tool and Saturn model represent 8 user classes:

- Compliant Car trips
- Non-Compliant Car trips
- Compliant LGV trips
- Non-Compliant LGV trips
- Compliant OGV trips
- Non-Compliant OGV trips
- Compliant (all purpose) Taxi trips

- Non-Compliant (all purpose) Taxi trips

3.18 Buses are not included in the assignment matrices in the Saturn model, but are represented in the model as fixed link loads, with routes defined as chains of nodes in the buffer and simulation networks. Modelled bus services are based on 2015 service patterns and flows.

Model Coverage

3.19 Geographically, the model is focused on Greater Manchester, although it does extend to cover all of Great Britain, albeit in increasingly less detail with increasing distance from the county boundary, as illustrated Figure 1.

3.20 A model of this size was required as options were considered that covered different areas and town centres across the whole of GM. Options were considered, for example, in Wigan and Oldham, which are 30 miles apart.

3.21 Further details of the Saturn model are available in the T2 and T3 reports (References 3 and 4).

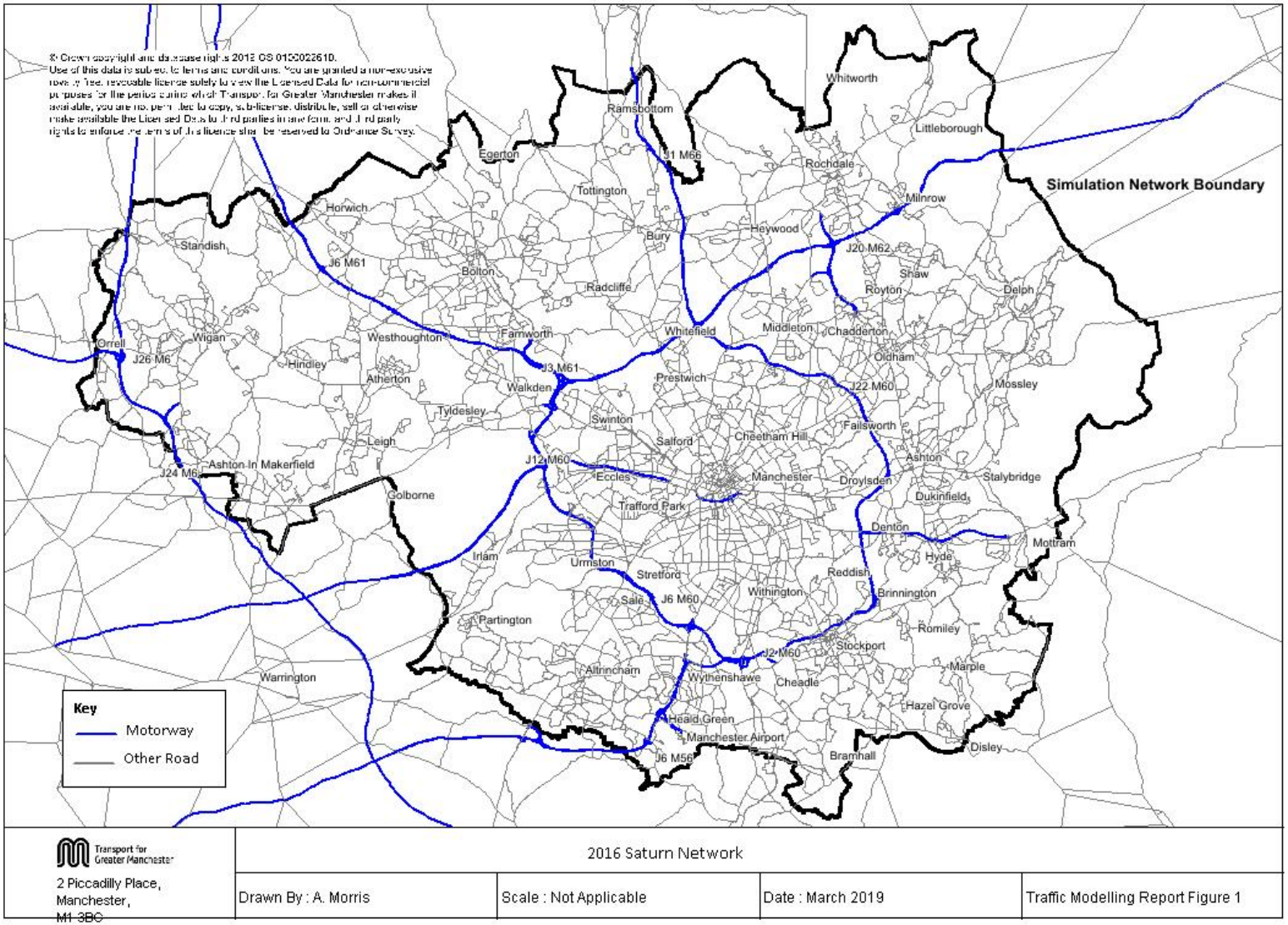
Boundaries Considered

3.22 A number of different CAZ boundaries have been considered throughout the development of the GM CAP given the geographic spread of exceedances across GM. Sites have been selected based on town centres and physical boundaries (Motorways, ring roads, train lines, etc.) with the aim of affecting traffic on key corridors contributing to exceedances. In summary the boundaries considered were:

- County Wide – Covering the whole of Greater Manchester
- The M60 – A physical boundary containing many exceedances
- Manchester “Intermediate Ring road” – Not a true ring road but a series of links that allow for diversion around Manchester City Centre
- Manchester Inner Relief Road – A signed route that diverts traffic around Manchester City Centre and parts of Salford. These areas are known to have significant AQ issues.
- Town Centres outside of the M60 – Boundaries defined by available physical boundaries (ring roads, rail lines, rivers etc.) around 10 towns in Greater Manchester where it estimated that a charging CAZ could impact exceedance points.

3.23 In the modelling process there are differences between how zones are modelled in the Demand Sifting Tool and the SATURN model given the zone structure of the GM SATURN model, as zones have been based on LSOA and District boundaries they do not always match with the road network. However, any Clean Air Zones would be expected to make use of physical boundaries to aid enforcement. A plot of the boundaries considered in the development of the GM CAP are in Appendix B.

Figure 1: 2016 Saturn Network



4 Transport Modelling Methodology

Modelling of the Do-Minimum

4.1 The do-minimum model represents what is likely to happen in the absence of the CAP proposals. The modelling process comprises 4 stages, as shown in Table 3.

Table 3: Modelling Process

Stage	Description	What is involved
A	Transport modelling to estimate traffic flows	Demand modelling and traffic assignment via the GM countywide SATURN model to estimate traffic flows
		Validation following DfT WebTAG guidance to compare modelled and observed traffic flows and speeds
		The process includes committed road changes appropriate to the year being modelled.
B	Converting Traffic Flows to Mass Emissions	Traffic flows and speeds, split by vehicle and engine type, are input to TfGM's EMIGMA software to convert traffic demands to vehicle emissions
		The process includes all traffic, comprising cars, Light Goods Vehicles, Heavy Goods Vehicles, Buses and taxis
		The emissions are validated by comparing local outputs to JAQU PCM model outputs
		Note that the most recent emission rates for converting traffic flows to vehicle emissions (as calculated from the EFT) have increased compared to outputs from earlier versions of the software, so that emissions for this study are greater than estimates from EMIGMA in previous GM air quality exercises
C	Converting Mass Emissions to Air Quality Concentrations	Using the ADMS Urban dispersion modelling software to convert traffic emissions to air quality concentrations
		The process includes urban topology and other data such as wind speed and direction
		The process includes emissions from non-traffic sources from Defra data and outputs modelled concentrations at 'receptor points' corresponding to sites close to the road network
D	Validation/Verification for the Base Year	Comparison of the NO2 outputs from steps A to C above against GM monitoring data
		The calculation of adjustment factors to improve the fit between modelled and observed concentrations at the GM level

4.2 In modelling of the future year Do Minimum scenarios, the process runs through stages A, B and C and includes forecast national changes to vehicle fleet and engine technology, so that air quality improves over time. Forecasts include future road network and travel demand changes, where these are known. Further Details on methodology for the Do Minimum scenario is provided in T3.

5 Modelling of the Do Something

5.1 Similar to how the Do Minimum is modelled the Do Something modelling progresses through a number of stages as shown in Table 4 and outlined in the sections below.

Table 4: Modelling Process

Stage	Description	What is involved
A	Behavioural Modelling of Measures	Estimated responses to behavioural modelling are applied to the Do Minimum traffic due to measures being introduced to represent vehicles upgrading, trips being cancelled etc.
		This leads to new Do Something matrices being produced for use in Stage B
B	Highway Assignment Modelling	Changes to the SATURN network are made to represent any changes as appropriate (for example introducing cordon charges to represent distinct CAZ boundaries)
		New Do Something Matrices are assigned to the Do-Something network to investigate the impact of changing traffic volumes and re-routing due to any cordon charges.
		Produces outputs for use in Stage C
C	Converting Traffic Flows to Mass Emissions	Traffic flows and speeds, split by vehicle and engine type, are input to TfGM's EMIGMA software to convert traffic demands to vehicle emissions
		The process includes all traffic, comprising cars, Light Goods Vehicles, Heavy Goods Vehicles, Buses and taxis
D	Converting Mass Emissions to Air Quality Concentrations	Using the ADMS Urban dispersion modelling software to convert traffic emissions to air quality concentrations
		The process includes emissions from non-traffic sources from Defra data and outputs modelled concentrations at 'receptor points' corresponding to sites close to the road network

5.2 This process is carried out for each modelled year.

5.3 In early tests used to sift potential options not all measures were progressed through all four stages with some options only progressing through Stage A or Stages A to C.

Behavioural Response to Measures

5.4 The Behavioural Response to most measures has been modelled using a spreadsheet based “Demand Sifting Tool” developed as part of option sifting and assessment. The tool makes use of available stated preference data weighted towards the characteristics of Greater Manchester to estimate potential responses to the introduction of a charging Clean Air Zone such as:

- Paying the charge and continuing to travel into the zone;
- Cancelling the journey;
- Upgrading the vehicle (replacing the trip with a journey in a compliant vehicle); or
- Opting to use Public Transport.

5.5 In addition, the tool also models the behavioural response of:

- The impact of upgrading the local authority fleet;
- The impact of improving public transport (in conjunction with the Greater Manchester Public Transport model); and
- The impact of early incentivisation schemes.

5.6 A more detailed methodology is provided in Appendix A. A brief description of the process for feeding the outputs from the demand sifting tool into the Saturn modelling is provided below.

Modelling of Measures in SATURN

5.7 The CAZ options that have been taken forward for full appraisal comprise elements of charging in association with non-charging measures to promote the increased take up of electric vehicles and the retrofitting of buses to increase the number of compliant vehicles in the County.

5.8 The three options that were taken forward for full appraisal are summarised as follows:

- **Option 5(i):** a Clean Air Zone (CAZ) Category D within the Inner Relief Route (IRR) to be delivered in Phase 1 alongside a CAZ Category B across Greater Manchester. In Phase 2, the CAZ across Greater Manchester extends to a Category C. The CAZ proposals are included alongside required measures to communicate the message, promote cleaner vehicles and help people, businesses and buses upgrade.
- **Option 5(ii):** An enhanced CAZ Category D+ within the IRR such that all diesel cars and private hire vehicles would be subject to a penalty as well as non-compliant petrol vehicles and larger diesel vehicles older than Euro 6, reflecting that even compliant diesel cars have higher emissions affecting air quality than their petrol equivalents. To be delivered in Phase 1 alongside a CAZ Category B across Greater Manchester. In Phase 2, the CAZ across Greater Manchester extends to a Category C. The CAZ proposals are included alongside required measures to communicate the message, promote cleaner vehicles and help people, businesses and buses upgrade.
- **Option 8:** A CAZ Category B across Greater Manchester implemented as Phase 1. In Phase 2, the CAZ across Greater Manchester extends to a Category C. The CAZ proposals are included alongside required Measures to communicate the message, promote cleaner vehicles and help businesses and buses upgrade.

5.9 The nature of the proposals means that some but not all vehicles will face a daily charge for travelling in parts of Greater Manchester. Re-routing responses to the CAZ charges are represented in the Saturn model by coding monetary charges (tolls) for non-compliant vehicles into the highway networks, which may differ by vehicle type (e.g. cars, LGVs, OGVs and Taxis). The tolls are defined as charges per cordon crossing link and have been divided equally between inbound and outbound sites on the proposed charging cordons. Note, however, that charges are not coded into the Saturn model for GM-wide Clean Air Zones, as it assumed that there will be no re-routing responses for these measures as motorists cannot change their routes to avoid paying the charge, so that drivers of non-compliant vehicles will either choose to pay the toll or make a different behavioural response, as described below.

5.10 The Demand Sifting Tool has been developed to assist in modelling the behavioural responses to the CAP measures based on guidance provided by JAQU concerning the proportions of drivers of affected vehicles who would pay the charge, cancel their journey or upgrade to a compliant vehicle etc. These responses are implemented in the study by using the output demand change matrices from the sifting tool to adjust the do-minimum demands in the Saturn model at a sector level to create do-something forecasts. The updated do-something matrices are then assigned to the highway networks to assess the demand changes on specific links in the Saturn model and the impact on emissions using EMIGMA.

5.11 The CAZ charges for the Inner Relief Route zone (for Option 5) that were coded into the Saturn model are shown below in Table 5, based on assumed charges of £7.50 for non-compliant cars and Light Goods Vehicles entering the zone. It was also assumed that non-compliant buses and heavy goods vehicles would have to pay a charge of £100 per day, with taxis and private hire vehicles paying £7.50 per day, although these charges were not included in the Saturn model because the proposed scheme for these vehicles is region-wide.

5.12 The assumed location of the Regional Centre charging cordon is shown below, in Figure 2.

Table 5: Option 5 IRR Cordon Crossing Charges (Non-Compliant Vehicles, £'s, 2010 Prices)

	2021					2023 + 2025				
Vehicle type	Car	LGV	OGV	Bus	Taxi	Car	LGV	OGV	Bus	Taxi
Charge	£7.50	£7.50	NA	NA	NA	£7.50	NA	NA	NA	NA

Note:

1. Charges are divided equally between inbound and outbound cordon crossing links.

2. No cordon charge is applied to LGVs in 2023 or 2025 as at this stage the charge for LGVs is introduced GM wide meaning re-routing impacts in the city centre are not expected.

Modelling the Take Up of Electric Vehicles and the Retrofitting of the Bus Fleet

5.13 The air quality impacts of measures to promote the increased take up of electric vehicles (by drivers whose vehicles are non-compliant) have been modelled post assignment by adjusting the non-compliant vehicle flows that are output from the Saturn model and that are input to EMIGMA assuming that electric vehicles generate zero emissions at the exhaust. The impacts of these measures have been included in the appraisal of the CAP options by assuming that measures to promote electric vehicles could deliver an additional 68,000 electric cars and 7,000 electric LGVs within the county, with a combined annual vehicle mileage of approximately 700 million miles per year.

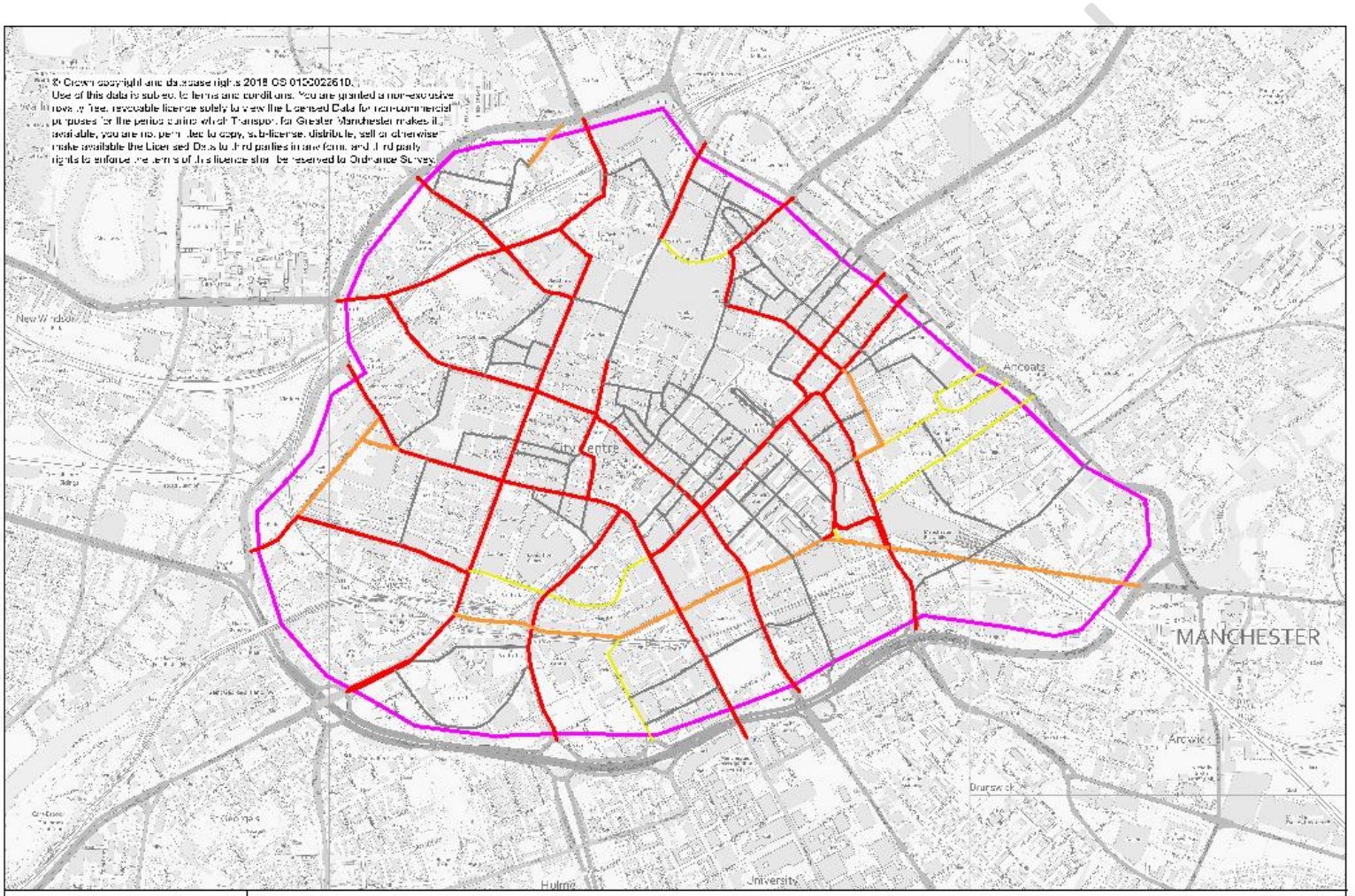
5.14 The impacts of the retrofitting of the bus fleet were modelled by adjusting the bus fleet mix that was input to EMIGMA assuming that all bus services in the do-something models would be compliant with Euro 6 emission standards. It was assumed that bus service levels would remain unchanged as part of this process.

5.15 The impacts of the modelled take-up of electric vehicles and the retrofitting of the bus fleet have been included in the appraisal of each of the Options described above, as they are assumed to be essential components of the overall CAP package.

Air Quality Modelling for Option 5(ii)

5.16 The air quality impacts for Option 5(ii) were modelled using an approximate procedure agreed with JAQU, which assumed that all compliant cars using roads inside the IRR would be petrol powered. This was implemented within EMIGMA by setting the proportion of diesel cars in the compliant car flow to zero for zones inside the Regional Centre cordon, using the Option 5(i) Saturn flows as inputs. The fleet composition data for zones outside the Regional Centre cordon was not changed in this process, so that emissions in the external area were the same as those for Option 5(i).

Figure 2: Inner Relief Road CAZ D Cordon Location



Transport for Greater Manchester 2 Piccadilly Place, Manchester, M1 3BG	GM CAP Study Option 5 Regional Centre Cordon			
	Drawn By : A. Morris	Scale : Not Applicable	Date : August 2018	Traffic Forecasting Report Figure 4.1

Air Quality Modelling

5.17 The air quality modelling was undertaken using TfGM's EMIGMA software, which provides estimates of mass emissions for vehicles traveling on roads represented in the Saturn model.

5.18 Inputs to the modelling procedures comprise:

- Traffic speed and flow data from the Saturn model.
- Fleet weighted road traffic emission factors, by vehicle type, for vehicles travelling at different speeds.
- Information about the proportions of petrol and diesel powered vehicle (by road type) in the vehicle fleet, which are used to disaggregate the assigned flows from the traffic model by method of propulsion.
- Road traffic annualisation factors to convert hourly emissions for the time periods represented in the Saturn model to annual totals.

5.19 The road traffic emission factors for input to the process have been derived using information from version 8.0 of DEFRA's Emission Factor Toolkit (EFT) for NOx, PM10 and PM2.5 emissions. (The fraction of NOx emitted by vehicles as NO2 is also estimated using information from the EFT, separately by vehicle type).

5.20 Information about the fleet composition in the base year for use in the study has been derived from national data for motorways and from ANPR surveys on the local road network in Greater Manchester for other roads, which have been used to derive estimates of the age profile of the vehicle fleet on the local road network. Information about the age profile of the bus fleet has been obtained (by service) using data collected during TfGM's (bus service) Punctuality and Reliability Monitoring Survey (PRMS), for 2015.

5.21 The projected fleet mix for buses and other road traffic in the forecast year is estimated using the methodology provided by JAQU via huddle, based on an assumption that the age profile of the vehicle fleet remains unchanged over time.

5.22 The main outputs from the EMIGMA modelling comprise estimates of mass road traffic emissions (broken down by vehicle type in tonnes per year) for the links the Saturn model. Emissions from these sources can be reported separately, or grouped to provide summary totals for all sources combined. The outputs from the procedures also provide inputs to TfGM's atmospheric dispersion model, ADMS Urban, which provides estimates of pollution concentrations (measured in µg/m3) at selected sites, to allow concentrations to be compared with national and local targets for improving air quality.

6 Baseline Traffic Forecasts

6.1 This section presents results from the do-minimum road traffic modelling, which represents what is forecast to happen in the absence of the CAP scheme proposals. Information is provided describing:

- The modelled fleet mix
- The do-minimum demand matrices
- Vehicle km totals from the do-minimum assignments
- Modelled road traffic emissions

Fleet Mix Proportions

6.2 Information about the vehicle fleet composition in Greater Manchester has been derived from Automatic Number Plate Recognition surveys (ANPR) undertaken in 2016. The analysis used Greater Manchester Police vehicle class information to identify vehicle and fuel type, plus cross referencing with local authority licensing data for taxis (hackney carriage and private hire).

6.3 The fleet mix projection was estimated by identifying the date of registration from the licence plate number. These were then matched against the date of enforcement of the relevant Euro standard, to develop the Euro standard for that vehicle type.

6.4 The projection approach keeps the vehicle age profile constant for any the given future year (e.g. 2021), and then re-calculates the Euro standard at this point in time. The approach conserves the age distribution of the vehicle population for each vehicle class/fuel type, to produce the fleet mix for the future year based on this constant distribution.

6.5 In addition, the JAQU guidance on change in petrol to diesel splits for cars into future years was applied. This involved using JAQU assumptions on proportions of vehicles that would switch to diesel, and using ANPR trip frequency information to convert a journey based change (vehicle kilometre equivalent).

6.6 Details of the local fleet composition data used in the process are given below in Table 6 and Table 7. An alternative summary showing the proportions of compliant vehicles by year is shown in Figure 3.

Table 6: Fleet Composition by Vehicle Type, Euro Standard and Year, Do Minimum

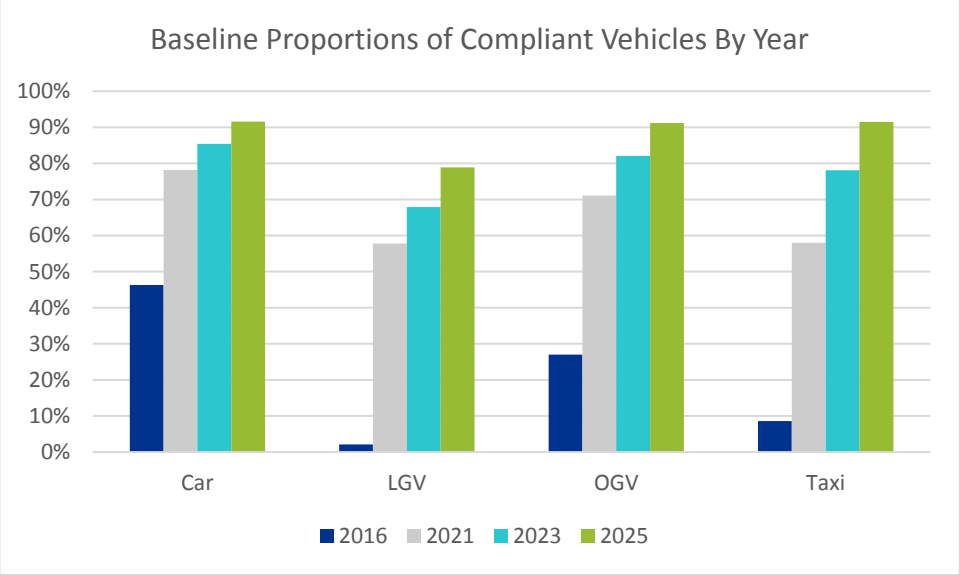
Euro Standard	Petrol Car	Diesel Car	Petrol Taxi	Diesel Taxi	Petrol LGV	Diesel LGV	Diesel HGV	Diesel Bus
2016								
Pre-Euro	0.3%	0.2%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%
Euro 1	0.5%	0.4%	0.3%	0.1%	0.0%	0.2%	0.4%	0.4%
Euro 2	2.6%	1.2%	0.8%	0.3%	0.0%	0.2%	1.8%	2.9%
Euro 3	22.5%	9.7%	7.4%	4.1%	0.0%	15.3%	10.9%	8.9%
Euro 4	33.7%	27.1%	37.1%	38.0%	0.0%	26.4%	15.8%	28.0%
Euro 5	31.9%	47.8%	54.3%	52.5%	0.0%	55.6%	44.1%	44.9%
Euro 6	8.5%	13.5%	0.0%	5.1%	0.0%	2.1%	27.0%	15.0%
Euro 6c	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro 6d	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All	100%	100%	100%	100%	100%	100%	100%	100%
2021								
Pre-Euro	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro 1	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Euro 2	0.4%	0.4%	0.3%	0.0%	0.0%	0.2%	0.3%	0.3%
Euro 3	2.8%	1.4%	0.8%	0.3%	0.0%	0.3%	1.9%	2.9%
Euro 4	22.5%	9.7%	7.4%	4.1%	0.0%	15.3%	3.7%	2.9%
Euro 5	33.7%	27.1%	37.1%	38.0%	0.0%	26.4%	22.9%	34.0%
Euro 6	11.3%	14.4%	30.5%	25.7%	0.0%	16.2%	71.1%	59.9%
Euro 6c	29.1%	33.4%	23.9%	26.8%	0.0%	39.5%	0.0%	0.0%
Euro 6d	0.0%	13.5%	0.0%	5.1%	0.0%	2.1%	0.0%	0.0%
All	100%	100%	100%	100%	100%	100%	100%	100%
2023								
Pre-Euro	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro 1	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro 2	0.2%	0.2%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%

Euro Standard	Petrol Car	Diesel Car	Petrol Taxi	Diesel Taxi	Petrol LGV	Diesel LGV	Diesel HGV	Diesel Bus
Euro 3	0.9%	0.7%	0.3%	0.2%	0.0%	0.3%	0.9%	0.6%
Euro 4	12.4%	4.4%	4.1%	1.3%	0.0%	6.8%	1.9%	3.8%
Euro 5	33.5%	21.8%	22.2%	20.8%	0.0%	24.9%	14.8%	11.6%
Euro 6	12.5%	11.6%	19.1%	20.2%	0.0%	10.1%	82.1%	83.9%
Euro 6c	40.4%	23.2%	54.3%	36.0%	0.0%	27.3%	0.0%	0.0%
Euro 6d	0.0%	38.2%	0.0%	21.6%	0.0%	30.4%	0.0%	0.0%
All	100%	100%	100%	100%	100%	100%	100%	100%
2025								
Pre-Euro	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro 1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro 2	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Euro 3	0.7%	0.6%	0.3%	0.1%	0.0%	0.3%	0.4%	0.4%
Euro 4	4.4%	1.8%	2.6%	0.4%	0.0%	1.5%	1.2%	1.1%
Euro 5	27.4%	13.6%	8.4%	8.3%	0.0%	19.3%	7.1%	5.5%
Euro 6	14.5%	11.1%	15.2%	13.4%	0.0%	11.0%	91.2%	93.0%
Euro 6c	52.9%	18.3%	73.4%	33.1%	0.0%	17.8%	0.0%	0.0%
Euro 6d	0.0%	54.6%	0.0%	44.6%	0.0%	50.1%	0.0%	0.0%
All	100%	100%	100%	100%	100%	100%	100%	100%

Table 7: Percentage Petrol/Diesel Car Splits By Year, Do Minimum

Year	Cars Including Taxis		Cars Excluding Taxis	
	Petrol	Diesel	Petrol	Diesel
2016	50.7%	49.3%	54.1%	45.9%
2021	47.8%	52.2%	51.2%	48.8%
2023	48.6%	51.4%	52.0%	48.0%
2025	50.2%	49.8%	53.6%	46.4%

Figure 3: Compliant Vehicle Proportions By Year, Do Minimum



Demand Forecasts

6.7 Table 8 shows trip totals from the 2016 base and forecast year demand matrices broken down by user class for trips with an origin or destination inside Greater Manchester. The table shows that 46% of car trips in 2016 are made in compliant vehicles, with only 2% of LGV trips being compliant, reflecting the increased use of diesel fuel for these vehicle types. The equivalent figures for OGV and taxi trips in the base year are 27% and 9% respectively, with approximately 39% of vehicles overall being compliant.

6.8 The equivalent figures for the 2021 do-minimum model show that 78% of car trips are made by compliant vehicles in this year, as older more polluting vehicles are replaced by newer/cleaner models as the age profile of the vehicle fleet evolves over time. Approximately 74% of vehicles in total are forecast to be compliant in the 2021 do-minimum modelling.

6.9 Approximately 80% of vehicles are forecast to be compliant in 2023, with 90% of vehicles achieving compliance by 2025. The numbers of trips (with an internal origin or destination) in the assignment matrices are forecast to grow by between 8 and 9 percent between 2016 and 2021 and by between 12 and 13 percent between 2016 and 2025. The development of the demand matrices is described in **References 3 and 4**.

Table 8: Highway Assignment Matrix Totals (PCUs, Trips With an Origin or Destination Inside Greater Manchester), 2016 Do Minimum

Vehicle type	AM Peak		Inter-Peak		PM Peak	
	Trips	%	Trips	%	Trips	%
Compliant Car	147,060	46.3%	120,288	46.3%	150,683	46.3%
Non-Compliant Car	170,564	53.7%	139,513	53.7%	174,766	53.7%
All Car	**317,624**	**100%**	**259,801**	**100%**	**325,449**	**100%**
Compliant LGV	887	2.1%	858	2.1%	745	2.1%
Non-Compliant LGV	41,358	97.9%	39,986	97.9%	34,723	97.9%
All LGV	**42,246**	**100%**	**40,844**	**100%**	**35,468**	**100%**
Compliant OGV	5,189	27.0%	5,630	27.0%	2,537	27.0%
Non-Compliant OGV	14,030	73.0%	15,221	73.0%	6,859	73.0%
All OGV	**19,218**	**100%**	**20,850**	**100%**	**9,396**	**100%**
Compliant Taxi	1,993	8.6%	1,630	8.6%	2,042	8.6%
Non-Compliant Taxi	21,181	91.4%	17,325	91.4%	21,703	91.4%
All Taxi	**23,174**	**100%**	**18,955**	**100%**	**23,745**	**100%**
All Compliant	155,129	38.6%	128,405	37.7%	156,007	39.6%
All Non-Compliant	247,133	61.4%	212,045	62.3%	238,051	60.4%
All Vehicle	**402,262**	**100%**	**340,450**	**100%**	**394,058**	**100%**

Table 9: Highway Assignment Matrix Totals (PCUs, Trips With an Origin or Destination Inside Greater Manchester), 2021 Do Minimum

Vehicle type	AM Peak		Inter-Peak		PM Peak	
	Trips	%	Trips	%	Trips	%
Compliant Car	265,956	78.2%	220,025	78.2%	271,873	78.2%
Non-Compliant Car	74,141	21.8%	61,337	21.8%	75,791	21.8%
All Car	**340,097**	**100%**	**281,362**	**100%**	**347,664**	**100%**
Compliant LGV	29,042	57.8%	28,071	57.8%	24,386	57.8%
Non-Compliant LGV	21,204	42.2%	20,495	42.2%	17,804	42.2%
All LGV	**50,246**	**100%**	**48,565**	**100%**	**42,190**	**100%**
Compliant OGV	14,162	71.1%	15,360	71.1%	6,923	71.1%
Non-Compliant OGV	5,756	28.9%	6,243	28.9%	2,814	28.9%
All OGV	**19,918**	**100%**	**21,604**	**100%**	**9,738**	**100%**
Compliant Taxi	14,392	58.0%	11,907	58.0%	14,712	58.0%
Non-Compliant Taxi	10,422	42.0%	8,622	42.0%	10,654	42.0%
All Taxi	**24,814**	**100%**	**20,529**	**100%**	**25,366**	**100%**
All Compliant	323,552	74.4%	275,363	74.0%	317,895	74.8%
All Non-Compliant	111,523	25.6%	96,697	26.0%	107,063	25.2%
All Vehicle	**435,075**	**100%**	**372,060**	**100%**	**424,958**	**100%**

Table 10: Highway Assignment Matrix Totals (PCUs, Trips With an Origin or Destination Inside Greater Manchester), 2023 Do Minimum

Vehicle type	AM Peak		Inter-Peak		PM Peak	
	Trips	%	Trips	%	Trips	%
Compliant Car	294,699	85.4%	244,172	85.4%	301,401	85.4%
Non-Compliant Car	50,380	14.6%	41,740	14.6%	51,526	14.6%
All Car	**345,079**	**100%**	**285,912**	**100%**	**352,927**	**100%**
Compliant LGV	35,634	67.9%	34,462	67.9%	29,920	67.9%
Non-Compliant LGV	16,844	32.1%	16,288	32.1%	14,142	32.1%
All LGV	**52,478**	**100%**	**50,750**	**100%**	**44,062**	**100%**
Compliant OGV	16,580	82.1%	17,979	82.1%	8,100	82.1%
Non-Compliant OGV	3,613	17.9%	3,918	17.9%	1,765	17.9%
All OGV	**20,194**	**100%**	**21,897**	**100%**	**9,864**	**100%**
Compliant Taxi	19,579	78.1%	16,235	78.1%	20,027	78.1%
Non-Compliant Taxi	5,485	21.9%	4,546	21.9%	5,610	21.9%
All Taxi	**25,064**	**100%**	**20,780**	**100%**	**25,636**	**100%**
All Compliant	366,493	82.8%	312,848	82.5%	359,447	83.1%
All Non-Compliant	76,322	17.2%	66,493	17.5%	73,042	16.9%
All Vehicle	**442,814**	**100%**	**379,340**	**100%**	**432,489**	**100%**

Table 11: Highway Assignment Matrix Totals (PCUs, Trips With an Origin or Destination Inside Greater Manchester), 2025 Do Minimum

Vehicle type	AM Peak		Inter-Peak		PM Peak	
	Trips	%	Trips	%	Trips	%
Compliant Car	320,490	91.6%	265,995	91.6%	327,666	91.6%
Non-Compliant Car	29,389	8.4%	24,391	8.4%	30,048	8.4%
All Car	**349,879**	**100%**	**290,386**	**100%**	**357,714**	**100%**
Compliant LGV	43,169	78.9%	41,769	78.9%	36,244	78.9%
Non-Compliant LGV	11,542	21.1%	11,167	21.1%	9,690	21.1%
All LGV	**54,711**	**100%**	**52,935**	**100%**	**45,934**	**100%**
Compliant OGV	18,669	91.2%	20,240	91.2%	9,114	91.2%
Non-Compliant OGV	1,799	8.8%	1,951	8.8%	878	8.8%
All OGV	**20,469**	**100%**	**22,191**	**100%**	**9,992**	**100%**
Compliant Taxi	23,267	91.5%	19,315	91.5%	23,763	91.5%
Non-Compliant Taxi	2,158	8.5%	1,790	8.5%	2,203	8.5%
All Taxi	**25,425**	**100%**	**21,105**	**100%**	**25,967**	**100%**
All Compliant	405,595	90.0%	347,319	89.8%	396,787	90.3%
All Non-Compliant	44,889	10.0%	39,299	10.2%	42,819	9.7%
All Vehicle	**450,483**	**100%**	**386,617**	**100%**	**439,607**	**100%**

Forecast Traffic Volumes

6.10 Table 12 shows modelled do-minimum annual vehicle km totals for roads in the Regional Centre and the whole of Greater Manchester from the Saturn and EMIGMA modelling, broken down by compliant and non-compliant vehicle types. (The location of the Regional Centre cordon is shown in Figure 2).

6.11 The results show that traffic flows in the Regional Centre are forecast to remain stable between 2021 and 2025. This is broadly in line with observed trends for highway trips in the City Centre, where traffic flows have been stationary or falling since 2010. Vehicle kilometres across the County as-a-whole are forecast to increase by approximately 5% between 2021 and 2025, which is slightly higher than the growth in the numbers of trips shown in Table 10. This is caused by a small increase in average trip lengths in the Saturn model, which often happens due to re-routing responses in the highway assignment caused by lower vehicle operating costs and higher values of time in forecast years.

6.12 The breakdown of vehicle kilometres by compliant and non-compliant vehicle types matches that in the demand matrices (shown in Table 10), as expected.

Table 12: Modelled Do-Minimum Vehicle KM Totals by Year for Compliant and Non-Compliant Vehicle Types (Millions)

Vehicle Type	2021 DM	% Total	2023 DM	% Total	2025 DM	% Total
Regional centre						
Compliant Car	44	78.2%	48	85.4%	51	91.6%
Non-Compliant Car	12	21.8%	8	14.6%	5	8.4%
All Car	56	-	56	-	56	-
Compliant LGV	6	57.8%	7	67.9%	9	78.9%
Non-Compliant LGV	4	42.2%	3	32.1%	2	21.1%
All LGV	10	-	10	-	11	-
Compliant OGV	1	71.1%	1	82.1%	1	91.2%
Non-Compliant OGV	0	28.9%	0	17.9%	0	8.8%
All OGV	1	-	1	-	1	-
Compliant Taxi	2	58.0%	3	78.1%	4	91.5%
Non-Compliant Taxi	2	42.0%	1	21.9%	0	8.5%
All Taxi	4	-	4	-	4	-
Bus	6	-	6	-	6	-
Total	78	-	77	-	78	-
Greater Manchester						
Compliant Car	10,281	78.2%	11,525	85.4%	12,652	91.6%
Non-Compliant Car	2,866	21.8%	1,971	14.6%	1,161	8.4%
All Car	13,147	-	13,496	-	13,813	-
Compliant LGV	1,560	57.8%	1,911	67.9%	2,311	78.9%
Non-Compliant LGV	1,139	42.2%	903	32.1%	618	21.1%
All LGV	2,700	-	2,814	-	2,928	-
Compliant OGV	724	71.1%	848	82.1%	953	91.2%
Non-Compliant OGV	295	28.9%	185	17.9%	92	8.8%

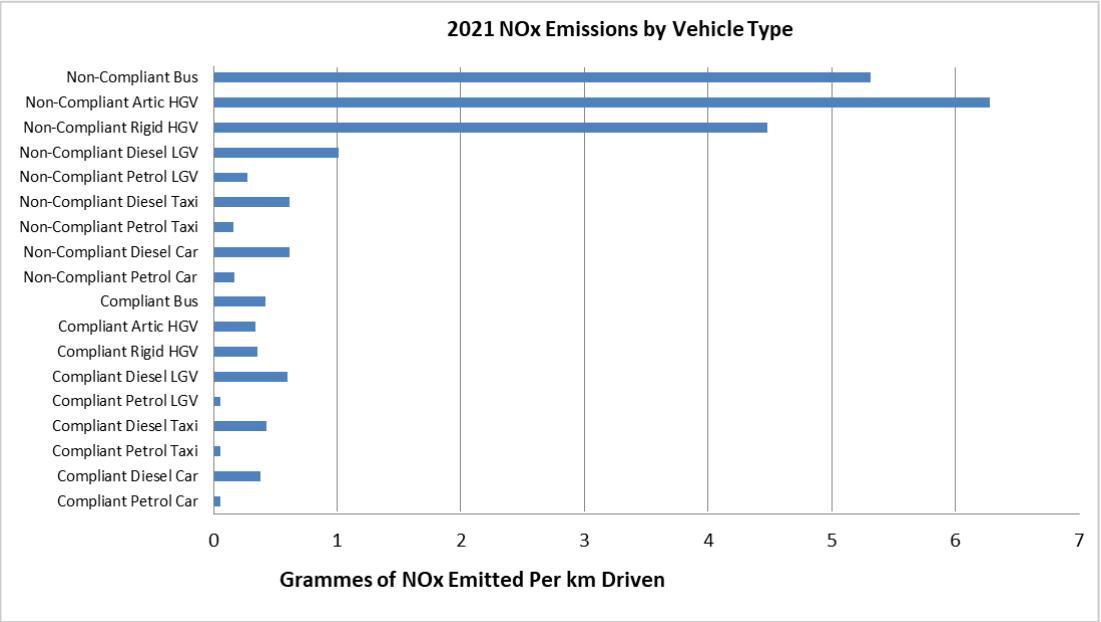
Vehicle Type	2021 DM	% Total	2023 DM	% Total	2025 DM	% Total
All OGV	1,019	-	1,032	-	1,045	-
Compliant Taxi	495	58.1%	677	78.2%	812	91.6%
Non-Compliant Taxi	357	41.9%	189	21.8%	75	8.4%
All Taxi	852	-	866	-	887	-
Bus	118	-	118	-	118	-
Total	17,836	-	18,327	-	18,791	-
Notes: Totals may not sum due to rounding The location of the Regional Centre cordon is shown in Figure 2						

Road Traffic Emissions

6.13 This section presents summary details of do-minimum road traffic emissions from the air quality modelling. The results should be viewed in the context that road traffic emissions represented approximately two thirds of total NOx emissions in Greater Manchester in 2014, as described in Reference 5.

6.14 Figure 4 shows NOx emission rates (in grammes per km travelled) for different vehicles travelling at average speeds from the 2021 EMIGMA modelling. In general, the figure shows that non-compliant vehicles have higher emissions than equivalent compliant vehicle types, and that diesel vehicles have higher emission rates than petrol powered vehicles. It can also be seen that non-compliant HGVs and buses have much higher emissions than other vehicle types, and will therefore have a disproportionate impact on air quality levels relative to their overall contribution to the total traffic flow.

Figure 4: 2021 NOx Emissions from Different Vehicle Types at Average Speeds



6.15 Figure 5 shows modelled NOx emissions by year, illustrating how emissions from road traffic are forecast to decline between 2016 and 2025 due to improvements in vehicle emission standards over time. (This occurs despite the forecast increase in demand over this period).

6.16 The breakdown of road traffic NOx emissions by vehicle type for 2021 is shown in Figure 6. The figure shows emissions from private cars represent approximately 45% of the total in this year, with emissions from LGVs and HGVs representing 29% and 15% of the total respectively. Emissions from buses represent 7% of the total.

6.17 Table 13 provides a more detailed breakdown of the information described above, showing modelled road traffic NOx emissions by year for compliant and non-compliant vehicle types travelling on roads in Greater Manchester.

6.18 The figures in the columns headed '% Total' show the fraction of total emissions for the corresponding road and vehicle type. Non-compliant cars travelling on motorways, for example, generate approximately 11% of total road traffic emissions in the County in 2016. Traffic travelling on motorways generates 40% of total NOx emissions in 2016, with emissions from non-compliant LGVs representing approximately 25% of the county-wide total. Emissions from non-compliant cars represent approximately 20% of total road traffic emissions in 2021, with emissions from non-compliant Light Goods Vehicles representing just over 16% of the total. Emissions from non-compliant vehicles as-a-whole represent approximately 50% of total road traffic NOx emissions in 2021, although they represent only 25% of the total vehicle fleet.

Figure 5: Modelled Road Traffic NOx Emissions By Year

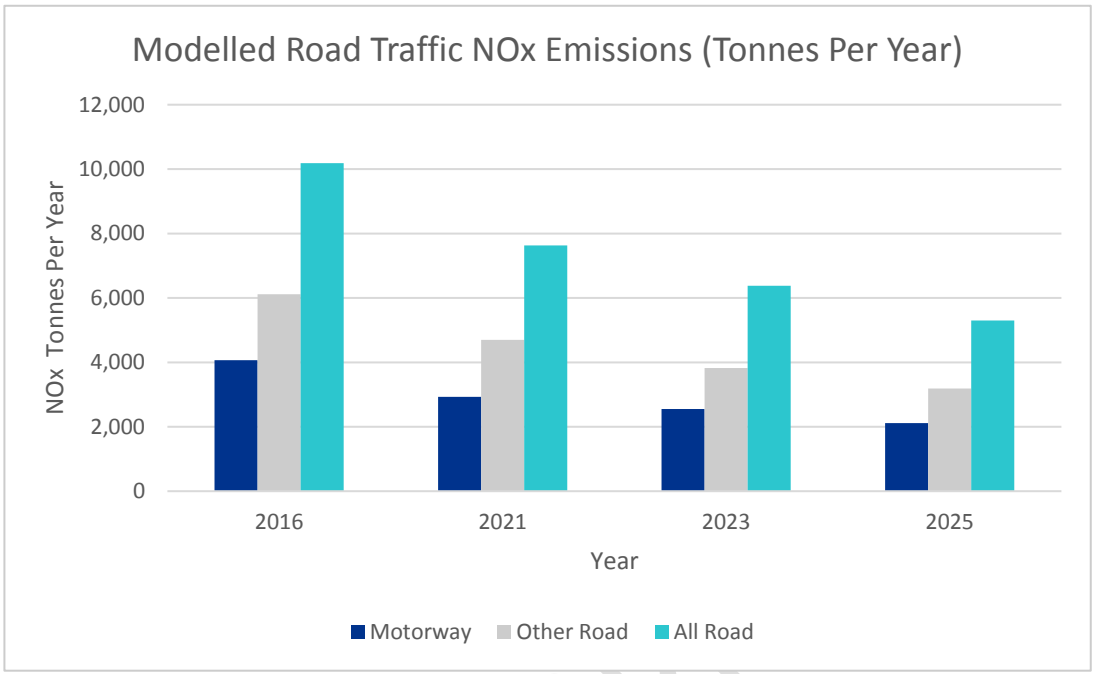


Figure 6: 2021 Road Traffic Emission Sources

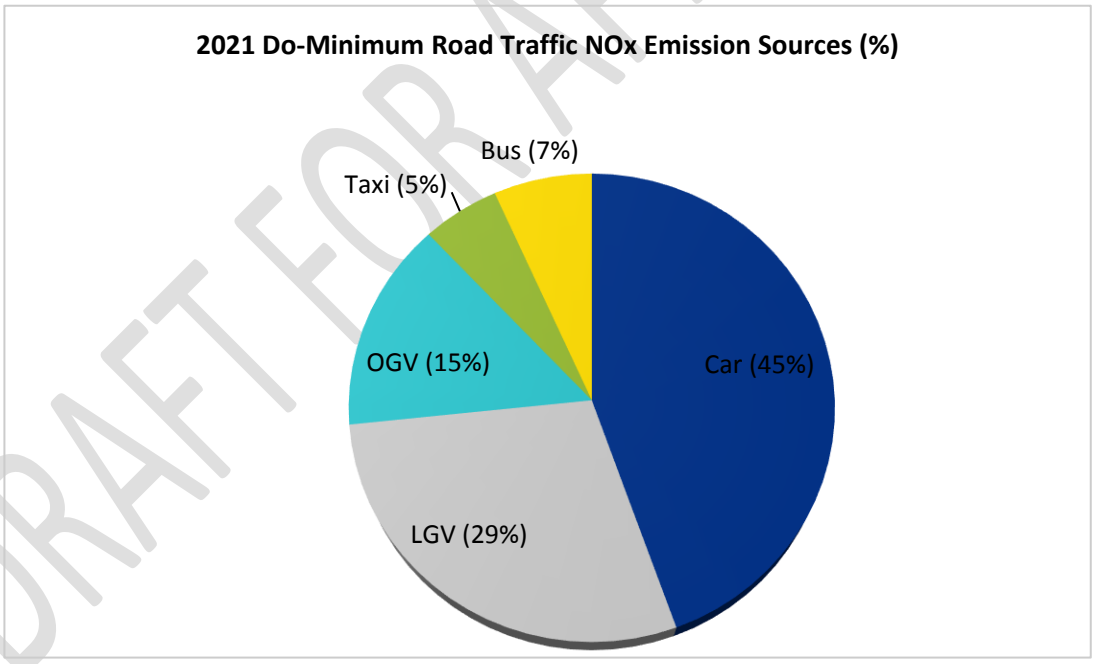


Table 13: Modelled Road Traffic NOx Emission Totals By Year, Vehicle and Road Type (Millions of Tonnes Per Year)

Vehicle Type	2016						2021					
	M'way	%	Other Road	%	All Road	%	M'way	%	Other Road	%	All Road	%
Compliant Car	322	3.2%	424	4.2%	746	7.3%	722	9.5%	1,129	14.8%	1,851	24.3%
Non-Compliant Car	1,097	10.8%	2,000	19.6%	3,097	30.4%	535	7.0%	1,011	13.2%	1,546	20.3%
All Car	1,419	13.9%	2,424	23.8%	3,843	37.7%	1,258	16.5%	2,139	28.0%	3,397	44.5%
Compliant LGV	24	0.2%	24	0.2%	48	0.5%	436	5.7%	515	6.8%	952	12.5%
Non-Compliant LGV	1,172	11.5%	1,212	11.9%	2,384	23.4%	619	8.1%	628	8.2%	1,248	16.4%
All LGV	1,196	11.7%	1,235	12.1%	2,432	23.9%	1,056	13.8%	1,144	15.0%	2,199	28.8%
Compliant OGV	22	0.2%	38	0.4%	60	0.6%	60	0.8%	110	1.4%	170	2.2%
Non-Compliant OGV	1,315	12.9%	1,263	12.4%	2,577	25.3%	441	5.8%	501	6.6%	942	12.3%
All OGV	1,337	13.1%	1,301	12.8%	2,638	25.9%	501	6.6%	611	8.0%	1,112	14.6%
Compliant Taxi	5	0.1%	14	0.1%	20	0.2%	60	0.8%	140	1.8%	200	2.6%
Non-Compliant Taxi	112	1.1%	290	2.9%	403	4.0%	58	0.8%	148	1.9%	206	2.7%
All Taxi	117	1.2%	305	3.0%	422	4.1%	118	1.5%	288	3.8%	406	5.3%
Bus	0	0.0%	850	8.3%	850	8.3%	0	0.0%	516	6.8%	516	6.8%
Total	4,070	40.0%	6,115	60.0%	10,185	100.0%	2,932	38.4%	4,698	61.6%	7,629	100.0%

Vehicle Type	2023						2025					
	M'way	%	Other Road	%	All Road	%	M'way	%	Other Road	%	All Road	%
Compliant Car	783	12.3%	1,094	17.2%	1,877	29.4%	806	15.2%	1,120	21.1%	1,926	36.3%
Non-Compliant Car	380	6.0%	700	11.0%	1,080	16.9%	227	4.3%	405	7.6%	632	11.9%
All Car	1,163	18.2%	1,794	28.1%	2,957	46.4%	1,032	19.5%	1,525	28.8%	2,558	48.2%
Compliant LGV	432	6.8%	467	7.3%	899	14.1%	452	8.5%	503	9.5%	955	18.0%
Non-Compliant LGV	514	8.1%	524	8.2%	1,038	16.3%	337	6.4%	375	7.1%	712	13.4%
All LGV	946	14.8%	991	15.5%	1,937	30.4%	788	14.9%	879	16.6%	1,667	31.4%
Compliant OGV	72	1.1%	131	2.1%	203	3.2%	83	1.6%	149	2.8%	232	4.4%
Non-Compliant OGV	271	4.3%	313	4.9%	584	9.2%	131	2.5%	156	2.9%	288	5.4%
All OGV	343	5.4%	444	7.0%	787	12.3%	214	4.0%	306	5.8%	520	9.8%
Compliant Taxi	66	1.0%	163	2.6%	229	3.6%	67	1.3%	163	3.1%	230	4.3%
Non-Compliant Taxi	31	0.5%	77	1.2%	109	1.7%	12	0.2%	30	0.6%	43	0.8%
All Taxi	98	1.5%	240	3.8%	338	5.3%	80	1.5%	193	3.6%	273	5.1%
Bus	0	0.0%	358	5.6%	358	5.6%	0	0.0%	284	5.4%	284	5.4%
Total	2,551	40.0%	3,826	60.0%	6,376	100.0%	2,115	39.9%	3,186	60.1%	5,301	100.0%

7 Scenario Forecasts

Assessment Scenarios

7.1 Many options have been tested throughout the option development process to first test that the approach adopted was giving sensible results and then to investigate the potential impacts of combinations of different measures.

7.2 Option testing using the demand sifting tool largely was undertaken using three different versions of the tool which each had different assumptions within the tool:

- Initial Version of the tool (Spring 2018) – This version of the tool used a coarser sector system and made high level assessments of scheme impact in line with the default figures in JAQU guidance and WebTAG suggested values for car elasticities. At this stage the tool was largely used to assess the potential scale of impact of measures and did not integrate with the GM SATURN model for option assessment.
- Second Version of the Tool (Early Summer 2018) – This version of the tool used a more disaggregated sector system and had updated responses modelled for car elasticities to give results more line with expected results in JAQU's guidance. At this stage the tool was used to sift several options down and started to produce outputs for use in SATURN for further option assessment.
- Third Version of the tool (August 2018) – This version further disaggregated the sector system and updated the responses to charging to make use of data from weighted Stated Preference work in Bristol. This version of the tool was used to undertake assessment of shortlisted options taken forward to the business case.
- Final Version of the model (January 2019) – This version updated the PHV responses to charging to what is believed to be more realistic and in keeping with how other areas have modelled PHV response. This tool was used to test Options 7 and 8 which were developed at a later date.

7.3 Ultimately a large number of tests were undertaken using these different versions of the Demand Sifting Tool as shown in Table 14 below while some options (such as the impact of Bus retrofitting) were only modelled at the Mass Emissions stage of the process

Table 14: Key Option tests conducted in modelling process

Demand Sifting Tool	Option	CAZ Boundary	Other Measures	2021	2023	2025
Second Version of Tool	Option 3	Manchester Inner Relief Road CAZ D	- Local Authority Fleet Upgrade - Bus Retro-fit scheme - Taxi Retro-fit/upgrade - EV incentivisation	✓		
	Option 4	Manchester Inner Relief Road CAZ D & CAZ C on M60 and Satellites		✓		
	Option 5	Manchester Inner Relief Road CAZ D & GM CAZ C		✓		
	Option 6	GM CAZ D		✓		
Third Version of Tool	Option 4	Manchester Inner Relief Road CAZ D & CAZ B on M60 and Satellites moving to CAZ C in 2023	- Local Authority Fleet Upgrade - Car Incentive Scheme - LGV incentive scheme - PHV incentive scheme - Taxi Retro-fit/upgrade - Bus Retro-fit scheme - EV incentivisation	✓	✓	✓
	Option 5(i)	Manchester Inner Relief Road CAZ D & GM CAZ B moving to CAZ C in 2023		✓	✓	✓
	Option 5(ii)	Manchester Inner Relief Road CAZ D with all diesel cars non-compliant & GM CAZ B moving to CAZ C in 2023		✓	✓	✓
Current Version of Tool	Option 5(i)	Manchester Inner Relief Road CAZ D & GM CAZ B moving to CAZ C in 2023		✓	✓	✓
	Option 5(ii)	Manchester Inner Relief Road CAZ D with all diesel cars non-compliant & GM CAZ B moving to CAZ C in 2023		✓	✓	✓
	Option 7	GM CAZ B		✓	✓	✓
	Option 8	GM CAZ B moving to CAZ C		✓	✓	✓

7.4 Following a review of option performance in terms of achieving compliance 3 options were taken forward for economic appraisal and their results are summarised in this report:

- Option 5(i) – A GM wide CAZ C starting in 2021 (with a phased introduction of LGV charges to 2023) and a CAZ D on Manchester Inner Relief Road.
- Option 5(ii) - A GM wide CAZ C starting in 2021 (with a phased introduction of LGV charges to 2023) and a CAZ D+ on Manchester Inner Relief Road where all diesel cars would be subject to charge.
- Option 8 – A GM wide CAZ C starting in 2021 (with a phased introduction of LGV charges to 2023)

7.5 In terms of traffic modelling and what is considered a compliant and non-compliant vehicle, there is no difference between Option 5(i) and Option 5(ii) as such their results are not differentiated.

Compliance level achieved across Greater Manchester

7.6 Each option's performance has been summarised by looking at the compliant/non-compliant split of traffic achieved for trips with an origin and destination within greater Manchester and the total reduction in traffic volumes from the DM for 2021, 2023 and 2025 as appropriate. It should be noted that these results are at a matrix level so do not reflect an options performance in terms of reducing the number of non-compliant sites.

7.7 Table 15**,**Table 16Table 17present the results of each option in 2021, 2023 and 2025 respectively.

Table 15: Option Performance in 2021

	DM		Option 5			Option 8		
	Compliant	Non-Compliant	Compliant	Non-Compliant	% reduction in traffic	Compliant	Non-Compliant	% reduction in traffic
Car	79%	21%	80%	20%	0%	79%	21%	0%
LGV	58%	42%	59%	41%	0%	60%	40%	0%
HGV	71%	29%	97%	3%	1%	97%	3%	1%
Taxi	71%	29%	93%	7%	10%	92%	8%	0%

Table 16: Option Performance in 2023

	DM		Option 5			Option 8		
	Compliant	Non-Compliant	Compliant	Non-Compliant	% reduction in traffic	Compliant	Non-Compliant	% reduction in traffic
Car	88%	12%	88%	12%	0%	88%	12%	0%
LGV	67%	33%	96%	4%	5%	96%	4%	5%
HGV	82%	18%	98%	2%	1%	98%	2%	1%
Taxi	96%	4%	99%	1%	1%	99%	1%	0%

Table 17: Option Performance in 2025

	DM		Option 5			Option 8		
	Compliant	Non-Compliant	Compliant	Non-Compliant	% reduction in traffic	Compliant	Non-Compliant	% reduction in traffic
Car	93%	7%	93%	7%	0%	93%	7%	0%
LGV	79%	21%	97%	3%	3%	97%	3%	3%
HGV	91%	9%	99%	1%	0%	99%	1%	0%
Taxi	96%	4%	99%	1%	1%	99%	1%	0%

7.8 As can be seen from the tables above there is very little difference between Options 5 and 8. This is because, in terms of traffic demand across the whole of Greater Manchester, a very small percentage of trips (less than 4%) of trips are travelling, into, out of or within the IRR and of these 79% are compliant.

7.9 A difference can be seen between how Taxis are impacted; however, this is due to the impact of changing assumptions around PHV responses to charging between the testing of Option 5 (Autumn 2018) and Option 8 (January 2019). In January assumptions were updated to reflect that it is unlikely that a PHV trip will change mode or cancel trip as there is a demand for a private hire trip so if one operator cancels the trip due to cost then another service will take the booking.

Highway Network Statistics

Highway Model Convergence

7.10 WebTAG notes the importance of achieving appropriate levels of network convergence in transport models used for appraisal purposes, in order to provide stable and consistent model results. The DMRB also stresses that it is important that the levels of convergence achieved in the do-minimum and do-something assignments are similar, and that they are sufficiently robust to ensure that differences in the results are not confused with oscillation effects or assignment ‘noise’.

7.11 The WebTAG criteria for an acceptable level of network convergence are that:

- the Delta and %GAP statistics should be less than 0.1% on the final assignment iteration; and
- more than 98% of links should have a flow that changes by less than 1% on the final 4 iterations.

7.12 Table 18 shows the above values for the three time periods for the do-minimum and do-something models for each of the forecast years and modelled scenarios. The table indicates that the models were satisfactorily converged for all tests, with Delta and GAP values well below 0.1% and the percentage of links with flows changing by less than 1% meeting the criteria for all model runs.

Table 18: Forecast Highway Assignment Convergence Statistics

Criterion	Target	2021			2023			2025		
		AM Peak	Inter-Peak	PM Peak	AM Peak	Inter-Peak	PM Peak	AM Peak	Inter-Peak	PM Peak
Do Minimum										
Delta	< 0.1%	0.023%	0.022%	0.032%	0.031%	0.027%	0.039%	0.027%	0.034%	0.035%
%GAP	< 0.1%	0.034%	0.025%	0.032%	0.039%	0.028%	0.047%	0.031%	0.033%	0.041%
% of links with < 1% flow change on final iteration	> 98%	98.6%	98.4%	98.6%	98.0%	98.6%	98.0%	98.2%	98.2%	98.4%
Final iteration -1		98.3%	98.4%	98.0%	98.2%	98.4%	98.1%	98.4%	98.1%	98.2%
Final iteration -2		98.8%	98.3%	98.0%	98.2%	98.6%	98.0%	98.2%	98.3%	98.1%
Final iteration -3		98.6%	98.4%	98.0%	98.3%	98.1%	98.0%	98.0%	98.1%	98.3%
Option 5										
Delta	< 0.1%	0.032%	0.021%	0.029%	0.032%	0.021%	0.028%	0.029%	0.024%	0.032%
%GAP	< 0.1%	0.029%	0.026%	0.038%	0.030%	0.027%	0.047%	0.035%	0.034%	0.040%
% of links with < 1% flow change on final iteration	> 98%	98.3%	98.2%	98.4%	98.1%	98.5%	98.1%	98.3%	98.3%	98.4%
Final iteration -1		98.1%	98.4%	98.3%	98.2%	98.5%	98.0%	98.3%	98.3%	98.1%
Final iteration -2		98.5%	98.0%	98.1%	98.2%	98.2%	98.2%	98.4%	98.3%	98.1%
Final iteration -3		98.2%	98.1%	98.2%	98.0%	98.2%	98.1%	98.5%	98.2%	98.3%

Criterion	Target	2021			2023			2025		
		AM Peak	Inter-Peak	PM Peak	AM Peak	Inter-Peak	PM Peak	AM Peak	Inter-Peak	PM Peak
Option 8										
Delta	< 0.1%	0.024%	0.019%	0.032%	0.036%	0.023%	0.032%	0.026%	0.024%	0.036%
%GAP	< 0.1%	0.038%	0.027%	0.038%	0.046%	0.025%	0.040%	0.035%	0.024%	0.043%
% of links with < 1% flow change on final iteration	> 98%	98.0%	98.2%	98.2%	98.0%	98.5%	98.2%	98.1%	98.5%	98.3%
Final iteration -1		98.1%	98.2%	98.1%	98.4%	98.3%	98.3%	98.5%	98.4%	98.3%
Final iteration -2		98.1%	98.1%	98.1%	98.6%	98.4%	98.0%	98.1%	98.4%	98.3%
Final iteration -3		98.0%	98.2%	98.3%	98.3%	98.3%	98.3%	98.2%	98.2%	98.0%

Forecast Traffic Flows

7.13 Table 19 and Table 20 show modelled annual vehicle km totals by year for Options 5 and 8 broken down by vehicle type for the Regional Centre and the county-as-a-whole.

7.14 The results for Option 5 show that vehicle km's in the Regional Centre are forecast to be approximately 5% lower in 2021 when compared to the do-minimum, mainly due to drivers choosing to cancel their journeys or opting to use public transport (as modelled using the demand sifting tool), but also due to some re-assignment effects as drivers of non-compliant vehicles change their routes to avoid entering the modelled Regional Centre charging zone. The reductions in vehicle km's relative to the do-minimums fall over time, (as would be expected), as the proportions of non-compliant vehicles in the fleet that would be affected by the CAP measures fall.

7.15 The vehicle km comparisons for Option 5 for the county-as-a-whole show that the reduction in vehicle km's is not as great as was the case for the Regional Centre, with totals falling by between 1.0% and 0.5% relative to the do-minimums. Once again, this is in line with expectations, as the category B/C CAZ that is being proposed for the whole of Greater Manchester would not affect private cars.

7.16 The proportions of compliant cars in 2021 have increased from 78% for the do-minimum to slightly over 97% for the Regional Centre (for Option 5) and from 78% to 83% across the whole of the county for this option. This reflects the increased impacts of a CAZ D for the Regional Centre, but will also include the impacts of the measures to promote electric vehicles more generally, as described in Section 4.

7.17 The vehicle km comparisons for Option 8 follow a similar pattern to those described above for Option 5, albeit with smaller impacts for the Regional Centre, as would be expected.

Table 19: Option 5 Annual Vehicle KM Totals By Year for Compliant and Non-Compliant Vehicle Types (Millions), Regional Centre.

Vehicle Type	2021					2023					2025				
	DM	% Total	DS	% Total	% Change	DM	% Total	DS	% Total	% Change	DM	% Total	DS	% Total	% Change
Regional Centre															
Compliant Car	44	78.2%	52	97.3%	17.7%	48	85.4%	52	98.4%	10.1%	51	91.6%	54	99.4%	5.7%
Non-Compliant Car	12	21.8%	1	2.7%	-88.1%	8	14.6%	1	1.6%	-89.4%	5	8.4%	0	0.6%	-93.0%
All Car	56		53		-5.4%	56		53		-4.4%	56		55		-2.6%
Compliant LGV	6	57.8%	9	95.1%	55.0%	7	67.9%	10	97.0%	39.6%	9	78.9%	10	98.2%	21.5%
Non-Compliant LGV	4	42.2%	0	4.9%	-89.0%	3	32.1%	0	3.0%	-90.8%	2	21.1%	0	1.8%	-91.5%
All LGV	10		10		-5.7%	10		10		-2.3%	11		11		-2.3%
Compliant OGV	1	71.1%	1	97.2%	39.0%	1	82.1%	1	98.3%	21.2%	1	91.2%	1	99.2%	9.3%
Non-Compliant OGV	0	28.9%	0	2.8%	-90.2%	0	17.9%	0	1.7%	-90.5%	0	8.8%	0	0.8%	-90.3%
All OGV	1		1		1.7%	1		1		1.3%	1		1		0.5%
Compliant Taxi	2	58.0%	4	94.5%	65.6%	3	78.1%	4	97.0%	10.2%	4	91.5%	4	99.0%	9.0%
Non-Compliant Taxi	2	42.0%	0	5.5%	-86.6%	1	21.9%	0	3.0%	-87.8%	0	8.5%	0	1.0%	-87.9%
All Taxi	4		4		1.7%	4		4		-11.3%	4		4		0.8%
Bus	6		6		0.4%	6		6		0.5%	6		6		0.2%
Total	78		74		-4.5%	77		74		-4.0%	78		76		-2.1%

Vehicle Type	2021					2023					2025				
	DM	% Total	DS	% Total	% Change	DM	% Total	DS	% Total	% Change	DM	% Total	DS	% Total	% Change
Greater Manchester															
Compliant Car	10,281	78.2%	10,888	83.0%	5.9%	11,525	85.4%	12,112	89.8%	5.1%	12,652	91.6%	13,221	95.8%	4.5%
Non-Compliant Car	2,866	21.8%	2,237	17.0%	-22.0%	1,971	14.6%	1,371	10.2%	-30.4%	1,161	8.4%	587	4.2%	-49.5%
All Car	13,147		13,125		-0.2%	13,496		13,483		-0.1%	13,813		13,808		0.0%
Compliant LGV	1,560	57.8%	1,707	63.3%	9.4%	1,911	67.9%	2,552	94.3%	33.5%	2,311	78.9%	2,713	94.9%	17.4%
Non-Compliant LGV	1,139	42.2%	988	36.7%	-13.2%	903	32.1%	154	5.7%	-83.0%	618	21.1%	146	5.1%	-76.4%
All LGV	2,700		2,696		-0.2%	2,814		2,706		-3.9%	2,928		2,860		-2.4%
Compliant OGV	724	71.1%	894	88.3%	23.4%	848	82.1%	969	94.2%	14.3%	953	91.2%	1,006	96.4%	5.6%
Non-Compliant OGV	295	28.9%	118	11.7%	-59.9%	185	17.9%	59	5.8%	-67.8%	92	8.8%	37	3.6%	-59.7%
All OGV	1,019		1,012		-0.7%	1,032		1,029		-0.4%	1,045		1,044		-0.2%
Compliant Taxi	495	58.1%	581	83.4%	17.5%	677	78.2%	693	94.2%	2.3%	812	91.6%	828	97.2%	2.0%
Non-Compliant Taxi	357	41.9%	116	16.6%	-67.6%	189	21.8%	43	5.8%	-77.5%	75	8.4%	24	2.8%	-67.6%
All Taxi	852		697		-18.2%	866		735		-15.1%	887		853		-3.8%
Bus	118		118		0.1%	118		118		0.1%	118		118		0.1%
Total	17,836		17,648		-1.1%	18,327		18,070		-1.4%	18,791		18,681		-0.6%
Notes: Totals may not sum due to rounding.															

Road Traffic Emission Forecasts

7.18 Table 20 shows forecast road traffic emissions with percentage changes relative to the do-minimums for the modelled options for each of the forecast years, separately for the Regional Centre, the area inside the M60 and the whole of GM.

7.19 The results show that Option 5(ii) (where it was assumed that all diesel cars would be charged inside the IRR) delivers the greatest percentage reductions in NOx in the Regional Centre, which are approximately 58% lower than the do-minimum total in 2021 and 50% lower than the do-minimum total in 2023. The corresponding reductions in NOx emissions in the Regional Centre for Option 5(i) relative to the do-minimums are 49% and 37% in 2021 and 2023 respectively. Option 8 performs less well in terms of reducing NOx emissions within the Regional Centre. This would be expected, however, as this option has less impact of non-compliant cars within the central area, which would not be charged for Option 8, but which would be charged for Options 5(i) and 5(ii).

7.20 The performance of all three options at the GM level are broadly similar, with reductions in NOx emissions of approximately 25% relative to the do-minimum in 2023 and 20% relative to the do-minimum in 2025 in all cases.

Table 20: Forecast Road Traffic Emissions with Percentage Changes from the Do-Minimums (Tonnes Per Year)

Location	2021				2023				2025			
	NOx	NO2	PM10	CO2	NOx	NO2	PM10	CO2	NOx	NO2	PM10	CO2
Do Minimum												
Regional Centre	74	13	7	16,849	55	9	6	16,498	48	8	6	16,327
Inside M60	1,415	354	225	575,817	1,134	285	224	572,462	949	233	226	570,375
GM	7,639	2,016	1,290	3,695,750	6,385	1,682	1,295	3,716,273	5,309	1,383	1,318	3,737,385
Option 5(i)												
Regional Centre	-47.8%	-47.4%	-9.8%	-5.9%	-37.3%	-41.2%	-6.7%	-4.9%	-30.7%	-32.8%	-3.9%	-3.1%
Inside M60	-28.3%	-20.9%	-6.6%	-5.3%	-29.0%	-28.0%	-5.9%	-5.4%	-24.5%	-24.7%	-4.4%	-4.3%
GM	-19.8%	-14.3%	-5.7%	-4.2%	-25.1%	-24.1%	-5.3%	-4.6%	-20.0%	-20.4%	-4.1%	-3.8%
Option 5(ii)												
Regional Centre	-57.8%	-67.5%	-10.4%	-4.3%	-48.9%	-65.0%	-7.3%	-3.8%	-43.6%	-61.2%	-4.6%	-2.7%
Inside M60	-28.8%	-21.6%	-6.6%	-5.3%	-29.6%	-28.8%	-5.9%	-5.4%	-25.2%	-25.6%	-4.4%	-4.3%
GM	-19.9%	-14.4%	-5.7%	-4.2%	-25.2%	-24.3%	-5.3%	-4.6%	-20.1%	-20.6%	-4.1%	-3.8%
Option 8												
Regional Centre	-39.7%	-28.5%	-7.2%	-3.5%	-32.3%	-31.5%	-6.2%	-4.4%	-28.0%	-28.6%	-4.8%	-3.8%
Inside M60	-25.5%	-16.6%	-5.6%	-4.4%	-27.6%	-25.9%	-5.6%	-5.1%	-23.9%	-23.8%	-4.4%	-4.3%
GM	-19.7%	-13.3%	-5.3%	-3.8%	-24.5%	-23.4%	-5.1%	-4.4%	-20.9%	-21.2%	-4.0%	-3.7%

8 Sensitivity Testing

8.1 A number of sensitivity tests have been carried out to assess the impact of uncertainty on the modelling carried out to date. All tests have been carried out on Option 8 in 2023, the first year in which LGVs are subject to charge. Initially tests have focused on the following areas:

- Fuel Costs
- Traffic Growth
- Charge Levels
- Fleet Age
- Emissions at Low Speeds
- Electric Vehicle Uptake.

8.2 Further Details of the tests carried out and their outcomes are provided in Appendix C.

9 Summary and Conclusions

9.1 This document has presented the overall transport modelling process adopted during the development of the GM CAP both in showing how the Do Minimum scenario has been developed and how the impacts of measures to improve NOx emissions are expected to impact traffic volumes through behavioural change driven by measures such as a charging clean air zone or measures such as the Local Authorities within GM committing to ensure their vehicle fleets are compliant as part of the CAP.

9.2 From a review of the natural progression of the fleet mix it can be seen that over time the proportion of compliant vehicles is expected to dramatically increase to the point where over 90% of vehicles are forecast to be compliant by the final modelled year (2025) naturally.

9.3 However, it is clear that implementation of measures to improve NOx emissions are likely to lead to a much higher proportion of compliant vehicles across LGVs, HGVs and Taxis.

9.4 It can be seen there is little difference between the performance of Option 5 and Option 8 in terms of traffic volumes given the Inner Relief Road only covers a very small geographic area that is well served by alternative public transport routes and as such a very small percentage of car traffic within GM is impacted.

9.5 The traffic modelling undertaken to date on the GM CAP does not differentiate between Option 5i and Option 5ii due to diesel vehicles not being modelled separately from petrol.

References

1. JAQU Inception Package Guidance
   Huddle, October 2017
2. JAQU Transport and Air Quality Evidence
   Huddle, October 2017
3. Greater Manchester Clean Air Plan
   Local Plan Transport Validation report (T2)
   March 2019
4. Greater Manchester Clean Air Plan
   Local Plan Transport Modelling Methodology Report (T3)
   March 2019

Appendix A – Demand Sifting Tool Methodology

Appendix B – Boundaries considered for charging clean air zones in Greater Manchester

Appendix C – GM Clean Air Plan Highways Modelling Sensitivity Tests