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

Evidence Submission for a new GM Clean Air Plan

Local Plan Transport Model Validation Report (T2)

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Version Status:	APPROVED	**Prepared by:**	Transport for Greater Manchester on behalf of the 10 Local Authorities of Greater Manchester
Date:	October 2024		

Contents

1 Purpose of this Document

1.1.1 This document describes the development of the 2016 base year transport model to support the evidence submission for the Greater Manchester Clean Air Plan (GM CAP). The purpose of the report is to describe the main features of the model and to present details of the base year model validation, including comparisons of modelled and observed traffic flows and journey times in the study area.

1.1.2 It should be noted that from Section 4 onwards, the content of this report is materially unchanged from the previously submitted version in January 2020 as part of the Option for Consultation. The base model has not been changed because it builds from the Target Determination process agreed with JAQU in 2018.

1.1.3 This document is part of a suite of documents that have been produced to describe the transport and air quality modelling deliverables for the study. The documents in the series include:

- Local Plan Transport Modelling Tracking Table (T1), which demonstrates that the transport modelling requirements for the study are being met;
- Local Plan Transport Model Validation Report (T2)(this document), which explains in detail how the road traffic model was validated against real-world data;
- Local Plan Transport Modelling Methodology Report (T3), this document details the development of the future year without scheme model (Do Minimum);
- Local Plan Transport Model Forecasting Report (T4), which presents baseline and scenario forecasts for GM CAP;
- Local Plan Air Quality Modelling Tracking Table (AQ1), which demonstrates that the air quality modelling requirements for the study are being met;
- 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;
- Sensitivity Testing Report, which provides a summary of the sensitivity tests carried out on the core scenarios to test areas of uncertainty, understand whether the tests result in a positive or negative benefit and the scale of benefit; and
- Analytical Assurance Statement, consider the limitations, uncertainties and risks in the evidence base, and the implications of these for decision makers.

2 Greater Manchester Clean Air Plan Overview

2.1 Background to the Clean Air Plan

2.1.1 In 2017 the Secretary of State (SoS) for Environment, Food and Rural Affairs issued directions under the Environment Act 1995 requiring many local authorities, to produce feasibility studies to identify the option which will deliver compliance with the requirement to meet legal limits for nitrogen dioxide (NO_2) in the shortest possible time. The legal limit being defined as the long-term annual mean legal limit of 40 $\mu g/m^3$.

2.1.2 In Greater Manchester (GM), the ten local authorities, the Greater Manchester Combined Authority (GMCA) and Transport for Greater Manchester (TfGM) are working together to develop a Clean Air Plan to tackle NO_2 exceedances at the roadside, herein known as Greater Manchester Clean Air Plan (GM CAP).

2.1.3 The development of the GM CAP is funded by government and is overseen by the Joint Air Quality Unit (JAQU), the joint Department for Environment, Food and Rural Affairs (DEFRA) and Department for Transport (DfT) unit established to deliver national plans to improve air quality and meet legal limits. The costs related to the business case, implementation and operation of the GM CAP are either directly funded or underwritten by government acting through JAQU and any net deficit over the life of the GM CAP will be covered by the New Burdens Doctrine, subject to a reasonableness test[1].

2.1.4 In March 2019, the ten GM Local Authorities collectively submitted an Outline Business Case (OBC)[2] for the GM CAP to JAQU outlining a package of measures to deliver regional compliance with legal limits for NO_2 emissions in the shortest possible time.

2.1.5 In July 2019, the Environment Act 1995 (Greater Manchester) Air Quality Direction 2019 was made, which required all ten of the GM local authorities to implement a charging Clean Air Zone Class C[3] with additional measures. There was also an obligation to provide further scenarios appraisal information to demonstrate the applicable Class of Charging CAZ and other matters to provide assurance that the local plan would deliver compliance in the shortest possible time and by 2024 at the latest.

[1] The new burdens doctrine is part of a suite of measures to ensure Council Tax payers do not face excessive increases. New burdens doctrine: guidance for government departments - GOV.UK (www.gov.uk)

[2] https://cleanairgm.com/technical-documents/#outline-business-case

[3] https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england/annex-a-clean-air-zone-minimum-classes-and-standards

2.1.6 In March 2020, the Environment Act 1995 (Greater Manchester) Air Quality Direction 2020 was made, which required the submission of an Interim FBC (along with confirmation that all public consultation activity has completed) as soon as possible and by no later than 30 October 2020. The 2020 direction confirmed that legal duty remains to ensure the GM CAP (Charging Clean Air Zone Class C with additional measures) is implemented so that NO_2 compliance is achieved in the shortest possible time and by 2024 at the latest and that human exposure is reduced as quickly as possible. The Ministerial letter accompanying the March 2020 direction confirmed that the minister was satisfied that the main evidence queries from the July 2019 direction had been addressed.

2.1.7 A statutory consultation on the proposals took place in Autumn 2020.

2.1.8 The GMCA - Clean Air Final Plan report[4] on 25th June 2021[5] endorsed GM's Final CAP and policy in compliance with this direction, following a review of all of the information gathered through the GM CAP consultation and wider data, evidence and modelling work. Throughout the development of the previous Plan, the JAQU reviewed and approved all technical and delivery submissions. Within this document, this is referred to as the Previous GM CAP.

2.2 The Previous GM CAP and the impacts of Covid-19

2.2.1 Under the Previous GM CAP, GM was awarded £123 million by government for funds aimed at encouraging vehicle upgrades to secure compliance and mitigating the impacts of the GM-wide CAZ. The funds included £15.4 million for bus retrofit, £3.2 million for bus replacement, £10.2 million for Private Hire Vehicles (PHVs), £10.1 million for Hackney Carriages, £7.6 million for Heavy Goods Vehicles (HGVs), £4.4 million for coaches, £2.0 million for minibuses and £70.0 million for Light Goods Vehicles (LGVs).

2.2.2 The June 2021 Clean Air Final Plan report set out that the Air Quality Administration Committee (AQAC) had the authority to establish and distribute the funds set out in the agreed GM Clean Air Plan policy. On 21 September 2021 the AQAC approved the establishment and distribution of the agreed bus replacement funds.

2.2.3 On 13 October 2021 the AQAC agreed the distribution of Clean Air funds set out in the agreed GM Clean Air Plan policy as follows:

- From 30 November 2021 applications for funding would open for HGVs.
- From the end of January 2022 applications for funding would open for PHVs, Hackney Carriages, coaches, minibuses and LGVs.

[4] https://democracy.greatermanchester-ca.gov.uk/documents/s15281/GMCA%20210621%20Report%20Clean%20Air%20Plan%20-%20FINAL%20FINAL.pdf
[5] Also considered by the GM authorities through their own constitutional decision-making arrangements.

2.2.4 On 20th January 2022, the AQAC considered the findings of an initial review of conditions within the supply chain of LGVs in particular following Covid-19 related impacts, which were impacting the availability of compliant vehicles and supply-side constraints resulting in price increases, particularly in the second-hand market[6]. The AQAC agreed that a request should be made to the SoS to pause the opening of the next phase of Clean Air Funds. This was to allow an urgent and fundamental joint policy review with government, to identify how a revised policy could be agreed to deal with the supply issues and local businesses' ability to comply with the GM CAP.

2.2.5 On 8th February 2022, the AQAC noted the submission of a report "Issues Leading to Delayed Compliance Based on the Approved GM CAP Assumptions". The report concluded that on balance, the latest emerging evidence suggested that with the approved plan in place, it was no longer likely that compliance would be achieved in 2024. Members also requested that arrangements were put in place for those vehicles owners who had already placed orders pending funding opening at the end of January to ensure they are not detrimentally impacted by the decision to pause the opening of the funds. Government subsequently issued The Environment Act 1995 (Greater Manchester) Air Quality Direction 2022[7] which confirmed that the March 2020 Direction had been revoked and required that by 1st July 2022 the GM authorities should:

- Review the measures specified in the local plan for NO_2 compliance and associated mitigation measures; and
- Determine whether to propose any changes to the detailed design of those measures, or any additional measures.

2.2.6 This Direction ('the Direction') also stated that the local plan for NO_2 compliance, with any proposed changes, must ensure the achievement of NO_2 compliance in the shortest possible time and by 2026 at the latest. It should also ensure that human exposure to concentrations of NO_2 above the legal limit is reduced as quickly as possible.

2.3 The Case for a new GM CAP

2.3.1 On 1st July 2022, the AQAC noted that the 'Case for a new Greater Manchester Clean Air Plan[8] document and associated appendices would be submitted to the SoS as a draft document subject to any comments of GM Authorities.

2.3.2 On 17th August 2022, the AQAC agreed to submit the 'Case for a new Greater Manchester Clean Air Plan' to the SoS as a final version and approved the Case for a New Plan - Air Quality Modelling Report for submission to JAQU.

[6] https://democracy.greatermanchester-ca.gov.uk/documents/s18685/ARUP%20Technical%20Note.pdf
[7] The Environment Act 1995 (Greater Manchester) Air Quality Direction 2022 (publishing.service.gov.uk)
[8] https://assets.ctfassets.net/tlpgbvy1k6h2/7jtkDc5AODypDQIw0cYwsl/67091a85f26e7c503a19ec7aeb2e8137/Appendix_1_-_Case_for_a_new_Greater_Manchester_Clean_Air_Plan.pdf

2.3.3 The 'Case for a new Greater Manchester Clean Air Plan' set out that challenging economic conditions, rising vehicle prices and ongoing pandemic impacts meant that the original plan of a GM-wide charging CAZ was no longer the right solution to achieve compliance, instead proposing an investment-led, non-charging GM CAP.

2.3.4 The primary focus of the 'Case for a new Greater Manchester Clean Air Plan' was to identify a plan to achieve compliance with the legal limit value for NO_2 in a way that considered the cost-of-living crisis and associated economic challenges faced by businesses and residents. This would be achieved through an investment-led approach combined with wider measures that the GM Authorities are implementing and aimed to reduce NO_2 emissions to within legal limits, in the shortest possible time and at the latest by 2026.

2.3.5 The 'Case for a new Greater Manchester Clean Air Plan' proposed using the remaining funding that the government has awarded to GM for the Previous GM CAP to deliver an investment-led approach to invest in vehicle upgrades, rather than imposing daily charges, and deliver new Zero Emission Buses (ZEBs) as part of the Bee Network[9] (a London-style integrated transport network for GM). The new plan would ensure that the reduction of harmful emissions would be at the centre of GM's wider objectives. Within this document, this plan is referred to as the 'Investment-led Plan'.

2.3.6 The GM Authorities committed to a participatory approach to the development of the new plan to ensure that the GM Authorities' proposals would be well-grounded in evidence in terms of the circumstances of affected groups and possible impacts of the new plan on them, and therefore the deliverability and effectiveness of that plan.

2.3.7 Between August and November 2022, the GM Authorities carried out engagement and research with key stakeholders - vehicle-owning groups and representatives of other impacted individuals, such as community, business, environment and equality-based groups. This activity included targeted engagement sessions with all groups, and an online survey and supporting qualitative research activity with vehicle-owning groups.

2.3.8 Input from those engaged informed the ongoing policy development process as the GM Authorities developed the package of measures forming the Investment-led Plan.

[9] The Bee Network is Greater Manchester integrated transport system joining together bus, Metrolink, rail and active travel https://tfgm.com/corporate/business-plan/case-studies/bee-network

2.4 The Investment-led Plan and the impact of bus retrofit issues

2.4.1 Having submitted the 'Case for a new Greater Manchester Clean Air Plan'[10] in July 2022, the GM Authorities were asked by government in January[11] 2023 to:

- *Provide modelling results for a benchmark CAZ to address the persistent exceedances identified in central Manchester and Salford, in order for these to be compared against your proposals.*
- *Identify a suitable approach to address persistent exceedances identified in your data on the A58 Bolton Road in Bury in 2025, and to propose a suitable benchmark.*
- *Set out how the measures you have proposed will be modelled and evidenced overall, and to ensure that they are modelled without any unnecessary delay.*

2.4.2 The GM Authorities undertook the work required to supply this further evidence and on 8th March 2023 submitted the report 'Approach to Address Persistent Exceedances Identified on the A58 Bolton Road, Bury'[12]. GM Authorities also worked to address the remaining two requests from government by June 2023 on the basis of providing further information to support its Investment-led Plan and testing the proposal against a suitable benchmark CAZ, herein referred to as the 'CAZ Benchmark'.

2.4.3 In April 2023, government advised TfGM that it was to pause any new spending on bus retrofit as it had evidence that retrofitted buses have poor and highly variable performance in real-world conditions[13]. This new evidence followed a JAQU-funded study to quantify nitrogen oxide (NO_X) and NO_2 emissions from buses under real-world driving conditions in three cities across the UK, including Manchester (monitoring took place in Manchester City Centre between 21st November and 12th December 2022). The monitoring indicated that retrofitted buses were not reducing emissions as expected, with significant variation in performance between bus models with retrofit technologies. Furthermore, emissions of primary-NO_2 (as opposed to NO_X) were highly variable, potentially worsening roadside NO_2 concentrations despite an overall reduction in NO_X emissions.

2.4.4 Government therefore commenced a six-month focused research programme to quickly investigate the causes of this poor performance and scope how it could be improved, which was anticipated to be reported in Autumn 2023.

[10] https://assets.ctfassets.net/tlpgbvy1k6h2/7jtkDc5AODypDQIw0cYwsl/67091a85f26e7c503a19ec7aeb2e8137/Appendix_1_-_Case_for_a_new_Greater_Manchester_Clean_Air_Plan.pdf

[11] https://democracy.greatermanchester-ca.gov.uk/documents/s24937/Appendix%201.%20Ministerial%20Letter%20to%20GM%20with%20attachment.pdf

[12] https://democracy.greatermanchester-ca.gov.uk/documents/s24939/Appendix%203.%20GM%20CAP%20A58%20Bury%20Measure%20Report%20DRAFT%20for%20AQAC%20Approval%20Feb%2023.pdf

[13] https://democracy.greatermanchester-ca.gov.uk/documents/s27699/Appendix%201.%20Letter%20from%20DfT%20to%20Greater%20Manchester%20regarding%20Bus%20Retrofit%20Update.pdf

2.4.5 In the light of government's new evidence, JAQU issued revised general guidance[14] to authorities producing CAPs nationwide. In summary, this required that air quality modelling should no longer assume any air quality benefits from a retrofitted bus.

2.4.6 GM incorporated the revised guidance, as agreed with JAQU, into the modelling which underpins the development of its CAP to produce a report that appraises the ability of the Investment-led Plan and the CAZ Benchmark to deliver compliance with the legal limit value in the shortest possible time and by no later than 2026. The key findings from government's six-month focused research programme were not available at the time this work was undertaken.

2.4.7 The first version of the *Appraisal Report* and supporting documentation was submitted to government in December 2023. The *Appraisal Report* concluded that GM's Investment-led Plan can deliver compliance in 2025 and performs better than a CAZ Benchmark.

2.5 Key developments since December 2023 submission

2.5.1 Since the submission of evidence to JAQU in December 2023 there have been a number of key developments, resulting in a need to update the modelling, the *Appraisal Report* and supporting documentation.

2.5.2 Further modelling was undertaken in Summer 2024 to consider and address the following key developments:

- Delay to Stockport all-electric bus depot;
- Changes to bus fleets (operational and planned); and
- Correction to Euro V retrofit bus modelling emission values.

2.5.3 Drafts of the *Appraisal Report* and supporting documentation were updated to take account of the key developments and the Summer 2024 modelling, in preparation for submission to government. These updates did not change GM's conclusion that the Investment-led, non-charging plan can deliver compliance in 2025 and performs better than a CAZ Benchmark.

2.6 Developments following Summer 2024 modelling

2.6.1 Following the substantial drafting to update the *Appraisal Report* and supporting material (to address the key developments since the December 2023 submission), two additional issues have arisen.

2.6.2 Firstly, a risk identified in the December 2023 submission "Delays to bus depot electrification" has materialised and there is now a delivery delay to the electrification of Queens Road depot. This was due to take place by January 2025, which was the assumed delivery date in the modelling of the Investment-led Plan.

[14] Bus Retrofit Update - Technical Guidance for Local Authorities, JAQU Guidance, May 2023

2.6.3 This poses a significant challenge to achieving compliance in 2025, as 73 ZEBs are to be operated out of Queens Road depot. The issue affects 12 bus services, which run through 17 forecast ‘Do Minimum’ exceedance sites in 2025.

2.6.4 Secondly, in July 2024 National Highways also advised TfGM that the temporary speed limit on the M602 is to be removed, and the 70mph speed limit reinstated. The M602 temporary speed limit is assumed to be in place in the Investment-led Plan modelling assumptions.

2.6.5 The implications of these two issues are addressed in the *Supplementary Appraisal Report*, included as part of this evidence submission documentation. Therefore, the *Appraisal Report* and associated documentation, including this report, should be read in conjunction with the *Supplementary Appraisal Report*.

2.6.6 In addition, since the drafting of the *Appraisal Report* and supporting material, government published the ‘Bus Retrofit Performance Report’[15] on the 12th September 2024. The key findings of this report include that the retrofit technology fitted onto retrofitted buses is not reducing NO_X emissions to the levels expected and retrofit performance is highly variable. These findings are consistent with the guidance issued in May 2023. Therefore, the publication of the study findings has no impact on the Investment-led Plan, the *Appraisal Report* and supporting material.

[15] https://assets.publishing.service.gov.uk/media/66e1ab11951c1776394a003c/bus-retrofit-performance-24.pdf

3 Modelling Background

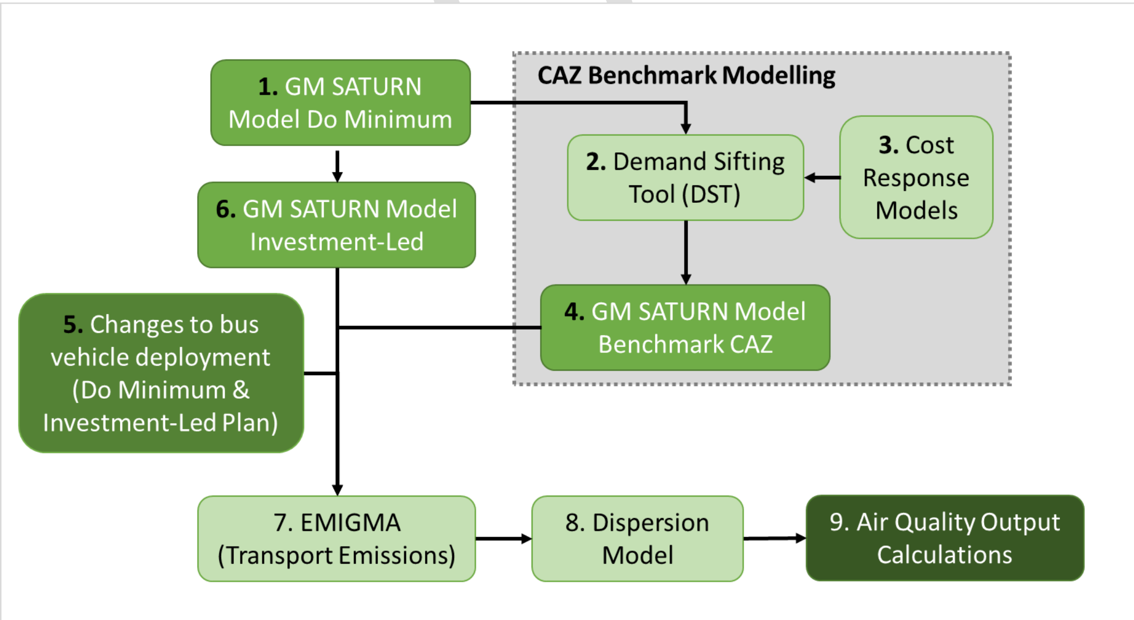
3.1 The Modelling Process

3.1.1 The overall modelling process has remained consistent throughout the development of the GM CAP, whilst updates have been made at relevant stages to take account of a number of factors including reflecting changes to revised vehicle fleet age assumptions (due to Covid-19) or as a response to policy refinements as a result of public consultations.

3.1.2 Throughout the development of the GM CAP, GM has worked closely with JAQU to meet the stated requirements and undertake proportionate analysis, as agreed with JAQU, and updates to the Plan to reflect external factors influence in complying with the Direction. GM has sought to undertake updates to the Plan to provide an accurate representation of modelled forecast conditions whilst recognising the need to act in the shortest possible time and that exposure to levels above the legal limit for nitrogen dioxide is reduced as quickly as possible.

3.1.3 The modelling for the study is being undertaken using the CAP modelling suite as illustrated below in **Figure 3-1**.

Figure 3-1: Overview of Modelling Suite



3.1.4 The modelling system consists of five the following components:

- **The Greater Manchester highway SATURN model (GMSM),** which uses information about the road network and travel demands for different years and growth scenarios to estimate traffic flows and speeds for input to the emissions model and forecasts of travel times, distances and flows for input to the economic appraisal.

- **Cost Response** models, which are models developed to better understand commercial vehicles, taxi, and coach/minibus behavioural changes to the GM CAP. These have been developed by assembling available data on the known fleets and movements within GM (and have been primarily developed to assess the impacts of GM CAP in the context of a CAZ Benchmark).
- **The Demand Sifting Tool (DST**) has been developed to allow measures to be tested in a quick and efficient way prior to detailed assessments being undertaken using the highway and air quality models. The sifting tool uses fleet specific Cost Response models to determine behavioural responses to the CAP proposals (pay charge, upgrade vehicle, change mode, cancel trip etc.). The outputs comprise demand change factors which are applied to the Do-Minimum Saturn matrices to create do-something demands for assignment (The DST has primarily been developed to assess the impacts of GM CAP in the context of a CAZ Benchmark).
- **The emissions model**, which uses TfGM's EMIGMA (Emissions Inventory for GM) software to combine information about traffic speeds and flows from the Saturn model with road traffic emission factors and fleet composition data from the Emission Factor Toolkit (EFT) to provide estimates of annual mass emissions for a range of pollutants including oxides of nitrogen (NOx), primary-NO_2, particulate matter (PM_{10} and $PM_{2.5}$) and CO_2.
- **The dispersion model**, which uses ADMS-Urban software to combine information about mass emissions of pollution (from EMIGMA) with dispersion parameters such as meteorological data and topography to produce pollutant concentrations.

3.1.5 Finally, the outputs of the dispersion model are processed to convert them to the verified air quality concentrations, using DEFRA tools and national background maps. The DST 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. This is considered to be acceptable, however, as the CAP does not affect travel by private cars and is not expected to have an appreciable impact on travel choices or congestion on the road network. It is noted that the DST and Cost Models are only utilised in the context of a CAZ Benchmark.

3.2 Data Sources

3.2.1 The following data is being used in the study in the context of the base model development:

- Traffic speed and flow data from the highway model
- Information about the vehicle fleet composition in GM from Automatic Number Plate Recognition surveys (ANPR)

- Road traffic emission factors and national fleet composition data from version 9.1a of Defra's EFT
- Information about the bus fleet composition in Greater Manchester from TfGM's Punctuality and Reliability Monitoring Survey (PRMS) and the GM Bus Route Mapping system for 2015 and 2019

3.3 Model Specifications

3.3.1 The modelling system that is being used in the study consists of five components:

- Cost Response models, which are models developed to better understand commercial vehicle, taxi, and coach/minibus behavioural changes to the GM CAP. These have been developed by assembling available data on the known fleets and movements within GM;
- A DST, 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 software to combine information about traffic flows and speeds from the highway model with road traffic emission factors and fleet composition data from DEFRA's emission factor toolkit to provide estimates of annual mass emissions for a range of pollutants including Oxides of Nitrogen (NOx), Particulate Matter (PM_{10} and $PM_{2.5}$) and CO_2;
- 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.

3.3.2 This approach has been consistently applied throughout the GM CAP and has been reviewed and approved by JAQU through previous submission of the transport reporting documentation.

3.4 Documentation

3.4.1 The report is part of a suite of documents that have been produced to describe the transport modelling deliverables for the study. The 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), this document;

- *Local Plan Transport Modelling Methodology Report (T3)*, which discusses the development of the future year do minimum modelling;
- *Local Plan Transport Model Forecasting Report (T4)*, which presents baseline and scenario forecasts for the CAP;
- *Local Plan Air Quality Modelling Tracking Table (AQ1)*, which is a live document, that is intended to demonstrate that the modelling requirements for the study are being met;
- *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 NO_2 concentrations for the base and forecast years, including comparisons with measured concentrations for the base year; and
- *Sensitivity Testing Report*, which provides a summary of the sensitivity tests carried out on the core scenarios to test areas of uncertainty, understand whether the tests result in a positive or negative benefit and the scale of benefit.

4 Highway Modelling

4.1 Overview

4.1.1 The highway modelling is being carried out using TfGM's Greater Manchester Saturn model. Geographically, the model is focused on GM, although it does extend to cover all of Great Britain, albeit in increasingly less detail with increasing distance from the GM boundary.

4.1.2 Separate versions of the model are maintained for a weekday morning peak hour 0800-0900, evening peak hour 1700-1800 and an average inter-peak hour for the time period 1000-1530.

4.1.3 The model has two main components comprising:

- The highway networks, which represent the roads and junctions used by traffic and bus services
- The trip matrices, which represent the demand for travel and the flow of vehicles between the zones in the model.

4.1.4 There are, however, a number of subsidiary files associated with the model, including:

- Files providing additional data items for network links, such as the road class and number
- A GIS file, used by Saturn to display links as curves rather than straight lines
- MapInfo node and link tables, to allow the network to be viewed in MapInfo and other GIS packages that make use of the ESRI file format.

4.1.5 The GMSM trip matrices contain representations of all vehicle trips with an origin or destination inside GM and all external-to-external trips that cross the GM boundary. The matrices also include partial representations of other external-to-external trips that do not enter GM, but which are included in the model to produce generalised cost responses in the buffer network area.

4.1.6 Separate demand matrices are maintained for car, Light Goods Vehicle (LGV) and Other Goods Vehicle (OGV) trips, with the car matrices being disaggregated into three 'user classes' comprising:

- Commuting cars trips
- Employers' business car trips
- Other car trips

4.1.7 The standard model therefore represents five user classes in total.

4.1.8 Buses are not included in the assignment matrices but are represented in the model as fixed link loads, with routes defined as chains of nodes in the buffer and simulation networks.

4.2 Model Availability

4.2.1 Several versions of the Saturn model were available for use in the GM CAP project, which had been previously developed for the appraisal of different transport schemes for different future year situations. It was decided, however, to use the version of the model that been developed for the appraisal of the planned extension of the GM Metrolink system through Trafford Park as the starting point for this study. This model (referred to as the TPL variant of the GMSM) was considered to be most appropriate given its base year of 2013, (which was close to the 2016 base year required for this project), and its forecast year of 2020, which was close to the anticipated opening year of the final package of measures which will be taken forward by GM.

4.2.2 Further information about the TPL model is available in References 4 and 5.

4.3 Updates to the Base Year Model

4.3.1 The base year for the GM CAP highway model is 2016. The starting point for the re-validated 2016 Saturn model was the 2013 Trafford Park model. The model was formed in two stages comprising:

- Updates to the 2013 highway networks
- Updates to the 2013 trip matrices

4.4 Network Updates

4.4.1 The following updates were made to the 2013 highway networks:

- Coding updates to include the highway impacts of the Manchester Metrolink Phase 3B extensions to Ashton-Under-Lyne (which opened in October 2013), Oldham Town Centre (which opened in January 2014), Rochdale Town Centre (which opened in March 2014) and Manchester Airport (which opened in November 2014);
- Coding updates to implement speed limit restrictions associated with roadworks for the M60 Jn 8 - M62 Jn 20 ‘Smart Motorway’ scheme;
- Updates to the bus routing data (described below); and
- Updates to the values of time and distance, (PPM and PPK), used during the assignments, based on the latest values of time, GDP growth rates and vehicle operating costs derived from the TAG data book, July 2017.

4.5 Bus Data

4.5.1 The bus routing data was updated to include up-to-date information about local bus flows based on 2015 services.

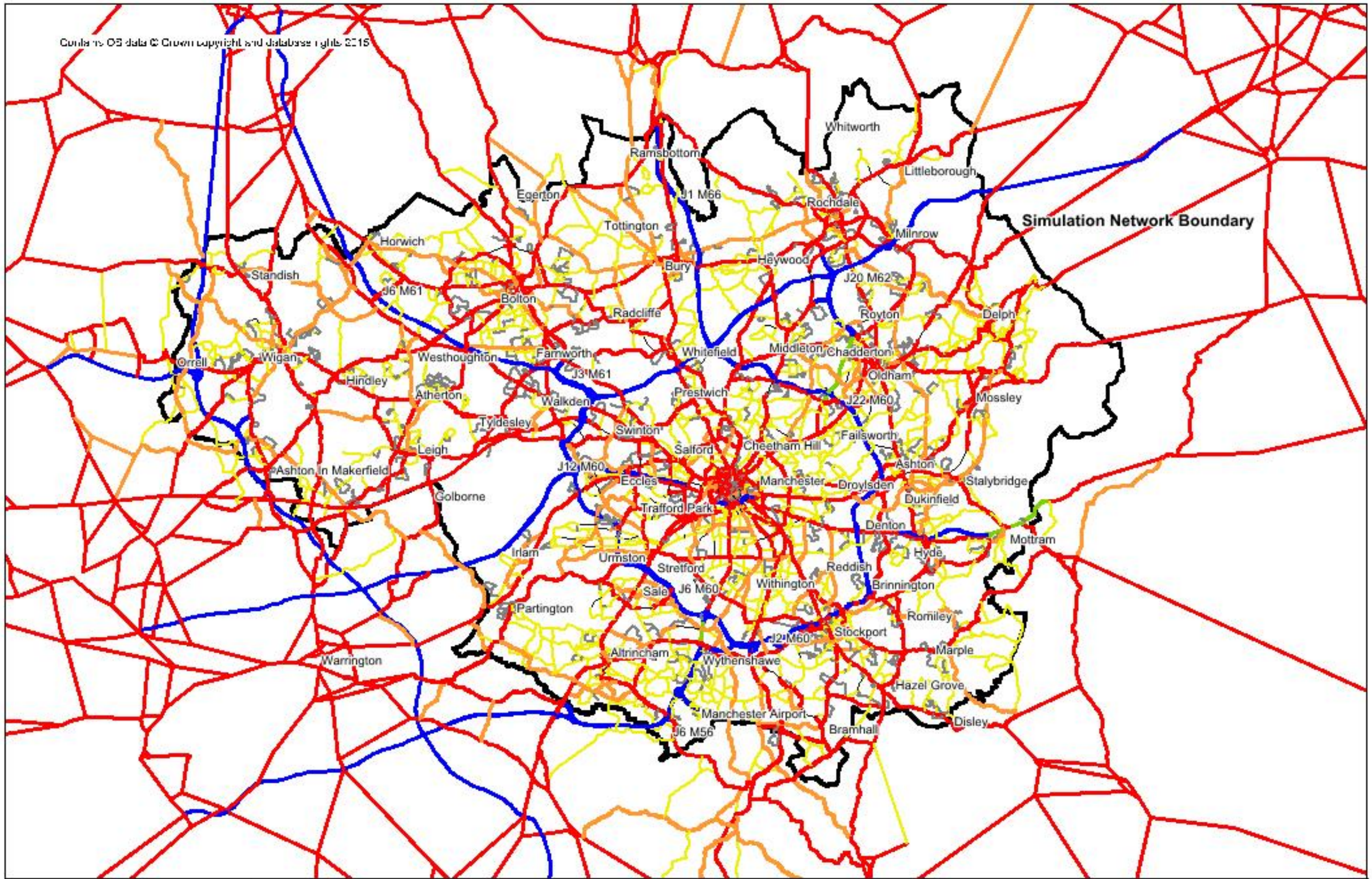
4.5.2 The fleet mix of the bus services (i.e. the percentages of buses that are compliant with different emission standards) was adjusted assuming that the age profile for each service (i.e. the percentage of buses that are x years old) would be unchanged in the future. Adopting this approach, if, (for example), 5% of the buses for a given service in 2015 were two years old (or had been retrofitted to have the emission standard equivalent to a three year old bus), then it was assumed that 5% of buses for that service would also be two years old in 2016, and would therefore meet the equivalent emission standard for 2014. This allowed an estimate of the proportion of vehicles meeting different Euro standards in the 2016 base year to be made, based on their age.

4.5.3 The 2016 values of time (pence per minute – PPM) and distance (pence per kilometre – PPK) are shown below in **Table 4- 1**. The 2016 Saturn network is shown in **Figure 4- 1**.

Table 4- 1: 2016 Generalised Cost Parameters (2010 Prices)

Period	User Class	PPM (Pence/Min)	PPK (Pence/km)
AM Peak Hour	Compliant/Non-Compliant Cars	19.34	7.98
	Compliant/Non-Compliant LGVs	21.12	14.23
	Compliant/Non-Compliant OGVs	21.60	52.03
	Compliant/Non-Compliant Taxis	26.62	14.45
Inter-Peak Hour	Compliant/Non-Compliant Cars	18.14	7.31
	Compliant/Non-Compliant LGVs	21.12	13.51
	Compliant/Non-Compliant OGVs	21.60	46.25
	Compliant/Non-Compliant Taxis	26.62	13.14
PM Peak Hour	Compliant/Non-Compliant Cars	18.81	7.47
	Compliant/Non-Compliant LGVs	21.12	14.04
	Compliant/Non-Compliant OGVs	21.60	50.74
	Compliant/Non-Compliant Taxis	26.62	14.15

Figure 4- 1: 2016 Saturn Network



Transport for Greater Manchester 2 Piccadilly Place, Manchester, M1 3BG	The 2016 Saturn Network			
	Drawn By : A. Morris	Scale : Not Applicable	Date : February 2018	Traffic Modelling Report Figure 3.1

4.6 Trip Matrix Updates

4.6.1 The 2013 TPL demand matrices were built using roadside interview data that TfGM had collected on cordons and screenlines in GM over the period Spring 2002 to Autumn 2013 since the completion of the final section of the M60 Manchester outer Ring Road. In total, data from approximately 450 sites was used.

4.6.2 Car trips that were not observed in the roadside interview surveys were estimated using information from:

- Census journey to work data for commuting trips
- Synthetic movements from pre-existing matrices for other purposes.

4.6.3 Non-observed movements in the commercial vehicle matrices were infilled using data from pre-existing matrices for LGV trips, and using information from the Great Britain Freight Model (GBFM) for OGV trips. (Further information about the development of the Trafford Park matrices is available in Reference 4).

4.6.4 The 2013 matrices were converted to the new base year of 2016 in three stages, as illustrated below in **Figure 4- 2**.

- First, matrix estimation was used to improve the fit between modelled and counted flows in the 2013 network at key sites in the study area
- Second, the updated matrices were factored from 2013 to 2016
- Third, the matrices were disaggregated to eight user classes to allow the different vehicle types that might be affected by a charging CAZ to be separately identified in the updated model.

4.6.5 Separate runs of the matrix estimation procedure were carried out for car, LGV and OGV trips using traffic counts derived from TfGM's traffic counts database. The counts that were input to the procedure were focused on town centre cordons and screenlines where it was thought that they would provide a significant improvement to the original matrix, and at 11 sites identified by JAQU using the national Pollution Climate Mapping Model, (PCM), where target NO_2 concentrations were likely to be exceeded in 2015. (Further details of the matrix estimation runs are provided in *Appendix A*, including comparisons of matrix totals, trip end totals and trip length distributions for the prior and updated matrices).

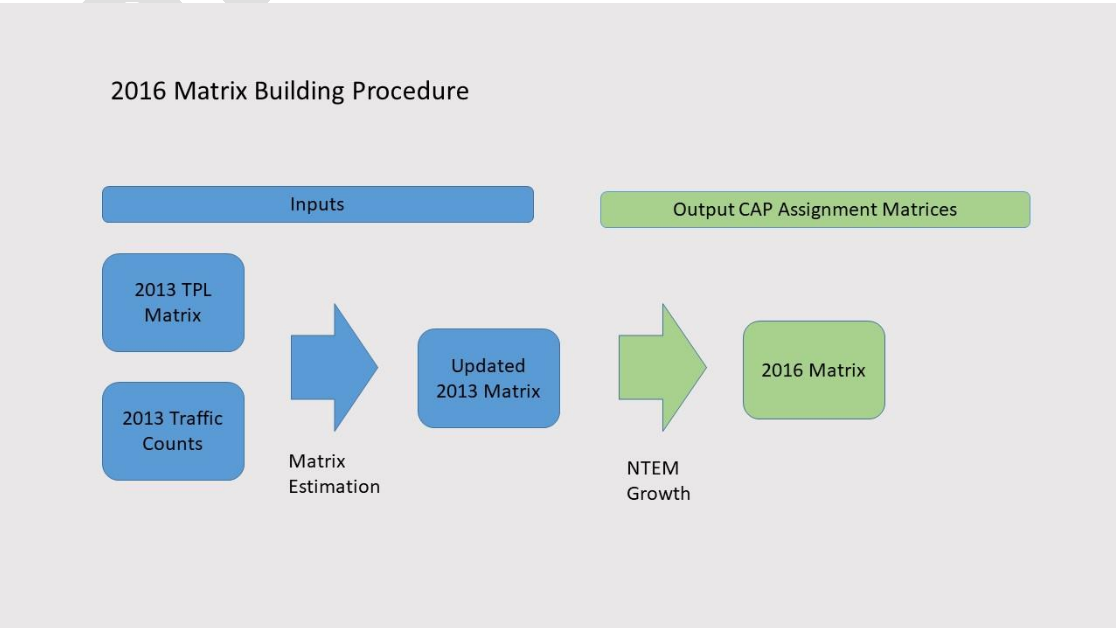
4.6.6 The updated 2013 car matrices (as output from the matrix estimation procedure) were factored to 2016 using traffic growth factors calculated from the DfT's TEMPro/NTEM Version 7.2 datasets. The growth factors were applied at local authority district level within GM, separately by journey purpose, using Saturn's matrix furnessing procedure.

4.6.7 The commercial vehicle matrices were adjusted by applying blanket factors to the LGV and OGV matrices, based on forecast changes in freight traffic calculated from the National Transport Model (NTM) for the North West Region between 2013 and 2016.

4.6.8 The percentage changes in all vehicle trip totals made by the TEMPro factoring were as follows:

- AM Peak Hour: -2.1%
- Inter-Peak Hour -2.1%
- PM Peak Hour -1.8%

Figure 4- 2: 2016 Matrix Building Procedure



4.7 Matrix Segmentation

4.7.1 The number of user classes in the demand matrices used with the model was expanded to allow the different vehicle types that might be affected by a charging CAZ to be separately identified in the re-validated model. The updated matrices represented eight user classes comprising:

- 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

4.7.2 The matrices were formed in two stages:

- First, taxi matrices (comprising black cab and private hire cars combined) were created by applying blanket factors to the car matrices (for trips with an origin or destination inside GM) based on the number of taxi trips as a proportion of total car trips calculated from ANPR data collected in 2016 at sites within GM The estimated taxi trips were then subtracted from the car matrices to avoid any 'double counting'.
- Next, the matrices were disaggregated into compliant and non-compliant vehicle types using information about the local fleet mix also obtained from the ANPR data.

4.7.3 The ANPR analysis used GM Police vehicle class information to identify vehicle type and fuel, plus cross referencing with local authority licensing information on buses, and taxis (hackney carriage and private hire).

4.7.4 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.

4.7.5 The projection approach keeps the vehicle age profile constant for any given future year (e.g. 2025), and then re-calculates the Euro standard at this point in time. The approach conserves the age distribution of the vehicle population for each class/fuel, to produce the fleet mix for the future year based on this constant distribution.

4.7.6 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).

4.7.7 Details of the local fleet composition data used in the process are given below in **Table 4- 2** and **Table 4- 3**.

Table 4- 2: Fleet Composition by Euro Standard

Euro Standard	2016 Base							
	Petrol Car	Diesel Car	Petrol Taxi	Diesel Taxi	Petrol LGV	Diesel LGV	Diesel HGV	Diesel Bus
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	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4- 3: Percentage Petrol/Diesel Cars/Taxis by Year

Year	Cars		Taxis	
	Petrol	Diesel	Petrol	Diesel
2016	50.7%	49.3%	4.0%	96.0%

4.8 Sector to Sector Movements

4.8.1 **Table 4- 4** shows sector to sector movements from the 2016 demand matrices for all vehicle PCU trips with an origin or destination inside GM, for the five areas shown in **Figure 4- 3**.

4.8.2 The results for the AM peak hour show that approximately 10% of vehicles with an origin or destination inside the Regional Centre are travelling to or from areas outside of GM (External). The majority of these trips are made by cars, which represent 90% of the total. Trips with an origin or destination inside the Intermediate Ring Road sector represent 9% of total trips to and from the Regional Centre, with trips starting and ending within the 'Inside M60' area representing 40% of the total and the 'Outside M60 area 31% of the total.

4.8.3 Approximately 13% of the vehicles with an origin or destination inside the M60 are travelling to and from areas outside GM in the morning peak hour (External), with approximately 40% of trips having an origin or destination in the 'Outside M60 area, which comprises zones outside of the M60 but inside GM. Approximately 48% of trips begin and end in the internal area (comprising the Regional Centre, IRR and 'Inside M60' Sectors).

4.8.4 The origins and destinations of trips in the other time periods follow a similar pattern, with the sector to sector movements for the M60 area showing that approximately 36% of trips have an origin or destination in the 'Outside M60' area in the Inter-peak hour and 44% of trips having an origin or destination in this area in the PM peak hour. Approximately 52% of trips begin and end inside the M60 in the inter-peak hour, with 42% of trips beginning or ending in the internal area in the evening peak hour.

4.8.5 **Table 4- 5** shows trip totals from the 2016 demand matrices broken down by user class for trips with an origin or destination inside GM. The table shows that 46% of cars trips 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 are 27% and 9% respectively, with approximately 39% of vehicles overall being compliant.

Table 4- 4: Sector to Sector Movements for Trips with an Origin or Destination Inside GM (2016, All Vehicle PCUs)

AM Peak Hour						
Sector	**Regional Centre**	**IRR**	**Inside M60**	**Outside M60**	**External**	**Total**
Regional Cen	1,453	722	1,415	1,128	518	5,236
IRR	778	1,981	5,041	1,014	619	9,432
Inside M60	4,828	10,389	39,420	22,106	7,534	84,278
Outside M60	3,771	4,419	24,268	186,901	35,220	254,581
External	1,025	1,537	7,183	38,990	N/A	48,735
Total	11,855	19,049	77,328	250,140	43,890	402,262
Inter-Peak Hour						
Sector	**Regional Centre**	**IRR**	**Inside M60**	**Outside M60**	**External**	**Total**
Regional Cen	1,707	979	1,796	1,375	776	6,635
IRR	850	2,037	6,058	1,695	932	11,572
Inside M60	2,326	5,777	37,630	17,654	5,616	69,002
Outside M60	1,714	1,645	16,887	174,328	25,742	220,317
External	805	704	5,081	26,334	N/A	32,924
Total	7,403	11,142	67,452	221,387	33,066	340,450
PM Peak Hour						
Sector	**Regional Centre**	**IRR**	**Inside M60**	**Outside M60**	**External**	**Total**
Regional Cen	791	1,213	4,583	3,749	1,190	11,527
IRR	877	1,613	8,477	5,089	1,720	17,777
Inside M60	3,066	4,942	33,103	27,464	7,532	76,106
Outside M60	1,635	1,542	22,390	175,784	35,226	236,578
External	593	1,229	7,195	43,053	N/A	52,070
Total	6,962	10,540	75,747	255,140	45,668	394,058

Figure 4- 3: Matrix Sectoring System

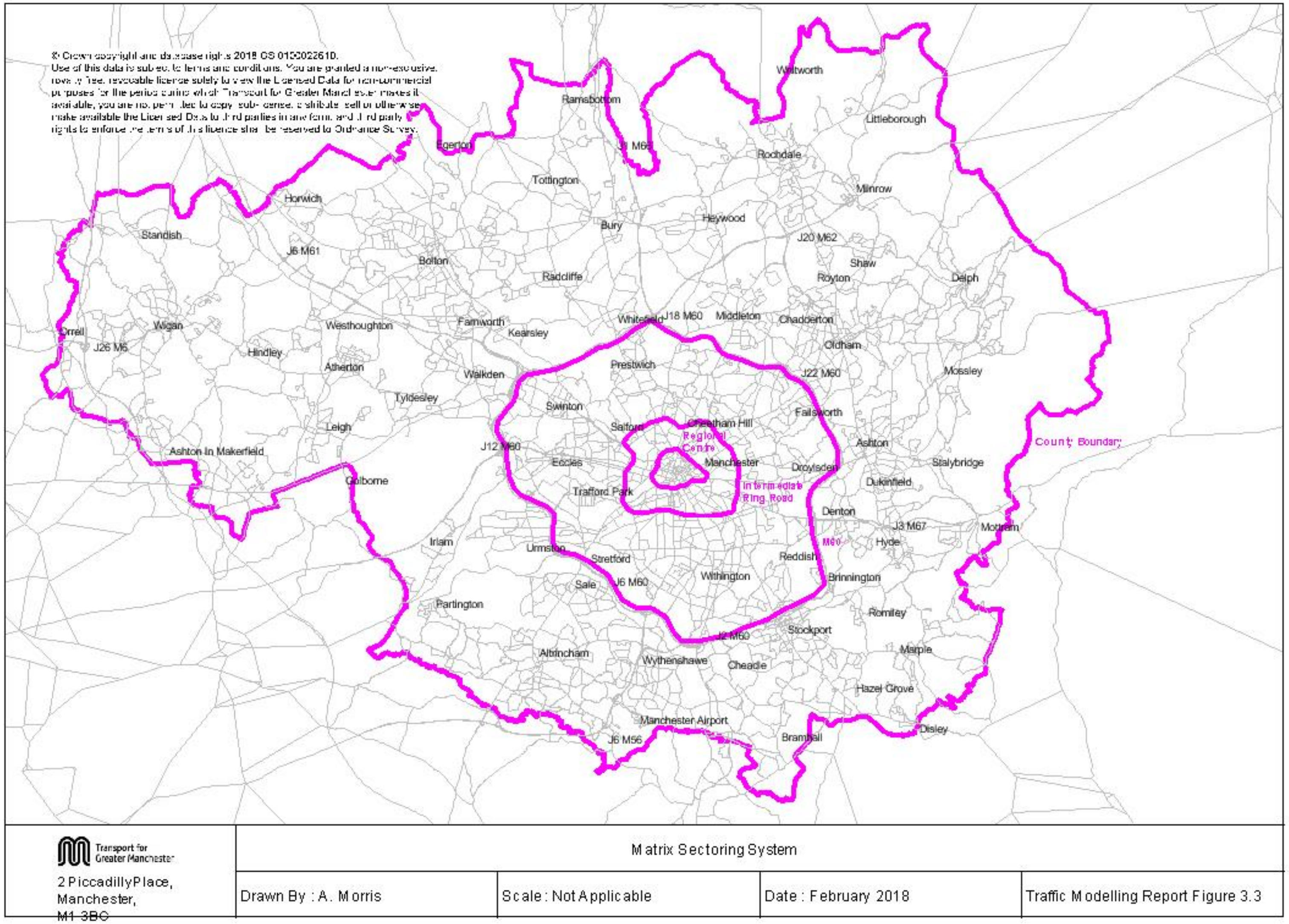


Table 4- 5: Matrix Totals for Trips with an Origin or Destination Inside GM (2016, PCUs)

Vehicle Type	2016					
	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		259,801		325,449	
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		40,844		35,468	
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		20,850		9,396	
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		18,955		23,745	
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		340,450		394,058	

5 Assignment Validation

5.1 Introduction

5.1.1 This section presents the assignment validation results for the re-validated 2016 Saturn model. It summarises the level of network convergence and compares assigned and observed link flows for the modelled time periods using criteria set out in TAG Unit M3.1 (Reference 6).

5.2 Network Convergence

5.2.1 The process of assigning the trip matrices to the highway networks involves an iterative procedure, that includes a looped sequence of steps in which the routes between the zones in the traffic model are determined, the movements between these zones in the trip matrices are loaded onto the network, the network link speeds are re-calculated using the flow-delay relationships within the model, new routes are determined etc. until the traffic flows and link speeds do not change significantly from one iteration to the next. At this point, the network is said to be 'converged'. It is important that the assignment is satisfactorily converged if it is to provide stable and reliable results. Particular efforts were therefore made to ensure that the highway networks were as highly converged as possible.

5.2.2 The TAG 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
- more than 98% of links should have a flow that changes by less than 1% on the final 4 iterations.

5.2.3 **Table 5-1** shows the above values for each of the modelled hours. The table indicates that the model was well converged in all time periods, with Delta and GAP values well below 0.1% and the percentage of links with flows changing by less than 1% meeting the criteria in all cases.

Table 5- 1: 2016 Saturn Model Network Convergence Statistics

Criterion	Target	AM Peak	Inter Peak	PM Peak
Delta	< 0.1%	0.030%	0.013%	0.025%
%GAP	< 0.1%	0.018%	0. 018%	0.028%
% of links with < 1% flow change on final iteration	> 98%	98.1%	98.3%	98.2%
Final iteration -1		98.3%	98.3%	98.2%
Final iteration -2		98.2%	98.3%	98.1%
Final iteration -3		98.7%	98.1%	98.1%

5.3 Link Flow Validation Criteria

5.3.1 TAG M3.1 Table 2 sets out validation acceptability guidelines for comparing modelled and observed traffic flows based on the level of flow in vehicles per hour (vph). These are:

- **For observed flows less than 700 vph**, at least 85% of model flows should be within 100 vph of observations
- **For observed flows of between 700 and 2,700 vph**, at least 85% of model flows should be within 15% of observations
- **For observed flows greater than 2,700 vph**, at least 85% of model flows should be within 400 vph of observations

These guidelines are referred to as the TAG flow criteria in the text, and as '% Flow Criteria' in the tables.

5.3.2 Given that Saturn matrices are generally stored in units of PCUS, the above criteria are assumed to apply in PCUS per hour.

5.3.3 In addition to the flow criteria described above, TAG also refers to the GEH statistic, where;

$$GEH = \sqrt{\frac{(M-C)^2}{(M+C) \quad /2}}$$

and M is the modelled flow and C is the counted (observed) flow.

The GEH statistic is a form of Chi squared statistic, incorporating both relative and absolute errors. TAG recommends that greater than 85% of counted links should have a GEH value of less than 5.0.

5.3.4 The guidance also requires that for any cordons and screenlines, that the difference between the modelled and counted flows should be less than 5% of the counts in nearly all cases.

5.4 Traffic Count Data

5.4.1 The traffic count for use in the validation was derived from Manual Classified Counts from TfGM's traffic counts database.

5.4.2 The manual counts were selected by extracting all link and turn counts carried out by HFAS between 1st January 2010 and the present day, excluding any counts affected by known 'unusual' events such as accidents, road works, adverse weather conditions and holidays. (1st January 2010 was chosen as the earliest count date to exclude older counts that might be unreliable due to changes in travel patterns and traffic flows over time). Note, however, that some older counts undertaken before 1st January 2010 were subsequently included, to help fill 'holes' in cordons and screenlines. Note, also, that the turn counts were aggregated to form 'derived' link counts for model validation/calibration purposes.

5.4.3 Separate counts were obtained for cars, LGVs, OGVs and all vehicle PCUs, for the morning peak hour (0800-0900), the evening peak hour (1700-1800) and an average inter-peak hour for the period 1000-1600/6. All of the counts that were used in the validation were factored to a 2016 October average weekday using locally derived factors (Reference 7).

5.5 Results – Overview

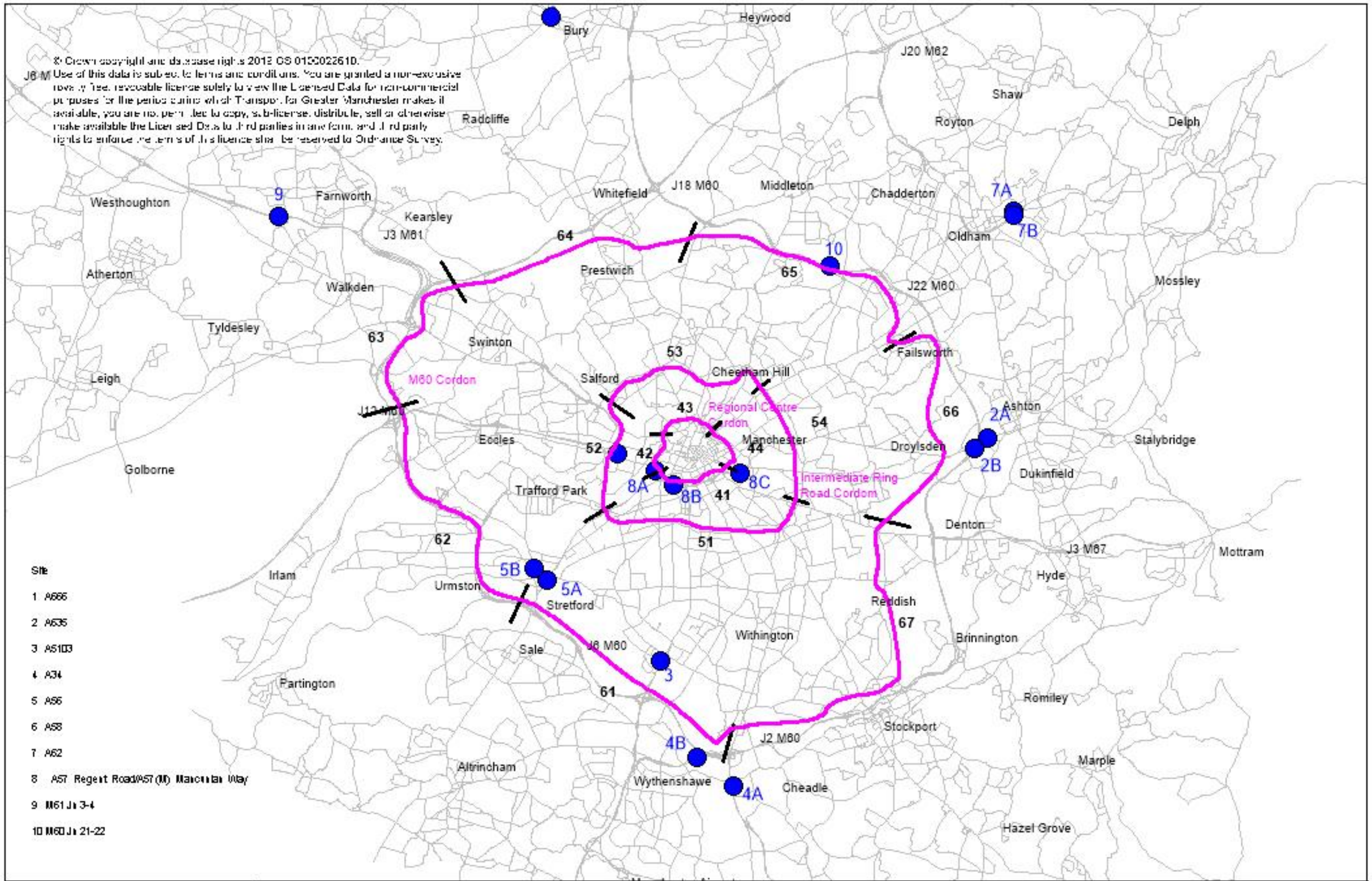
5.5.1 The performance of the updated highway model has been assessed by comparing modelled and counted link flows in the inbound and outbound directions on three cordons comprising:

- A cordon around Manchester City Centre;
- A cordon inside the Intermediate Ring Road; and
- A cordon inside the M60.

5.5.2 Comparisons have also been undertaken at 10 sites identified by JAQU using the national PCM model where target NO_2 concentrations were likely to be exceeded in 2021, as illustrated in **Figure 5- 1**.

5.5.3 When considering the results, it is important to bear in mind that the TAG validation criteria will be difficult to achieve in large scale strategic models, and that a failure to meet the validation standards does not necessarily mean that the model is not fit for purpose. It should also be borne in mind that the majority of the counts that have been used in the validation were also used as inputs to the matrix estimation procedure described earlier. Whilst this does not follow the guidance given in TAG, which recommends that an independent set of counts should always be reserved for validation purposes, it does ensure that maximum use is made of the available data, and is more likely to provide reliable estimates of present day traffic movements for assignment.

Figure 5- 1: Link Flow Validation Count Site Locations



Transport for Greater Manchester 2 Piccadilly Place, Manchester, M1 3BC	Clean Air Zone Modelling Link Flow Validation Cordons and Isolated Count Sites			
	Drawn By : A. Morris	Scale : Not Applicable	Date : February 2019	Traffic Modelling Report Figure 4.1

5.6 Cordon Comparisons

5.6.1 **Table 5- 2** to **Table 5- 5** present assignment validation statistics for the three time periods for car, LGV, OGV and all-vehicle PCU flows.

5.6.2 For each cordon, the tables show the number of count sites, the total observed flow, the total modelled flow, the difference between the modelled and observed flows and the percentage difference between the modelled and observed flows. The tables also show the percentage of sites with a GEH value of less than five and the GEH value for the cordon as-a-whole. The figures in the column headed '% Flow Criteria' give the percentage of counted links that meet TAG link flow criteria, as described above.

5.6.3 The validation results for the car flows (as shown in **Table 5- 2**) are generally good for the AM peak hour, with only the M60 cordon in the inbound direction failing the 5% difference criteria across the cordon as-a-whole. The cordon only marginally fails the criteria however, with a 3% over-assignment in the outbound direction and a five percent under-assignment in the in the inbound direction.

5.6.4 The results for the PM peak hour are also reasonably good, with only the Intermediate Ring Road cordon in the outbound direction failing the 5% difference criteria. The results for the Regional Centre cordon show that the modelled flows are within 1% of the of the observed flows in both the inbound and outbound direction, with cordon GEH values less than 1.0 in both cases. The results for the inter-peak hour slightly lower, with the Intermediate Ring Road cordon failing to meet the percentage flow criteria in both the inbound and outbound directions. There is a general under-assignment in the inter-peak hour, with modelled flows across all cordons being less than the observed flows and the total flow as-a-whole being approximately 3% less than the count. Approximately 79% of the sites have a GEH values of less than 5.0, however, which is fairly good.

5.6.5 The link flow comparisons for LGVs are shown in **Table 5- 3**. In general, the results are reasonably good, with most cordons having a GEH value of less than 4.0 and more than 90% of sites having a GEH values of less than 5.0 in all time periods. The majority of the cordons have a percentage difference between modelled and counted flows of less than 5%, although only two out of six of the cordons meet this criterion in the PM peak hour. In general, however, the absolute differences between the flows for the cordons are small, and are still considered to be within an acceptable level.

5.6.6 The cordon comparisons for OGV flows are shown in **Table 5- 4**. Overall, the results are reasonably good, with all cordons having a GEH value of less than 4.0 in all time periods, with the exception of the M60 cordon in the inbound direction in the PM peak hour. The results for the PM peak hour appear to be the worst overall, with only the Intermediate Ring Road and the M60 cordons in the outbound direction meeting the 5% difference criteria. In most cases, however, the absolute differences between the modelled and observed flows are small, with the possible exception of the M60 cordon in the inbound direction, where there is an under-assignment of approximately 160 PCUs per hour, which is equivalent to approximately 80 vehicles.

5.6.7 Further details the link flow validation are provided in *Appendix B*, including summaries of modelled cordon crossing flows broken down into screenlines.

Table 5- 2: Modelled and Observed Car Cordon Crossing Flows

Cordon	Direction	No of sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Cordon GEH
Weekday AM Peak Hour									
Regional Centre	Inbound	22	10,781	10,588	-193	-1.8%	81.8%	72.7%	1.9
	Outbound	20	4,498	4,448	-50	-1.1%	90.0%	80.0%	0.7
Intermediate Ring Road	Inbound	41	27,530	27,229	-301	-1.1%	82.9%	78.0%	1.8
	Outbound	41	13,277	13,024	-253	-1.9%	97.6%	90.2%	2.2
M60 Cordon	Inbound	46	42,418	40,190	-2,228	-5.3%	87.0%	82.6%	11.0
	Outbound	46	27,723	28,464	741	2.7%	69.6%	71.7%	4.4
All		216	126,227	123,943	-2,284	-1.8%	84.3%	79.6%	6.5
Weekday Inter-Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	5,357	5,125	-232	-4.3%	77.3%	72.7%	3.2
	Outbound	20	4,094	3,955	-139	-3.4%	80.0%	75.0%	2.2
Intermediate Ring Road	Inbound	41	14,379	13,456	-923	-6.4%	87.8%	80.5%	7.8
	Outbound	41	13,636	12,570	-1,066	-7.8%	80.5%	65.9%	9.3
M60 Cordon	Inbound	46	24,169	23,497	-672	-2.8%	91.3%	89.1%	4.4
	Outbound	46	24,608	24,755	147	0.6%	87.0%	84.8%	0.9
All		216	86,243	83,358	-2,885	-3.3%	85.2%	79.2%	9.9
Weekday PM Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	6,335	6,305	-30	-0.5%	72.7%	50.0%	0.4
	Outbound	20	9,967	9,894	-73	-0.7%	65.0%	65.0%	0.7
Intermediate Ring Road	Inbound	41	16,614	16,359	-255	-1.5%	90.2%	82.9%	2.0
	Outbound	41	26,930	25,457	-1,473	-5.5%	82.9%	73.2%	9.1
M60 Cordon	Inbound	46	33,051	32,140	-911	-2.8%	76.1%	78.3%	5.0
	Outbound	46	44,717	44,942	225	0.5%	71.7%	73.9%	1.1
All		216	137,614	135,097	-2,517	-1.8%	77.8%	73.2%	6.8

Table 5- 3: Modelled and Observed Light Goods Vehicle Cordon Crossing Flows

Weekday AM Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	848	870	22	2.6%	100.0%	86.4%	0.8
	Outbound	20	514	532	18	3.5%	100.0%	95.0%	0.8
Intermediate Ring Road	Inbound	41	2,420	2,631	211	8.7%	100.0%	100.0%	4.2
	Outbound	41	1,626	1,774	148	9.1%	100.0%	90.2%	3.6
M60 Cordon	Inbound	46	5,102	5,231	129	2.5%	100.0%	97.8%	1.8
	Outbound	46	4,248	4,247	-1	0.0%	100.0%	91.3%	0.0
All		216	14,758	15,285	527	3.6%	100.0%	94.0%	4.3
Weekday Inter-Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	894	875	-19	-2.1%	100.0%	86.4%	0.6
	Outbound	20	859	851	-8	-0.9%	100.0%	85.0%	0.3
Intermediate Ring Road	Inbound	41	2,410	2,477	67	2.8%	100.0%	97.6%	1.4
	Outbound	41	2,517	2,598	81	3.2%	100.0%	92.7%	1.6
M60 Cordon	Inbound	46	4,261	4,572	311	7.3%	100.0%	100.0%	4.7
	Outbound	46	4,465	4,842	377	8.4%	100.0%	93.5%	5.5
All		216	15,406	16,215	809	5.3%	100.0%	94.0%	6.4
Weekday PM Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	384	409	25	6.5%	100.0%	100.0%	1.3
	Outbound	20	498	531	33	6.6%	100.0%	100.0%	1.5
Intermediate Ring Road	Inbound	41	1,316	1,421	105	8.0%	100.0%	97.6%	2.8
	Outbound	41	1,885	1,843	-42	-2.2%	100.0%	95.1%	1.0
M60 Cordon	Inbound	46	3,315	3,369	54	1.6%	100.0%	93.5%	0.9
	Outbound	46	4,061	4,266	205	5.1%	100.0%	95.7%	3.2
All		216	11,459	11,839	380	3.3%	100.0%	96.3%	3.5

Table 5- 4: Modelled and Observed Other Goods Vehicle Cordon Crossing Flows (PCUs)

Weekday AM Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	227	230	3	1.3%	100.0%	100.0%	0.2
	Outbound	20	243	248	5	2.1%	100.0%	100.0%	0.3
Intermediate Ring Road	Inbound	41	958	1,069	111	11.6%	100.0%	92.7%	3.5
	Outbound	41	921	939	18	2.0%	100.0%	90.2%	0.6
M60 Cordon	Inbound	46	2,518	2,348	-170	-6.8%	100.0%	91.3%	3.4
	Outbound	46	2,562	2,481	-81	-3.2%	100.0%	89.1%	1.6
All		216	7,429	7,315	-114	-1.5%	100.0%	92.6%	1.3
Weekday Inter-Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	247	238	-9	-3.6%	100.0%	95.5%	0.6
	Outbound	20	280	275	-5	-1.8%	100.0%	95.0%	0.3
Intermediate Ring Road	Inbound	41	1,117	1,102	-15	-1.3%	100.0%	92.7%	0.5
	Outbound	41	1,166	1,206	40	3.4%	100.0%	92.7%	1.2
M60 Cordon	Inbound	46	2,615	2,513	-102	-3.9%	97.8%	87.0%	2.0
	Outbound	46	2,747	2,713	-34	-1.2%	97.8%	89.1%	0.7
All		216	8,172	8,047	-125	-1.5%	99.1%	91.2%	1.4
Weekday PM Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	60	70	10	16.7%	100.0%	95.5%	1.2
	Outbound	20	81	93	12	14.8%	100.0%	100.0%	1.3
Intermediate Ring Road	Inbound	41	298	313	15	5.0%	100.0%	100.0%	0.9
	Outbound	41	368	374	6	1.6%	100.0%	97.6%	0.3
M60 Cordon	Inbound	46	1,106	949	-157	-14.2%	97.8%	91.3%	4.9
	Outbound	46	1,222	1,245	23	1.9%	100.0%	78.3%	0.7
All		216	3,135	3,044	-91	-2.9%	99.5%	92.6%	1.6

Table 5- 5: Modelled and Observed All Vehicle PCU Cordon Crossing Flows

Cordon	Direction	No of sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Cordon GEH
Weekday AM Peak Hour									
Regional Centre	Inbound	22	12,739	12,498	-241	-1.9%	72.7%	68.2%	2.1
	Outbound	20	6,111	5,958	-153	-2.5%	85.0%	85.0%	2.0
Intermediate Ring Road	Inbound	41	31,809	31,754	-55	-0.2%	82.9%	78.0%	0.3
	Outbound	41	16,761	16,528	-233	-1.4%	97.6%	90.2%	1.8
M60 Cordon	Inbound	46	50,955	48,575	-2,380	-4.7%	87.0%	84.8%	10.7
	Outbound	46	35,402	36,017	615	1.7%	63.0%	67.4%	3.3
All		216	153,777	151,330	-2,447	-1.6%	81.5%	79.2%	6.3
Weekday Inter-Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	7,487	6,959	-528	-7.1%	77.3%	68.2%	6.2
	Outbound	20	6,232	5,776	-456	-7.3%	70.0%	70.0%	5.9
Intermediate Ring Road	Inbound	41	18,977	17,745	-1,232	-6.5%	80.5%	73.2%	9.1
	Outbound	41	18,409	17,111	-1,298	-7.1%	78.0%	70.7%	9.7
M60 Cordon	Inbound	46	32,198	31,272	-926	-2.9%	87.0%	84.8%	5.2
	Outbound	46	33,006	33,047	41	0.1%	82.6%	80.4%	0.2
All		216	116,309	111,910	-4,399	-3.8%	80.6%	75.9%	13.0
Weekday PM Peak Hour									
Cordon	**Direction**	**No of sites**	**Observed Flow**	**Modelled Flow**	**Diff**	**% Diff**	**% Flow Criteria**	**% GEH <5**	**Cordon GEH**
Regional Centre	Inbound	22	7,738	7,432	-306	-4.0%	77.3%	54.5%	3.5
	Outbound	20	11,619	11,239	-380	-3.3%	70.0%	65.0%	3.6
Intermediate Ring Road	Inbound	41	19,263	18,735	-528	-2.7%	90.2%	82.9%	3.8
	Outbound	41	30,357	28,433	-1,924	-6.3%	85.4%	78.0%	11.2
M60 Cordon	Inbound	46	38,722	37,023	-1,699	-4.4%	76.1%	78.3%	8.7
	Outbound	46	51,345	51,138	-207	-0.4%	73.9%	76.1%	0.9
All		216	159,044	154,000	-5,044	-3.2%	79.6%	75.0%	12.7

5.7 PCM Site Comparisons

5.7.1 **Table 5- 6** to **Table 5- 9** present assignment validation statistics for the PCM sites for Cars, LGVs, OGVs and All Vehicle PCU flows.

5.7.2 The validation results for the car flows are shown in **Table 5- 6**. The results for the AM peak hour are reasonably good, with 90% of the sites having a GEH value of less than 5.0. 60% of the sites have an absolute difference between the modelled flows and counts of less than 5%. The worst results are for the A56 in Stretford (Site 5A) in the southbound direction where the difference between the modelled and counted flows is +16% and the A58 in Bury (site 6,) where there is an approximate 40% under-assignment in the westbound direction. The counted flows in the in the reverse directions for these sites are, however, modelled reasonably well. In total, the counted flow across all sites is reproduced very well, with a difference between the total modelled and counted flows across all sites of slightly over 1%.

5.7.3 The validation results for car flows in the inter-peak hour are also reasonably good, with 90% of the sites having a GEH value of less than 5.0 and 50% of sites having an absolute difference between the modelled and counted flows of less than 5 percent. The worst results are for the M56 between junctions 2 and 1 (Site 4b), where the difference between the modelled and counted flows is +16% in the westbound direction and +15% in the eastbound direction, and the A58 in Bury (Site 6, which was also poorly modelled in the AM peak hour), where there is a 28% under-assignment in the westbound direction. There is a small under-assignment overall, with a difference between the total modelled and counted flows across all sites of approximately 1%.

5.7.4 The car validation results for the PM peak hour follow a similar pattern to the other time periods, with 84% of the sites having a GEH value of less than 5.0 and 69% of the sites have an absolute difference between the modelled and counted flows of less than 5%. The worst results are for the M56 between junctions 2 and 1 (Site 4b) where the difference between the modelled and counted flows is +33% in the westbound direction and -13% in the eastbound direction, the M61 between Junctions 3 and 4 (Site 9) where the percentage difference between modelled and counted flows is +18% in the northwest bound direction and +12% in the southeast bound direction and the A58 in Bolton (Site 6), where there is a 54% under-assignment in the westbound direction. There is a small over-assignment overall, with a difference between the total modelled and counted flows across all sites of approximately two percent.

5.7.5 The PCM link flow comparisons for LGVs are shown in **Table 5- 7**. In general, the results are reasonably good, with more than 90% of the sites having a GEH value of less than 5.0 in all time periods. The percentage of sites with an absolute difference between the modelled and counted flows of less than 5% varies from 34% of sites in the PM peak hour to 60% of sites in the inter-peak hour. The absolute differences between the flows are, however, generally small, with the exception of the motorway sites which carry heavier flows.

5.7.6 The PCM flow comparisons for OGVs are shown in **Table 5- 8**. The results show that the percentage of sites with a GEH value of less than 5.0 is greater than 90% in all time periods, which is very good. The percentage of sites with an absolute difference between the modelled and counted flows of less than 5% varies from 12% in the PM peak hour to 47% in the inter-peak hour. In general, however, the absolute differences between the flows are small, with the modelled flow being within 20 PCUs (which is equivalent to approximately 10 vehicles per hour) at 75% of the sites in each of the time periods. The greatest absolute differences are on the motorway links (which carry the heaviest OGV flows).

5.7.7 The link flow comparisons presented in this section suggest that OGV flows vary significantly throughout day, with higher volumes in the morning and inter-peak hours and lower flows in the evening peak. This is supported by the comparisons of cordon crossing flows described above and the comparisons of matrix totals described in Section 4.

5.8 All Site Comparisons

5.8.1 **Table 5- 6** shows summary assignment validation statistics for all sites combined (i.e. all cordon plus PCM sites).

Table 5- 6: Assignment Validation Summary by Time Period and Vehicle Type for All Sites Combined (261 Sites)

Time Period	Vehicle Type	% Flow Criteria	% Sites GEH < 5
AM Peak Hour	Car	85.5%	81.0%
	LGV	99.2%	93.5%
	OGV	99.2%	93.1%
	All PCU	83.1%	81.0%
Inter-Peak Hour	Car	86.3%	80.6%
	LGV	99.2%	94.4%
	OGV	98.4%	91.5%
	All PCU	82.3%	77.8%
PM Peak Hour	Car	79.8%	74.6%
	LGV	99.2%	96.0%
	OGV	98.8%	92.7%
	All PCU	81.5%	76.2%

5.8.2 The table shows that approximately 85% of the sites have a GEH value of less than five in the AM peak hour (for all vehicle flows in PCUs), with 81% of sites having a GEH value in the inter-peak and PM peak hours.

Table 5- 7: Modelled and Observed Car Flows at PCM Sites

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
1	A666 St Peters Way	NW	1,977	1,959	-18	-0.9%	0.4	1,330	1,248	-82	-6.6%	2.3	1,710	1,699	-11	-0.6%	0.3
	A666 St Peters Way	SE	2,043	2,000	-43	-2.2%	1.0	1,573	1,511	-62	-4.1%	1.6	2,248	2,245	-3	-0.1%	0.1
2A	A635 Manchester Road	W	1,483	1,458	-25	-1.7%	0.7	1,018	993	-25	-2.5%	0.8	1,582	1,605	23	1.4%	0.6
	A635 Manchester Road	E	1,315	1,279	-36	-2.8%	1.0	896	809	-87	-10.8%	3.0	1,269	1,188	-81	-6.8%	2.3
2B	M60 A6140 to A635	NE	3,052	2,796	-256	-9.2%	4.7	1,574	1,609	35	2.2%	0.9	3,009	3,201	192	6.0%	3.4
	M60 A6140 to A635	SW	2,081	2,226	145	6.5%	3.1	1,709	1,696	-13	-0.8%	0.3	3,651	3,512	-139	-4.0%	2.3
3	A5103 Princess Road	NE	2,649	2,691	42	1.6%	0.8	1,919	1,834	-85	-4.6%	2.0	2,877	2,981	104	3.5%	1.9
	A5103 Princess Road	SW	3,122	3,050	-72	-2.4%	1.3	2,025	1,944	-81	-4.2%	1.8	3,225	3,240	15	0.5%	0.3
4A	A34 Kingsway	N	2,421	2,449	28	1.1%	0.6	1,592	1,469	-123	-8.4%	3.1	2,177	2,275	98	4.3%	2.1
	A34 Kingsway	S	2,301	2,304	3	0.1%	0.1	1,481	1,468	-13	-0.9%	0.3	2,250	2,337	87	3.7%	1.8
4B	M56 Jn 1 to Jn 2	W	2,992	3,088	96	3.1%	1.7	2,013	2,403	390	16.2%	8.3	2,337	3,485	1,148	32.9%	21.3
	M56 Jn 2 to Jn 1	E	2,836	2,667	-169	-6.3%	3.2	1,922	2,267	345	15.2%	7.5	2,412	2,132	-280	-13.1%	5.9
5A	A56 Chester Road	N	2,454	2,283	-171	-7.5%	3.5	930	885	-45	-5.1%	1.5	1,664	1,596	-68	-4.3%	1.7
	A56 Chester Road	S	1,548	1,840	292	15.9%	7.1	1,359	1,313	-46	-3.5%	1.3	2,758	2,727	-31	-1.1%	0.6
5B	A5181 Park Road	N	550	512	-38	-7.4%	1.6	343	320	-23	-7.2%	1.3	442	421	-21	-5.0%	1.0
	A5181 Park Road	S	145	147	2	1.4%	0.2	344	413	69	16.7%	3.5	754	778	24	3.1%	0.9

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
6	A58 Bolton Street	E	2,480	2,358	-122	-5.2%	2.5	1,566	1,463	-103	-7.0%	2.6	1,695	1,636	-59	-3.6%	1.4
	A58 Bolton Street	W	1,669	1,216	-453	-37.3%	11.9	1,637	1,276	-361	-28.3%	9.5	2,748	1,782	-966	-54.2%	20.3
7A	A62 Bottom O' th' Moor	SW	1,259	1,221	-38	-3.1%	1.1	792	714	-78	-10.9%	2.8	977	952	-25	-2.6%	0.8
	A62 Bottom O' th' Moor	NE	776	838	62	7.4%	2.2	869	811	-58	-7.2%	2.0	1,320	1,175	-145	-12.3%	4.1
7B	A669 Lees Road	W	780	802	22	2.7%	0.8	487	488	1	0.2%	0.0	540	553	13	2.4%	0.6
	A669 Lees Road	E	321	340	19	5.6%	1.0	405	438	33	7.5%	1.6	709	712	3	0.4%	0.1
8A	A57 Egerton Street	N	1,857	1,901	44	2.3%	1.0	1,649	1,571	-78	-5.0%	1.9	2,042	2,056	14	0.7%	0.3
	A57 Egerton Street	S	2,104	2,060	-44	-2.1%	1.0	1,738	1,638	-100	-6.1%	2.4	2,228	2,312	84	3.6%	1.8
8B	A57(M) Mancunian Way	W	2,525	2,563	38	1.5%	0.8	1,727	1,683	-44	-2.6%	1.1	2,282	2,292	10	0.4%	0.2
	A57(M) Mancunian Way	E	2,279	2,237	-42	-1.9%	0.9	1,829	1,738	-91	-5.2%	2.2	2,770	2,763	-7	-0.3%	0.1
8C	A635 Mancunian Way	NE	1,142	1,143	1	0.1%	0.0	809	765	-44	-5.8%	1.6	1,932	1,985	53	2.7%	1.2
	A635 Mancunian Way	SW	1,942	1,972	30	1.5%	0.7	856	817	-39	-4.8%	1.3	1,176	1,186	10	0.8%	0.3
9	M61 Jn 3 to Jn 4	NW	2,457	2,615	158	6.0%	3.1	1,992	1,995	3	0.2%	0.1	2,997	3,648	651	17.8%	11.3
	M61 Jn 4 to Jn 3	SE	2,610	2,344	-266	-11.3%	5.3	2,008	2,095	87	4.2%	1.9	2,801	3,182	381	12.0%	7.0
10	M60 Jn 20 to Jn 21	SE	2,819	2,754	-65	-2.4%	1.2	1,586	1,600	14	0.9%	0.4	2,669	2,865	196	6.8%	3.7
	M60 Jn 21 to Jn 20	NW	2,746	2,798	52	1.9%	1.0	1,647	1,730	83	4.8%	2.0	3,441	3,595	154	4.3%	2.6
All			62,735	61,911	-824	-1.3%	3.3	43,625	43,004	-621	-1.4%	3.0	66,692	68,116	1,424	2.1%	5.5

Table 5- 8: Modelled and Observed LGV Flows at PCM Sites

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
1	A666 St Peters Way	NW	307	325	18	5.5%	1.0	374	371	-3	-0.8%	0.2	271	284	13	4.6%	0.8
	A666 St Peters Way	SE	380	395	15	3.8%	0.8	407	399	-8	-2.0%	0.4	238	259	21	8.1%	1.3
2A	A635 Manchester Road	W	217	221	4	1.8%	0.3	266	277	11	4.0%	0.7	165	174	9	5.2%	0.7
	A635 Manchester Road	E	247	227	-20	-8.8%	1.3	249	238	-11	-4.6%	0.7	144	159	15	9.4%	1.2
2B	M60 A6140 to A635	NE	368	604	236	39.1%	10.7	471	452	-19	-4.2%	0.9	433	515	82	15.9%	3.8
	M60 A6140 to A635	SW	544	477	-67	-14.0%	3.0	456	456	0	0.0%	0.0	330	564	234	41.5%	11.1
3	A5103 Princess Road	NE	229	243	14	5.8%	0.9	294	291	-3	-1.0%	0.2	198	213	15	7.0%	1.0
	A5103 Princess Road	SW	206	193	-13	-6.7%	0.9	315	315	0	0.0%	0.0	221	242	21	8.7%	1.4
4A	A34 Kingsway	N	212	230	18	7.8%	1.2	269	284	15	5.3%	0.9	165	160	-5	-3.1%	0.4
	A34 Kingsway	S	271	293	22	7.5%	1.3	231	242	11	4.5%	0.7	134	151	17	11.3%	1.4
4B	M56 Jn 1 to Jn 2	W	527	687	160	23.3%	6.5	426	498	72	14.5%	3.3	329	437	108	24.7%	5.5
	M56 Jn 2 to Jn 1	E	445	610	165	27.0%	7.2	457	596	139	23.3%	6.1	265	333	68	20.4%	3.9
5A	A56 Chester Road	N	167	161	-6	-3.7%	0.5	144	170	26	15.3%	2.1	118	112	-6	-5.4%	0.6
	A56 Chester Road	S	188	186	-2	-1.1%	0.1	208	240	32	13.3%	2.1	148	137	-11	-8.0%	0.9
5B	A5181 Park Road	N	52	52	0	0.0%	0.0	63	58	-5	-8.6%	0.6	51	48	-3	-6.3%	0.4
	A5181 Park Road	S	40	43	3	7.0%	0.5	56	75	19	25.3%	2.3	54	55	1	1.8%	0.1

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
6	A58 Bolton Street	E	238	225	-13	-5.8%	0.9	258	252	-6	-2.4%	0.4	172	182	10	5.5%	0.8
	A58 Bolton Street	W	257	255	-2	-0.8%	0.1	237	244	7	2.9%	0.5	250	279	29	10.4%	1.8
7A	A62 Bottom O' th' Moor	SW	188	187	-1	-0.5%	0.1	186	192	6	3.1%	0.4	112	111	-1	-0.9%	0.1
	A62 Bottom O' th' Moor	NE	136	144	8	5.6%	0.7	171	157	-14	-8.9%	1.1	148	170	22	12.9%	1.7
7B	A669 Lees Road	W	122	133	11	8.3%	1.0	126	109	-17	-15.6%	1.6	80	82	2	2.4%	0.2
	A669 Lees Road	E	86	93	7	7.5%	0.7	93	89	-4	-4.5%	0.4	75	85	10	11.8%	1.1
8A	A57 Egerton Street	N	296	318	22	6.9%	1.3	420	418	-2	-0.5%	0.1	194	204	10	4.9%	0.7
	A57 Egerton Street	S	286	286	0	0.0%	0.0	319	321	2	0.6%	0.1	215	229	14	6.1%	0.9
8B	A57(M) Mancunian Way	W	346	363	17	4.7%	0.9	430	430	0	0.0%	0.0	149	158	9	5.7%	0.7
	A57(M) Mancunian Way	E	341	343	2	0.6%	0.1	449	450	1	0.2%	0.0	224	238	14	5.9%	0.9
8C	A635 Mancunian Way	NE	124	125	1	0.8%	0.1	206	206	0	0.0%	0.0	196	207	11	5.3%	0.8
	A635 Mancunian Way	SW	234	229	-5	-2.2%	0.3	201	208	7	3.4%	0.5	73	76	3	3.9%	0.3
9	M61 Jn 3 to Jn 4	NW	492	513	21	4.1%	0.9	508	488	-20	-4.1%	0.9	527	530	3	0.6%	0.1
	M61 Jn 4 to Jn 3	SE	535	520	-15	-2.9%	0.7	532	501	-31	-6.2%	1.4	439	440	1	0.2%	0.0
10	M60 Jn 20 to Jn 21	SE	550	542	-8	-1.5%	0.3	502	519	17	3.3%	0.8	481	500	19	3.8%	0.9
	M60 Jn 21 to Jn 20	NW	527	533	6	1.1%	0.3	515	547	32	5.9%	1.4	581	596	15	2.5%	0.6
All			9,158	9,756	598	6.1%	6.1	9,839	10,093	254	2.5%	2.5	7,180	7,930	750	9.5%	8.6

Table 5- 9: Modelled and Observed OGV Flows at PCM Sites (PCUs)

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
1	A666 St Peters Way	NW	183	208	25	12.0%	1.8	144	151	7	4.6%	0.6	35	51	16	31.4%	2.4
	A666 St Peters Way	SE	114	139	25	18.0%	2.2	142	147	5	3.4%	0.4	61	66	5	7.6%	0.6
2A	A635 Manchester Road	W	143	153	10	6.5%	0.8	168	159	-9	-5.7%	0.7	53	47	-6	-12.8%	0.8
	A635 Manchester Road	E	98	96	-2	-2.1%	0.2	159	160	1	0.6%	0.1	41	43	2	4.7%	0.3
2B	M60 A6140 to A635	NE	316	512	196	38.3%	9.6	402	501	99	19.8%	4.7	160	282	122	43.3%	8.2
	M60 A6140 to A635	SW	375	420	45	10.7%	2.3	430	483	53	11.0%	2.5	179	286	107	37.4%	7.0
3	A5103 Princess Road	NE	76	81	5	6.2%	0.6	104	109	5	4.6%	0.5	46	50	4	8.0%	0.6
	A5103 Princess Road	SW	86	129	43	33.3%	4.1	118	117	-1	-0.9%	0.1	31	42	11	26.2%	1.8
4A	A34 Kingsway	N	118	136	18	13.2%	1.6	172	186	14	7.5%	1.0	73	82	9	11.0%	1.0
	A34 Kingsway	S	132	147	15	10.2%	1.3	158	162	4	2.5%	0.3	52	64	12	18.8%	1.6
4B	M56 Jn 1 to Jn 2	W	384	391	7	1.8%	0.4	372	387	15	3.9%	0.8	179	213	34	16.0%	2.4
	M56 Jn 2 to Jn 1	E	477	515	38	7.4%	1.7	357	396	39	9.8%	2.0	160	152	-8	-5.3%	0.6
5A	A56 Chester Road	N	31	38	7	18.4%	1.2	38	79	41	51.9%	5.4	12	11	-1	-9.1%	0.3
	A56 Chester Road	S	33	50	17	34.0%	2.6	40	48	8	16.7%	1.2	11	8	-3	-37.5%	1.0
5B	A5181 Park Road	N	15	36	21	58.3%	4.2	26	43	17	39.5%	2.9	14	13	-1	-7.7%	0.3
	A5181 Park Road	S	11	26	15	57.7%	3.5	16	44	28	63.6%	5.1	3	5	2	40.0%	1.0

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
6	A58 Bolton Street	E	84	88	4	4.5%	0.4	96	88	-8	-9.1%	0.8	17	16	-1	-6.3%	0.2
	A58 Bolton Street	W	89	90	1	1.1%	0.1	99	106	7	6.6%	0.7	31	34	3	8.8%	0.5
7A	A62 Bottom O' th' Moor	SW	77	72	-5	-6.9%	0.6	82	79	-3	-3.8%	0.3	19	16	-3	-18.8%	0.7
	A62 Bottom O' th' Moor	NE	60	60	0	0.0%	0.0	70	62	-8	-12.9%	1.0	21	21	0	0.0%	0.0
7B	A669 Lees Road	W	44	45	1	2.2%	0.1	44	31	-13	-41.9%	2.1	14	15	1	6.7%	0.3
	A669 Lees Road	E	24	25	1	4.0%	0.2	39	40	1	2.5%	0.2	16	14	-2	-14.3%	0.5
8A	A57 Egerton Street	N	155	165	10	6.1%	0.8	205	221	16	7.2%	1.1	46	74	28	37.8%	3.6
	A57 Egerton Street	S	156	164	8	4.9%	0.6	196	210	14	6.7%	1.0	43	53	10	18.9%	1.4
8B	A57(M) Mancunian Way	W	189	205	16	7.8%	1.1	230	256	26	10.2%	1.7	97	108	11	10.2%	1.1
	A57(M) Mancunian Way	E	230	242	12	5.0%	0.8	224	236	12	5.1%	0.8	88	73	-15	-20.5%	1.7
8C	A635 Mancunian Way	NE	112	120	8	6.7%	0.7	232	242	10	4.1%	0.6	46	52	6	11.5%	0.9
	A635 Mancunian Way	SW	190	208	18	8.7%	1.3	254	262	8	3.1%	0.5	43	48	5	10.4%	0.7
9	M61 Jn 3 to Jn 4	NW	574	548	-26	-4.7%	1.1	621	627	6	1.0%	0.2	315	368	53	14.4%	2.9
	M61 Jn 4 to Jn 3	SE	529	538	9	1.7%	0.4	697	679	-18	-2.7%	0.7	307	333	26	7.8%	1.5
10	M60 Jn 20 to Jn 21	SE	459	470	11	2.3%	0.5	471	452	-19	-4.2%	0.9	234	230	-4	-1.7%	0.3
	M60 Jn 21 to Jn 20	NW	417	427	10	2.3%	0.5	479	468	-11	-2.4%	0.5	248	241	-7	-2.9%	0.4
All			5,981	6,544	563	8.6%	7.1	6,885	7,231	346	4.8%	4.1	2,695	3,111	416	13.4%	7.7

Table 5- 10: Modelled and Observed All Vehicle PCU Flows at PCM Sites

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
1	A666 St Peters Way	NW	2,475	2,497	22	0.9%	0.4	1,873	1,771	-102	-5.8%	2.4	2,041	2,034	-7	-0.3%	0.2
	A666 St Peters Way	SE	2,537	2,534	-3	-0.1%	0.1	2,150	2,056	-94	-4.6%	2.0	2,582	2,570	-12	-0.5%	0.2
2A	A635 Manchester Road	W	1,877	1,848	-29	-1.6%	0.7	1,485	1,441	-44	-3.1%	1.2	1,845	1,840	-5	-0.3%	0.1
	A635 Manchester Road	E	1,674	1,621	-53	-3.3%	1.3	1,336	1,220	-116	-9.5%	3.2	1,496	1,402	-94	-6.7%	2.5
2B	M60 A6140 to A635	NE	3,724	3,912	188	4.8%	3.0	2,440	2,562	122	4.8%	2.4	3,616	3,998	382	9.6%	6.2
	M60 A6140 to A635	SW	3,000	3,122	122	3.9%	2.2	2,586	2,635	49	1.9%	1.0	4,183	4,363	180	4.1%	2.8
3	A5103 Princess Road	NE	3,016	3,046	30	1.0%	0.5	2,402	2,264	-138	-6.1%	2.9	3,213	3,264	51	1.6%	0.9
	A5103 Princess Road	SW	3,467	3,399	-68	-2.0%	1.2	2,539	2,404	-135	-5.6%	2.7	3,578	3,548	-30	-0.8%	0.5
4A	A34 Kingsway	N	2,785	2,819	34	1.2%	0.6	2,065	1,939	-126	-6.5%	2.8	2,458	2,517	59	2.3%	1.2
	A34 Kingsway	S	2,705	2,748	43	1.6%	0.8	1,903	1,871	-32	-1.7%	0.7	2,469	2,552	83	3.3%	1.7
4B	M56 Jn 1 to Jn 2	W	3,895	4,174	279	6.7%	4.4	2,808	3,294	486	14.8%	8.8	2,865	4,140	1,275	30.8%	21.5
	M56 Jn 2 to Jn 1	E	3,753	3,797	44	1.2%	0.7	2,731	3,265	534	16.4%	9.8	2,863	2,623	-240	-9.1%	4.6
5A	A56 Chester Road	N	2,675	2,503	-172	-6.9%	3.4	1,149	1,154	5	0.4%	0.1	1,848	1,736	-112	-6.5%	2.6
	A56 Chester Road	S	1,814	2,107	293	13.9%	6.6	1,648	1,621	-27	-1.7%	0.7	2,965	2,890	-75	-2.6%	1.4
5B	A5181 Park Road	N	634	612	-22	-3.6%	0.9	458	433	-25	-5.8%	1.2	543	487	-56	-11.5%	2.5
	A5181 Park Road	S	206	239	33	13.8%	2.2	441	547	106	19.4%	4.8	843	845	2	0.2%	0.1

			AM Peak Hour					Inter-Peak Hour					PM Peak Hour				
Site	**Location**	**Dir**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**% Diff**	**GEH**	**Obs**	**Mod**	**Diff**	**Obs**	**Mod**
6	A58 Bolton Street	E	2,888	2,749	-139	-5.1%	2.6	2,013	1,866	-147	-7.9%	3.3	1,966	1,893	-73	-3.9%	1.7
	A58 Bolton Street	W	2,087	1,607	-480	-29.9%	11.2	2,071	1,669	-402	-24.1%	9.3	3,142	2,140	-1,002	-46.8%	19.5
7A	A62 Bottom O' th' Moor	SW	1,597	1,528	-69	-4.5%	1.7	1,142	1,026	-116	-11.3%	3.5	1,197	1,117	-80	-7.2%	2.4
	A62 Bottom O' th' Moor	NE	1,054	1,099	45	4.1%	1.4	1,211	1,086	-125	-11.5%	3.7	1,609	1,418	-191	-13.5%	4.9
7B	A669 Lees Road	W	984	1,012	28	2.8%	0.9	701	654	-47	-7.2%	1.8	673	670	-3	-0.4%	0.1
	A669 Lees Road	E	447	469	22	4.7%	1.0	561	579	18	3.1%	0.8	829	825	-4	-0.5%	0.1
8A	A57 Egerton Street	N	2,328	2,392	64	2.7%	1.3	2,322	2,218	-104	-4.7%	2.2	2,332	2,341	9	0.4%	0.2
	A57 Egerton Street	S	2,561	2,511	-50	-2.0%	1.0	2,303	2,168	-135	-6.2%	2.9	2,551	2,594	43	1.7%	0.8
8B	A57(M) Mancunian Way	W	3,058	3,130	72	2.3%	1.3	2,410	2,368	-42	-1.8%	0.9	2,562	2,558	-4	-0.2%	0.1
	A57(M) Mancunian Way	E	2,851	2,822	-29	-1.0%	0.5	2,525	2,425	-100	-4.1%	2.0	3,121	3,075	-46	-1.5%	0.8
8C	A635 Mancunian Way	NE	1,379	1,387	8	0.6%	0.2	1,276	1,213	-63	-5.2%	1.8	2,206	2,244	38	1.7%	0.8
	A635 Mancunian Way	SW	2,361	2,411	50	2.1%	1.0	1,343	1,287	-56	-4.4%	1.5	1,314	1,310	-4	-0.3%	0.1
9	M61 Jn 3 to Jn 4	NW	3,518	3,676	158	4.3%	2.6	3,109	3,111	2	0.1%	0.0	3,856	4,545	689	15.2%	10.6
	M61 Jn 4 to Jn 3	SE	3,667	3,402	-265	-7.8%	4.5	3,223	3,275	52	1.6%	0.9	3,565	3,956	391	9.9%	6.4
10	M60 Jn 20 to Jn 21	SE	3,819	3,767	-52	-1.4%	0.8	2,552	2,571	19	0.7%	0.4	3,401	3,595	194	5.4%	3.3
	M60 Jn 21 to Jn 20	NW	3,682	3,758	76	2.0%	1.2	2,634	2,745	111	4.0%	2.1	4,297	4,432	135	3.0%	2.0
All			78,518	78,698	180	0.2%	0.6	61,410	60,738	-672	-1.1%	2.7	78,029	79,522	1,493	1.9%	5.3

6 Journey Time Validation

6.1 Introduction

6.1.1 Modelled and observed journey times have been compared on 52 two-way routes within the County, as illustrated in **Figure 6- 1**, and described in **Table 6- 1** and **Table 6- 2**. For presentational purposes, the routes have been divided into two groups comprising:

- Radial/orbital routes, (routes 1-32), which are primarily on A class roads, but which also include some sections of motorway for routes 19/20 and 31/32
- Motorway routes, (routes 33-52), representing journeys on the M602, M56, M60, M61, M62, M66 and M67 motorways.

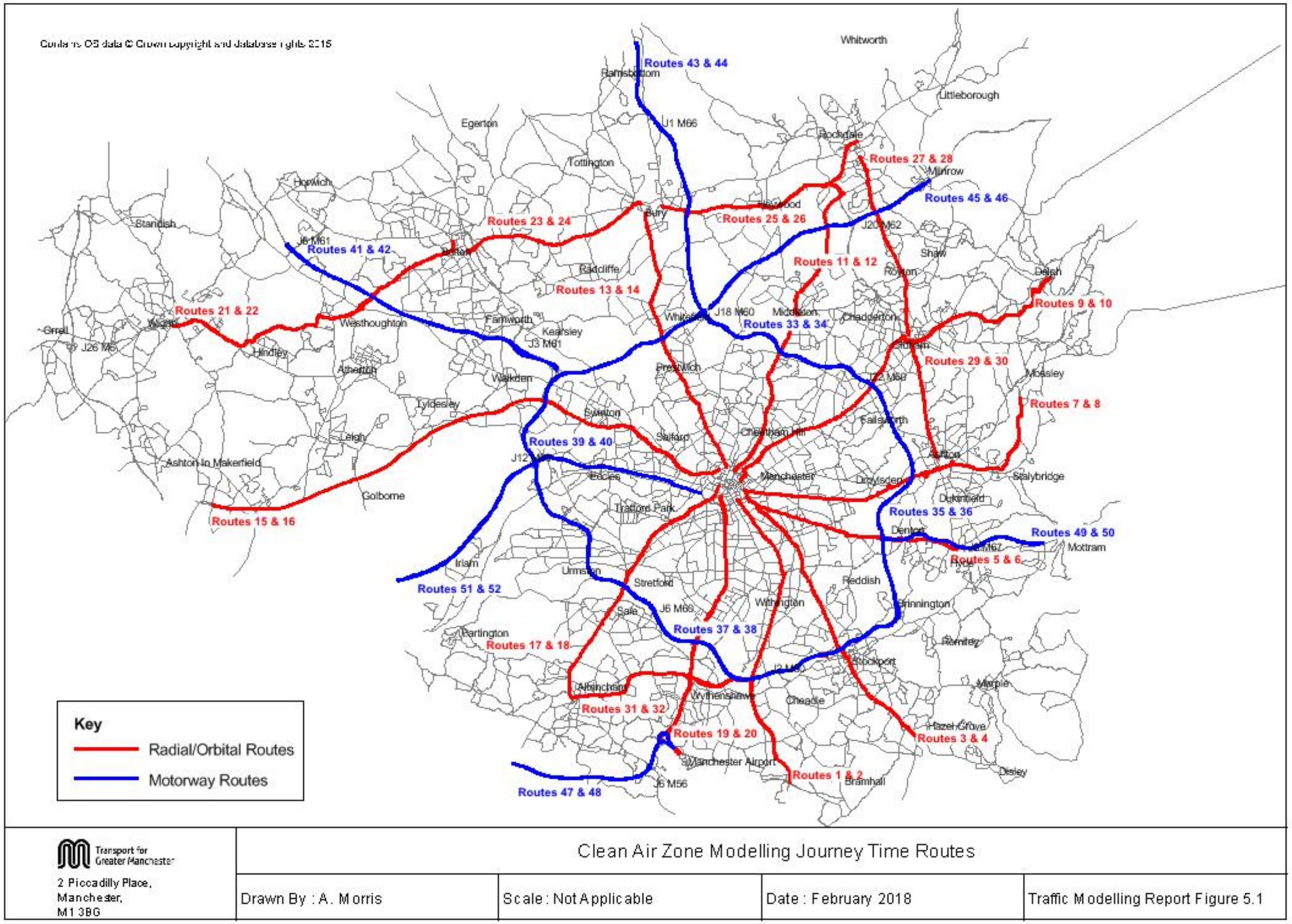
The routes are designed to intercept typical journeys between district centres and on motorways within the county, with an average route length of about 14 km.

6.1.2 The observed journey times have been estimated using GPS data for October 2016 from the TrafficMaster database. This data is collected on behalf of the Department for Transport by TrafficMaster Plc, and provides information about average vehicle speeds on roads across the UK for vehicles fitted with GPS devices.

6.1.3 The information in the TrafficMaster database has been processed by TfGM's Highways Forecasting and Analytical Services (HFAS) to calculate average times for non-stopping vehicles (i.e. excluding buses and taxis), for standardized time periods, excluding observations collected during school and national holidays. For the purpose of this analysis, the modelled times have been compared with observed times for weekdays collected during for the morning peak hour 0800-0900, the evening peak hour 1700-1800 and the inter-peak period 1000-1530.

Taken together, the journey time routes cover almost 700 km of the major road network within GM, or approximately 11% of the simulation network in GM.

Figure 6- 1: Journey Time Validation Routes



6.2 Journey Time Validation Guidelines

6.2.1 The TAG requirement for journey time validation is that modelled times should be within 15% (or one minute if this is higher) of the observed time on more than 85% of routes.

6.2.2 It should be noted, however, that paragraph 11.4.9 of the Traffic Appraisal Manual (TAM, Reference 8) states:

"In congested conditions, where the journey times are flow dependent, the assignment package will provide estimates of link speeds and journey times for different times of day. These are not as accurate as the predictions of flows, as they are based on theoretical speed/flow relations that may not be the most appropriate for all parts of the network, and the standards for acceptance will generally be lower. Research has shown that, as long as the estimation of total travel time is unbiased, an empirically determined 95% confidence interval of +/- 20% can be taken to signify that the journey times are adequately modelled."

6.2.3 This range is also used for comparison in the following paragraphs.

6.2.4 Finally, please note that the modelled times that are referred to here represent the sum of the link travel times comprising each route, and therefore include flow-weighted delays for each of the turns at the downstream ends of the constituent links. As a consequence, the route times do not necessarily represent the time taken to travel from the start of the route to the routes end point, (as would be calculated using the Saturn 'Joy Ride' facility, for example), as this would only include the turning delays for the specific set of turns made in the course of the journey. Any differences should, however, be relatively small, since routes generally follow the major traffic movements. (This approach has been adopted for compatibility with the TrafficMaster data, and its procedure for allocating turning delays to links).

Table 6- 1: Radial/Orbital Journey Time Routes

Route Number	Description	Route Length (Modelled km)
1	A34 Handforth to Manchester City Centre	14.6
2	A34 Manchester City Centre to Handforth	14.5
3	A6 Hazel Grove to Manchester City Centre	14.2
4	A6 Manchester City Centre to Hazel Grove	14.2
5	A57 Hyde to Manchester City Centre	10.5
6	A57 Manchester City Centre to Hyde	10.6
7	A635 Mossley to Manchester City Centre	16.0
8	A635 Manchester City Centre to Mossley	16.1
9	A62 Delph to Manchester City Centre	19.2
10	A62 Manchester City Centre to Delph	19.3
11	A58/A664 Rochdale to Manchester City Centre	18.3
12	A664/A58 Manchester City Centre to Rochdale	18.2
13	A56 Bury to Manchester City Centre	12.7
14	A56 Manchester City Centre to Bury	12.7
15	A580 Golbourne to Manchester City Centre	25.6
16	A580 Manchester City Centre to Golbourne	25.6
17	A56 Altrincham to Manchester City Centre	12.6
18	A56 Manchester City Centre to Altrincham	12.6
19	M56/A5103 Manchester Airport to Manchester City Centre	13.2
20	A5103/M56 Manchester Airport to Manchester City Centre	12.7
21	A577/A58/A676 Bolton to Wigan	15.5
22	A676/A577/A58/ Wigan to Bolton	15.5
23	A58 Bolton to Bury	8.8
24	A58 Bury to Bolton	8.7
25	A58 Bury to Rochdale	10.7

Route Number	Description	Route Length (Modelled km)
26	A58 Rochdale to Bury	10.7
27	A671 Rochdale to Oldham	8.6
28	A671 Oldham to Rochdale	8.7
29	A627 Oldham to Ashton-Under-Lyne	5.5
30	A627 Ashton-Under-Lyne to Oldham	5.5
31	M60/M56/A560 Stockport to Altrincham	12.9
32	A560/M56/M60 Altrincham to Stockport	12.8

Table 6- 2: Motorway Journey Time Routes

Route Number	Description	Route Length (Modelled km)
33	M60 Junction 18 to Junction 23 (Clockwise)	14.3
34	M60 Junction 23 to Junction 18 (Anti-Clockwise)	13.5
35	M60 Junction 23 to Junction 4 (Clockwise)	14.4
36	M60 Junction 4 to Junction 23 (Anti-Clockwise)	15.1
37	M60 Junction 4 to Junction 12 (Clockwise)	15.9
38	M60 Junction 12 to Junction 4 (Anti-Clockwise)	16.1
39	M60 Junction 12 to Junction 18 (Clockwise)	12.0
40	M60 Junction 18 to Junction 12 (Anti-Clockwise)	11.4
41	M61 Junction 6 to Junction 1 (Inbound)	13.9
42	M61 Junction 1 to Junction 6 (Outbound)	14.0
43	M66 GM boundary to Junction 4 (Inbound)	12.8
44	M66 Junction 4 to GM boundary (Outbound)	13.6
45	M62 Junction 21 to Junction 18 (Inbound)	11.9
46	M62 Junction 18 to Junction 21 (Outbound)	11.6
47	M56 Junction 8 to Manchester Airport	8.7
48	M56 Manchester Airport to Junction 8	8.6
49	M67 Junction 4 to Denton (Inbound)	7.6
50	M67 Denton to Junction 4 (Outbound)	7.5
51	M62/M602/A57 GM Boundary to Manchester City Centre	16.6
52	A57/M602/M62 Manchester City Centre to GM Boundary	16.6

6.3 AM Peak Hour Journey Time Validation Results

6.3.1 **Table 6- 3** compares modelled and observed journey times in the AM peak hour for the 32 radial/orbital routes. For each route, the table shows the route number, the route length, the observed time, the modelled time, the difference between the modelled and observed times and the percentage error. The final column indicates whether or not the modelled time meets the TAG journey time validation criteria.

6.3.2 In total, 19 out of 32 (or approximately 59%) of the routes meet the TAG criteria that the modelled times should be within 15% of the observed times. Approximately 75% of the routes meet the less stringent TAM criteria that the modelled time should be within 20% of the observed time. The greatest percentage difference between the modelled and observed times is for route number 19, (representing journeys on the M56/A5103 between Manchester Airport and Manchester City Centre), where the observed time is approximately 13 minutes greater than the modelled time. The travel time in the reverse direction is modelled reasonably well, however, although the observed time in this direction of travel is markedly lower.

6.3.3 **Table 6- 4** compares modelled and observed journey times in the AM peak hour for the 20 motorway routes (routes 33 to 52).

6.3.4 Overall, 40% of the routes meet the TAG criteria, with 50% of the routes meeting the less stringent TAM criteria. The greatest percentage differences are for routes 35 and 41, (representing journeys on the M60 in the clockwise direction between junctions 23 and 4, and on the M61 in the inbound direction between the GM boundary and junction 15 of the M60), where the modelled times are too low in both cases, suggesting that the effects of congestion on travel times are not being adequately modelled for these routes. The modelled times for the reverse direction journeys, (routes 36 and 42), are reasonably good, however, with both routes meeting the TAM criteria.

6.3.5 Considering all routes together, (both motorway and non-motorway), 27 out of 52 (or 52%) of the routes meet the TAG criteria, with 65% of the routes meeting the TAM criteria. For all routes combined, the total modelled time is approximately 8% lower than the total observed time, (representing a difference in average speed of approximately 3 kph), which is reasonably good, but suggests that modelled speeds are too high in general.

Table 6- 3: Modelled Versus Observed Radial/Orbital Journey Times in the AM Peak Hour (Minutes)

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
1	14.6	37.4	29.0	-8.4	22.5%	N
2	14.5	32.3	31.9	-0.4	1.3%	Y
3	14.2	48.7	45.0	-3.7	7.6%	Y
4	14.2	42.4	42.0	-0.4	0.9%	Y
5	10.5	36.5	27.0	-9.6	26.2%	N
6	10.6	22.9	26.7	3.8	16.8%	N
7	16.0	45.4	42.6	-2.9	6.3%	Y
8	16.1	35.2	39.2	4.0	11.4%	Y
9	19.2	50.5	47.6	-2.9	5.8%	Y
10	19.3	38.8	45.6	6.8	17.5%	N
11	18.3	53.7	52.2	-1.5	2.8%	Y
12	18.2	38.5	49.6	11.1	29.0%	N
13	12.7	42.4	32.7	-9.7	22.8%	N
14	12.7	31.8	30.1	-1.8	5.5%	Y
15	25.6	53.6	39.9	-13.7	25.5%	N
16	25.6	45.3	41.4	-3.8	8.4%	Y
17	12.6	41.8	34.8	-7.1	16.9%	N
18	12.6	32.0	33.5	1.5	4.7%	Y
19	13.2	33.0	19.7	-13.3	40.3%	N
20	12.7	18.5	19.5	1.0	5.5%	Y
21	15.5	36.4	36.1	-0.2	0.6%	Y
22	15.5	36.3	33.4	-2.8	7.8%	Y
23	8.8	18.1	20.1	2.0	11.2%	Y
24	8.7	18.1	18.5	0.4	2.2%	Y
25	10.7	23.9	27.6	3.6	15.1%	N

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
26	10.7	26.8	28.1	1.3	5.0%	Y
27	8.6	19.1	25.8	6.6	34.8%	N
28	8.7	18.8	24.5	5.7	30.2%	N
29	5.5	14.3	15.0	0.7	4.9%	Y
30	5.5	12.0	13.0	1.0	8.5%	Y
31	12.9	25.6	20.9	-4.6	18.1%	N
32	12.8	21.5	22.1	0.6	2.6%	Y
Total	437.0	1051.8	1015.3	-36.4	3.5%	Y
Number of routes satisfying TAG Criteria = 19 out of 32 (59.4%)						

Table 6- 4: Modelled Versus Observed Motorway Journey Times in the AM Peak Hour (Minutes)

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
33	14.3	9.4	9.6	0.2	2.0%	Y
34	13.5	10.2	8.9	-1.2	12.2%	Y
35	14.4	27.6	11.6	-16.0	58.0%	N
36	15.1	10.6	10.5	-0.1	0.5%	Y
37	15.9	14.1	11.8	-2.2	15.8%	N
38	16.1	12.8	12.0	-0.8	6.2%	Y
39	12.0	14.1	10.8	-3.3	23.2%	N
40	11.4	20.6	10.1	-10.5	51.0%	N
41	13.9	21.7	8.9	-12.8	58.9%	N
42	14.0	8.0	9.3	1.3	16.5%	N
43	12.8	9.3	9.2	-0.1	0.7%	Y
44	13.6	8.1	9.1	1.0	12.1%	Y
45	11.9	18.9	9.3	-9.6	50.9%	N
46	11.6	8.7	9.1	0.4	4.8%	Y
47	8.7	7.6	5.9	-1.6	21.6%	N
48	8.6	5.1	5.7	0.6	11.2%	Y
49	7.6	10.6	5.0	-5.6	52.6%	N
50	7.5	5.8	4.6	-1.3	21.4%	N
51	16.6	26.5	18.8	-7.8	29.3%	N
52	16.6	13.1	15.8	2.7	20.6%	N
Total	255.9	262.7	196.1	-66.6	25.4%	N
Number of routes satisfying TAG Criteria = 8 out of 20 (40.0%)						

6.4 Inter-Peak Hour Journey Time Validation Results

6.4.1 **Table 6- 5** compares modelled and observed journey times in the inter-peak hour for the radial/orbital routes.

6.4.2 In total, 27 out of 32 (or approximately 84%) of the routes meet the TAG criteria that the modelled time should be within 15% of the observed time, with 93% of the routes meeting the less stringent TAM criteria of +/-20%.

6.4.3 **Table 6- 6** compares modelled and observed times in the inter-peak hour for the 20 motorway routes.

6.4.4 Overall, 85% of the motorway routes meet the TAG criteria, with 95% of the routes meeting the TAM criteria. The greatest percentage difference between the modelled and observed times is for route 50, (representing journeys on the M67 between Denton and Junction 4 at Mottram), where the modelled time is too low.

6.4.5 Considering all routes together, (both motorway and non-motorway), 44 out of 52 (or approximately 84%) of the routes meet the TAG criteria, with 94% of the routes meeting the TAM criteria. For all routes combined, the total modelled time is within 7% of the observed time, which is reasonably good.

Table 6- 5: Modelled Versus Observed Radial/Orbital Journey Times in the Inter-Peak Hour (Minutes)

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
1	14.6	25.4	20.8	-4.5	17.9%	N
2	14.5	24.9	21.3	-3.6	14.5%	Y
3	14.2	36.2	30.6	-5.6	15.5%	N
4	14.2	34.9	31.3	-3.6	10.2%	Y
5	10.5	22.7	21.0	-1.7	7.6%	Y
6	10.6	23.2	21.3	-1.9	8.1%	Y
7	16.0	31.8	28.6	-3.2	10.2%	Y
8	16.1	33.2	30.0	-3.3	9.8%	Y
9	19.2	38.6	35.2	-3.5	9.0%	Y
10	19.3	36.8	34.7	-2.1	5.8%	Y
11	18.3	36.1	37.0	0.9	2.5%	Y
12	18.2	37.0	36.6	-0.4	1.0%	Y
13	12.7	27.6	23.5	-4.1	14.9%	Y
14	12.7	28.9	22.6	-6.3	21.7%	N
15	25.6	32.6	28.9	-3.7	11.3%	Y
16	25.6	32.4	29.2	-3.2	10.0%	Y
17	12.6	28.1	25.3	-2.7	9.8%	Y
18	12.6	27.1	24.6	-2.5	9.2%	Y
19	13.2	17.2	16.3	-0.9	5.4%	Y
20	12.7	15.7	15.4	-0.3	2.1%	Y
21	15.5	31.2	26.0	-5.1	16.4%	N
22	15.5	32.6	24.6	-8.0	24.5%	N
23	8.8	15.9	15.4	-0.4	2.8%	Y
24	8.7	15.3	16.7	1.4	9.0%	Y
25	10.7	21.9	20.9	-1.0	4.7%	Y

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
26	10.7	22.5	23.1	0.6	2.5%	Y
27	8.6	17.8	17.6	-0.2	1.3%	Y
28	8.7	17.4	17.8	0.4	2.5%	Y
29	5.5	11.4	10.5	-0.9	8.0%	Y
30	5.5	10.6	9.2	-1.4	13.4%	Y
31	12.9	16.6	16.8	0.2	1.0%	Y
32	12.8	17.6	17.3	-0.3	1.8%	Y
Total	437.0	821.2	750.0	-71.2	8.7%	Y
Number of routes satisfying TAG Criteria = 27 out of 32 (84.4%)						

Table 6- 6: Modelled Versus Observed Motorway Journey Times in the Inter-Peak Hour (Minutes)

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
33	14.3	8.5	9.2	0.7	8.0%	Y
34	13.5	7.8	8.5	0.7	9.3%	Y
35	14.4	9.2	10.9	1.8	19.2%	N
36	15.1	9.3	9.9	0.6	6.4%	Y
37	15.9	11.4	11.1	-0.2	2.2%	Y
38	16.1	10.9	11.4	0.5	4.4%	Y
39	12.0	11.3	10.5	-0.7	6.7%	Y
40	11.4	11.1	9.8	-1.4	12.2%	Y
41	13.9	8.5	8.9	0.4	4.6%	Y
42	14.0	7.9	8.9	1.0	12.3%	Y
43	12.8	7.2	8.4	1.2	16.5%	N
44	13.6	7.8	8.8	1.0	12.6%	Y
45	11.9	9.5	9.2	-0.2	2.4%	Y
46	11.6	8.8	9.0	0.2	2.2%	Y
47	8.7	5.1	5.5	0.4	7.7%	Y
48	8.6	5.0	5.5	0.5	10.6%	Y
49	7.6	5.3	5.5	0.2	4.0%	Y
50	7.5	7.1	4.6	-2.5	35.2%	N
51	16.6	15.4	14.2	-1.2	7.5%	Y
52	16.6	12.5	13.8	1.3	10.6%	Y
Total	255.9	179.5	183.7	4.2	2.3%	Y
Number of routes satisfying TAG Criteria = 17 out of 20 (85.0%)						

6.5 Evening Peak Hour Journey Time Validation Results

6.5.1 **Table 6- 7** compares modelled and observed journey times in the PM peak hour for the 32 radial/orbital routes.

6.5.2 In total, 13 out of 32 (41%) of the routes meet the TAG criteria of +/-15%, with approximately 53% of the routes meeting the less stringent TAM criteria of +/-20%. The greatest percentage difference between the modelled and observed times is for route 2, (A34 Manchester City Centre to Handforth), where the modelled time is approximately 15 minutes lower than the observed time, representing a difference between the modelled and observed speeds of approximately 13 kph (8 mph) over the route as a whole. The travel time in the reverse direction is modelled slightly better, but is also too low, with a difference between the modelled and observed average speeds of approximately 10 kph (6 mph).

6.5.3 **Table 6- 8** compares modelled and observed journey times in the PM peak hour for the 20 motorway routes (routes 33 to 52).

6.5.4 Overall, 6 out of 20 (or 30%) of the routes meet the TAG criteria, with 40% of the routes meeting the less stringent TAM criteria. The greatest percentage differences are for routes 37 and 50, (M60 Junctions 4 to 12 clockwise and M67 Denton to Mottram), where the modelled times are too low in both cases. The modelled times for the reverse direction routes are better, but also fail to meet the TAG criteria. The difference between the modelled and observed journey time for route 50 is almost seven minutes, mainly caused by problems representing observed delays at the eastern end of the route, on the approach to the Mottram roundabout.

6.5.5 Considering all routes together, (both motorway and non-motorway), 19 out of 52 (or 37%) of the routes meet the TAG criteria, with 48% of the routes meeting the less stringent TAM criteria. For all routes combined, the total modelled time is approximately 20% lower than the total observed time, indicating that modelled speeds in the evening peak hour are too high in general, and that the effects of congestion in this time period are underestimated.

Table 6- 7: Modelled Versus Observed Radial/Orbital Journey Times in the PM Peak Hour (Minutes)

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
1	14.6	36.3	25.8	-10.5	28.9%	N
2	14.5	39.7	25.1	-14.5	36.7%	N
3	14.2	43.7	39.0	-4.7	10.8%	Y
4	14.2	51.9	37.2	-14.7	28.3%	N
5	10.5	26.2	26.2	-0.1	0.2%	Y
6	10.6	33.9	26.9	-7.0	20.7%	N
7	16.0	34.9	36.9	2.0	5.9%	Y
8	16.1	50.0	37.3	-12.8	25.5%	N
9	19.2	42.9	43.0	0.1	0.2%	Y
10	19.3	50.3	47.8	-2.5	5.0%	Y
11	18.3	41.5	48.6	7.1	17.0%	N
12	18.2	52.7	47.4	-5.3	10.1%	Y
13	12.7	36.6	28.9	-7.7	21.0%	N
14	12.7	44.5	29.2	-15.4	34.5%	N
15	25.6	40.5	37.6	-2.9	7.2%	Y
16	25.6	62.5	42.3	-20.2	32.3%	N
17	12.6	42.4	30.9	-11.5	27.1%	N
18	12.6	43.0	33.3	-9.7	22.7%	N
19	13.2	25.5	17.8	-7.7	30.1%	N
20	12.7	27.0	18.3	-8.8	32.5%	N
21	15.5	37.5	31.8	-5.7	15.2%	N
22	15.5	46.3	33.0	-13.3	28.7%	N
23	8.8	22.4	17.8	-4.6	20.5%	N
24	8.7	17.6	21.1	3.5	19.9%	N
25	10.7	28.7	24.3	-4.4	15.4%	N

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
26	10.7	30.2	26.8	-3.4	11.2%	Y
27	8.6	19.2	21.0	1.8	9.6%	Y
28	8.7	22.9	20.8	-2.1	9.0%	Y
29	5.5	13.0	13.6	0.6	4.5%	Y
30	5.5	12.7	13.6	0.9	7.2%	Y
31	12.9	22.5	20.4	-2.0	9.0%	Y
32	12.8	34.9	22.2	-12.7	36.4%	N
Total	437.0	1133.7	945.7	-188.0	16.6%	N
Number of routes satisfying TAG Criteria = 13 out of 32 (40.6%)						

Table 6- 8: Modelled Versus Observed Motorway Journey Times in the PM Peak Hour (Minutes)

Route Number	Route Length (km)	Observed Time	Modelled Time	Modelled-Observed	% Error	TAG Compliant
33	14.3	8.9	9.7	0.7	8.2%	Y
34	13.5	15.8	9.5	-6.3	39.6%	N
35	14.4	15.5	11.9	-3.6	23.4%	N
36	15.1	14.8	10.4	-4.4	29.4%	N
37	15.9	28.9	11.4	-17.5	60.5%	N
38	16.1	21.3	12.1	-9.2	43.0%	N
39	12.0	22.2	10.8	-11.4	51.3%	N
40	11.4	12.3	10.0	-2.2	18.1%	N
41	13.9	9.1	9.3	0.2	2.1%	Y
42	14.0	8.3	9.4	1.2	14.0%	Y
43	12.8	7.4	8.7	1.3	17.1%	N
44	13.6	9.7	10.3	0.6	6.4%	Y
45	11.9	14.6	9.4	-5.1	35.2%	N
46	11.6	9.3	9.2	-0.1	1.4%	Y
47	8.7	11.1	5.7	-5.4	48.5%	N
48	8.6	6.5	6.3	-0.2	3.0%	Y
49	7.6	7.3	5.3	-2.0	27.4%	N
50	7.5	11.5	4.6	-6.9	59.7%	N
51	16.6	28.3	14.7	-13.6	48.0%	N
52	16.6	25.4	18.7	-6.6	26.1%	N
Total	255.9	288.2	197.7	-90.5	31.4%	N
Number of routes satisfying TAG Criteria = 6 out of 20 (30.0%)						

7 Summary and Conclusions

7.1 Model Development

7.1.1 This report has described the production and validation of the 2016 highway model developed for use in the GM CAP. The purpose of the report is to describe the development of the model and to present the results of the link flow and journey time validation using the criteria set out in TAG.

7.1.2 The 2016 highway networks were formed by updating the 2013 base year networks developed for the appraisal of the planned extension of the GM Metrolink system through Trafford Park. The following updates were made to the TPL networks as part of this process:

- Coding updates to include the highway impacts of the Manchester Metrolink Phase 3B extensions to Ashton-Under-Lyne, Oldham Town Centre, Rochdale Town Centre and Manchester Airport
- Coding updates to implement speed limit restrictions associated with roadworks for the M60 Jn 8 - M62 Jn 20 Smart Motorway scheme
- Updates to the bus routing data to include information about local bus flows based on 2015 services
- Updates to the values of time and distance, (PPM and PPK), used during the assignments based on the latest values of time, GDP growth rates and vehicle operating costs derived from the TAG data book.

7.1.3 The 2016 trip matrices were built in two stages:

- First, matrix estimation was used to improve the fit between modelled and counted flows at key sites in the study area for 2013
- Next, the updated matrices were factored from 2013 to 2016.

7.1.4 Separate matrices were built for the AM peak hour (0800-0900), the PM peak hour (1700-1800) and an average inter-peak hour for the time period 1000-1600.

7.1.5 The number of user classes in the demand matrices was increased as part of the modelling process to allow the different vehicle types that might be affected by a charging CAZ to be separately identified. The updated matrices represented eight user classes comprising:

- Compliant Car trips
- Non-Compliant Car trips
- Compliant LGV trips
- Non-Compliant LGV trips
- Compliant OGV trips, representing compliant Medium and Heavy Goods Vehicles
- Non-Compliant OGV trips

- Compliant (all purpose) Taxi trips
- Non-Compliant (all purpose) Taxi trips

7.1.6 Information about the fleet mix for disaggregating the taxi matrices and estimating the proportions of compliant and non-compliant vehicle types was derived from local ANPR data collected in 2016.

7.2 Model Validation

7.2.1 The updated model has been validated using the guidelines set out in TAG Unit M3.1, Highway Assignment Modelling.

7.2.2 The TAG 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
- more than 98% of links should have a flow that changes by less than 1% on the final four iterations.

7.2.3 The 2016 model was well converged in all time periods, with Delta and GAP values well below 0.1% and the percentage of links with flows changing by less than 1% meeting the criteria in all periods.

7.2.4 The TAG guidelines for link flow validation recommend that at least 85% of counted links should have a GEH value of less than five, and that for cordons and screenlines, that the difference between modelled and counted flows should be less than 5% of the counts in nearly all cases.

7.2.5 The link flow validation was carried out at two levels:

- Firstly, comparing modelled and observed flows for cordons around Manchester City Centre, inside the Intermediate Ring Road and inside the M60
- Secondly, comparing modelled and observed flows at sites identified by JAQU using the National Pollution Climate Mapping model where target NO_2 concentrations were likely to be exceeded in 2021 in GM.

7.2.6 The validation results for all sites combined, (for all vehicle flows in PCUs), showed that 81% of sites had a GEH value of less than five in the AM peak hour. The corresponding figures for the inter-peak and PM peak hours were 78% and 76% respectively.

7.2.7 The validation results for the cordons (for all vehicle flows expressed in PCUs) indicated that all of the six (two-way) cordons had modelled flows within 5% of the counted flows in the AM peak hour and that five out of six of the cordons had modelled flows within 5% of the counted flows in the PM peak hour. The cordon link flow comparisons for the inter-peak hour were the worst, with only the M60 cordons having modelled flows within 5% of the counts. The results at the site level were reasonably good however, with approximately 76% of the sites having a GEH value of less 5.0 across the cordons as-a-whole, and 81% of sites satisfying the TAG link flow criteria for an acceptable validation.

7.2.8 The journey time validation compared modelled and observed journey times on 52 routes within GM, using observed times from TrafficMaster data for October 2016. In total, the routes covered almost 700 km, or approximately 11% of the simulation network within GM.

7.2.9 The TAG guidelines for journey time validation state that modelled times should be within 15% (or one minute if higher) of the observed times on more than 85% of routes. The TAM, however, suggests that a range of +/-20% is acceptable in congested conditions. Both of these criteria were used during the validation.

7.2.10 For presentational purposes, the journey time routes were divided into two groups comprising 32 radial/orbital routes, primarily on A roads, and 20 routes on motorways.

7.2.11 The percentage of radial/orbital routes meeting the TAG criteria ranged from 41% in the PM peak hour to 85% in the inter-peak hour. The percentage of routes meeting the less stringent TAM criteria was 75% in the AM peak hour, 53% in the PM peak hour and 93% in the inter-peak hour.

7.2.12 The journey time comparisons for the motorway routes were less good, with 40% of the routes meeting the TAG criteria in the AM peak hour and 30% of the routes achieving the criteria in the PM peak hour. 85% of the routes achieved the criteria in the inter-peak hour. The percentage of motorway routes meeting the TAM criteria was 50% in the AM peak hour, 40% in the PM peak hour and 95% in the average inter-peak hour.

7.2.13 Considering all routes together, (both motorway and non-motorway), the percentage of routes meeting the TAG journey time criteria was 52% in the AM peak hour, 37% in the PM peak hour and 84% in the inter-peak hour. Overall, the modelled time in the AM peak hour across all routes was within 8% of the observed time, representing a difference in average speed of approximately 3 kph across the network as-a-whole. The total modelled time in the PM peak hour was approximately 20% lower than the observed time, indicating that modelled speeds in the evening peak hour are slightly too high in general, and that delays in this time period are too high in general and that the effects of congestion in this time period are underestimated. The total modelled and observed times in the inter-peak hour were within 7%, however, which is reasonably good.

7.2.14 Tests have been carried out to investigate how errors in the journey time validation might impact on modelled road traffic emission totals for 2016 by applying adjustment factors to the modelled link speeds (at an aggregate level) to give a closer fit between the modelled and observed speeds across GM-as-a-whole, which were then run through the EMIGMA software. The results of these tests indicated that there was relatively little impact on the calculated emissions, with an increase of approximately 3% in total road traffic NOx emissions within GM. Discrepancies of this size are considered to be acceptable, especially taking into account the size and complexity of the modelled area.

7.2.15 It should also be recognised that the errors associated with the journey time validation are just one extra source of uncertainty that are addressed by the application of adjustments to the modelled NO_2 concentrations from the dispersion model software to improve the fit between modelled and observed concentrations as part of the dispersion model verification process.

7.3 Conclusions

7.3.1 Considering the validation as a whole, the link flow and journey time comparisons are similar to those for other versions of the Saturn model of comparable size.

7.3.2 Whilst the validation does not fully achieve the standards required by TAG, the overall performance of the model is still considered to be acceptable, especially taking into account the size and complexity of the modelled area. It is believed that the model provides a sufficiently accurate representation of the base year situation, and is therefore acceptable for use in forecasting and testing the impacts of the GM CAP proposals.

Glossary of Terms and Abbreviations

	Term or Abbreviation	Explanation
A	ADMS-Urban	Atmospheric Dispersion Modelling System developed by Cambridge Environmental Research Consultants (CERC) to model the dispersion of pollutants from industrial, domestic and road transport sources in urban areas.
	ANPR	Automatic Number Plate Recognition; mass surveillance technique that uses optical character recognition to read the registration plates of vehicles.
B		
C	CAP	Clean Air Plan
	CAZ	Clean Air Zone
D	DfT	Department for Transport
	DEFRA	Department of Environment, Food & Rural Affairs
	Delta	A measure of network convergence describing the difference in modelled travel costs along the chosen routes and those along the minimum cost routes summed over the whole network and expressed as a percentage of the minimum costs
E	EFT	Emission Factor Toolkit; software developed by DEFRA to assist with calculating road vehicle pollutant emission rates for NOx, PM_{10}, $PM_{2.5}$ and CO_2 for specified years, road types, vehicle speeds and composition.
	EMIGMA	Emissions Inventory for GM; software developed by TfGM to calculate mass road traffic emissions using information about traffic speeds and flows from the GM Saturn model and road traffic emission factors and fleet composition data from the EFT.
F		
G	%GAP	A measure of network convergence similar to Delta, except that costs are calculated after the simulation. In general, GAP values are greater than DELTA values since the routes chosen based on the assignment cost estimates will tend to be slightly worse when the costs are further changed by the simulation.
	GEH	A formula used in traffic forecasting/modelling to compare two sets of traffic volumes
	GM	Greater Manchester.
	GMBusRoutes	Bus route mapping system which is used to build and check bus service routes within GM.
	GMCounts	A traffic counts database developed by HFAS to validate, store and display traffic count data within GM.

	Term or Abbreviation	Explanation
	GMSF	GM Spatial Framework; GM's Plan for the development of Homes, Jobs and the Environment up to 2037.
	GMBusRoutes	Bus route mapping system which is used to build and check bus service routes within GM.
H	HFAS	Highways Forecasting and Analytical Services.
I		
J	JAQU	Joint Air Quality Unit; Unit established in 2016 by DEFRA and DfT to coordinate delivery of the government's plans for achieving NO_2 compliance.
K		
L	LGV	Light Goods Vehicle.
M	ME	Matrix Estimation.
N	NTM	National Transport Model; a transport model developed by the DfT to evaluate the national consequences of alternative national transport policies
	NTEM	National Trip End Model; a model developed by the DfT to forecast the growth in trip origin-destinations (or productions-attractions) for use in transport modelling.
O	OD	Origin-Destination.
	OGV	Other Goods Vehicle (i.e. a medium or heavy goods vehicle).
P	PPM/PPK	Monetary values expressed in units of Pence Per Minute and Pence Per Kilometre used in Saturn to convert times and distances into generalised costs for assignment purposes.
	PCU	Passenger Car Unit, a standard unit of traffic used in modelling work; a car or LGV is generally 1 PCU, an OGV is 1.9 PCUs and a bus is 2 PCUs.
Q		
R	RSI	Road Side Interview.
S	Saturn	Simulation and Assignment of Traffic to Urban Road Networks; a commonly used road traffic modelling suite developed by the Institute for Transport Studies at Leeds University which allows the detailed modelling of junctions and their associated delays.

	Term or Abbreviation	Explanation
T	TAM	Traffic Appraisal Manual; the publication which provides advice on data collection for the development of highway assignment models, including roadside interview data, traffic count data and journey time data.
	TEMPRO	Trip End Model Presentation Program; software developed by the DfT to allow analysis of trip-end, car ownership and population data from the National Trip End Model (NTEM).
	Trafficmaster	Company providing fleet management and vehicle information systems, including real time road speed data and satnav services.
U	Updated Matrix	The trip matrix that has been subjected to matrix estimation.
V		
W	TAG	DfT website providing guidance on the conduct of transport studies.
X		
Y		
Z		

Appendix A: Refinement of Trip Matrices by Matrix Estimation

A.1 Introduction

A.1.1 Appendix A provides details of the 2013 matrix estimation runs.

A.1.2 Separate matrix estimation runs were carried out for the car, LGV and OGV matrices for each of the modelled hours. A total of six rounds of matrix estimation were carried out for each run, to ensure that the updated matrices did not change significantly between successive iterations, and that the procedure was satisfactorily converged. The method was as follows:

- Assign the prior matrix to the highway network to produce paths
- Run matrix estimation to produce a revised (estimated) demand matrix
- Assign the estimated demand matrix to produce revised paths
- Re-run matrix estimation using the prior matrix and the revised paths from above to produce a further estimate of the demand matrix
- Repeat.

A.1.3 Matrix Estimation stops once a degree of matrix 'stability' is reached (after 6 iterations).

A.1.4 The results of the matrix estimation runs are described in the remainder of the Appendix, as follows:

- The next section describes the traffic count data that was input to the procedure
- The third section describes the results of the matrix estimation runs, including comparisons of matrix totals, trip end totals and trip length distributions for the prior and updated matrices.

A.2 Traffic Counts

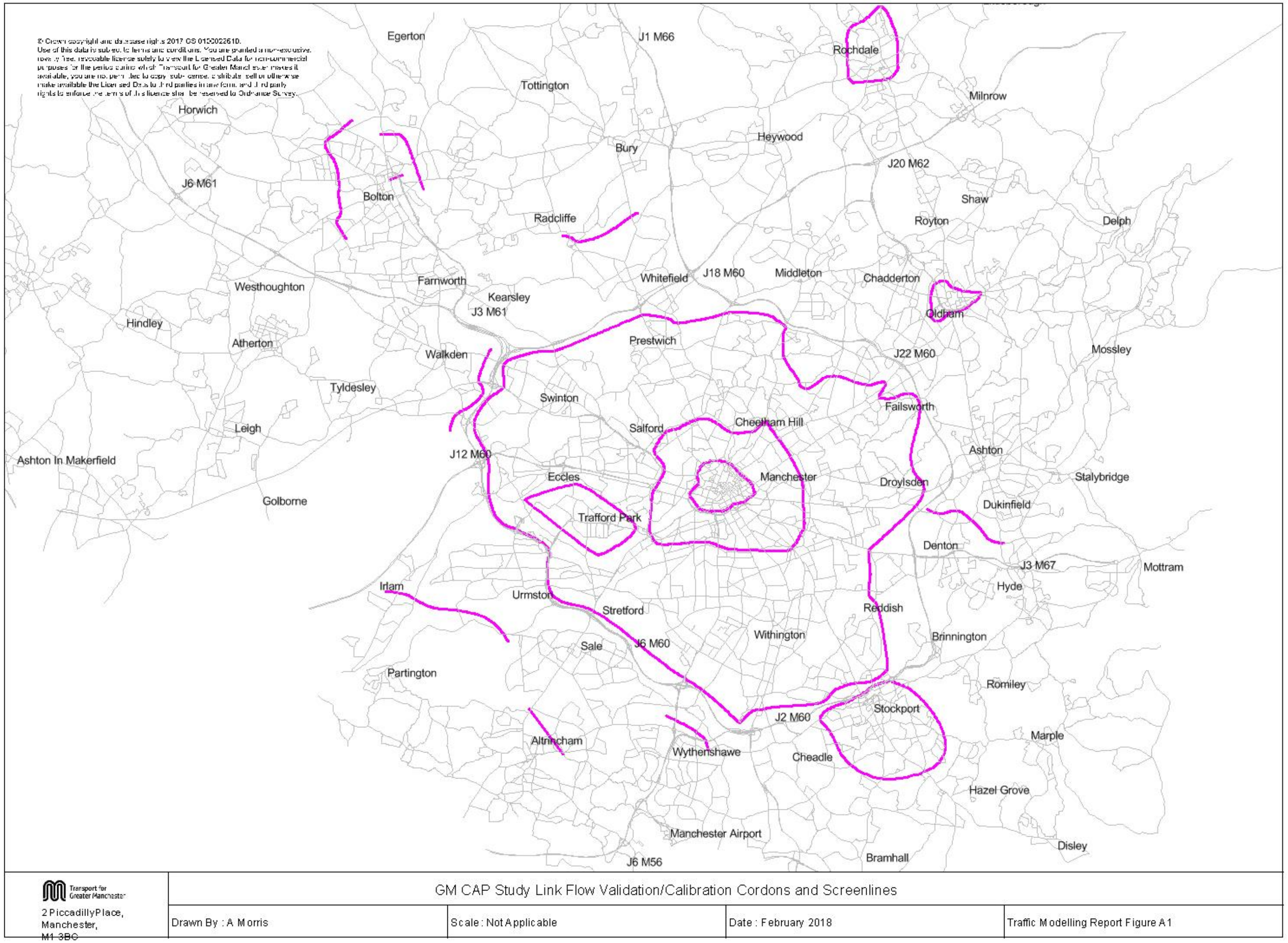
A.2.1 The traffic count data for input to the matrix estimation runs was derived from manual classified counts from TfGM's traffic counts database. Link and turn counts were selected that had been undertaken between 1st January 2010 and the present day, excluding any counts affected by known 'unusual' events such as accidents, road works, adverse weather conditions and holidays. (1st January 2010 was chosen as the earliest count date to exclude older counts that might be unreliable due to changes in travel patterns and traffic flows over time). Note, however, that a small number of counts undertaken before 1st January 2010 were subsequently included, to help fill 'holes' in cordons and screenlines. Note, also, that the turn counts were aggregated to form 'derived' link counts for model validation/calibration purposes.

A.2.2 Separate counts were obtained for cars, LGVs, OGVs and all vehicle PCUs, for the morning peak hour (0800-0900), the evening peak hour (1700-1800) and an average inter-peak hour for the period 1000-1600/6. All of the counts that were input to the procedure were factored to a 2013 October average weekday using locally derived count conversion factors.

A.2.3 The counts that were input to the matrix estimation procedure were grouped to form cordons and screenlines, as illustrated in **Figure A 1**. In total, approximately 400 counts were used in total, although not all counts were used in all time periods, as sites were only included in the procedure for screenlines where there was a significant difference between the modelled and counted flows from the assignments of the prior matrix, of greater than 5%. (This approach was adopted to minimise the changes brought about by the matrix estimation procedure, to try to ensure that they were not significant).

A.2.4 Ad-hoc counts at 11 sites identified by JAQU where target NO_2 concentrations were likely to be exceeded in 2021 were also input to the matrix estimation runs to ensure that the fit between modelled and observed flows at these sites in the base year was as accurate as possible.

Figure A 1: Matrix Calibration Cordon and Screenline Locations



A.3 Matrix Estimation Results

Changes to Matrix Totals

A.3.1 **Table A 1** shows the total trips for the estimated matrix and the percentage change from the prior matrix by user class, vehicle type and time period.

A.3.2 In general, the changes to matrix totals are modest, with the numbers of car trips changing by less than 1% in all time periods. For LGVs, the total trips have increased by 0.6% in the AM peak hour and 1.3% in the inter-peak hour, and have fallen by 1.3% in the PM peak hour. OGV trips have fallen in all three time periods, with reductions of approximately 4% in the AM peak and inter-peak hours and 6% in the PM peak hour.

A.3.3 Overall, the total change in PCU trips is very modest, with reductions in total trips of less than 1% in all time periods.

Table A 1: Total Trips in Estimated Matrices and Percentage Change from Prior Matrices by User Class and Time Period

User Class	Time Period					
	AM Peak		Inter-Peak		PM Peak	
	Trips	% Change	Trips	% Change	Trips	% Change
Commuting Car	587,739	-0.2%	136,191	-0.2%	463,596	-0.1%
EB Car	39,573	-0.5%	41,004	-0.4%	46,139	0.2%
Other Car	586,184	-0.2%	777,824	-0.5%	610,987	-0.1%
All Car	1,213,496	-0.2%	955,019	-0.4%	1,120,722	-0.1%
LGV	41,006	0.6%	40,051	1.3%	34,760	-1.3%
OGV (PCU)	30,688	-3.6%	33,424	-4.0%	16,148	-5.8%
Total (PCUS)	1,285,190	-0.3%	1,028,494	-0.5%	1,171,630	-0.2%

Changes to Zonal trip Ends

A.3.4 **Table A 2** shows regression statistics (slopes, intercepts and R-Squared values) for the best fit line obtained by regressing trip end totals from the estimated matrix against the prior matrix. Separate results are presented for the car, LGV, OGV and all vehicle PCU matrices, for each of the modelled hours. TAG suggests that the slope of the regression line should fall within the range 0.99 to 1.01, that the intercept should be near to zero and that the R-squared value should be in excess of 0.98.

A.3.5 The R-Squared values for the car matrices meet the TAG criteria in all time periods. The values of the slope statistics also meet the benchmark figures in all periods. The values of the intercepts range from 1 for the PM peak matrix to -8 for the AM peak matrix, which is very good.

A.3.6 The regression statistics for the LGV and OGV matrices are reasonably good, with R-squared values ranging from 0.98 to 1.00, and slopes ranging from 0.96 to 1.01. The results for the all-vehicle PCU matrices are very good, with the R-squared and slope values achieving the benchmark criteria in all time periods.

Table A 2: Summary of Matrix Estimation Zonal Trip End Changes

Time Period	Matrix	Slope	Intercept	R-Squared
Weekday AM Peak	Car	1.00	-3.9	1.00
	LGV	0.98	2.06	0.99
	OGV (PCU)	0.97	-0.59	1.00
	All Vehicle (PCU)	1.00	-5.45	1.00
Weekday Inter-Peak	Car	1.00	-8.20	1.00
	LGV	1.01	-0.08	0.99
	OGV (PCU)	0.97	-0.74	0.98
	All Vehicle (PCU)	1.00	-9.46	1.00
Weekday PM Peak	Car	1.00	1.33	1.00
	LGV	0.98	0.65	0.99
	OGV (PCU)	0.96	-0.63	1.00
	All Vehicle (PCU)	1.00	-0.76	1.00

Changes to Trip Length Distributions

A.3.7 **Table A 3** compares mean trip lengths for movements in the prior and estimated matrices by vehicle type and time period, for movements with an origin or destination inside GM. (External-to-external trips have been excluded from this analysis to prevent these movements from biasing the results, since external-to-external trips would tend to have longer trip lengths, and would not (in most cases) have been affected by matrix estimation, which only used counts on roads in GM).

Table A 3: Comparison of Mean Trips Lengths in the Estimated Matrices and Percentage Change From the Prior Matrices for Trips With an Origin or Destination Inside GM

Time	Car		LGV		OGV	
Period	**Mean**	**% Change**	**Mean**	**% Change**	**Mean**	**% Change**
AM Peak Hour	14.0	-1.4%	19.8	-1.1%	34.2	-2.8%
Inter Peak Hour	11.8	-0.6%	18.6	0.6%	34.9	-3.8%
PM Peak Hour	15.4	9.5%	19.9	0.2%	40.5	15.3%

A.3.8 For the car matrices, the mean trip lengths have reduced by approximately 1% in the AM peak and inter-peak hours, but have increased by approximately 10% the PM peak hour, which equates to an average increase of roughly 1.3 km in absolute terms, which is relatively modest.

A.3.9 The changes in mean trip lengths for the LGV matrices are very modest, with a reduction of approximately 1% in the AM peak hour and increases of 0.6% and 0.2% in the inter-peak and PM peak hours respectively.

A.3.10 The mean trip lengths for the OGV matrices have fallen by approximately 3% in the AM peak hour and 4% in the inter-peak hour. The mean trip length has increased by approximately 15% in the PM peak hour, which equates to an average lengthening of the mean OGV trip length of approximately 5.4 km in this time period.

A.3.11 The changes in the prior and estimated trip length distributions are shown graphically in **Figure A 2** to **Figure A 10**, for each of the modelled time periods and vehicle types.

Figure A 2

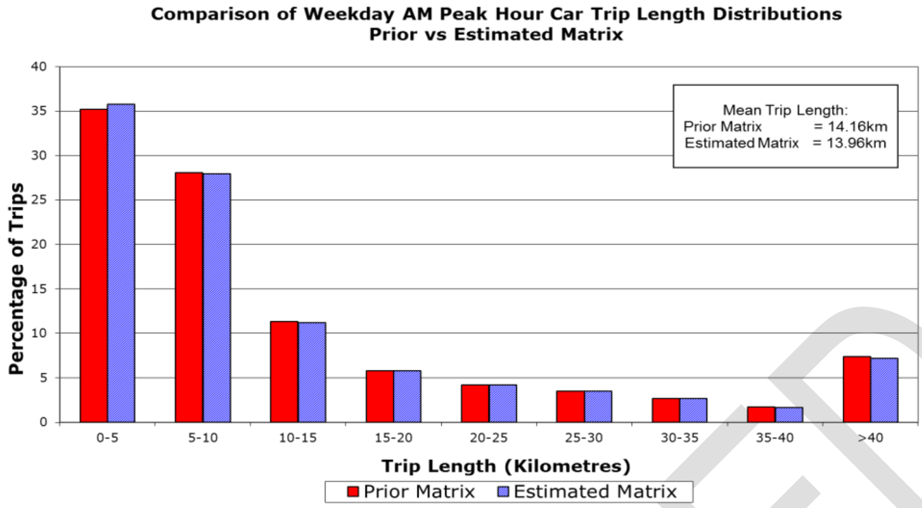


Figure A 3

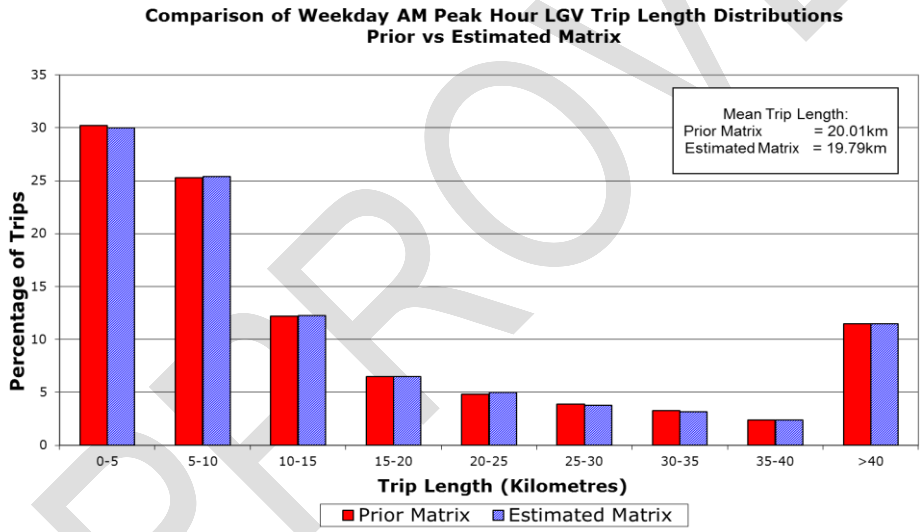


Figure A 4

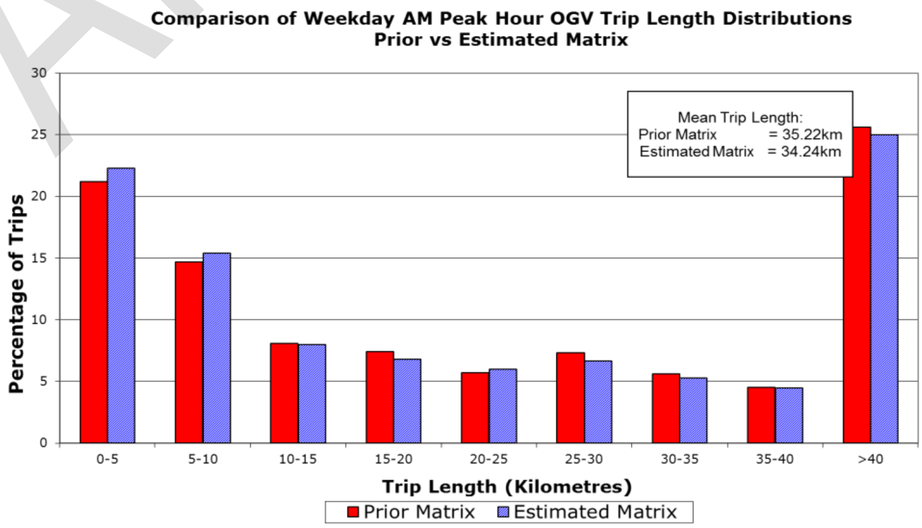


Figure A 5

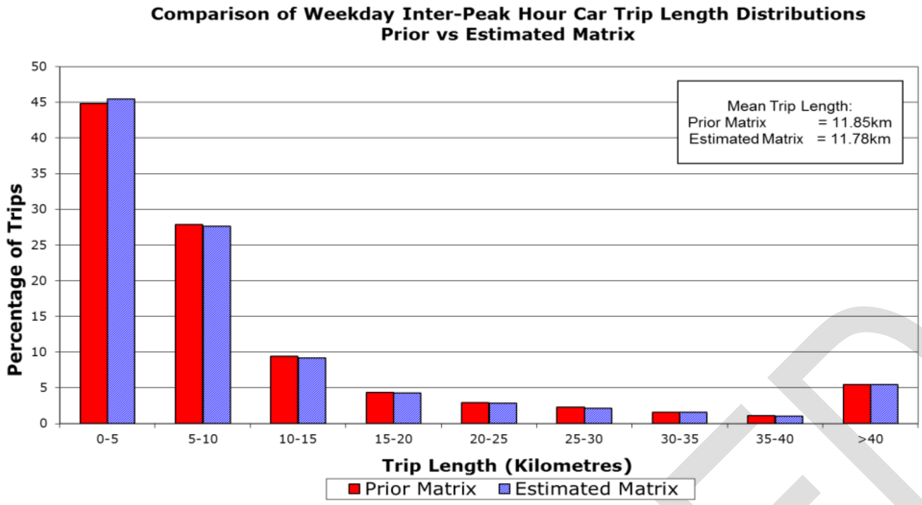


Figure A 6

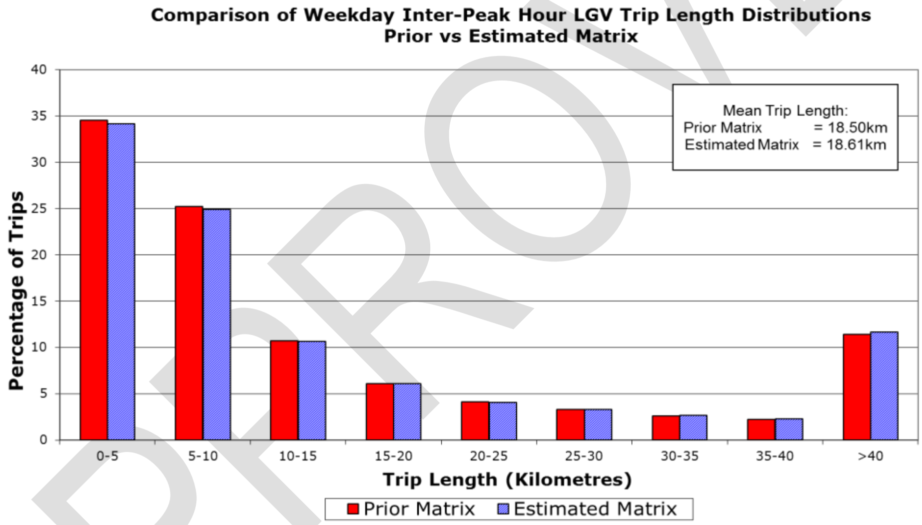


Figure A 7

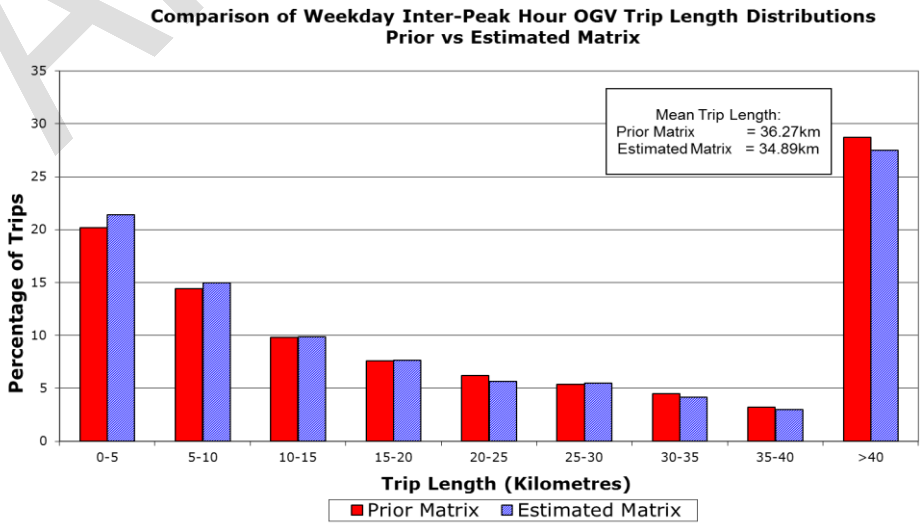


Figure A 8

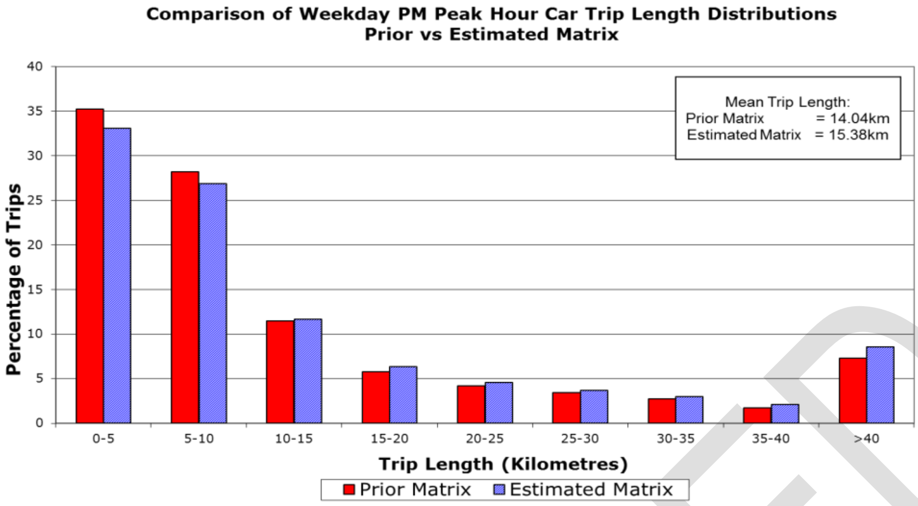


Figure A 9

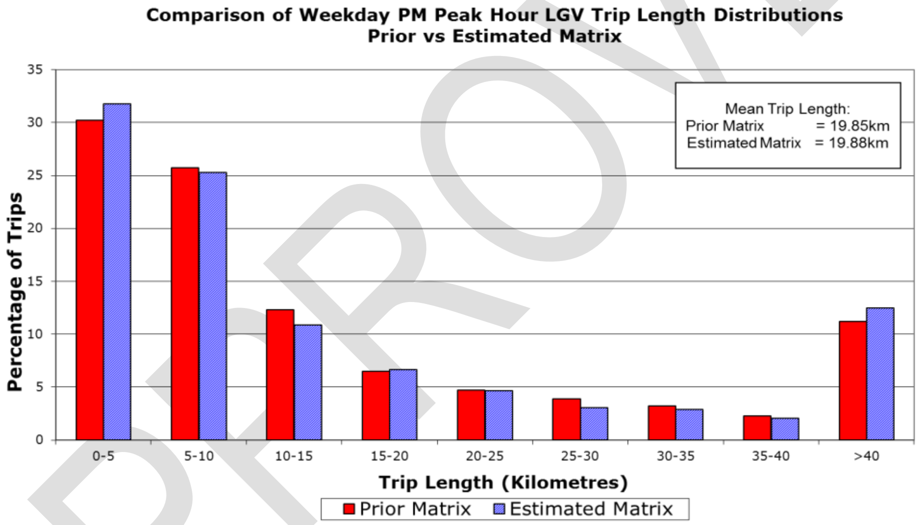
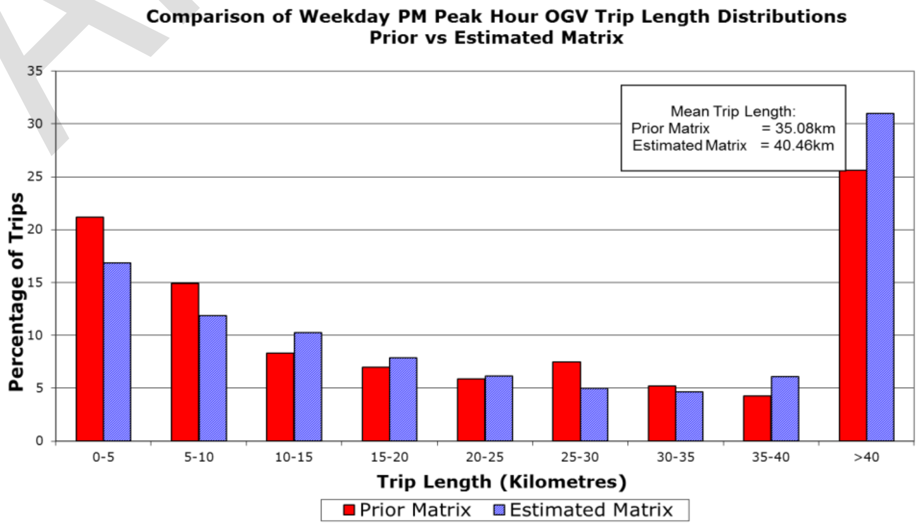


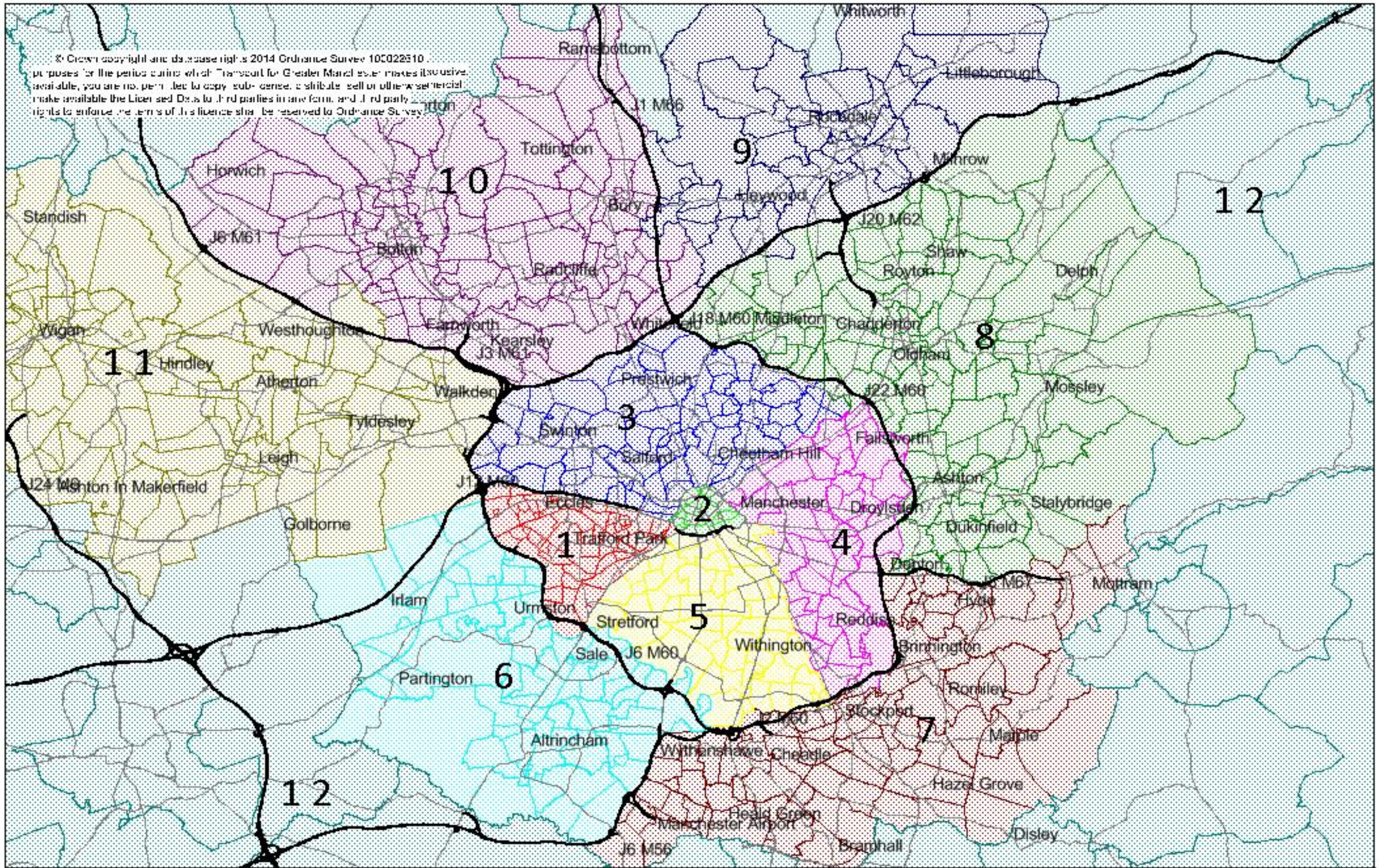
Figure A 10



Matrix Changes by Sector

A.3.12 **Table A 4** to **Table A 6** present comparisons of the prior and estimated all vehicle PCU matrices based on the aggregation of the 1034 zone assignment matrices to the 12 sectors shown in **Figure A 11**. The tables show absolute and percentage changes, with shading to identify sector to sector movements where the percentage difference is greater than 5% and the absolute difference between the demand totals is greater than 500 trips.

Figure A 11: Matrix Comparison Sectors



Transport for Greater Manchester 2 Piccadilly Place, Manchester, M1 3BQ	Matrix Comparison Sectors			
	Drawn By : A. Morris	Scale : Not Applicable	Date : August 2014	Report : 1806 Figure : A2.1

Table A 4: AM Peak Hour All Vehicle PCU Sector to Sector Matrix Comparison - Prior Versus Estimated Matrix

Sectors	Matrix	1	2	3	4	5	6	7	8	9	10	11	12	Origin Totals
1	Prior	3325.1	398.7	1930.7	527.0	1808.6	2374.3	397.9	202.6	101.6	296.4	375.2	1388.8	13126.7
	Estimated	3324.8	469.3	1915.9	587.7	1907.1	2350.8	382.2	199.4	101.5	304.5	393.8	1384.7	13321.8
	Perc Diff	0.0%	17.7%	-0.8%	11.5%	5.5%	-1.0%	-3.9%	-1.5%	-0.1%	2.7%	4.9%	-0.3%	1.5%
2	Prior	323.3	1469.3	908.5	365.1	694.5	359.4	207.7	331.3	50.0	121.0	79.3	556.9	5466.3
	Estimated	288.4	1467.8	832.7	347.5	643.1	339.5	217.8	351.9	45.5	111.2	72.2	506.9	5224.4
	Perc Diff	-10.8%	-0.1%	-8.3%	-4.8%	-7.4%	-5.5%	4.8%	6.2%	-9.0%	-8.1%	-8.8%	-9.0%	-4.4%
3	Prior	3039.6	1394.6	11687.0	2503.0	2176.7	459.6	442.0	1444.3	445.5	1683.3	1319.4	1961.6	28556.5
	Estimated	3028.3	1528.0	11690.8	2546.9	2377.1	448.2	452.9	1517.0	445.5	1738.9	1270.8	1929.4	28973.7
	Perc Diff	-0.4%	9.6%	0.0%	1.8%	9.2%	-2.5%	2.5%	5.0%	0.0%	3.3%	-3.7%	-1.6%	1.5%
4	Prior	1004.1	1494.2	1956.6	5238.4	4549.4	433.0	2256.6	2818.6	190.3	250.0	81.5	1336.0	21608.6
	Estimated	842.7	1505.9	1899.7	5255.7	4341.8	441.1	2400.3	2971.7	194.6	245.3	67.9	1299.7	21466.3
	Perc Diff	-16.1%	0.8%	-2.9%	0.3%	-4.6%	1.9%	6.4%	5.4%	2.2%	-1.9%	-16.7%	-2.7%	-0.7%
5	Prior	2427.4	1955.0	1414.7	3082.3	10499.5	2196.8	2969.4	831.6	122.5	272.1	145.6	3231.1	29148.0
	Estimated	2381.5	2084.3	1235.9	3047.8	10541.5	2223.3	3322.1	955.9	117.7	248.6	134.1	3442.4	29735.0
	Perc Diff	-1.9%	6.6%	-12.6%	-1.1%	0.4%	1.2%	11.9%	14.9%	-3.9%	-8.6%	-7.9%	6.5%	2.0%
6	Prior	3517.2	1136.9	1105.9	419.8	2753.3	16967.7	2997.1	479.2	187.3	245.1	325.3	4237.1	34372.0
	Estimated	3477.2	1176.9	1075.9	381.5	2621.2	16588.8	2939.2	422.3	175.6	252.6	324.1	4159.6	33594.9
	Perc Diff	-1.1%	3.5%	-2.7%	-9.1%	-4.8%	-2.2%	-1.9%	-11.9%	-6.2%	3.1%	-0.4%	-1.8%	-2.3%
7	Prior	1049.3	303.7	314.8	1883.0	2195.7	2429.4	25654.3	2581.6	285.2	246.7	178.0	6823.2	43945.0
	Estimated	914.3	292.1	312.8	1846.0	2365.6	2219.3	25939.5	2574.0	323.4	231.7	196.1	6981.8	44196.5
	Perc Diff	-12.9%	-3.8%	-0.7%	-2.0%	7.7%	-8.6%	1.1%	-0.3%	13.4%	-6.1%	10.2%	2.3%	0.6%

Sectors	Matrix	1	2	3	4	5	6	7	8	9	10	11	12	Origin Totals
8	Prior	510.9	1529.7	2495.6	2987.6	655.2	288.2	2332.8	32984.4	3266.2	721.0	100.8	3782.2	51654.7
	Estimated	482.5	1570.3	2493.6	2906.5	603.2	282.0	2752.6	33742.2	3187.9	827.7	100.5	3757.3	52706.2
	Perc Diff	-5.5%	2.7%	-0.1%	-2.7%	-7.9%	-2.2%	18.0%	2.3%	-2.4%	14.8%	-0.3%	-0.7%	2.0%
9	Prior	194.4	69.1	524.4	240.6	112.4	51.1	180.4	3730.0	13619.9	1812.7	49.0	2825.6	23409.7
	Estimated	194.5	75.1	522.2	237.3	110.7	48.2	180.6	3748.9	13619.9	1968.6	48.7	2822.5	23577.1
	Perc Diff	0.0%	8.7%	-0.4%	-1.4%	-1.5%	-5.8%	0.1%	0.5%	0.0%	8.6%	-0.8%	-0.1%	0.7%
10	Prior	886.2	412.7	2777.6	487.8	414.0	256.4	719.5	933.9	1835.6	34906.3	2234.7	6196.1	52061.0
	Estimated	825.0	419.1	2625.4	434.2	374.5	224.0	637.5	802.3	1559.2	33545.3	2285.7	5997.8	49730.0
	Perc Diff	-6.9%	1.6%	-5.5%	-11.0%	-9.5%	-12.7%	-11.4%	-14.1%	-15.1%	-3.9%	2.3%	-3.2%	-4.5%
11	Prior	1155.5	320.6	3072.5	131.6	276.9	392.1	456.3	272.1	378.0	4468.3	32231.2	11970.5	55125.4
	Estimated	1023.0	318.6	2892.8	111.3	250.3	349.7	372.9	211.3	318.3	4601.0	32235.2	11880.6	54564.9
	Perc Diff	-11.5%	-0.6%	-5.8%	-15.4%	-9.6%	-10.8%	-18.3%	-22.3%	-15.8%	3.0%	0.0%	-0.8%	-1.0%
12	Prior	2425.6	1042.2	3103.6	1355.5	2756.9	5524.5	9980.8	5822.3	3685.1	6293.7	9066.5	878993.3	930050.1
	Estimated	2277.2	1048.1	2896.7	1241.6	2454.1	5344.4	9473.7	5616.3	3638.2	6258.5	9064.4	878786.4	928099.6
	Perc Diff	-6.1%	0.6%	-6.7%	-8.4%	-11.0%	-3.3%	-5.1%	-3.5%	-1.3%	-0.6%	0.0%	0.0%	-0.2%
Dest Totals	Prior	19858.5	11526.5	31292.0	19222.0	28893.0	31732.6	48594.8	52431.9	24167.2	51316.5	46186.6	923302.3	1288523.9
	Estimated	19059.4	11955.6	30394.5	18944.0	28590.2	30859.2	49071.3	53113.1	23727.3	50333.9	46193.3	922948.8	1285190.5
	Perc Diff	-4.0%	3.7%	-2.9%	-1.4%	-1.0%	-2.8%	1.0%	1.3%	-1.8%	-1.9%	0.0%	0.0%	-0.3%

Note:

The shading indicates those sector to sector comparisons where the percentage difference is >5% **and** the absolute difference is >500.

Table A 5: Inter-Peak Hour All Vehicle PCU Sector to Sector Matrix Comparison - Prior Versus Estimated Matrix

Sectors	Matrix	1	2	3	4	5	6	7	8	9	10	11	12	Origin Totals
1	Prior	3511.3	271.3	2290.1	533.4	1780.5	2074.7	512.0	291.8	102.6	407.6	493.8	1855.7	14124.9
	Estimated	3510.1	294.1	2278.5	447.2	1809.5	2053.5	499.8	267.0	102.7	393.2	418.9	1761.2	13835.8
	Perc Diff	0.0%	8.4%	-0.5%	-16.2%	1.6%	-1.0%	-2.4%	-8.5%	0.1%	-3.5%	-15.2%	-5.1%	-2.0%
2	Prior	293.6	1701.3	717.2	454.8	893.3	169.4	255.5	342.1	63.2	193.0	116.6	605.2	5805.1
	Estimated	320.7	1730.1	882.3	526.0	1035.3	202.8	321.0	417.0	78.2	234.4	119.6	769.3	6636.7
	Perc Diff	9.2%	1.7%	23.0%	15.7%	15.9%	19.7%	25.6%	21.9%	23.8%	21.5%	2.6%	27.1%	14.3%
3	Prior	2407.2	1265.4	12527.9	2156.1	954.5	486.2	279.7	1384.8	493.5	1705.5	1460.9	2221.9	27343.7
	Estimated	2389.2	1348.2	12527.4	2073.9	843.2	477.8	275.6	1404.3	493.5	1752.6	1272.2	2036.4	26894.4
	Perc Diff	-0.7%	6.5%	0.0%	-3.8%	-11.7%	-1.7%	-1.4%	1.4%	0.0%	2.8%	-12.9%	-8.3%	-1.6%
4	Prior	462.1	620.0	1875.9	4484.3	3246.1	286.9	2044.5	2467.9	249.3	218.3	105.7	1080.1	17141.0
	Estimated	308.6	640.9	1866.6	4499.1	2986.5	270.1	2092.2	2522.9	270.7	235.6	93.3	1064.0	16850.4
	Perc Diff	-33.2%	3.4%	-0.5%	0.3%	-8.0%	-5.9%	2.3%	2.2%	8.6%	7.9%	-11.7%	-1.5%	-1.7%
5	Prior	2317.5	821.2	809.9	3573.5	9889.8	1572.6	1857.7	566.4	92.1	196.2	131.7	1716.3	23544.9
	Estimated	2271.8	887.7	915.0	3366.4	9901.2	1633.9	1922.7	518.1	96.5	202.6	122.1	1675.9	23513.8
	Perc Diff	-2.0%	8.1%	13.0%	-5.8%	0.1%	3.9%	3.5%	-8.5%	4.8%	3.2%	-7.3%	-2.4%	-0.1%
6	Prior	2359.4	343.8	687.5	286.6	1295.4	16074.4	1975.4	281.4	89.9	198.2	169.0	2696.3	26457.2
	Estimated	2361.4	373.7	689.1	297.1	1341.4	15719.3	1984.8	294.5	89.0	183.3	148.2	2624.0	26105.7
	Perc Diff	0.1%	8.7%	0.2%	3.7%	3.6%	-2.2%	0.5%	4.7%	-0.9%	-7.5%	-12.3%	-2.7%	-1.3%
7	Prior	604.9	398.5	304.2	2005.2	1778.9	1938.2	26594.2	2504.9	291.7	388.6	111.7	5713.7	42634.6
	Estimated	596.1	433.0	291.0	1996.3	1822.4	1991.4	26581.2	2262.1	325.9	371.6	100.4	5721.8	42493.2
	Perc Diff	-1.5%	8.7%	-4.3%	-0.4%	2.4%	2.7%	0.0%	-9.7%	11.7%	-4.4%	-10.1%	0.1%	-0.3%

Sectors	Matrix	1	2	3	4	5	6	7	8	9	10	11	12	Origin Totals
8	Prior	253.1	363.7	1554.6	2069.9	506.4	235.1	2495.0	32311.9	2493.6	591.7	129.4	3096.5	46100.8
	Estimated	233.0	366.8	1546.6	1949.9	422.4	254.4	2291.9	31134.4	2412.5	630.5	112.4	2959.1	44313.8
	Perc Diff	-7.9%	0.9%	-0.5%	-5.8%	-16.6%	8.2%	-8.1%	-3.6%	-3.3%	6.6%	-13.2%	-4.4%	-3.9%
9	Prior	137.4	85.9	381.0	117.5	57.7	68.5	223.3	2490.0	15003.4	1351.5	166.2	2971.9	23054.3
	Estimated	137.0	91.6	381.0	117.1	57.4	68.3	229.1	2460.4	15003.4	1464.6	145.3	2951.5	23106.8
	Perc Diff	-0.3%	6.7%	0.0%	-0.4%	-0.5%	-0.2%	2.6%	-1.2%	0.0%	8.4%	-12.6%	-0.7%	0.2%
10	Prior	416.1	309.7	1492.7	162.4	214.6	120.9	446.8	641.6	1371.4	33982.1	2525.0	4653.5	46336.8
	Estimated	403.6	321.1	1473.2	159.1	210.2	110.8	430.1	644.8	1306.1	33035.1	2461.4	4391.0	44946.5
	Perc Diff	-3.0%	3.7%	-1.3%	-2.0%	-2.0%	-8.3%	-3.7%	0.5%	-4.8%	-2.8%	-2.5%	-5.6%	-3.0%
11	Prior	528.7	144.0	1533.5	47.7	140.8	199.5	246.1	172.8	80.0	2592.4	30494.4	7430.9	43610.6
	Estimated	534.7	136.2	1427.2	37.3	147.5	189.0	225.8	149.9	71.3	2535.7	30496.2	7346.8	43297.5
	Perc Diff	1.1%	-5.4%	-6.9%	-21.9%	4.8%	-5.3%	-8.2%	-13.2%	-11.0%	-2.2%	0.0%	-1.1%	-0.7%
12	Prior	1825.6	733.6	1979.3	849.2	1363.5	2623.6	6164.6	2995.4	2554.8	4775.0	7706.9	683956.3	717528.0
	Estimated	1744.7	798.0	1857.0	801.1	1325.0	2594.9	6170.7	2954.7	2524.6	4705.9	7641.3	683380.1	716498.2
	Perc Diff	-4.4%	8.8%	-6.2%	-5.7%	-2.8%	-1.1%	0.1%	-1.4%	-1.2%	-1.4%	-0.9%	-0.1%	-0.1%
Dest Totals	Prior	15117.0	7058.4	26153.8	16740.5	22121.4	25850.0	43094.6	46451.0	22885.6	46600.1	43611.1	717998.2	1033681.8
	Estimated	14810.9	7421.6	26134.9	16270.4	21901.9	25566.2	43024.9	45030.1	22774.5	45745.1	43131.2	716681.0	1028492.8
	Perc Diff	-2.0%	5.1%	-0.1%	-2.8%	-1.0%	-1.1%	-0.2%	-3.1%	-0.5%	-1.8%	-1.1%	-0.2%	-0.5%

Note

The shading indicates those sector to sector comparisons where the percentage difference is >5% **and** the absolute difference is >500.

Table A 6: PM Peak Hour All Vehicle PCU Sector to Sector Matrix Comparison - Prior Versus Estimated Matrix

Sectors	Matrix	1	2	3	4	5	6	7	8	9	10	11	12	Origin Totals
1	Prior	3682.1	390.2	3413.3	780.9	1946.1	3893.3	998.1	778.1	130.4	466.8	970.6	3074.7	20524.7
	Estimated	3559.1	363.5	3433.9	774.9	2205.3	3842.5	956.0	737.0	126.3	376.1	1012.7	2852.2	20239.4
	Perc Diff	-3.3%	-6.9%	0.6%	-0.8%	13.3%	-1.3%	-4.2%	-5.3%	-3.1%	-19.4%	4.3%	-7.2%	-1.4%
2	Prior	406.0	781.4	1851.8	924.7	1984.7	794.8	492.3	1574.7	332.9	372.7	182.9	1302.7	11001.6
	Estimated	393.9	789.3	2310.3	1055.1	1998.5	747.3	470.7	1713.5	333.9	357.8	194.8	1200.6	11565.7
	Perc Diff	-3.0%	1.0%	24.8%	14.1%	0.7%	-6.0%	-4.4%	8.8%	0.3%	-4.0%	6.5%	-7.8%	5.1%
3	Prior	1887.3	1323.0	9582.2	2148.6	1802.7	904.8	519.4	2338.5	474.9	3293.2	3489.2	2961.6	30725.3
	Estimated	1850.4	1656.6	10600.0	2064.7	1469.3	1007.7	548.1	2287.8	482.2	3174.8	3259.7	2553.4	30954.7
	Perc Diff	-2.0%	25.2%	10.6%	-3.9%	-18.5%	11.4%	5.5%	-2.2%	1.5%	-3.6%	-6.6%	-13.8%	0.7%
4	Prior	278.9	790.5	1518.4	4085.7	2328.8	450.5	2334.6	2908.2	422.6	683.5	177.2	1461.8	17440.7
	Estimated	229.9	828.9	1507.9	4104.5	2288.6	387.1	2220.0	2835.6	443.1	728.5	153.4	1409.7	17137.2
	Perc Diff	-17.6%	4.9%	-0.7%	0.5%	-1.7%	-14.1%	-4.9%	-2.5%	4.9%	6.6%	-13.4%	-3.6%	-1.7%
5	Prior	2149.4	1037.5	970.5	2979.8	7634.9	2901.6	3038.6	1496.1	164.1	284.1	163.6	2829.6	25649.8
	Estimated	2203.2	1074.3	1009.7	2974.5	7705.9	2982.7	3505.2	1367.2	146.2	251.5	188.0	2600.2	26008.6
	Perc Diff	2.5%	3.6%	4.0%	-0.2%	0.9%	2.8%	15.4%	-8.6%	-10.9%	-11.5%	14.9%	-8.1%	1.4%
6	Prior	2773.5	287.1	602.2	421.1	2195.3	13676.8	2782.1	390.7	86.4	299.1	440.3	4358.5	28313.1
	Estimated	2785.5	328.6	719.8	341.6	2172.8	14057.5	2455.3	326.1	87.8	271.7	468.1	4319.4	28334.1
	Perc Diff	0.4%	14.5%	19.5%	-18.9%	-1.0%	2.8%	-11.7%	-16.5%	1.6%	-9.2%	6.3%	-0.9%	0.1%
7	Prior	558.1	254.9	368.7	2347.4	2211.4	2929.7	21269.8	3415.1	422.4	318.3	204.2	7305.3	41605.3
	Estimated	544.4	262.4	387.7	2187.3	2253.2	2922.8	22270.5	3477.9	452.5	342.0	225.9	7420.2	42746.8
	Perc Diff	-2.5%	2.9%	5.1%	-6.8%	1.9%	-0.2%	4.7%	1.8%	7.1%	7.4%	10.6%	1.6%	2.7%

Sectors	Matrix	1	2	3	4	5	6	7	8	9	10	11	12	Origin Totals
8	Prior	232.8	558.3	2513.6	2525.6	787.7	553.4	3204.0	27626.4	3165.9	894.2	495.8	4506.6	47064.3
	Estimated	219.6	595.9	2495.7	2474.7	786.8	563.9	3077.7	28098.9	3171.2	926.3	652.9	4326.2	47389.9
	Perc Diff	-5.7%	6.7%	-0.7%	-2.0%	-0.1%	1.9%	-3.9%	1.7%	0.2%	3.6%	31.7%	-4.0%	0.7%
9	Prior	80.1	103.8	418.8	183.2	173.6	86.7	305.5	3704.2	12093.5	1839.1	175.1	4156.9	23320.6
	Estimated	79.6	119.8	420.8	179.5	181.5	86.7	279.5	3688.8	11670.2	1993.1	174.8	4024.4	22898.6
	Perc Diff	-0.6%	15.4%	0.5%	-2.0%	4.6%	0.0%	-8.5%	-0.4%	-3.5%	8.4%	-0.2%	-3.2%	-1.8%
10	Prior	368.5	224.2	1929.7	359.8	310.0	222.0	410.1	768.7	1665.6	33739.6	4686.2	6007.0	50691.6
	Estimated	364.1	246.3	2015.9	341.5	284.4	229.3	409.3	741.7	1718.6	33398.2	4606.2	5707.6	50063.2
	Perc Diff	-1.2%	9.8%	4.5%	-5.1%	-8.3%	3.3%	-0.2%	-3.5%	3.2%	-1.0%	-1.7%	-5.0%	-1.2%
11	Prior	561.1	97.8	1856.7	71.5	177.9	395.5	302.8	200.6	140.3	3493.6	30836.3	9798.3	47932.6
	Estimated	557.5	95.0	1865.5	51.1	162.4	404.5	264.7	148.8	124.6	3605.6	30829.9	9680.2	47789.7
	Perc Diff	-0.7%	-2.9%	0.5%	-28.5%	-8.7%	2.3%	-12.6%	-25.8%	-11.2%	3.2%	0.0%	-1.2%	-0.3%
12	Prior	1742.5	582.5	2846.5	1642.6	3240.1	6116.3	9063.4	7053.3	3376.5	6275.6	13333.7	774331.6	829604.6
	Estimated	1591.3	592.5	2944.2	1242.7	2664.8	5808.8	8658.4	6495.0	3373.8	6009.8	13319.4	773800.3	826501.1
	Perc Diff	-8.7%	1.7%	3.4%	-24.3%	-17.8%	-5.0%	-4.5%	-7.9%	-0.1%	-4.2%	-0.1%	-0.1%	-0.4%
Dest Totals	Prior	14720.4	6431.1	27872.5	18471.0	24793.2	32925.4	44720.9	52254.5	22475.6	51959.8	55155.2	822094.6	1173874.2
	Estimated	14378.6	6953.1	29711.4	17792.1	24173.5	33040.8	45115.6	51918.2	22130.4	51435.2	55085.9	819894.5	1171629.2
	Perc Diff	-2.3%	8.1%	6.6%	-3.7%	-2.5%	0.4%	0.9%	-0.6%	-1.5%	-1.0%	-0.1%	-0.3%	-0.2%

Note

The shading indicates those sector to sector comparisons where the percentage difference is >5% **and** the absolute difference is >500.

Appendix B: Modelled and Observed Screenline Crossing Flows

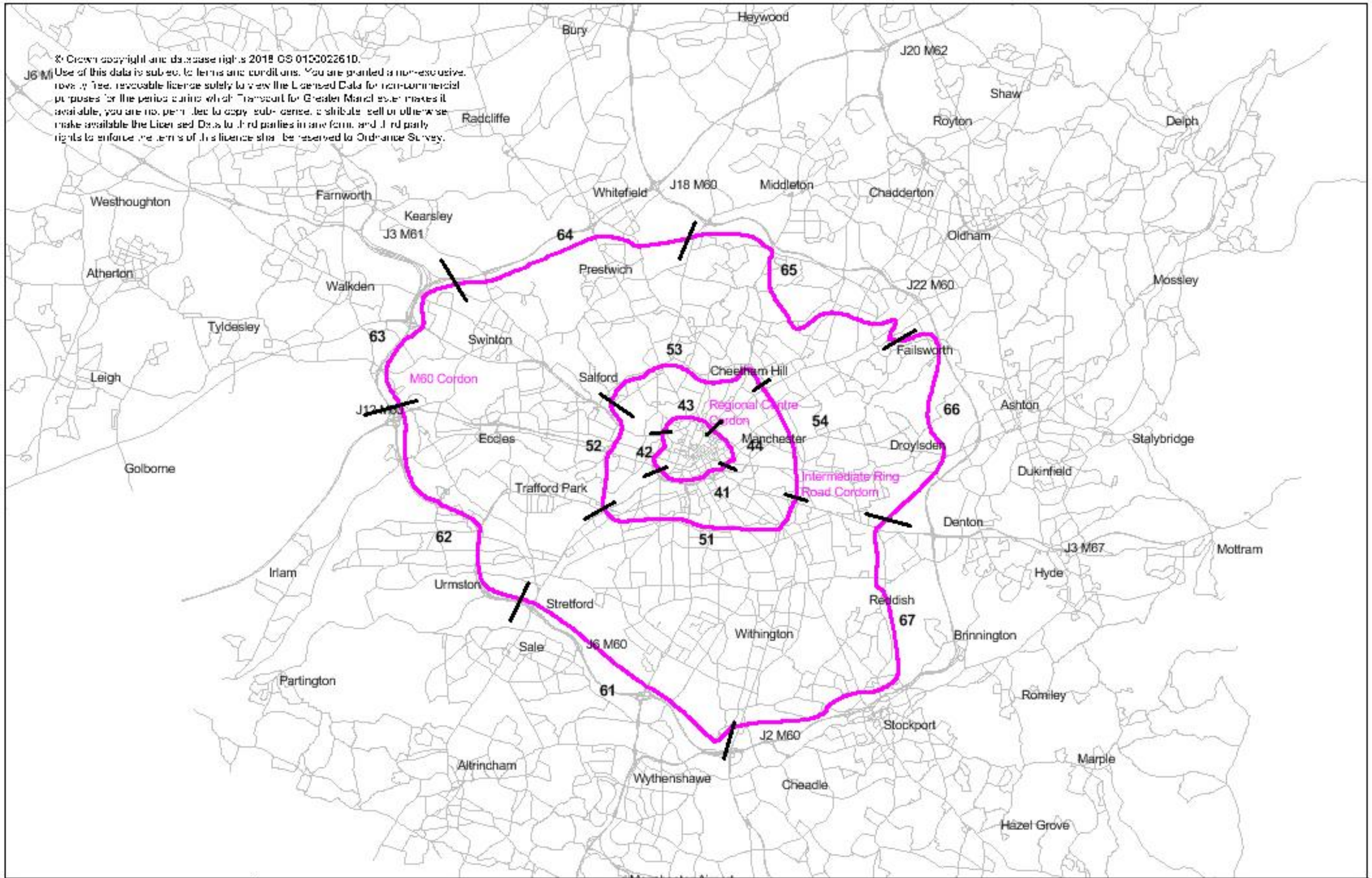
B.1 Overview

B.1.1 This Appendix provides comparisons of modelled and observed cordon crossing flows broken down into screenlines, as illustrated in **Figure B 1**.

List of Tables

Table B 20	M60 Screenline Modelled and Observed PM Peak Hour All Vehicle PCU Flows

Figure B 1: Link Flow Validation Screenline Locations



Transport for Greater Manchester

2 Piccadilly Place, Manchester, M1 3BG

Clean Air Zone Modelling Link Flow Validation Screenlines

Drawn By : A. Morris | Scale : Not Applicable | Date : February 2018 | Traffic Modelling Report Figure B1

Table B 1: Regional Centre Screenline Modelled and Observed Car Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
41	Inbound	6	4,907	5,205	298	6.1%	83.3%	83.3%	4.2
	Outbound	6	2,361	2,393	32	1.4%	83.3%	66.7%	0.7
	Two-Way	12	7,268	7,598	330	4.5%	83.3%	75.0%	3.8
42	Inbound	3	1,836	1,877	41	2.2%	100.0%	100.0%	1.0
	Outbound	3	888	839	-49	-5.5%	100.0%	100.0%	1.7
	Two-Way	6	2,724	2,716	-8	-0.3%	100.0%	100.0%	0.2
43	Inbound	6	2,139	1,766	-373	-17.4%	50.0%	33.3%	8.4
	Outbound	5	651	543	-108	-16.6%	100.0%	80.0%	4.4
	Two-Way	11	2,790	2,309	-481	-17.2%	72.7%	54.5%	9.5
44	Inbound	7	1,899	1,740	-159	-8.4%	100.0%	85.7%	3.7
	Outbound	6	598	673	75	12.5%	83.3%	83.3%	3.0
	Two-Way	13	2,497	2,413	-84	-3.4%	92.3%	84.6%	1.7
All	In Plus Out	42	15,279	15,036	-243	-1.6%	85.7%	76.2%	2.0
Weekday Inter-Peak Hour									
41	Inbound	6	2,310	2,463	153	6.6%	100.0%	100.0%	3.1
	Outbound	6	1,809	1,774	-35	-1.9%	83.3%	83.3%	0.8
	Two-Way	12	4,119	4,237	118	2.9%	91.7%	91.7%	1.8
42	Inbound	3	972	943	-29	-3.0%	100.0%	100.0%	0.9
	Outbound	3	765	863	98	12.8%	100.0%	100.0%	3.4
	Two-Way	6	1,737	1,806	69	4.0%	100.0%	100.0%	1.6
43	Inbound	6	1,075	808	-267	-24.8%	16.7%	16.7%	8.7
	Outbound	5	753	624	-129	-17.1%	80.0%	60.0%	4.9
	Two-Way	11	1,828	1,432	-396	-21.7%	45.5%	36.4%	9.8
44	Inbound	7	1,000	911	-89	-8.9%	100.0%	85.7%	2.9
	Outbound	6	767	694	-73	-9.5%	66.7%	66.7%	2.7
	Two-Way	13	1,767	1,605	-162	-9.2%	84.6%	76.9%	3.9
All	In Plus Out	42	9,451	9,080	-371	-3.9%	78.6%	73.8%	3.9

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
41	Inbound	6	2,836	2,938	102	3.6%	66.7%	66.7%	1.9
	Outbound	6	4,644	4,361	-283	-6.1%	50.0%	50.0%	4.2
	Two-Way	12	7,480	7,299	-181	-2.4%	58.4%	58.4%	2.1
42	Inbound	3	1,061	1,270	209	19.7%	66.7%	66.7%	6.1
	Outbound	3	1,820	1,994	174	9.6%	100.0%	100.0%	4.0
	Two-Way	6	2,881	3,264	383	13.3%	83.4%	83.4%	6.9
43	Inbound	6	1,241	920	-321	-25.9%	50.0%	33.3%	9.8
	Outbound	5	1,864	1,752	-112	-6.0%	40.0%	40.0%	2.6
	Two-Way	11	3,105	2,672	-433	-13.9%	45.5%	36.3%	8.1
44	Inbound	7	1,197	1,177	-20	-1.7%	100.0%	42.9%	0.6
	Outbound	6	1,639	1,787	148	9.0%	83.3%	83.3%	3.6
	Two-Way	13	2,836	2,964	128	4.5%	92.3%	61.5%	2.4
All	In Plus Out	42	16,302	16,199	-103	-0.6%	69.1%	57.1%	0.8

Table B 2: Regional Centre Screenline Modelled and Observed LGV Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
41	Inbound	6	298	303	5	1.7%	100.0%	100.0%	0.3
	Outbound	6	259	278	19	7.3%	100.0%	83.3%	1.2
	Two-Way	12	557	581	24	4.3%	100.0%	91.7%	1.0
42	Inbound	3	121	151	30	24.8%	100.0%	100.0%	2.6
	Outbound	3	80	77	-3	-3.8%	100.0%	100.0%	0.3
	Two-Way	6	201	228	27	13.4%	100.0%	100.0%	1.8
43	Inbound	6	188	202	14	7.5%	100.0%	66.7%	1.0
	Outbound	5	74	70	-4	-5.4%	100.0%	100.0%	0.5
	Two-Way	11	262	272	10	3.8%	100.0%	81.8%	0.6
44	Inbound	7	241	214	-27	-11.2%	100.0%	85.7%	1.8
	Outbound	6	101	107	6	5.9%	100.0%	100.0%	0.6
	Two-Way	13	342	321	-21	-6.1%	100.0%	92.3%	1.2
All	In Plus Out	42	1,362	1,402	40	2.9%	100.0%	90.5%	1.1
Weekday Inter-Peak Hour									
41	Inbound	6	366	408	42	11.5%	100.0%	100.0%	2.1
	Outbound	6	381	390	9	2.4%	100.0%	83.3%	0.5
	Two-Way	12	747	798	51	6.8%	100.0%	91.7%	1.8
42	Inbound	3	146	153	7	4.8%	100.0%	100.0%	0.6
	Outbound	3	142	169	27	19.0%	100.0%	100.0%	2.2
	Two-Way	6	288	322	34	11.8%	100.0%	100.0%	1.9
43	Inbound	6	169	148	-21	-12.4%	100.0%	66.7%	1.7
	Outbound	5	144	120	-24	-16.7%	100.0%	80.0%	2.1
	Two-Way	11	313	268	-45	-14.4%	100.0%	72.7%	2.6
44	Inbound	7	213	166	-47	-22.1%	100.0%	85.7%	3.4
	Outbound	6	192	172	-20	-10.4%	100.0%	83.3%	1.5
	Two-Way	13	405	338	-67	-16.5%	100.0%	84.6%	3.5
All	In Plus Out	42	1,753	1,726	-27	-1.5%	100.0%	85.7%	0.6

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
41	Inbound	6	153	151	-2	-1.3%	100.0%	100.0%	0.2
	Outbound	6	198	273	75	37.9%	100.0%	100.0%	4.9
	Two-Way	12	351	424	73	20.8%	100.0%	100.0%	3.7
42	Inbound	3	55	71	16	29.1%	100.0%	100.0%	2.0
	Outbound	3	87	104	17	19.5%	100.0%	100.0%	1.7
	Two-Way	6	142	175	33	23.2%	100.0%	100.0%	2.6
43	Inbound	6	61	70	9	14.8%	100.0%	100.0%	1.1
	Outbound	5	85	47	-38	-44.7%	100.0%	100.0%	4.7
	Two-Way	11	146	117	-29	-19.9%	100.0%	100.0%	2.5
44	Inbound	7	115	117	2	1.7%	100.0%	100.0%	0.2
	Outbound	6	128	107	-21	-16.4%	100.0%	100.0%	1.9
	Two-Way	13	243	224	-19	-7.8%	100.0%	100.0%	1.2
All	In Plus Out	42	882	940	58	6.6%	100.0%	100.0%	1.9

Table B 3: Regional Centre Screenline Modelled and Observed OGV Flows (PCUs)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
41	Inbound	6	58	69	11	19.0%	100.0%	100.0%	1.4
	Outbound	6	71	55	-16	-22.5%	100.0%	100.0%	2.0
	Two-Way	12	129	124	-5	-3.9%	100.0%	100.0%	0.4
42	Inbound	3	55	58	3	5.5%	100.0%	100.0%	0.4
	Outbound	3	44	54	10	22.7%	100.0%	100.0%	1.4
	Two-Way	6	99	112	13	13.1%	100.0%	100.0%	1.3
43	Inbound	6	63	51	-12	-19.1%	100.0%	100.0%	1.6
	Outbound	5	67	62	-5	-7.5%	100.0%	100.0%	0.6
	Two-Way	11	130	113	-17	-13.1%	100.0%	100.0%	1.5
44	Inbound	7	51	52	1	2.0%	100.0%	100.0%	0.1
	Outbound	6	61	77	16	26.2%	100.0%	100.0%	1.9
	Two-Way	13	112	129	17	15.2%	100.0%	100.0%	1.5
All	In Plus Out	42	470	478	8	1.7%	100.0%	100.0%	0.4
Weekday Inter-Peak Hour									
41	Inbound	6	67	72	5	7.5%	100.0%	100.0%	0.6
	Outbound	6	82	83	1	1.2%	100.0%	100.0%	0.1
	Two-Way	12	149	155	6	4.0%	100.0%	100.0%	0.5
42	Inbound	3	52	64	12	23.1%	100.0%	100.0%	1.6
	Outbound	3	46	49	3	6.5%	100.0%	100.0%	0.4
	Two-Way	6	98	113	15	15.3%	100.0%	100.0%	1.5
43	Inbound	6	64	55	-9	-14.1%	100.0%	83.3%	1.2
	Outbound	5	80	67	-13	-16.3%	100.0%	100.0%	1.5
	Two-Way	11	144	122	-22	-15.3%	100.0%	90.9%	1.9
44	Inbound	7	64	47	-17	-26.6%	100.0%	100.0%	2.3
	Outbound	6	72	76	4	5.6%	100.0%	83.3%	0.5
	Two-Way	13	136	123	-13	-9.6%	100.0%	92.3%	1.1
All	In Plus Out	42	527	513	-14	-2.7%	100.0%	95.2%	0.6

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
41	Inbound	6	20	17	-3	-15.0%	100.0%	100.0%	0.7
	Outbound	6	28	37	9	32.1%	100.0%	100.0%	1.6
	Two-Way	12	48	54	6	12.5%	100.0%	100.0%	0.8
42	Inbound	3	18	16	-2	-11.1%	100.0%	100.0%	0.5
	Outbound	3	11	21	10	90.9%	100.0%	100.0%	2.5
	Two-Way	6	29	37	8	27.6%	100.0%	100.0%	1.4
43	Inbound	6	12	12	0	0.0%	100.0%	100.0%	0.0
	Outbound	5	25	16	-9	-36.0%	100.0%	100.0%	2.0
	Two-Way	11	37	28	-9	-24.3%	100.0%	100.0%	1.6
44	Inbound	7	10	25	15	150.0%	100.0%	85.7%	3.6
	Outbound	6	17	19	2	11.8%	100.0%	100.0%	0.5
	Two-Way	13	27	44	17	63.0%	100.0%	92.3%	2.9
All	In Plus Out	42	141	163	22	15.6%	100.0%	97.6%	1.8

Table B 4: Regional Centre Screenline Modelled and Observed All Vehicle PCU Flows

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
41	Inbound	6	5,673	6,003	330	5.8%	83.3%	83.3%	4.3
	Outbound	6	3,087	3,087	0	0.0%	83.3%	83.3%	0.0
	Two-Way	12	8,760	9,090	330	3.8%	83.3%	83.3%	3.5
42	Inbound	3	2,121	2,183	62	2.9%	100.0%	100.0%	1.3
	Outbound	3	1,108	1,075	-33	-3.0%	100.0%	100.0%	1.0
	Two-Way	6	3,229	3,258	29	0.9%	100.0%	100.0%	0.5
43	Inbound	6	2,583	2,192	-391	-15.1%	33.3%	33.3%	8.0
	Outbound	5	1,020	855	-165	-16.2%	80.0%	80.0%	5.4
	Two-Way	11	3,603	3,047	-556	-15.4%	54.5%	54.5%	9.6
44	Inbound	7	2,362	2,120	-242	-10.3%	85.7%	71.4%	5.1
	Outbound	6	896	941	45	5.0%	83.3%	83.3%	1.5
	Two-Way	13	3,258	3,061	-197	-6.0%	84.6%	76.9%	3.5
All	In Plus Out	42	18,850	18,456	-394	-2.1%	78.6%	76.2%	2.9
Weekday Inter-Peak Hour									
41	Inbound	6	3,196	3,306	110	3.4%	100.0%	100.0%	1.9
	Outbound	6	2,759	2,602	-157	-5.7%	66.7%	66.7%	3.0
	Two-Way	12	5,955	5,908	-47	-0.8%	83.4%	83.4%	0.6
42	Inbound	3	1,308	1,255	-53	-4.1%	100.0%	100.0%	1.5
	Outbound	3	1,075	1,179	104	9.7%	100.0%	100.0%	3.1
	Two-Way	6	2,383	2,434	51	2.1%	100.0%	100.0%	1.0
43	Inbound	6	1,527	1,176	-351	-23.0%	16.7%	0.0%	9.5
	Outbound	5	1,220	990	-230	-18.9%	80.0%	80.0%	6.9
	Two-Way	11	2,747	2,166	-581	-21.2%	45.5%	36.4%	11.7
44	Inbound	7	1,456	1,222	-234	-16.1%	100.0%	85.7%	6.4
	Outbound	6	1,178	1,005	-173	-14.7%	50.0%	50.0%	5.2
	Two-Way	13	2,634	2,227	-407	-15.5%	76.9%	69.2%	8.3
All	In Plus Out	42	13,719	12,735	-984	-7.2%	73.8%	69.1%	8.6

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
41	Inbound	6	3,450	3,440	-10	-0.3%	83.3%	83.3%	0.2
	Outbound	6	5,375	5,043	-332	-6.2%	66.7%	50.0%	4.6
	Two-Way	12	8,825	8,483	-342	-3.9%	75.0%	66.7%	3.7
42	Inbound	3	1,254	1,441	187	14.9%	66.7%	66.7%	5.1
	Outbound	3	2,070	2,219	149	7.2%	100.0%	100.0%	3.2
	Two-Way	6	3,324	3,660	336	10.1%	83.4%	83.4%	5.7
43	Inbound	6	1,507	1,143	-364	-24.2%	50.0%	33.3%	10.0
	Outbound	5	2,230	1,986	-244	-10.9%	40.0%	40.0%	5.3
	Two-Way	11	3,737	3,129	-608	-16.3%	45.5%	36.3%	10.4
44	Inbound	7	1,527	1,408	-119	-7.8%	100.0%	42.9%	3.1
	Outbound	6	1,944	1,991	47	2.4%	83.3%	83.3%	1.1
	Two-Way	13	3,471	3,399	-72	-2.1%	92.3%	61.5%	1.2
All	In Plus Out	42	19,357	18,671	-686	-3.5%	73.8%	59.5%	5.0

Table B 5: Intermediate Ring Road Screenline Modelled and Observed Car Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
51	Inbound	18	12,319	12,185	-134	-1.1%	94.4%	77.8%	1.2
	Outbound	18	6,661	6,663	2	0.0%	100.0%	88.9%	0.0
	Two-Way	36	18,980	18,848	-132	-0.7%	97.2%	83.4%	1.0
52	Inbound	6	5,293	5,053	-240	-4.5%	83.3%	83.3%	3.3
	Outbound	6	3,667	3,329	-338	-9.2%	100.0%	100.0%	5.7
	Two-Way	12	8,960	8,382	-578	-6.5%	91.7%	91.7%	6.2
53	Inbound	11	5,950	5,544	-406	-6.8%	72.7%	72.7%	5.4
	Outbound	11	1,613	1,552	-61	-3.8%	100.0%	90.9%	1.5
	Two-Way	22	7,563	7,096	-467	-6.2%	86.4%	81.8%	5.5
54	Inbound	7	4,997	4,638	-359	-7.2%	85.7%	85.7%	5.2
	Outbound	7	1,456	1,458	2	0.1%	100.0%	85.7%	0.1
	Two-Way	14	6,453	6,096	-357	-5.5%	92.9%	85.7%	4.5
All	In Plus Out	84	41,956	40,422	-1,534	-3.7%	92.8%	84.5%	7.6
Weekday Inter-Peak Hour									
51	Inbound	18	6,404	6,183	-221	-3.5%	83.3%	83.3%	2.8
	Outbound	18	6,365	5,782	-583	-9.2%	83.3%	61.1%	7.5
	Two-Way	36	12,769	11,965	-804	-6.3%	83.3%	72.2%	7.2
52	Inbound	6	3,585	3,377	-208	-5.8%	100.0%	100.0%	3.5
	Outbound	6	3,227	3,069	-158	-4.9%	83.3%	83.3%	2.8
	Two-Way	12	6,812	6,446	-366	-5.4%	91.7%	91.7%	4.5
53	Inbound	11	2,600	2,415	-185	-7.1%	100.0%	72.7%	3.7
	Outbound	11	2,568	2,259	-309	-12.0%	90.9%	72.7%	6.3
	Two-Way	22	5,168	4,674	-494	-9.6%	95.5%	72.7%	7.0
54	Inbound	7	2,051	1,630	-421	-20.5%	71.4%	71.4%	9.8
	Outbound	7	2,190	1,642	-548	-25.0%	57.1%	57.1%	12.5
	Two-Way	14	4,241	3,272	-969	-22.8%	64.3%	64.3%	15.8
All	In Plus Out	84	28,990	26,357	-2,633	-9.1%	84.5%	73.8%	15.8

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
51	Inbound	18	7,642	7,355	-287	-3.8%	94.4%	94.4%	3.3
	Outbound	18	11,966	11,158	-808	-6.8%	94.4%	77.8%	7.5
	Two-Way	36	19,608	18,513	-1,095	-5.6%	94.4%	86.1%	7.9
52	Inbound	6	4,755	4,801	46	1.0%	100.0%	100.0%	0.7
	Outbound	6	5,174	5,120	-54	-1.0%	100.0%	100.0%	0.8
	Two-Way	12	9,929	9,921	-8	-0.1%	100.0%	100.0%	0.1
53	Inbound	11	2,510	2,300	-210	-8.4%	90.9%	81.8%	4.3
	Outbound	11	6,333	5,545	-788	-12.4%	72.7%	54.5%	10.2
	Two-Way	22	8,843	7,845	-998	-11.3%	81.8%	68.2%	10.9
54	Inbound	7	2,004	2,002	-2	-0.1%	100.0%	85.7%	0.0
	Outbound	7	4,777	4,298	-479	-10.0%	85.7%	85.7%	7.1
	Two-Way	14	6,781	6,300	-481	-7.1%	92.9%	85.7%	5.9
All	In Plus Out	84	45,161	42,579	-2,582	-5.7%	91.6%	83.3%	12.3

Table B 6: Intermediate Ring Road Screenline Modelled and Observed LGV Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
51	Inbound	18	857	925	68	7.9%	100.0%	100.0%	2.3
	Outbound	18	820	781	-39	-4.8%	100.0%	100.0%	1.4
	Two-Way	36	1,677	1,706	29	1.7%	100.0%	100.0%	0.7
52	Inbound	6	570	653	83	14.6%	100.0%	100.0%	3.4
	Outbound	6	377	436	59	15.7%	100.0%	100.0%	2.9
	Two-Way	12	947	1,089	142	15.0%	100.0%	100.0%	4.5
53	Inbound	11	448	471	23	5.1%	100.0%	100.0%	1.1
	Outbound	11	273	268	-5	-1.8%	100.0%	90.9%	0.3
	Two-Way	22	721	739	18	2.5%	100.0%	95.5%	0.7
54	Inbound	7	688	620	-68	-9.9%	100.0%	100.0%	2.7
	Outbound	7	338	277	-61	-18.1%	100.0%	71.4%	3.5
	Two-Way	14	1,026	897	-129	-12.6%	100.0%	85.7%	4.2
All	In Plus Out	84	4,371	4,431	60	1.4%	100.0%	96.4%	0.9
Weekday Inter-Peak Hour									
51	Inbound	18	1,004	1,092	88	8.8%	100.0%	100.0%	2.7
	Outbound	18	1,088	1,040	-48	-4.4%	100.0%	94.4%	1.5
	Two-Way	36	2,092	2,132	40	1.9%	100.0%	97.2%	0.9
52	Inbound	6	609	616	7	1.2%	100.0%	100.0%	0.3
	Outbound	6	652	713	61	9.4%	100.0%	100.0%	2.3
	Two-Way	12	1,261	1,329	68	5.4%	100.0%	100.0%	1.9
53	Inbound	11	418	393	-25	-6.0%	100.0%	90.9%	1.2
	Outbound	11	472	431	-41	-8.7%	100.0%	81.8%	1.9
	Two-Way	22	890	824	-66	-7.4%	100.0%	86.4%	2.3
54	Inbound	7	494	391	-103	-20.9%	100.0%	85.7%	4.9
	Outbound	7	536	449	-87	-16.2%	100.0%	85.7%	3.9
	Two-Way	14	1,030	840	-190	-18.4%	100.0%	85.7%	6.2
All	In Plus Out	84	5,273	5,125	-148	-2.8%	100.0%	92.8%	2.1

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
51	Inbound	18	538	554	16	3.0%	100.0%	100.0%	0.7
	Outbound	18	709	692	-17	-2.4%	100.0%	94.4%	0.6
	Two-Way	36	1,247	1,246	-1	-0.1%	100.0%	97.2%	0.0
52	Inbound	6	384	403	19	5.0%	100.0%	100.0%	1.0
	Outbound	6	396	428	32	8.1%	100.0%	100.0%	1.6
	Two-Way	12	780	831	51	6.5%	100.0%	100.0%	1.8
53	Inbound	11	261	260	-1	-0.4%	100.0%	100.0%	0.1
	Outbound	11	397	399	2	0.5%	100.0%	100.0%	0.1
	Two-Way	22	658	659	1	0.2%	100.0%	100.0%	0.0
54	Inbound	7	212	223	11	5.2%	100.0%	100.0%	0.7
	Outbound	7	402	356	-46	-11.4%	100.0%	85.7%	2.4
	Two-Way	14	614	579	-35	-5.7%	100.0%	92.9%	1.4
All	In Plus Out	84	3,299	3,315	16	0.5%	100.0%	97.6%	0.3

Table B 7: Intermediate Ring Road Screenline Modelled and Observed OGV Flows (PCUs)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
51	Inbound	18	364	318	-46	-12.6%	100.0%	100.0%	2.5
	Outbound	18	336	338	2	0.6%	100.0%	100.0%	0.1
	Two-Way	36	700	656	-44	-6.3%	100.0%	100.0%	1.7
52	Inbound	6	282	397	115	40.8%	100.0%	66.7%	6.2
	Outbound	6	386	323	-63	-16.3%	100.0%	83.3%	3.3
	Two-Way	12	668	720	52	7.8%	100.0%	75.0%	2.0
53	Inbound	11	108	87	-21	-19.4%	100.0%	100.0%	2.1
	Outbound	11	95	77	-18	-19.0%	100.0%	100.0%	1.9
	Two-Way	22	203	164	-39	-19.2%	100.0%	100.0%	2.9
54	Inbound	7	287	300	13	4.5%	100.0%	100.0%	0.8
	Outbound	7	198	200	2	1.0%	100.0%	100.0%	0.1
	Two-Way	14	485	500	15	3.1%	100.0%	100.0%	0.7
All	In Plus Out	84	2,056	2,040	-16	-0.8%	100.0%	96.4%	0.4
Weekday Inter-Peak Hour									
51	Inbound	18	353	286	-67	-19.0%	100.0%	94.4%	3.7
	Outbound	18	341	299	-42	-12.3%	100.0%	100.0%	2.3
	Two-Way	36	694	585	-109	-15.7%	100.0%	97.2%	4.3
52	Inbound	6	416	380	-36	-8.7%	100.0%	100.0%	1.8
	Outbound	6	428	409	-19	-4.4%	100.0%	100.0%	0.9
	Two-Way	12	844	789	-55	-6.5%	100.0%	100.0%	1.9
53	Inbound	11	129	112	-17	-13.2%	100.0%	100.0%	1.5
	Outbound	11	135	202	67	49.6%	100.0%	90.9%	5.2
	Two-Way	22	264	314	50	18.9%	100.0%	95.5%	2.9
54	Inbound	7	247	325	78	31.6%	100.0%	100.0%	4.6
	Outbound	7	272	322	50	18.4%	100.0%	100.0%	2.9
	Two-Way	14	519	647	128	24.7%	100.0%	100.0%	5.3
All	In Plus Out	84	2,321	2,335	14	0.6%	100.0%	97.6%	0.3

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
51	Inbound	18	107	114	7	6.5%	100.0%	100.0%	0.7
	Outbound	18	95	111	16	16.8%	100.0%	100.0%	1.6
	Two-Way	36	202	225	23	11.4%	100.0%	100.0%	1.6
52	Inbound	6	123	134	11	8.9%	100.0%	100.0%	1.0
	Outbound	6	126	143	17	13.5%	100.0%	100.0%	1.5
	Two-Way	12	249	277	28	11.2%	100.0%	100.0%	1.7
53	Inbound	11	26	29	3	11.5%	100.0%	100.0%	0.6
	Outbound	11	57	60	3	5.3%	100.0%	100.0%	0.4
	Two-Way	22	83	89	6	7.2%	100.0%	100.0%	0.6
54	Inbound	7	34	40	6	17.7%	100.0%	100.0%	1.0
	Outbound	7	77	79	2	2.6%	100.0%	100.0%	0.2
	Two-Way	14	111	119	8	7.2%	100.0%	100.0%	0.7
All	In Plus Out	84	645	710	65	10.1%	100.0%	100.0%	2.5

Table B 8: Intermediate Ring Road Screenline Modelled and Observed All Vehicle PCU Flows

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday AM Peak Hour									
51	Inbound	18	14,020	13,845	-175	-1.3%	94.4%	83.3%	1.5
	Outbound	18	8,340	8,143	-197	-2.4%	100.0%	88.9%	2.2
	Two-Way	36	22,360	21,988	-372	-1.7%	97.2%	86.1%	2.5
52	Inbound	6	6,248	6,213	-35	-0.6%	66.7%	66.7%	0.4
	Outbound	6	4,550	4,216	-334	-7.3%	100.0%	100.0%	5.0
	Two-Way	12	10,798	10,429	-369	-3.4%	83.4%	83.4%	3.6
53	Inbound	11	6,697	6,280	-417	-6.2%	72.7%	72.7%	5.2
	Outbound	11	2,175	2,079	-96	-4.4%	100.0%	90.9%	2.1
	Two-Way	22	8,872	8,359	-513	-5.8%	86.4%	81.8%	5.5
54	Inbound	7	6,179	5,680	-499	-8.1%	85.7%	85.7%	6.5
	Outbound	7	2,206	2,056	-150	-6.8%	100.0%	85.7%	3.2
	Two-Way	14	8,385	7,736	-649	-7.7%	92.9%	85.7%	7.2
All	In Plus Out	84	50,415	48,512	-1,903	-3.8%	91.7%	84.5%	8.6
Weekday Inter-Peak Hour									
51	Inbound	18	8,282	7,899	-383	-4.6%	77.8%	66.7%	4.3
	Outbound	18	8,315	7,465	-850	-10.2%	83.3%	61.1%	9.6
	Two-Way	36	16,597	15,364	-1,233	-7.4%	80.6%	63.9%	9.8
52	Inbound	6	4,788	4,480	-308	-6.4%	100.0%	100.0%	4.5
	Outbound	6	4,493	4,311	-182	-4.1%	83.3%	83.3%	2.7
	Two-Way	12	9,281	8,791	-490	-5.3%	91.7%	91.7%	5.2
53	Inbound	11	3,391	3,091	-300	-8.9%	100.0%	72.7%	5.3
	Outbound	11	3,417	3,065	-352	-10.3%	81.8%	81.8%	6.2
	Two-Way	22	6,808	6,156	-652	-9.6%	90.9%	77.3%	8.1
54	Inbound	7	3,004	2,440	-564	-18.8%	71.4%	57.1%	10.8
	Outbound	7	3,214	2,515	-699	-21.8%	57.1%	71.4%	13.1
	Two-Way	14	6,218	4,955	-1,263	-20.3%	64.3%	64.3%	16.9
All	In Plus Out	84	38,904	35,266	-3,638	-9.4%	82.1%	71.4%	18.9

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
Weekday PM Peak Hour									
51	Inbound	18	8,837	8,334	-503	-5.7%	94.4%	94.4%	5.4
	Outbound	18	13,344	12,325	-1,019	-7.6%	94.4%	83.3%	9.0
	Two-Way	36	22,181	20,659	-1,522	-6.9%	94.4%	88.9%	10.4
52	Inbound	6	5,438	5,433	-5	-0.1%	100.0%	100.0%	0.1
	Outbound	6	5,851	5,812	-39	-0.7%	100.0%	100.0%	0.5
	Two-Way	12	11,289	11,245	-44	-0.4%	100.0%	100.0%	0.4
53	Inbound	11	3,016	2,737	-279	-9.3%	90.9%	81.8%	5.2
	Outbound	11	7,073	6,173	-900	-12.7%	63.6%	54.5%	11.1
	Two-Way	22	10,089	8,910	-1,179	-11.7%	77.3%	68.2%	12.1
54	Inbound	7	2,444	2,353	-91	-3.7%	100.0%	85.7%	1.9
	Outbound	7	5,526	4,838	-688	-12.5%	85.7%	85.7%	9.6
	Two-Way	14	7,970	7,191	-779	-9.8%	92.9%	85.7%	8.9
All	In Plus Out	84	51,529	48,005	-3,524	-6.8%	90.5%	84.5%	15.8

Table B 9: M60 Screenline Modelled and Observed AM Peak Hour Car Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	7,151	6,520	-631	-8.8%	100.0%	80.0%	7.6
	Outbound	6	5,501	6,374	873	15.9%	33.3%	33.3%	11.3
	Two-Way	11	12,652	12,894	242	1.9%	63.6%	54.5%	2.1
62	Inbound	7	9,610	9,359	-251	-2.6%	85.7%	85.7%	2.6
	Outbound	6	3,991	3,965	-26	-0.7%	100.0%	100.0%	0.4
	Two-Way	13	13,601	13,324	-277	-2.0%	92.3%	92.3%	2.4
63	Inbound	5	4,008	3,401	-607	-15.1%	80.0%	80.0%	10.0
	Outbound	5	2,193	2,148	-45	-2.1%	100.0%	100.0%	1.0
	Two-Way	10	6,201	5,549	-652	-10.5%	90.0%	90.0%	8.5
64	Inbound	4	3,434	3,374	-60	-1.8%	100.0%	100.0%	1.0
	Outbound	4	2,360	2,407	47	2.0%	100.0%	100.0%	1.0
	Two-Way	8	5,794	5,781	-13	-0.2%	100.0%	100.0%	0.2
65	Inbound	13	8,949	7,938	-1,011	-11.3%	76.9%	76.9%	11.0
	Outbound	13	4,702	4,820	118	2.5%	100.0%	100.0%	1.7
	Two-Way	26	13,651	12,758	-893	-6.5%	88.5%	88.5%	7.8
66	Inbound	8	2,971	2,878	-93	-3.1%	100.0%	100.0%	1.7
	Outbound	8	2,155	2,383	228	10.6%	87.5%	87.5%	4.8
	Two-Way	16	5,126	5,261	135	2.6%	93.8%	93.8%	1.9
67	Inbound	9	7,840	7,564	-276	-3.5%	88.9%	77.8%	3.1
	Outbound	9	6,730	6,740	10	0.2%	66.7%	77.8%	0.1
	Two-Way	18	14,570	14,304	-266	-1.8%	77.8%	77.8%	2.2
All	In Plus Out	102	71,595	69,871	-1,724	-2.4%	86.3%	85.3%	6.5

Table B 10: M60 Screenline Modelled and Observed AM Peak Hour LGV Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	566	576	10	1.8%	100.0%	100.0%	0.4
	Outbound	6	619	549	-70	-11.3%	100.0%	100.0%	2.9
	Two-Way	11	1,185	1,125	-60	-5.1%	100.0%	100.0%	1.8
62	Inbound	7	1,280	1,284	4	0.3%	100.0%	100.0%	0.1
	Outbound	6	910	858	-52	-5.7%	100.0%	100.0%	1.7
	Two-Way	13	2,190	2,142	-48	-2.2%	100.0%	100.0%	1.0
63	Inbound	5	494	537	43	8.7%	100.0%	100.0%	1.9
	Outbound	5	340	401	61	17.9%	100.0%	100.0%	3.2
	Two-Way	10	834	938	104	12.5%	100.0%	100.0%	3.5
64	Inbound	4	382	382	0	0.0%	100.0%	100.0%	0.0
	Outbound	4	312	332	20	6.4%	100.0%	100.0%	1.1
	Two-Way	8	694	714	20	2.9%	100.0%	100.0%	0.8
65	Inbound	13	1,179	1,040	-139	-11.8%	100.0%	84.6%	4.2
	Outbound	13	803	837	34	4.2%	100.0%	100.0%	1.2
	Two-Way	26	1,982	1,877	-105	-5.3%	100.0%	92.3%	2.4
66	Inbound	8	477	420	-57	-12.0%	100.0%	100.0%	2.7
	Outbound	8	414	388	-26	-6.3%	100.0%	87.5%	1.3
	Two-Way	16	891	808	-83	-9.3%	100.0%	93.8%	2.8
67	Inbound	9	1,082	1,099	17	1.6%	100.0%	100.0%	0.5
	Outbound	9	874	1,029	155	17.7%	100.0%	100.0%	5.0
	Two-Way	18	1,956	2,128	172	8.8%	100.0%	100.0%	3.8
All	In Plus Out	102	9,732	9,732	0	0.0%	100.0%	97.1%	0.0

Table B 11:M60 Screenline Modelled and Observed AM Peak Hour OGV Flows (PCUs)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	153	196	43	28.1%	100.0%	100.0%	3.3
	Outbound	6	342	244	-98	-28.7%	100.0%	66.7%	5.7
	Two-Way	11	495	440	-55	-11.1%	100.0%	81.8%	2.5
62	Inbound	7	1,093	918	-175	-16.0%	100.0%	71.4%	5.5
	Outbound	6	950	961	11	1.2%	100.0%	100.0%	0.4
	Two-Way	13	2,043	1,879	-164	-8.0%	100.0%	84.6%	3.7
63	Inbound	5	173	247	74	42.8%	100.0%	80.0%	5.1
	Outbound	5	159	253	94	59.1%	100.0%	80.0%	6.5
	Two-Way	10	332	500	168	50.6%	100.0%	80.0%	8.2
64	Inbound	4	144	160	16	11.1%	100.0%	100.0%	1.3
	Outbound	4	136	187	51	37.5%	100.0%	75.0%	4.0
	Two-Way	8	280	347	67	23.9%	100.0%	87.5%	3.8
65	Inbound	13	315	347	32	10.2%	100.0%	92.3%	1.8
	Outbound	13	263	324	61	23.2%	100.0%	100.0%	3.6
	Two-Way	26	578	671	93	16.1%	100.0%	96.2%	3.7
66	Inbound	8	163	169	6	3.7%	100.0%	100.0%	0.5
	Outbound	8	149	109	-40	-26.9%	100.0%	87.5%	3.5
	Two-Way	16	312	278	-34	-10.9%	100.0%	93.8%	2.0
67	Inbound	9	325	364	39	12.0%	100.0%	100.0%	2.1
	Outbound	9	321	417	96	29.9%	100.0%	88.9%	5.0
	Two-Way	18	646	781	135	20.9%	100.0%	94.5%	5.1
All	In Plus Out	102	4,686	4,896	210	4.5%	100.0%	90.2%	3.0

Table B 12: M60 Screenline Modelled and Observed AM Peak Hour All Vehicle PCU Flows

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	8,061	7,417	-644	-8.0%	100.0%	80.0%	7.3
	Outbound	6	6,656	7,335	679	10.2%	33.3%	33.3%	8.1
	Two-Way	11	14,717	14,752	35	0.2%	63.6%	54.5%	0.3
62	Inbound	7	12,002	11,633	-369	-3.1%	85.7%	85.7%	3.4
	Outbound	6	5,903	5,835	-68	-1.2%	100.0%	100.0%	0.9
	Two-Way	13	17,905	17,468	-437	-2.4%	92.3%	92.3%	3.3
63	Inbound	5	4,735	4,261	-474	-10.0%	80.0%	80.0%	7.1
	Outbound	5	2,751	2,891	140	5.1%	100.0%	100.0%	2.6
	Two-Way	10	7,486	7,152	-334	-4.5%	90.0%	90.0%	3.9
64	Inbound	4	4,032	3,996	-36	-0.9%	100.0%	100.0%	0.6
	Outbound	4	2,883	3,009	126	4.4%	100.0%	100.0%	2.3
	Two-Way	8	6,915	7,005	90	1.3%	100.0%	100.0%	1.1
65	Inbound	13	10,692	9,542	-1,150	-10.8%	76.9%	76.9%	11.4
	Outbound	13	6,054	6,196	142	2.4%	100.0%	100.0%	1.8
	Two-Way	26	16,746	15,738	-1,008	-6.0%	88.5%	88.5%	7.9
66	Inbound	8	3,723	3,560	-163	-4.4%	100.0%	100.0%	2.7
	Outbound	8	2,839	2,983	144	5.1%	75.0%	75.0%	2.7
	Two-Way	16	6,562	6,543	-19	-0.3%	87.5%	87.5%	0.2
67	Inbound	9	9,520	9,238	-282	-3.0%	88.9%	88.9%	2.9
	Outbound	9	8,147	8,380	233	2.9%	66.7%	77.8%	2.6
	Two-Way	18	17,667	17,618	-49	-0.3%	77.8%	83.4%	0.4
All	In Plus Out	102	87,998	86,276	-1,722	-2.0%	85.3%	85.3%	5.8

Table B 13: M60 Screenline Modelled and Observed Inter-Peak Hour Car Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	3,520	3,563	43	1.2%	100.0%	100.0%	0.7
	Outbound	6	4,461	4,589	128	2.9%	100.0%	100.0%	1.9
	Two-Way	11	7,981	8,152	171	2.1%	100.0%	100.0%	1.9
62	Inbound	7	5,617	5,332	-285	-5.1%	100.0%	100.0%	3.9
	Outbound	6	4,298	4,227	-71	-1.7%	83.3%	66.7%	1.1
	Two-Way	13	9,915	9,559	-356	-3.6%	92.3%	84.6%	3.6
63	Inbound	5	2,120	1,884	-236	-11.1%	100.0%	80.0%	5.3
	Outbound	5	2,230	1,915	-315	-14.1%	80.0%	80.0%	6.9
	Two-Way	10	4,350	3,799	-551	-12.7%	90.0%	80.0%	8.6
64	Inbound	4	2,146	2,045	-101	-4.7%	100.0%	100.0%	2.2
	Outbound	4	2,259	2,147	-112	-5.0%	100.0%	100.0%	2.4
	Two-Way	8	4,405	4,192	-213	-4.8%	100.0%	100.0%	3.2
65	Inbound	13	5,129	4,331	-798	-15.6%	84.6%	76.9%	11.6
	Outbound	13	5,261	4,996	-265	-5.0%	100.0%	100.0%	3.7
	Two-Way	26	10,390	9,327	-1,063	-10.2%	92.3%	88.5%	10.7
66	Inbound	8	1,815	1,555	-260	-14.3%	100.0%	100.0%	6.3
	Outbound	8	2,034	1,779	-255	-12.5%	87.5%	87.5%	5.8
	Two-Way	16	3,849	3,334	-515	-13.4%	93.8%	93.8%	8.6
67	Inbound	9	5,252	5,122	-130	-2.5%	100.0%	100.0%	1.8
	Outbound	9	5,448	5,335	-113	-2.1%	100.0%	100.0%	1.5
	Two-Way	18	10,700	10,457	-243	-2.3%	100.0%	100.0%	2.4
All	In Plus Out	102	51,590	48,820	-2,770	-5.4%	95.1%	92.2%	12.4

Table B 14:M60 Screenline Modelled and Observed Inter-Peak Hour LGV Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	511	568	57	11.2%	100.0%	100.0%	2.5
	Outbound	6	653	740	87	13.3%	100.0%	100.0%	3.3
	Two-Way	11	1,164	1,308	144	12.4%	100.0%	100.0%	4.1
62	Inbound	7	1,020	1,097	77	7.6%	100.0%	100.0%	2.4
	Outbound	6	920	898	-22	-2.4%	100.0%	100.0%	0.7
	Two-Way	13	1,940	1,995	55	2.8%	100.0%	100.0%	1.2
63	Inbound	5	423	439	16	3.8%	100.0%	100.0%	0.8
	Outbound	5	437	487	50	11.4%	100.0%	100.0%	2.3
	Two-Way	10	860	926	66	7.7%	100.0%	100.0%	2.2
64	Inbound	4	347	353	6	1.7%	100.0%	100.0%	0.3
	Outbound	4	353	371	18	5.1%	100.0%	100.0%	0.9
	Two-Way	8	700	724	24	3.4%	100.0%	100.0%	0.9
65	Inbound	13	934	894	-40	-4.3%	100.0%	92.3%	1.3
	Outbound	13	923	963	40	4.3%	100.0%	100.0%	1.3
	Two-Way	26	1,857	1,857	0	0.0%	100.0%	96.2%	0.0
66	Inbound	8	354	339	-15	-4.2%	100.0%	100.0%	0.8
	Outbound	8	365	340	-25	-6.9%	100.0%	87.5%	1.3
	Two-Way	16	719	679	-40	-5.6%	100.0%	93.8%	1.5
67	Inbound	9	932	960	28	3.0%	100.0%	100.0%	0.9
	Outbound	9	1,010	1,089	79	7.8%	100.0%	100.0%	2.4
	Two-Way	18	1,942	2,049	107	5.5%	100.0%	100.0%	2.4
All	In Plus Out	102	9,182	9,538	356	3.9%	100.0%	98.0%	3.7

Table B 15:M60 Screenline Modelled and Observed Inter-Peak Hour OGV Flows (PCUs)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	176	235	59	33.5%	100.0%	80.0%	4.1
	Outbound	6	333	266	-67	-20.1%	100.0%	50.0%	3.9
	Two-Way	11	509	501	-8	-1.6%	100.0%	63.6%	0.4
62	Inbound	7	1,078	800	-278	-25.8%	100.0%	57.1%	9.1
	Outbound	6	1,002	962	-40	-4.0%	100.0%	100.0%	1.3
	Two-Way	13	2,080	1,762	-318	-15.3%	100.0%	76.9%	7.3
63	Inbound	5	194	328	134	69.1%	80.0%	80.0%	8.3
	Outbound	5	225	328	103	45.8%	80.0%	80.0%	6.2
	Two-Way	10	419	656	237	56.6%	80.0%	80.0%	10.2
64	Inbound	4	156	224	68	43.6%	100.0%	75.0%	4.9
	Outbound	4	159	200	41	25.8%	100.0%	75.0%	3.1
	Two-Way	8	315	424	109	34.6%	100.0%	75.0%	5.7
65	Inbound	13	349	328	-21	-6.0%	100.0%	100.0%	1.1
	Outbound	13	318	437	119	37.4%	92.3%	92.3%	6.1
	Two-Way	26	667	765	98	14.7%	96.2%	96.2%	3.7
66	Inbound	8	152	157	5	3.3%	100.0%	87.5%	0.4
	Outbound	8	175	126	-49	-28.0%	100.0%	87.5%	4.0
	Two-Way	16	327	283	-44	-13.5%	100.0%	87.5%	2.5
67	Inbound	9	408	394	-14	-3.4%	100.0%	100.0%	0.7
	Outbound	9	390	371	-19	-4.9%	100.0%	100.0%	1.0
	Two-Way	18	798	765	-33	-4.1%	100.0%	100.0%	1.2
All	In Plus Out	102	5,115	5,156	41	0.8%	97.1%	86.3%	0.6

Table B 16:M60 Screenline Modelled and Observed Inter-Peak Hour All Vehicle PCU Flows

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	4,433	4,485	52	1.2%	100.0%	100.0%	0.8
	Outbound	6	5,700	5,738	38	0.7%	83.3%	100.0%	0.5
	Two-Way	11	10,133	10,223	90	0.9%	90.9%	100.0%	0.9
62	Inbound	7	7,862	7,285	-577	-7.3%	85.7%	85.7%	6.6
	Outbound	6	6,379	6,143	-236	-3.7%	66.7%	50.0%	3.0
	Two-Way	13	14,241	13,428	-813	-5.7%	76.9%	69.2%	6.9
63	Inbound	5	2,825	2,717	-108	-3.8%	100.0%	100.0%	2.1
	Outbound	5	2,978	2,806	-172	-5.8%	100.0%	100.0%	3.2
	Two-Way	10	5,803	5,523	-280	-4.8%	100.0%	100.0%	3.7
64	Inbound	4	2,752	2,693	-59	-2.1%	100.0%	100.0%	1.1
	Outbound	4	2,876	2,791	-85	-3.0%	100.0%	100.0%	1.6
	Two-Way	8	5,628	5,484	-144	-2.6%	100.0%	100.0%	1.9
65	Inbound	13	6,753	5,745	-1,008	-14.9%	84.6%	76.9%	12.8
	Outbound	13	6,850	6,591	-259	-3.8%	92.3%	100.0%	3.2
	Two-Way	26	13,603	12,336	-1,267	-9.3%	88.5%	88.5%	11.1
66	Inbound	8	2,442	2,132	-310	-12.7%	87.5%	87.5%	6.5
	Outbound	8	2,694	2,324	-370	-13.7%	87.5%	87.5%	7.4
	Two-Way	16	5,136	4,456	-680	-13.2%	87.5%	87.5%	9.8
67	Inbound	9	6,886	6,644	-242	-3.5%	100.0%	100.0%	2.9
	Outbound	9	7,139	6,975	-164	-2.3%	88.9%	88.9%	2.0
	Two-Way	18	14,025	13,619	-406	-2.9%	94.5%	94.5%	3.5
All	In Plus Out	102	68,569	65,069	-3,500	-5.1%	90.2%	90.2%	13.5

Table B 17:M60 Screenline Modelled and Observed PM Peak Hour Car Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	5,405	5,491	86	1.6%	80.0%	80.0%	1.2
	Outbound	6	7,665	7,988	323	4.2%	83.3%	83.3%	3.7
	Two-Way	11	13,070	13,479	409	3.1%	81.8%	81.8%	3.5
62	Inbound	7	6,067	6,482	415	6.8%	71.4%	71.4%	5.2
	Outbound	6	8,901	8,812	-89	-1.0%	100.0%	100.0%	0.9
	Two-Way	13	14,968	15,294	326	2.2%	84.6%	84.6%	2.7
63	Inbound	5	3,188	3,088	-100	-3.1%	100.0%	100.0%	1.8
	Outbound	5	5,164	4,484	-680	-13.2%	80.0%	80.0%	9.8
	Two-Way	10	8,352	7,572	-780	-9.3%	90.0%	90.0%	8.7
64	Inbound	4	2,796	2,784	-12	-0.4%	100.0%	100.0%	0.2
	Outbound	4	4,018	3,906	-112	-2.8%	100.0%	100.0%	1.8
	Two-Way	8	6,814	6,690	-124	-1.8%	100.0%	100.0%	1.5
65	Inbound	13	6,545	5,506	-1,039	-15.9%	76.9%	69.2%	13.4
	Outbound	13	9,363	8,942	-421	-4.5%	92.3%	92.3%	4.4
	Two-Way	26	15,908	14,448	-1,460	-9.2%	84.6%	80.8%	11.9
66	Inbound	8	2,704	2,588	-116	-4.3%	100.0%	100.0%	2.3
	Outbound	8	3,575	3,151	-424	-11.9%	75.0%	75.0%	7.3
	Two-Way	16	6,279	5,739	-540	-8.6%	87.5%	87.5%	7.0
67	Inbound	9	7,239	6,449	-790	-10.9%	88.9%	88.9%	9.5
	Outbound	9	8,962	8,263	-699	-7.8%	77.8%	88.9%	7.5
	Two-Way	18	16,201	14,712	-1,489	-9.2%	83.4%	88.9%	12.0
All	In Plus Out	102	81,592	77,934	-3,658	-4.5%	86.3%	86.3%	13.0

Table B 18: M60 Screenline Modelled and Observed PM Peak Hour LGV Flows (Vehicles)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	416	427	11	2.6%	100.0%	100.0%	0.5
	Outbound	6	579	596	17	2.9%	100.0%	100.0%	0.7
	Two-Way	11	995	1,023	28	2.8%	100.0%	100.0%	0.9
62	Inbound	7	601	641	40	6.7%	100.0%	85.7%	1.6
	Outbound	6	679	766	87	12.8%	100.0%	100.0%	3.2
	Two-Way	13	1,280	1,407	127	9.9%	100.0%	92.3%	3.5
63	Inbound	5	385	328	-57	-14.8%	100.0%	100.0%	3.0
	Outbound	5	453	462	9	2.0%	100.0%	100.0%	0.4
	Two-Way	10	838	790	-48	-5.7%	100.0%	100.0%	1.7
64	Inbound	4	274	297	23	8.4%	100.0%	100.0%	1.4
	Outbound	4	351	354	3	0.9%	100.0%	100.0%	0.2
	Two-Way	8	625	651	26	4.2%	100.0%	100.0%	1.0
65	Inbound	13	788	792	4	0.5%	100.0%	92.3%	0.1
	Outbound	13	885	889	4	0.5%	100.0%	100.0%	0.1
	Two-Way	26	1,673	1,681	8	0.5%	100.0%	96.2%	0.2
66	Inbound	8	353	308	-45	-12.8%	100.0%	100.0%	2.5
	Outbound	8	393	386	-7	-1.8%	100.0%	100.0%	0.4
	Two-Way	16	746	694	-52	-7.0%	100.0%	100.0%	1.9
67	Inbound	9	675	706	31	4.6%	100.0%	100.0%	1.2
	Outbound	9	926	917	-9	-1.0%	100.0%	100.0%	0.3
	Two-Way	18	1,601	1,623	22	1.4%	100.0%	100.0%	0.5
All	In Plus Out	102	7,758	7,869	111	1.4%	100.0%	98.0%	1.3

Table B 19:M60 Screenline Modelled and Observed PM Peak Hour OGV Flows (PCUs)

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	67	83	16	23.9%	100.0%	100.0%	1.8
	Outbound	6	161	85	-76	-47.2%	100.0%	50.0%	6.9
	Two-Way	11	228	168	-60	-26.3%	100.0%	72.7%	4.3
62	Inbound	7	535	365	-170	-31.8%	85.7%	71.4%	8.0
	Outbound	6	442	522	80	18.1%	100.0%	50.0%	3.6
	Two-Way	13	977	887	-90	-9.2%	92.3%	61.5%	2.9
63	Inbound	5	92	128	36	39.1%	100.0%	100.0%	3.4
	Outbound	5	100	170	70	70.0%	100.0%	60.0%	6.0
	Two-Way	10	192	298	106	55.2%	100.0%	80.0%	6.8
64	Inbound	4	48	110	62	129.2%	100.0%	75.0%	7.0
	Outbound	4	43	120	77	179.1%	100.0%	75.0%	8.5
	Two-Way	8	91	230	139	152.7%	100.0%	75.0%	11.0
65	Inbound	13	69	111	42	60.9%	100.0%	92.3%	4.4
	Outbound	13	130	135	5	3.9%	100.0%	100.0%	0.4
	Two-Way	26	199	246	47	23.6%	100.0%	96.2%	3.2
66	Inbound	8	37	45	8	21.6%	100.0%	100.0%	1.2
	Outbound	8	64	68	4	6.3%	100.0%	100.0%	0.5
	Two-Way	16	101	113	12	11.9%	100.0%	100.0%	1.2
67	Inbound	9	117	103	-14	-12.0%	100.0%	100.0%	1.3
	Outbound	9	85	151	66	77.7%	100.0%	100.0%	6.1
	Two-Way	18	202	254	52	25.7%	100.0%	100.0%	3.4
All	In Plus Out	102	1,990	2,196	206	10.4%	99.0%	87.3%	4.5

Table B 20: M60 Screenline Modelled and Observed PM Peak Hour All Vehicle PCU Flows

Screenline	Direction	No of Sites	Observed Flow	Modelled Flow	Diff	% Diff	% Flow Criteria	% GEH <5	Screenline GEH
61	Inbound	5	5,405	5,491	86	1.6%	80.0%	80.0%	1.2
	Outbound	6	7,665	7,988	323	4.2%	83.3%	83.3%	3.7
	Two-Way	11	13,070	13,479	409	3.1%	81.8%	81.8%	3.5
62	Inbound	7	6,067	6,482	415	6.8%	71.4%	71.4%	5.2
	Outbound	6	8,901	8,812	-89	-1.0%	100.0%	100.0%	0.9
	Two-Way	13	14,968	15,294	326	2.2%	84.6%	84.6%	2.7
63	Inbound	5	3,188	3,088	-100	-3.1%	100.0%	100.0%	1.8
	Outbound	5	5,164	4,484	-680	-13.2%	80.0%	80.0%	9.8
	Two-Way	10	8,352	7,572	-780	-9.3%	90.0%	90.0%	8.7
64	Inbound	4	2,796	2,784	-12	-0.4%	100.0%	100.0%	0.2
	Outbound	4	4,018	3,906	-112	-2.8%	100.0%	100.0%	1.8
	Two-Way	8	6,814	6,690	-124	-1.8%	100.0%	100.0%	1.5
65	Inbound	13	6,545	5,506	-1,039	-15.9%	76.9%	69.2%	13.4
	Outbound	13	9,363	8,942	-421	-4.5%	92.3%	92.3%	4.4
	Two-Way	26	15,908	14,448	-1,460	-9.2%	84.6%	80.8%	11.9
66	Inbound	8	2,704	2,588	-116	-4.3%	100.0%	100.0%	2.3
	Outbound	8	3,575	3,151	-424	-11.9%	75.0%	75.0%	7.3
	Two-Way	16	6,279	5,739	-540	-8.6%	87.5%	87.5%	7.0
67	Inbound	9	7,239	6,449	-790	-10.9%	88.9%	88.9%	9.5
	Outbound	9	8,962	8,263	-699	-7.8%	77.8%	88.9%	7.5
	Two-Way	18	16,201	14,712	-1,489	-9.2%	83.4%	88.9%	12.0
All	In Plus Out	102	81,592	77,934	-3,658	-4.5%	86.3%	86.3%	13.0