Harrogate District Transport Model

Harrogate Borough Council and North Yorkshire County Council

Local Model Validation report

Revision 1

December 2015

Harrogate District Transport Model

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Contents

1. Introduction

1.1 Background

Following meetings with North Yorkshire County Council (NYCC) and Harrogate Borough Council (HBC) in late 2014 / early 2015, Jacobs were requested for the provision of a macro level transport model covering Harrogate, Ripon, Knaresborough, key connecting roads and the major routes of the A1(M) within Harrogate District and the A59 East to the Kirk Hammerton junction. A detailed plan of the area is available in the Appraisal Specification Report (ASR).

The main objectives for the development of the Harrogate District Transport Model (HDTM) were:

- To test the transport impacts of proposed Harrogate District Local Plan growth scenarios and assess the effectiveness of any associated transport infrastructure improvements;
- To provide an assessment of the existing highway infrastructure capacity to accommodate growth in housing, employment and other uses and test how that capacity increases when new infrastructure is provided.
- To provide an input into the Harrogate District Infrastructure Capacity Study and associated delivery plan in order to inform the new local plan for the district which will cover the period up to 2035.
- To assess the traffic benefits of a Relief Road and other potential major highway schemes; and
- To be constructed in such a way as to allow further development of the model, such as variable demand modelling and economic assessment, to support the development of future WebTAG compliant business cases .

The proposed deliverables to be provided in line with the above objectives were:

- **Phase 1 of the work**:
  - Appraisal Specification Report;
  - Traffic Data Collection Report;
  - 2015 base year highway model constructed in line with current WebTAG guidance for the AM and PM peaks;
  - Local Model Validation Report (LMVR);
  - Do-Minimum models for 2025 and 2035, including committed development.
- **Phase 2 of the work** (To be agreed and detailed through a separate Input Statement, but on the initial basis of):
  - Full uncertainty log;
  - Forecast Scenario for testing of the Harrogate District Local Plan growth options;
  - Forecast Scenario for testing of options for Harrogate relief road options; and
  - Option testing Report.

1.2 Purpose of the Report

This report covers the second part of the Phase 1 work laid out in the preceding section, namely the Local Model Validation Report (LMVR). The report summarises the work carried out by Jacobs in the development of the 2015 base year model. This will demonstrate that the model produces accurate representation of existing peak traffic conditions in the Harrogate Borough area, making it suitable for the evaluation of road network and land use options in current and future year scenarios. In order to assess this suitability, the accuracy of the model will be specifically quantified against WebTAG guidance.

The purpose of this report is therefore to:

- Describe the development of the model and related data sources used therein; and
- Present the calibration and validation outputs to highlight the level of model accuracy and its fitness for purpose

1.3 Model Development

The development of the Harrogate and Ripon Transport Models involved the following stages:

- Collecting observed on-site data to assist in the building of demand matrices and to allow effective model calibration and validation;
- Creating a suitable zone system to ensure that the model best represents the land usage within the extents of the study area, and in turn, produce and attract realistic traffic demand;
- Building demand matrices from observed and synthesised data that, when linked to the zone system, would accurately represent overall traffic volumes in the model for the base year and time period under consideration;
- Accurately representing the road network in the detailed model area to enable realistic traffic movements;
- Calibrating and validating the model to ensure it is fit for purpose; and
- Ensuring the model is scalable and upgradeable to include demand, forecasting and multi-modal modelling.

1.4 Report Structure

The report follows the suggested structure given in *WebTAG Unit 3.19 Appendix F.3*. This is:

- Chapter 2 –Proposed Uses of the Model;
- Chapter 3 – Model Standards;
- Chapter 4 – Key Features of the Model;
- Chapter 5 – Calibration and Validation Data;
- Chapter 6 – Network Development;

- Chapter 7 – Trip Matrix Development;
- Chapter 8 – Network Calibration and Validation;
- Chapter 9 – Route Choice Calibration and Validation;
- Chapter 10 – Trip Matrix Calibration and Validation;
- Chapter 11 – Assignment Calibration and Validation; and
- Chapter 12 – Summary.

2. Proposed Uses of the Model

2.1 Proposed Uses of the Model

Harrogate Borough Council has been set a Strategic Housing Market Assessment (SHMA) figure indicating a future growth requirement of 621 dwellings per year. A crucial aspect of the Local Plan is to assess the capacity of various types of infrastructure to be able to support the volume of new residential and employment development required over the next twenty years.

The HDTM will be required to test the transport impacts of potential growth options and the proposed Local Plan allocations and identify and assess the effectiveness of any associated transport infrastructure improvements that are required to deliver future growth. These tests will be carried out during Phase 2 of the commission.

An Infrastructure Capacity Study was commissioned during January and February 2015 to provide a thorough infrastructure assessment for the Local Plan evidence-base. The consultants commissioned to undertake the Infrastructure Capacity Study were required to have some involvement in the development of the model in order to ensure that they would be confident in the results produced by both the base (Phase 1) and the development scenario (Phase 2) outputs. The transport model will provide a critical component for the transport aspect of the Local Plan evidence-base.

Following the development of Phase 1, which is described within this LMVR, Phase 2 will have the following two requirements which the HDTM will be required to assess:

- The traffic benefits of a Harrogate relief road options and other potential major highway schemes to a sufficient level of detail to inform a Strategic Outline Business Case (further work will be required for full Business Case); and
- Capability to analyse the highway impacts of future development at 2025 and 2035, across the areas of Harrogate, Knaresborough and Ripon, and the core roads in the vicinity (A1(M), A61 and A59), in support of the Local Plan.

2.2 Key Model Design Considerations

In discussions with NYCC and HBC, two key decisions were made regarding the development of the transport model. These were as follows:

- Model Study Areas; and
- Model Software.

Following the discussions, Jacobs submitted to NYCC and HBC a proposition paper highlighting the options available for modelling the areas in question and capturing the impacts of development and any associated mitigation. The key conclusions of the paper were that a full Harrogate District Transport Model would be developed, which covers Harrogate, Knaresborough and Ripon within a single model. This would allow for a complete appraisal of the impacts of the Local Plan and the Harrogate relief road, whilst also incorporating key connecting roads and major routes.

In addition, VISUM was selected as the software package of choice. The benefits of using VISUM include:

- Being widely used in the UK in support of public transport schemes and business cases for highway schemes;

- Combined with VDM software including CUBE VOYAGER and EMME. In a recent project, we have developed a VDM model within VISUM itself and so this is now also an option;
- Directly links to VISSIM, which will likely be of consideration to provide operational assessment of local development access;
- Highway model build times in VISUM are generally reasonable;
- Direct Link to the TrafficMaster road routing information and journey time data on the network. This would provide a significant advantage and reduce cost in the processing of this data;
- ArcGIS integration to provide accurate link lengths and road network hierarchy; and
- Ease of transferring centre line road data for use within the Noise and Air Quality Assessment.

3. Model Standards

3.1 Validation Criteria and Acceptability Guidelines

The adequacy of the HDTM and its suitability to assess the interventions identified within **Section 2** has been measured against the following guidance document:

- WebTAG unit M3.1 Highway Assignment Modelling January 2014.
- WebTAG guidance sets out measures to compare the base year model results against independent observed data to quantify the level of fit. The validation of the highway assignment was assessed using the following measures taken from WebTAG unit M3.1 §3.2.3:
- Assigned flows and counts totalled for each screenline or cordon, as a check on the quality of the trip matrices;
- Assigned flows and counts on individual links and turning movements at junctions as a check on the quality of the assignment; and
- Modelled and observed journey times along routes, as a check on the quality of the network and the assignment.

3.2 Screenline Calibration/Validation

For the assessment of screenline flows, the WebTAG criteria are set out in **Table 3-1** below.

Table 3-1 Screenline Flow Validation Criterion

Criterion	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

Full detail of the screenlines used in the modelling can be found within **Section 5.3**. As per guidance the screenlines were split into those used as part of the matrix estimation and network building (calibration) and those used as a further independent check (validation).

The current WebTAG guidance is set as modelled screenlines being within 5% of the observed in order to be considered calibrated/validated. Due to the relatively small of flow on the screenlines within the HDTM compared to Highways England roads for which the guidance was written, it is proposed that a GEH of 4 in used as well as this indicator of suitability, this comes from DMRB guidance on traffic appraisal in urban areas (DMRB Volume 12, Section 2, Table 4.2).

Table 3-2 below shows an example of the small screenline flows in the model and the variance allowed depending on whether the 5% or GEH of 4 is used. This level of flow is more consistent with urban roads than major trunk road.

Table 3-2 Example screenline flow comparison

Time Period	Screenline	Direction	Flow	5% Variance	GEH 4 Variance
PM	C	Inbound	1417	67	182
PM	G	Inbound	1747	87	202

As can be seen, for flows of this size a 5% variance requires the modelled flows to be excessively precise making calibration difficult to achieve, especially through densely packed screenlines within an urban environment. The GEH of 4 indicator resulting in a variance more typical of the daily change in traffic and so this guidance is used in the screenline calibration/validation.

3.3 Individual Link Calibration/Validation

Comparison of the flows and counts at the individual links represents the main method of model calibration. The WebTAG suitability guidance for individual links are detailed below in **Table 3-3**.

Table 3-3 Link Flow and Turning Movement Validation Criteria

Criteria	Description of Criteria	Acceptability Guideline
1	Individual flows within 100 veh/hr of counts for flows less than 700 veh/hr	> 85% of cases
	Individual flows within 15% of counts for flows from 700 veh/hr to 2,700 veh/hr	> 85% of cases
	Individual flows within 400 veh/hr of counts for flows more than 2,700 veh/hr	> 85% of cases
2	GEH < 5 for individual flows	> 85% of cases

WebTAG guidance unit M3.1 §3.2.9 states that the above comparison of modelled and observed flows should be presented for total vehicle flows and for car flows, but not for LGV and HGV flows due to there being insufficient accuracy in the individual link counts for these vehicle types. In addition the above information should be presented by time period.

Data collection sites used in the development and validation of the base year model are presented within **Section 5.1**. As with the screenlines, the link counts are split between those used for calibration and validation purposes.

3.4 Journey Time Validation

WebTAG also contains acceptability guidelines for the validation of journey times. An assessment of the level of journey time validation has been undertaken against this criterion, which is given in **Table 3-4**.

Table 3-4 Journey Time Validation Criterion

Criterion	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times, or 1 minute if higher	> 85% of routes

WebTAG unit M3.1 §3.2.9 states that the speeds within the road network should be based upon separate relationships for light and other vehicle types. Network speeds were derived from Trafficmaster dataset (averaged across similar link types) and verified against collected 'moving car observations'.

3.5 Matrix Estimation

WebTAG provides guidance as to the acceptable changes to the highway 'prior' matrices that should result from the application of matrix estimation. These have been reproduced in .

Table 3-5 Significance of Matrix Estimation Changes

Criteria	Benchmark Criteria
Matrix zonal cell changes	Slope within 0.98 and 1.02
	Intercept near zero
	R2 in excess of 0.95
Matrix zonal trip-ends	Slope within 0.99 and 1.01
	Intercept near zero
	R2 in excess of 0.98
Trip length distributions	Means within 5%
	Standard deviations within 5%
Sector-to-sector level matrices	Differences within 5%

WebTAG Unit M3.1 §8.3.15 states that all exceedances of the above should be highlighted and assessed as to their importance to the model purpose. In addition §8.3.15 further states that the independent validation of the model as set out in **Table 3-1**, **Table 3-3** and **Table 3-4** should not be achieved at the expense of excessive changes to the matrices caused by the estimation process. In such cases, WebTAG states that a lower level of validation should be reported.

3.6 Convergence Criteria and Standards

WebTAG also provides guidance on the appropriate level of convergence a model should achieve. This reflects the stability of the assignment. That is to say that if the model runs were to run for one further iteration the flows on each road would not change significantly. In addition, it was required that the model converged to a point in which routes obeyed Wardrop's First Principle of Traffic Equilibrium, which unit M3.1 §2.7.3 defines as:

"Traffic arranges itself on networks such that the cost of travel on all routes used between each OD pair is equal to the minimum cost of travel and all unused routes have equal or greater cost."

In order to assess this, the following measures of convergence were used:

- Proximity to the assignment objective; and
- Stability of model outputs between consecutive iterations.

The first measure relates to how close the model is to a particular converged solution, which varies depending on the preferences of the user or software package being used. In VISUM this equates to how close the model is to Wardrop's Principle of Equilibrium and is measured using the Gap function. Gap (denoted δ) is calculated below:

$$\sigma = \frac{\sum T_{pij}(C_{pij} - C^*_{ij})}{\sum T_{ij}C^*_{ij}}$$

where:

Tpij	is the flow on route p from origin i to destination j
Tij	is the total travel from i to j
Cpij	is the (congested) cost of travel from i to j on path p
Cij*	is the minimum cost of travel from i to j

Source: WebTAG Unit M3.1 §C.2.4

The gap value therefore represents the excess cost incurred by failing to travel on the route with the lowest generalised cost and is expressed relative to that minimum route cost. The excess cost is summed over each route between each O/D pair and multiplied by the number of trips between each O/D pair. This is divided by the minimum cost summed over each route between each O/D pair, also multiplied by the number of trips between each O/D pair.

The second measure relates to the need for a stability indicator, which is demonstrated by measuring the level of flow change on links between iterations. WebTAG Unit M3.1 provides the convergence criteria that transport models should aim to achieve in order to provide stable, consistent and robust results. **Table 3-6** presents the acceptable levels of convergence required for the base model. The base model's performance against both proximity and stability measures is reported in full in **Section 11** of this report, in order to provide confidence in the modelled results.

Table 3-6 WebTAG Convergence Measures

Measure of Convergence	Base Model Acceptable Values
Delta and %Gap	Less than 0.1% or at least with convergence fully documented and all other criteria met
Percentage of links with flow change < 1%	Four consecutive iterations greater than 98%
Percentage of links with cost change < 1%	Four consecutive iterations greater than 98%

VISUM contains additional stability indicators built into its assignment process which relate to the ICA junction calculations. The ICA (Intersection Capacity Analysis) function in VISUM is used to calculate the operating capacity and therefore delay at junctions. This function provides the below criteria within **Table 3-7** which control when a model is said to be assigned to a sufficiently stable level.

Table 3-7 VISUM ICA Stability Measures

ICA Stability Function
GEH between turning flows in current and previous assignment <=1
GEH between turning flows in current and smoothed ICA assignment <=1
Relative GAP between ICA wait time and VDF wait time is <=0.05

These criteria will also be considered as part of the model convergence.

4. Key Features of the Model

4.1 Detailed Modelled Area and External Area

WebTAG unit M3.1 §2.2.1 provides guidance stating that the geographic coverage of highway assignment models generally needs to:

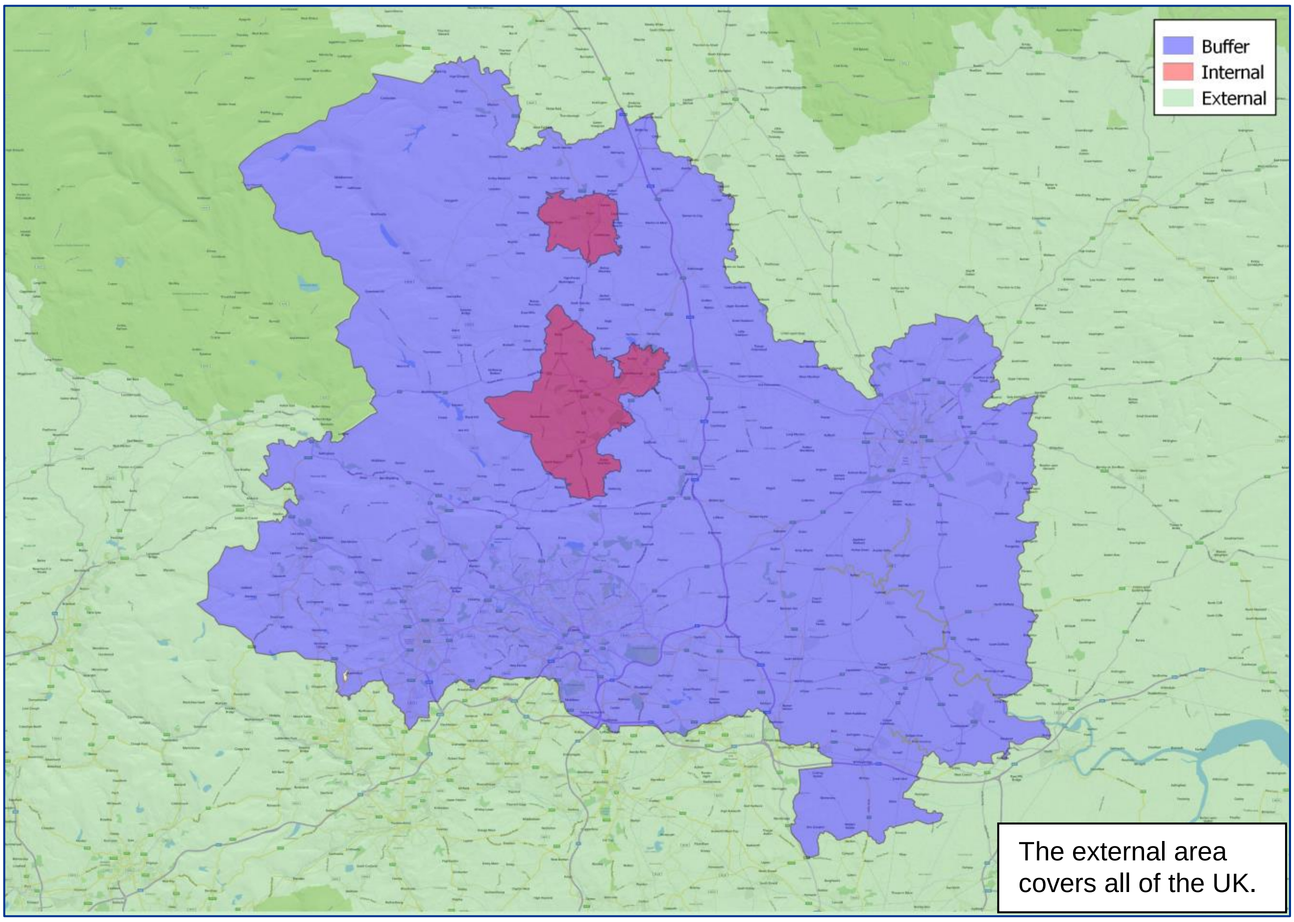
- Allow for the strategic re-routing impacts of interventions;
- Ensure that areas outside the main area of interest, which are potential alternative destinations, are properly represented; and
- Ensure that the full lengths of trips are represented for the purpose of deriving costs.

The primary purpose of the Harrogate District Transport Model is to assess the highway performance with the inclusion of Local Plan site allocations and potential Harrogate relief road options. Therefore, a key feature is an accurate reflection of the strategic alternatives to the trips from/to the North and West travelling through Harrogate and Knaresborough, and modelling these trip lengths in full. In addition, the zone system required a suitable level of disaggregation to allow for the assessment of various growth options and site allocations as part of the Phase 2 work.

In line with latest WebTAG Unit M3.1 guidance, the network for the Harrogate District Transport Model made use of a three tier structure with levels of detail reducing away from the centre of the study area. The breakdown of the network structure is outlined below:

- Fully modelled area:
  - Area of detailed modelling with full coding;
  - Rest of detailed modelled area (Buffer Area); and
- External Area.

Figure 4-1 HDTM Modelled Areas - Zoomed In



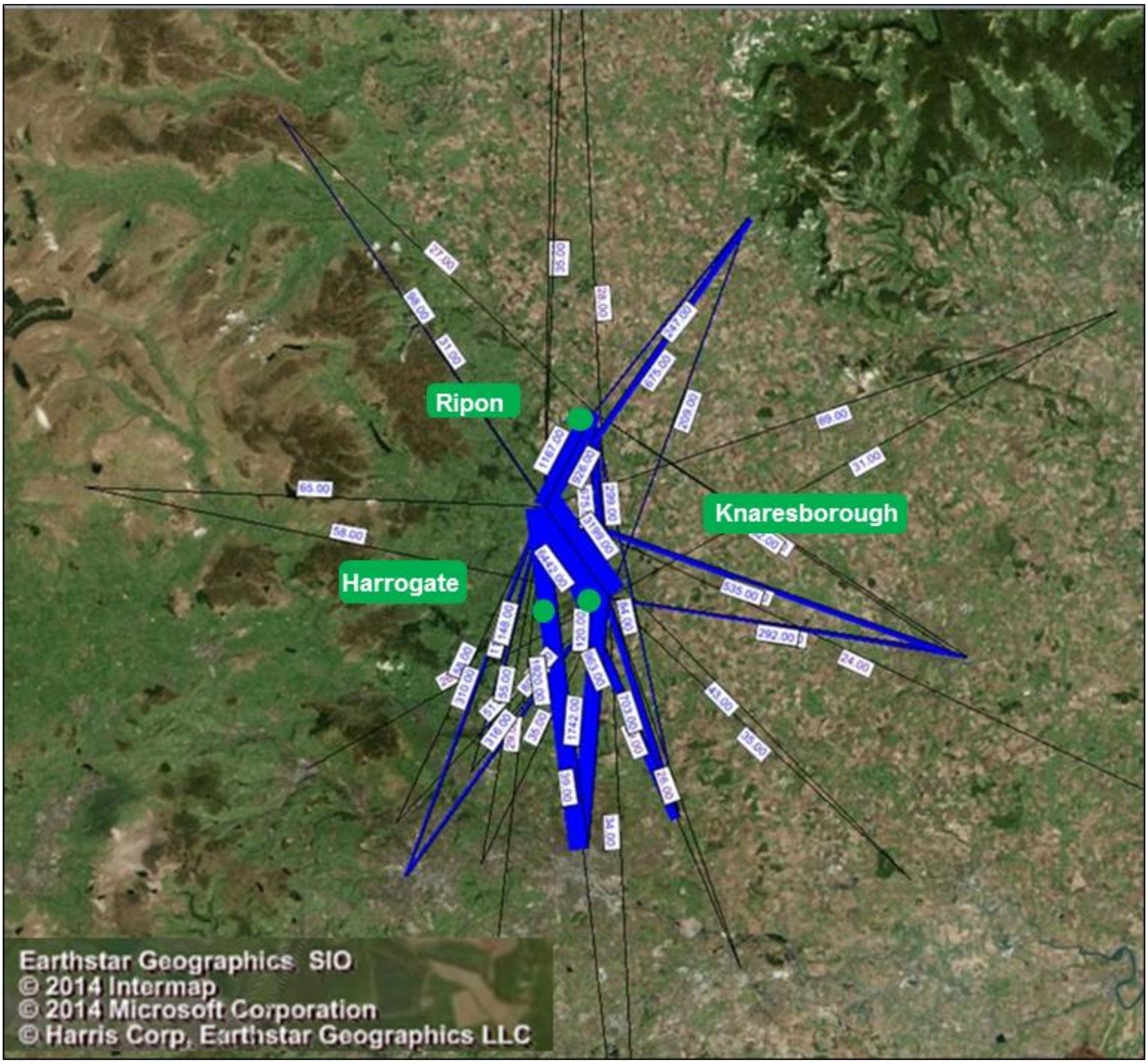
Intermap © 2015 Microsoft Corporation. Terms of Use

The area of detailed modelling is characterised by where the level of impact from the scheme will be significant and, as such, the detail within the network and demand matrices is required to be at its greatest. This area will have capacity restraint modelled via detailed junction modelling. The rest of the fully modelled area is where the level of detail is not as great and capacity restraint is modelled via link capacities, and the external area is where the level of detail is at its lowest and has no explicit capacity restraint modelled.

The external area of the model needs to include any commuter trips which may be impacted by any schemes being tested by the model. The area defined should be representative of any trips directly to and from the fully modelled area, but also be mindful of those trips which may pass through the fully modelled area and thus be impacted by the scheme or site allocation.

The definition of these areas has been made through the use of both Roadside Interview Data as outlined in **Section 5.1** and the 2011 Census Journey to work data. **Figure 4-2** below presents the Census Journey to Work key movements from the Harrogate District and the rest of the fully modelled area. The figure shows that the main movements are from rural Harrogate District into the main urban areas of Harrogate, Knaresborough and Ripon which will form the fully modelled area. There are also large movements south towards Leeds, and Eastbound towards York, which will be part of the external model area. The external model area is based on a skeleton network of key roads, covering all the major strategic routes.

Figure 4-2 Journey to Work and Modelled Area



4.2 Zoning System

Demand is built around model zones, which stipulate the type of land use and amounts of trips within them. For the HDTM a total of 294 zones were developed which covered the model extents shown in **Figure 4-4**. The zones were classified into three zone 'layers', each containing a different level of detail:

- Internal area;
- Buffer area; and
- External area.

Figure 4-3 HDTM Full Zone Structure

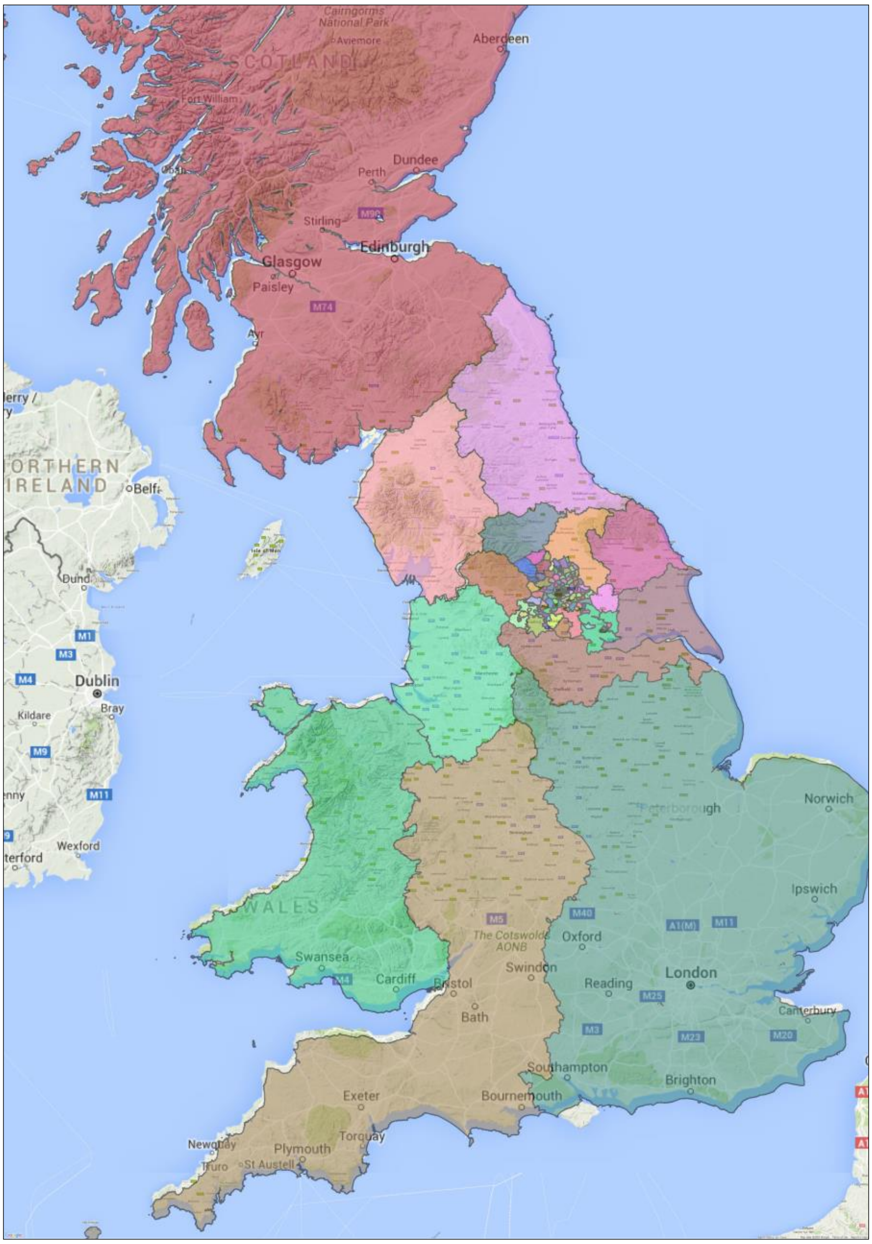
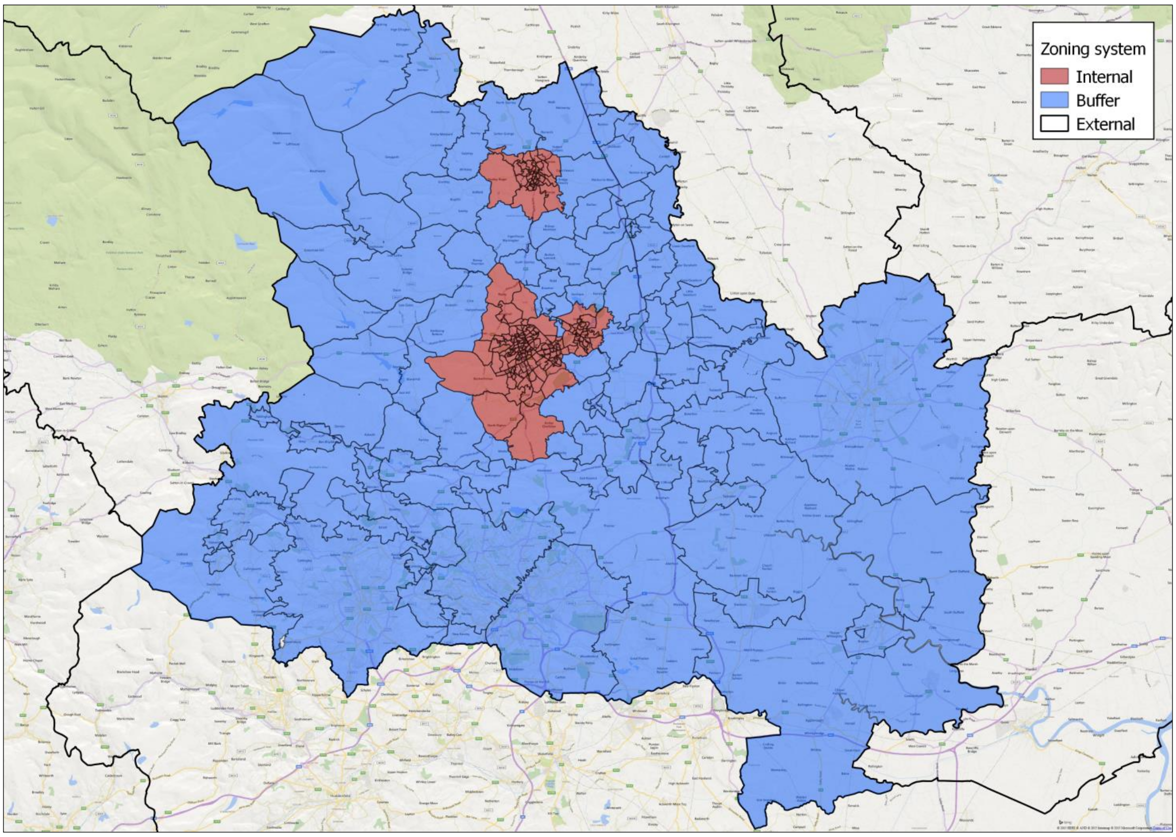


Figure 4-4 HDTM Detailed Zone Structure



Map data © 2015 Google. Terms of Use

4.3 Network Structure

WebTAG unit M3.1 §2.4 highlights the requirement of network structure for the area of detailed modelling, the buffer and the external area. The area of detailed modelling in Harrogate, Knaresborough and Ripon has been designed to include *all roads that carry significant volumes of traffic* and generally *should be of sufficient extent to include all realistic choices of routes available to drivers*. As such, within the area of detailed modelling, this includes all key main roads, secondary roads and residential roads which will be affected by rerouting caused by any development in the Harrogate District area. Any roads with greater than 200 vehicles per hour (as identified in DMRB guidance) will be retained as standard. The resulting network was reviewed by NYCC and HBC to ensure that none of the low trafficked but strategically important links were wrongly excluded.

The extent of the highway network in the model is shown in **Figure 4-5** is defined as the network which enables all major movements from all of the model zones to occur. Outside of the detailed model area the road network is stripped down to only motorway, A roads, B roads and a few key minor roads. This is sufficient given the less detailed zoning structure in these areas and combined with logical zone centroid positioning ensures that traffic enters and leaves the detailed model area by appropriate links.

The detailed highway network is defined as the junctions and linking roads that were the subject of calibration and validation during model building. This implies that forecast land use and supporting mitigation measures could be tested with a degree of confidence in the resulting traffic volumes and routing in the model. The detailed highway network can be considered to be the entire network contained within the detailed model area.

The highway network is derived from the Integrated Transport Network (ITN) layer, TrafficMaster layer and digital mapping from Ordnance Survey. This provides details of the unique characteristics of each highway element, including:

- Road type (motorway, trunk road, local route);
- distance;
- Carriageway type (Single Carriageway, Dual Carriage way, traffic Island);
- Restrictions such as one-way streets and HGV bans; and
- Other elements such as bus/cycle lanes.

These networks were loaded in ArcGIS and joined, based on their spatial location to give one complete network layer.

This network was loaded into VISUM where it is converted into a series of links and nodes. These are defined as:

- Links represent the road infrastructure. The links are bi-directional and each direction has its own unique properties which relate to the highway, e.g. capacity, speed limits etc. Links are connected to each other by nodes; and
- Nodes are objects which define the position of intersections (junctions) in the link network or where the characteristics of a link change. Nodes allow for all movements of vehicles to be possible, it is through coding that the nodes begin to accurately represent junctions.

Figure 4-5 Extent of Highway Network - Zoomed Out

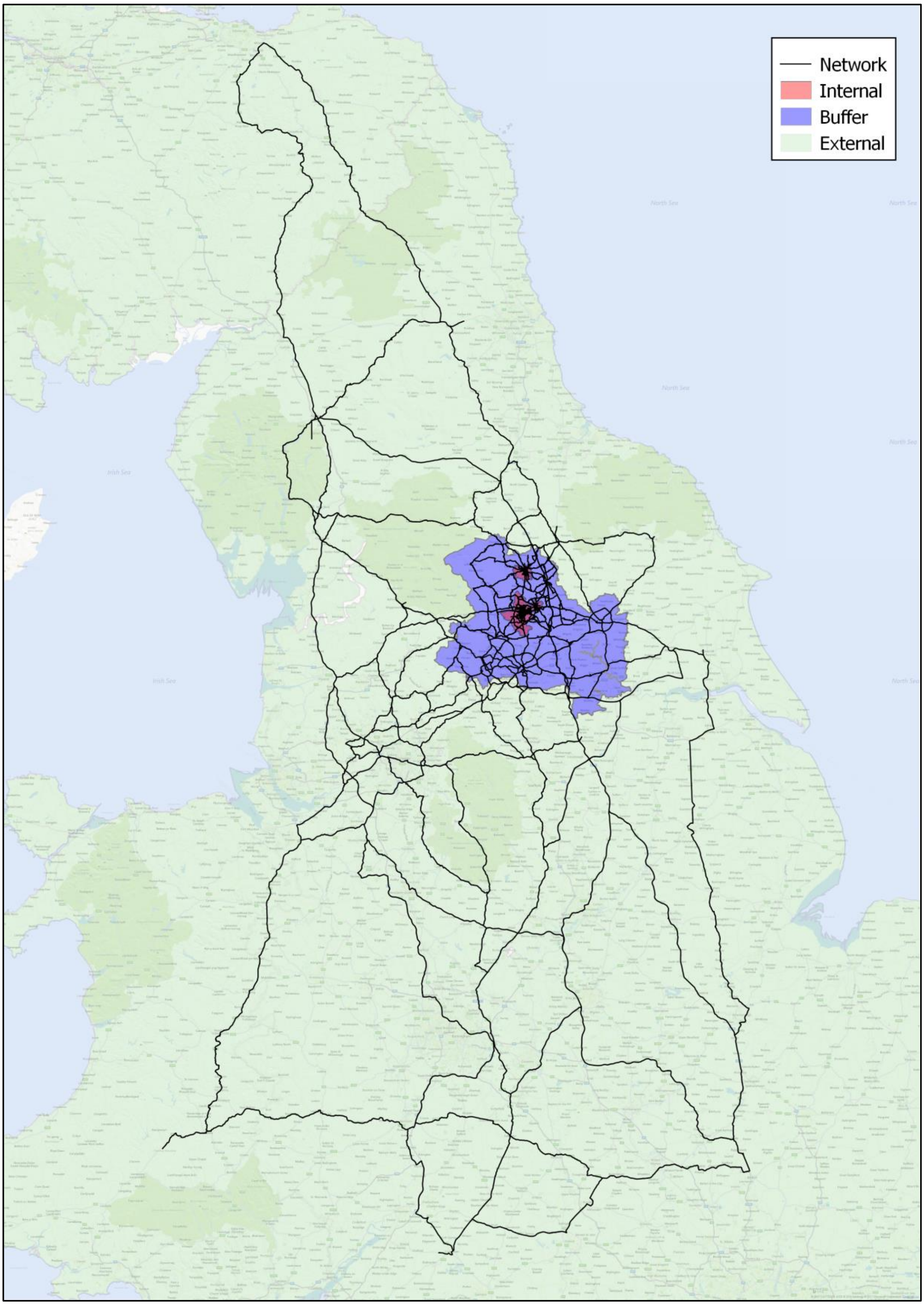
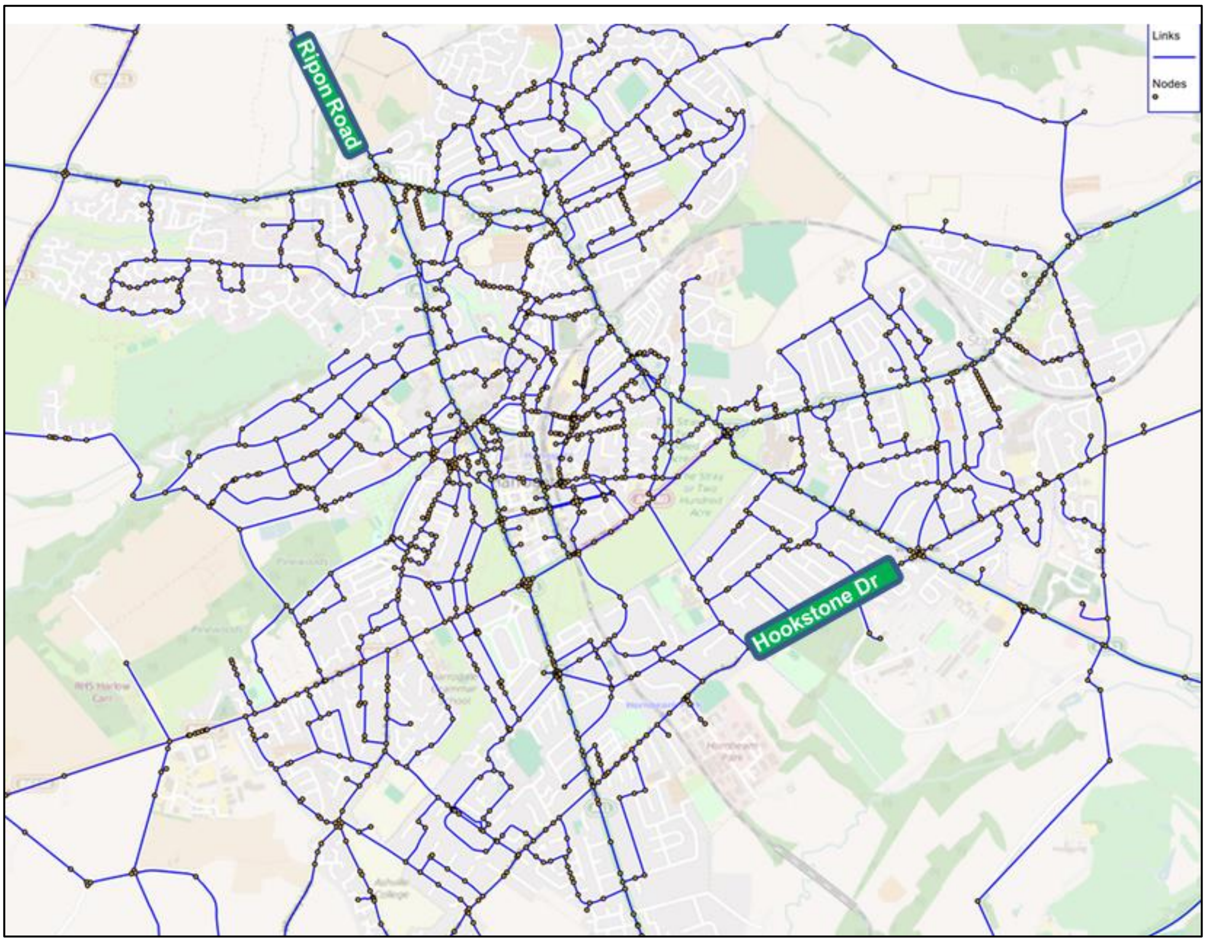


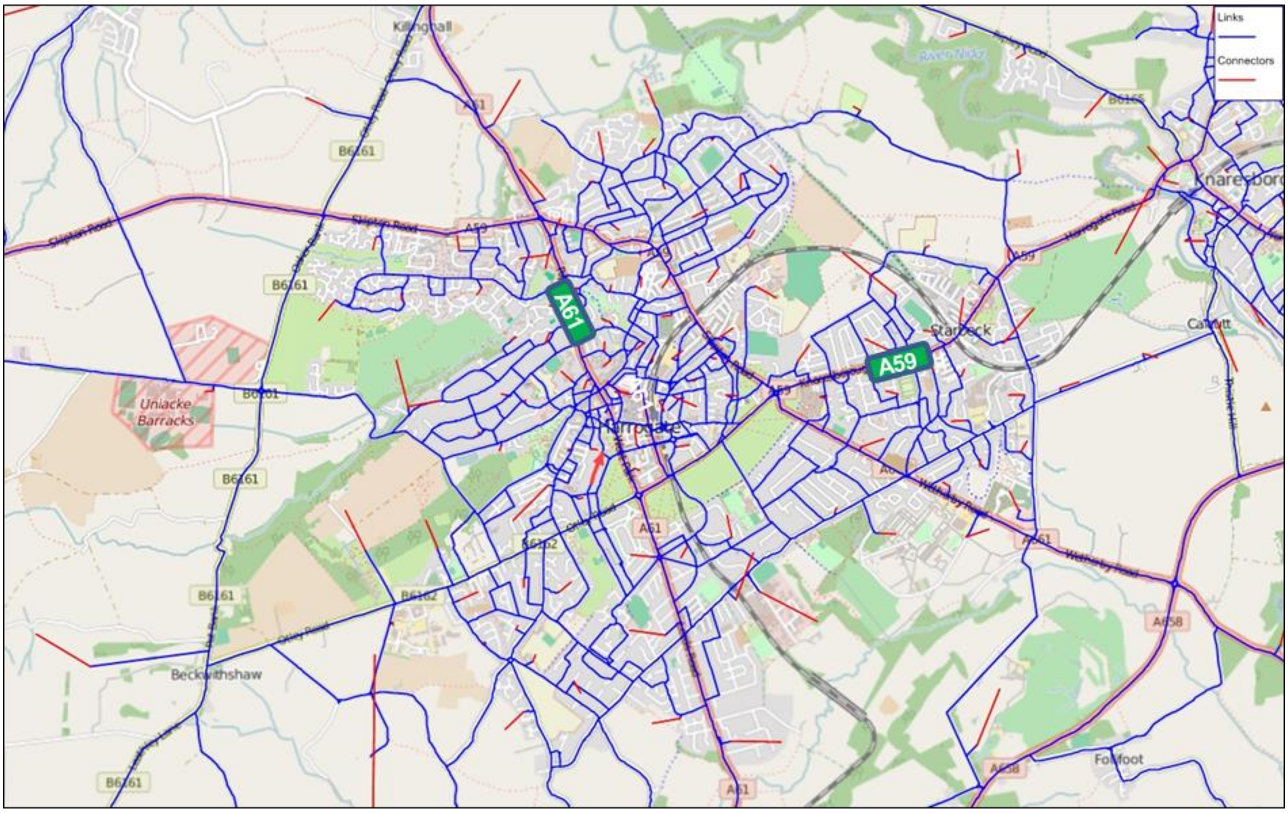
Figure 4-6 Extent of Highway Network in Central Harrogate - Zoomed In



4.4 Centroid Connectors

Centroid connectors are the means by which the zone demand enters and exits the network. They represent the distance to be covered between a zone's centre of gravity (or zone centroid) and the entry / exit node on the network. Most zones were given a single connector, though some were assigned two or more, in order to improve the stability of the model and provide realistic routing. An example of connector locations for the detailed model area in Harrogate is shown in **Figure 4-7**.

Figure 4-7 Centroid Connectors in Detailed Area

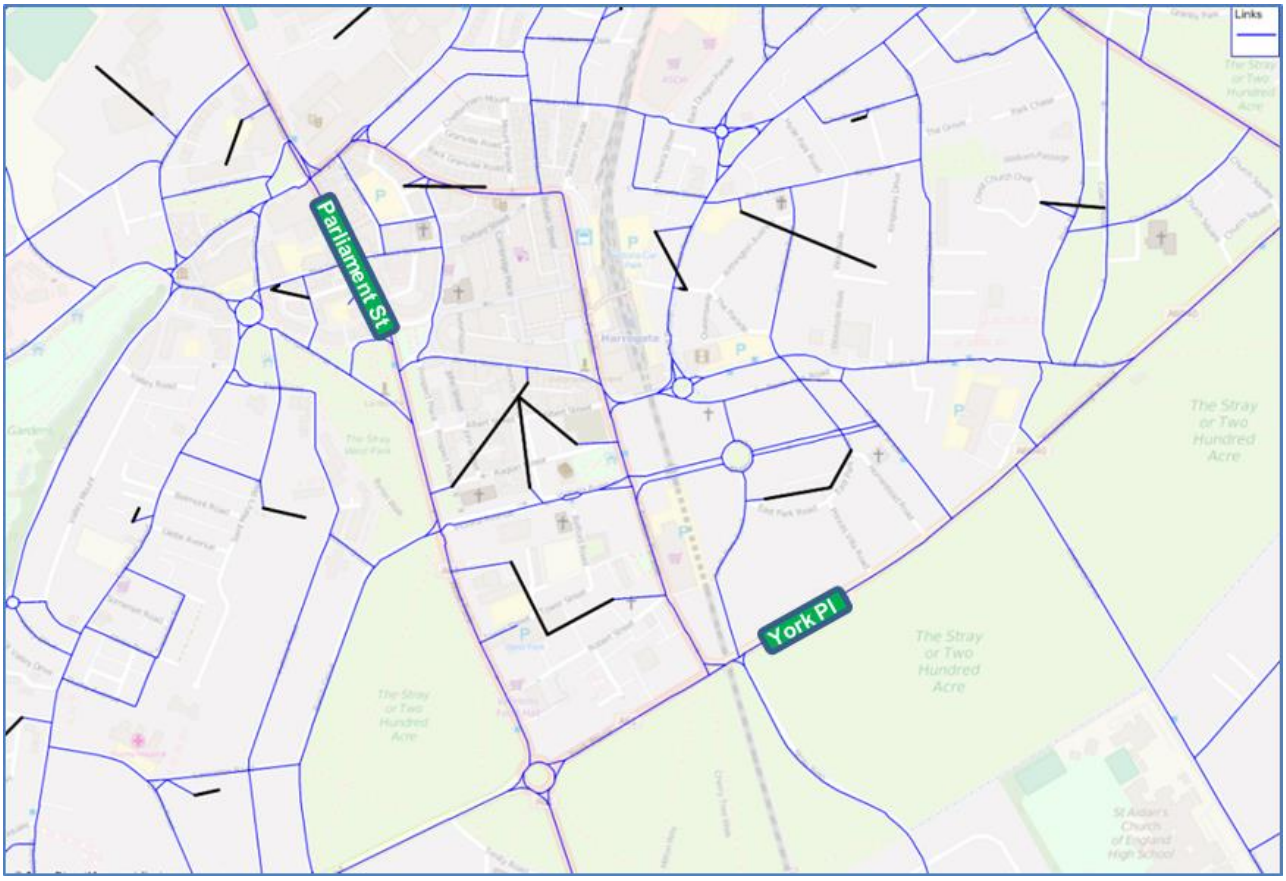


Map data © OpenStreetMap contributors

The loading node where the connector joined the road network was selected as the most representative place for demand to enter / exit the network. For the detailed model area every effort was made to ensure where possible that connectors did not join directly into the network at junctions or onto main roads, but instead joined via an appropriate loading side road.

As can be seen in **Figure 4-8**, some of the internal zones were given two or more connectors; this was to more accurately represent loading onto the network within these zones.

Figure 4-8 Example of Multiple Centroid Connectors



Map data © OpenStreetMap contributors

4.5 Time Periods

The Harrogate District Transport Model consists of the AM and PM Peak periods. The hours modelled were derived by analysis of local traffic counts, these sites are presented in **Figure 4-9** and were used to assess hourly variation in traffic.

Figure 4-9 ATC Traffic Count Location for Time Period Selection

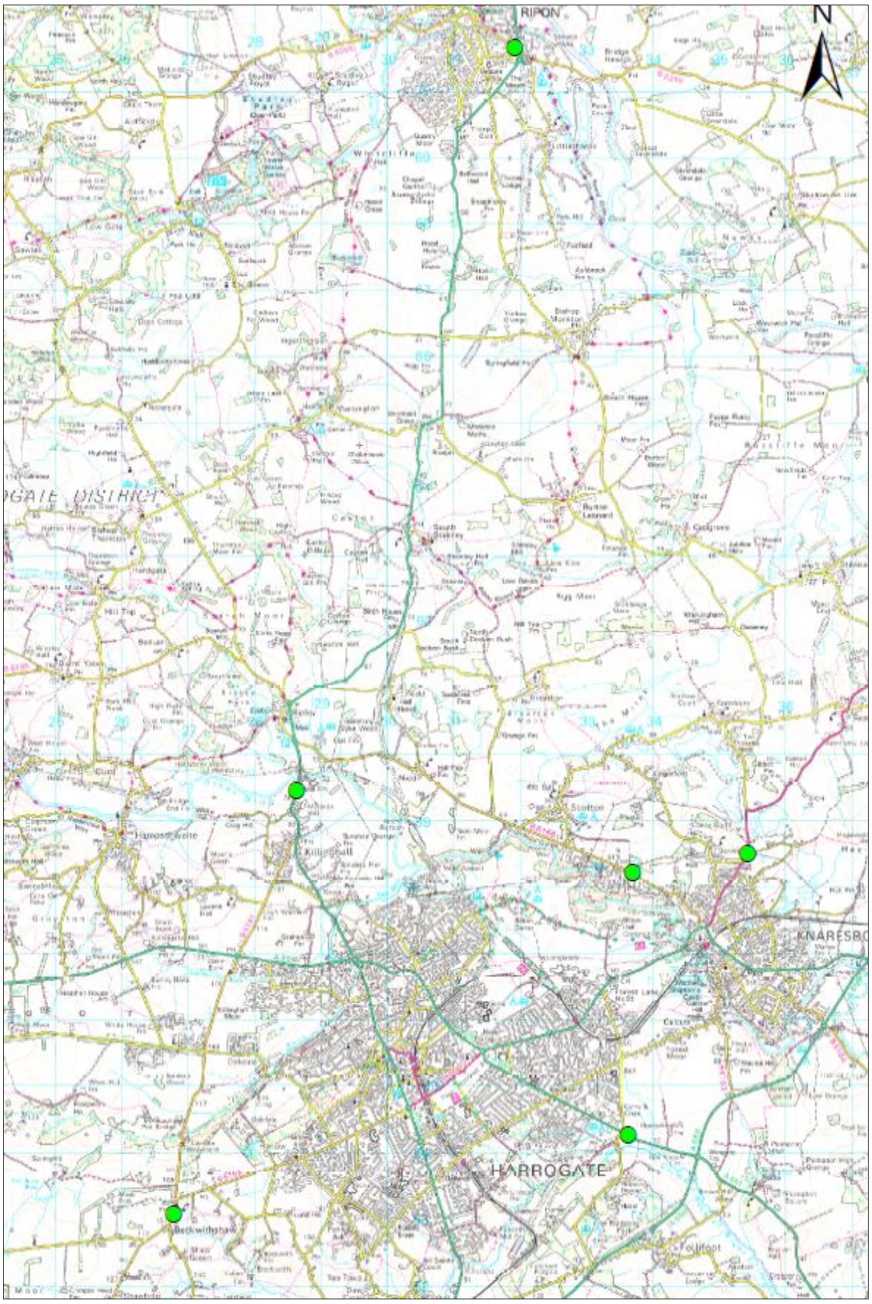
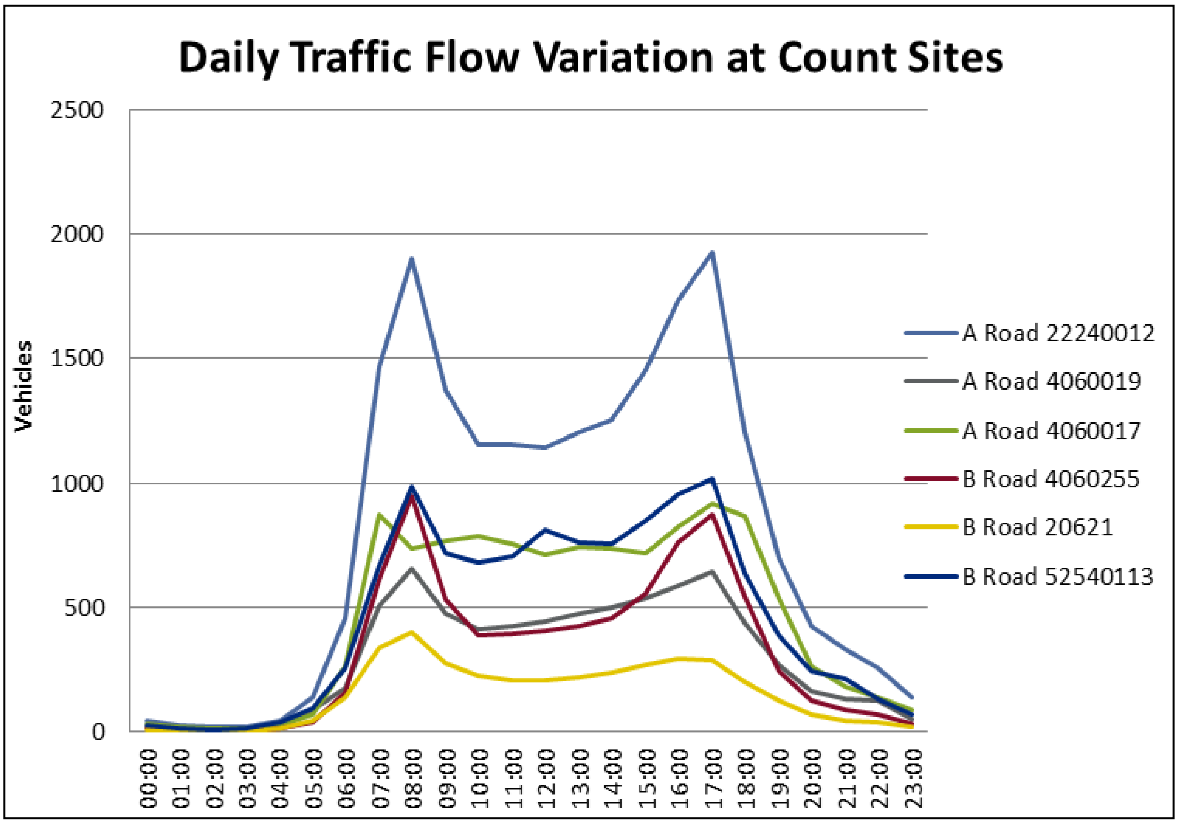


Figure 4-10 Daily Traffic Flow Variation at Count Sites



Analysis of this data showed that, in line with WebTAG unit M3.1 guidance, the following time periods will be assessed:

- AM Peak hour between 08:00 and 08:59; and
- PM Peak hour between 16:45 and 17:44.

To represent a cost-effective approach, with regards to initial land use testing, there was no perceived need for an inter-peak, off-peak (around 2% of daily flow each hour), or a weekend model. In order to ensure the transport model was suitable to be taken forward to full Business Case Appraisal, data was collected for the full day to allow for an inter-peak model to be developed should this be required.

Having peak hour models enables the most effective approach to usage of the model by NYCC and HBC for development planning, policy appraisals and development mitigation testing.

4.6 User Classes

The segmentation of demand as required by WebTAG unit M2 states that as a minimum there should be commute, employers business and 'other' trips. The following journey purpose segmentation was used within the Harrogate District Transport Model demand:

- Home based work;
- Home based employers business;
- Home based education;

- Home based shopping;
- Home based other;
- Non home based other; and
- Non home based employers business.

Within the assignment, five user classes were used based on the above segments. This represents a further disaggregation of car based trips to ensure that the benefits for those commuting, in work, and on other trips (as well as light goods vehicles and heavy goods vehicles) are represented.

Table 4-1 Purpose/User Class/ Vehicle Class Correspondence

<table>
<tr><th>Purpose</th><th>User Class (UC)</th><th>Vehicle Class (VC)</th></tr>
<tr><td>Home Based Work (HBW)</td><td>UC1</td><td rowspan="7">VC1</td></tr>
<tr><td>Home Based Employer’s Business (HBEB)</td><td rowspan="2">UC2</td></tr>
<tr><td>Non-Home Based Employer’s Business (NHBEB)</td></tr>
<tr><td>Home Based Education (HBED)</td><td rowspan="4">UC3</td></tr>
<tr><td>Home Based Shopping (HBS)</td></tr>
<tr><td>Home Based Other (HBO)</td></tr>
<tr><td>Non-Home Based Other (NHBO)</td></tr>
<tr><td>LGV</td><td>UC4</td><td>VC2</td></tr>
<tr><td>HGV</td><td>UC5</td><td>VC3</td></tr>
</table>

Each user class has a PCU factor of 1, although an average PCU factor of 2.0 will be applied to HGV demand. This is to reflect the greater size of HGVs in comparison with cars, with the assumption being that each HGV is equivalent to two cars within the assignment. No factor has been applied to assignment user classes aside from HGV demand.

WebTAG Unit M3.1 Appendix D section 7 states that a PCU factor of 2.5 should be used on motorways and all-purpose dual carriageway routes, with a factor of 2.0 being applied on all other roads. However, within the assignment model, a global PCU factor is required to be applied and therefore the PCU factor of 2.0 for the HGV demand factor was used due to the urban nature of the model.

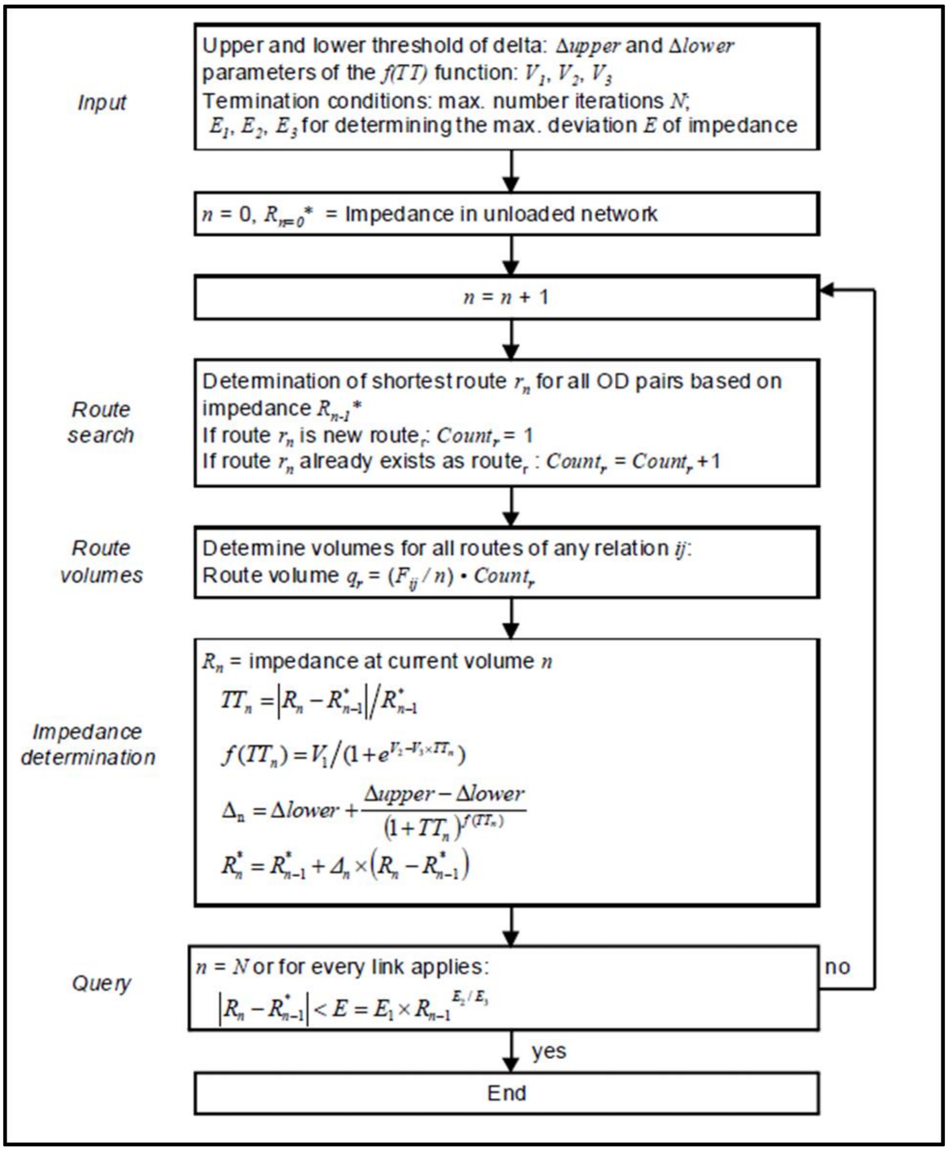
4.7 Assignment Methodology

The software package VISUM was selected for the highway assignment model through discussions with NYCC and HBC.

As stated in **Section 3.6** the assignment of demand on the network has been based on Wardrop’s principle of traffic equilibrium.

The assignment procedure selected with the VISUM modelling software was Equilibrium Lohse. This is a deterministic path based assignment procedure. The assignment procedure was selected as it models the learning process of drivers on the road network. Beginning with an all or nothing assignment the cost information gained during the last iteration is used in the next. The succeeding steps of the Equilibrium Lohse procedure are shown in **Figure 4-11.**

Figure 4-11 Equilibrium Lohse Procedure



Source: PTV VISUM 14 Fundamentals

The termination condition for the assignment was the number of iterations. The VISUM user guide recommended greater than 40 iterations. The number of iterations chosen was 100, which provided acceptable levels of stability and proximity.

4.8 Generalized Cost Formulations and Parameter Values

Within the assignment three parameters are defined for each journey purpose to calculate generalised cost. Generalised cost combines journey times, journey distances and any tolls included in the model into a standard unit of generalised time based on these there parameters.

The two parameters are the pence per second (pps) and the pence per metre (ppm) associated with each user class, and are used in the following formula to determine generalised cost:

$$GeneralisedCosts_{(s)} = JourneyTime_{(s)} + \left(\frac{ppm}{pps}\right) * JourneyDistance_{(m)} + \left(\frac{1}{pps}\right) * Toll_{pence}$$

The values of the pps and ppm parameters within the assignment are based on the latest WebTAG Unit A1.3 guidance (November 2014), linked to an average urban speed of 30 km/p/h. Based on the DfT's release programme it was originally expected that updated values of time and operating costs would be available from a Spring 2015 update. However, this is still yet to be released therefore the November 2014 values were used as they were the most up to date at the time of writing. This will be developed using a DfT audited spreadsheet for these calculations, a methodology which Jacobs have developed and successfully implemented on other similar projects.

Table 4-2 Pence per Second (2015)

Journey Purpose	AM Peak	PM Peak
Commute	0.229	0.224
Business	0.776	0.746
Other	0.291	0.312
LGV	0.350	0.350
HGV	0.354	0.354

Table 4-3 Pence per Metre (2015)

Journey Purpose	AM Peak	PM Peak
Commute	0.008	0.008
Business	0.016	0.016
Other	0.008	0.008
LGV	0.015	0.015
HGV	0.055	0.055

4.9 Junction Modelling

All junctions within the detailed model area as well as all key junctions in the immediately surrounding buffer area have been explicitly modelled, as were key pedestrian crossings which impacted on routing, for example, the high-demand pedestrian crossing near to the Empress Roundabout shown in **Figure 4-12**.

Figure 4-12 Empress Roundabout

Map data © 2015 Google. Terms of Use

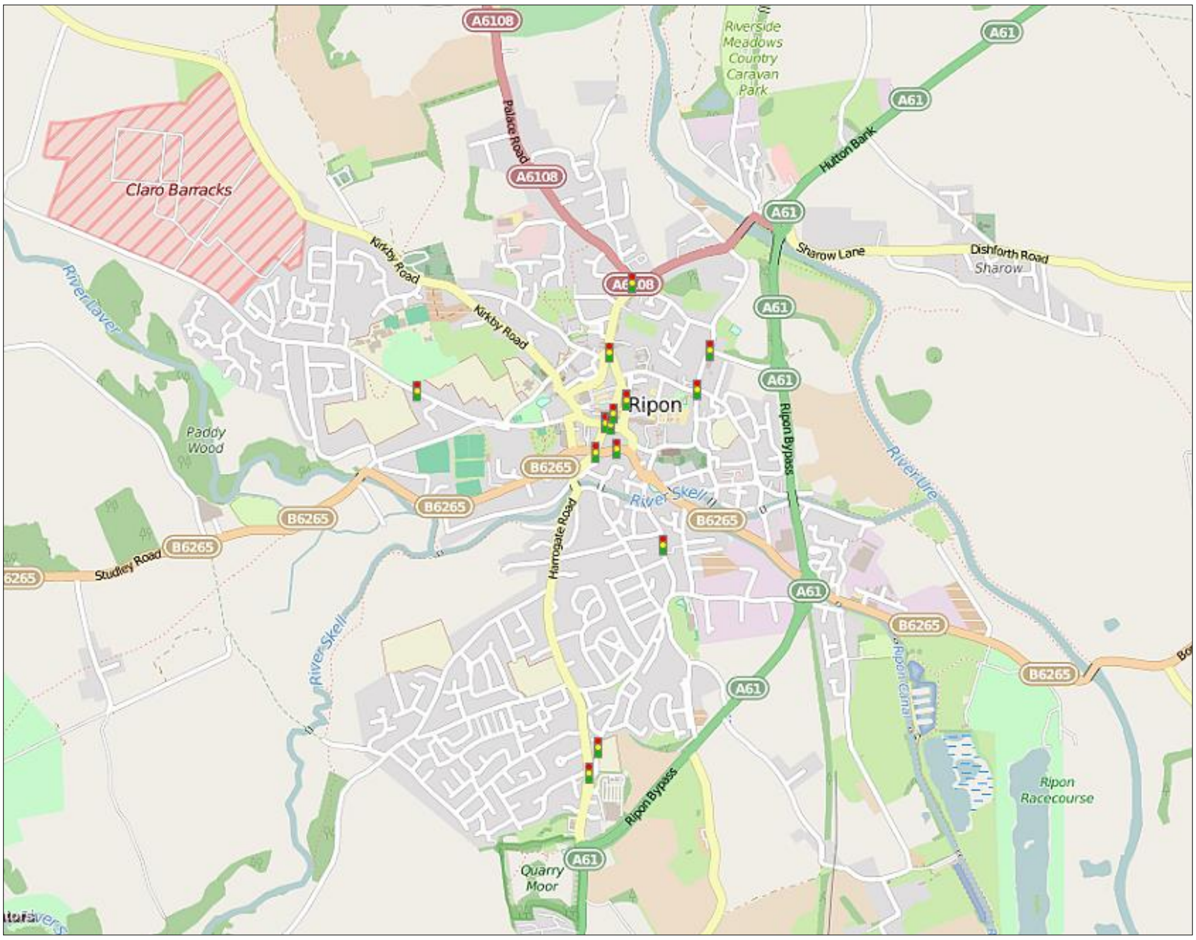
Junction modelling was calculated within VISUM based on the following guidance documentation:

- Signalised Junctions – HCM 2010;
- Roundabouts – TRL/Kimber 2010 ;
- Merge Modelling - TRL CR 279; and
- Priority Junctions – HCM 2010.

This required geometric information as well as signal timings to provide saturation flows within VISUM's Intersection Capacity Analysis (ICA) Modules. Geometric data was measured by hand using both Google Streetview and Ordnance Survey mapping.

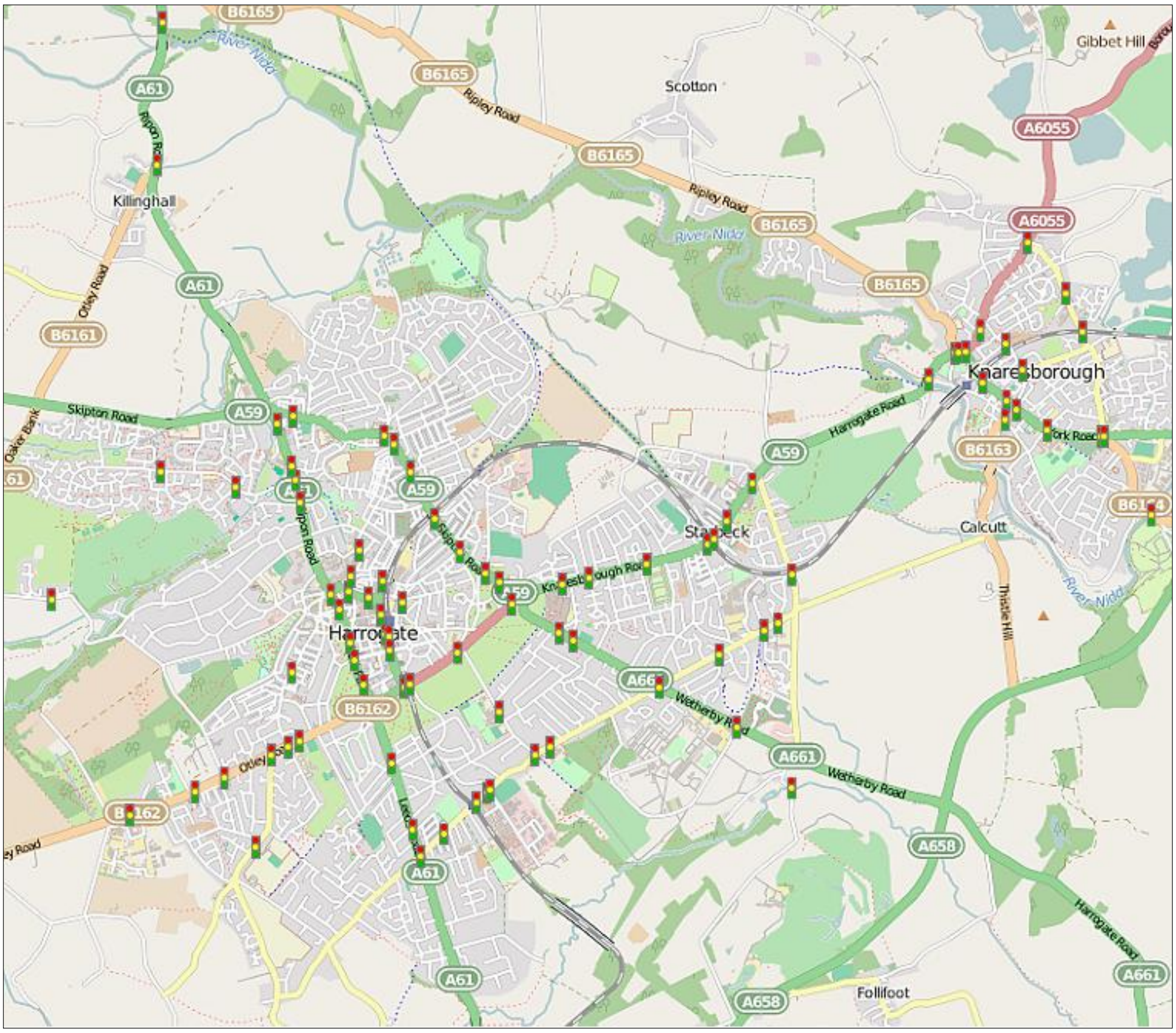
Signal timings were provided by NYCC to accurately reflect junction delays throughout the urban areas. The locations of these signals within the detailed model areas are presented in **Figure 4-13** and **Figure 4-14**.

Figure 4-13 Example of Detailed Modelled Area Traffic Signals – Ripon



Map data © OpenStreetMap contributors

Figure 4-14 Example of Detailed Modelled Area Traffic Signals – Harrogate and Knaresborough



Map data © OpenStreetMap contributors

Within the area of detailed modelling there are two level crossings in Starbeck which affect journey times and therefore vehicle routing. These were coded as traffic signals, with timings derived from average barrier down-times across each modelled time period.

There were three types of junction within the model:

- Signalised - 115 (56 of which are Pedestrian Crossings);
- Roundabout – 79; and
- Two-way yield – 958.

4.10 Speed Flow Relationships

Speed-flow curves describe the relationship between the level of traffic on a link and the speed that is possible for that level of flow. As the level of traffic increases, delays become more marked and the speed decreases until the road reaches its capacity and a speed at capacity is reached.

The exact nature of this relationship is dependent upon location specific characteristics:

- For rural roads, speed-flow curves are defined by link geometry only;
- For urban links, speed-flow curves are influenced by the level of development and concentration of junctions along the road.

A majority of links have speed flow curves applied to them. However, in urban areas, links which are less than 500m in length have a cruise speed applied.

Outside of the area of detailed modelling, a separate set of rest of fully modelled area speed-flow curves has been developed that also accounts for junction delays, in the absence of any detailed junction coding other than major intersections which affect route choice.

Speed-flow relationships have been applied as above as standard. However, as per WebTAG unit 3.1 Appendix D for rural and motorway links where they exceed 2km or on roads on which flows change as a result of the scheme, these were reviewed for their appropriateness and if necessary, updated. Full details of the speed flow curves used in the VISUM model can be found in Appendix H.

Different speed-flow curves were also derived to reflect typical changes in HGV proportions, and HGVs have separate speed-flow curves given to reflect that these vehicles are restricted to lower speeds than cars.

There are a number of functions available within VISUM for modelling the speed flow relationship on links. However, in order to accommodate different speed flow relationships between light and heavy vehicles, as discussed in TAG Unit M3.1, a user defined function has been created. This function is described below in **Figure 4-15**.

Figure 4-15 User defined Speed Flow function within VISUM

Case 1: T Sys <> „HGV“

a) $sat < sat_{crit}$: $t_{Cur} = t_0 \cdot (1.0 + a \cdot sat)$

b) $sat \geq sat_{crit}$: $t_{Cur} = t_0 \cdot [1.0 + a \cdot sat_{crit} + b \cdot (sat - sat_{crit})]$

Case 2: T Sys = „HGV“

a) $sat < d$: $t_{Cur} = t_0 \cdot (1.0 + a_2 \cdot sat)$

b) $d \leq sat$ AND $sat < f$: $t_{Cur} = t_0 \cdot [1.0 + a_2 \cdot d + b_2 \cdot (sat - d)]$

c) $Else$: $t_{Cur} = t_0 \cdot [1.0 + a_2 \cdot d + b_2 \cdot (f - d) + d_2 \cdot (sat - f)]$

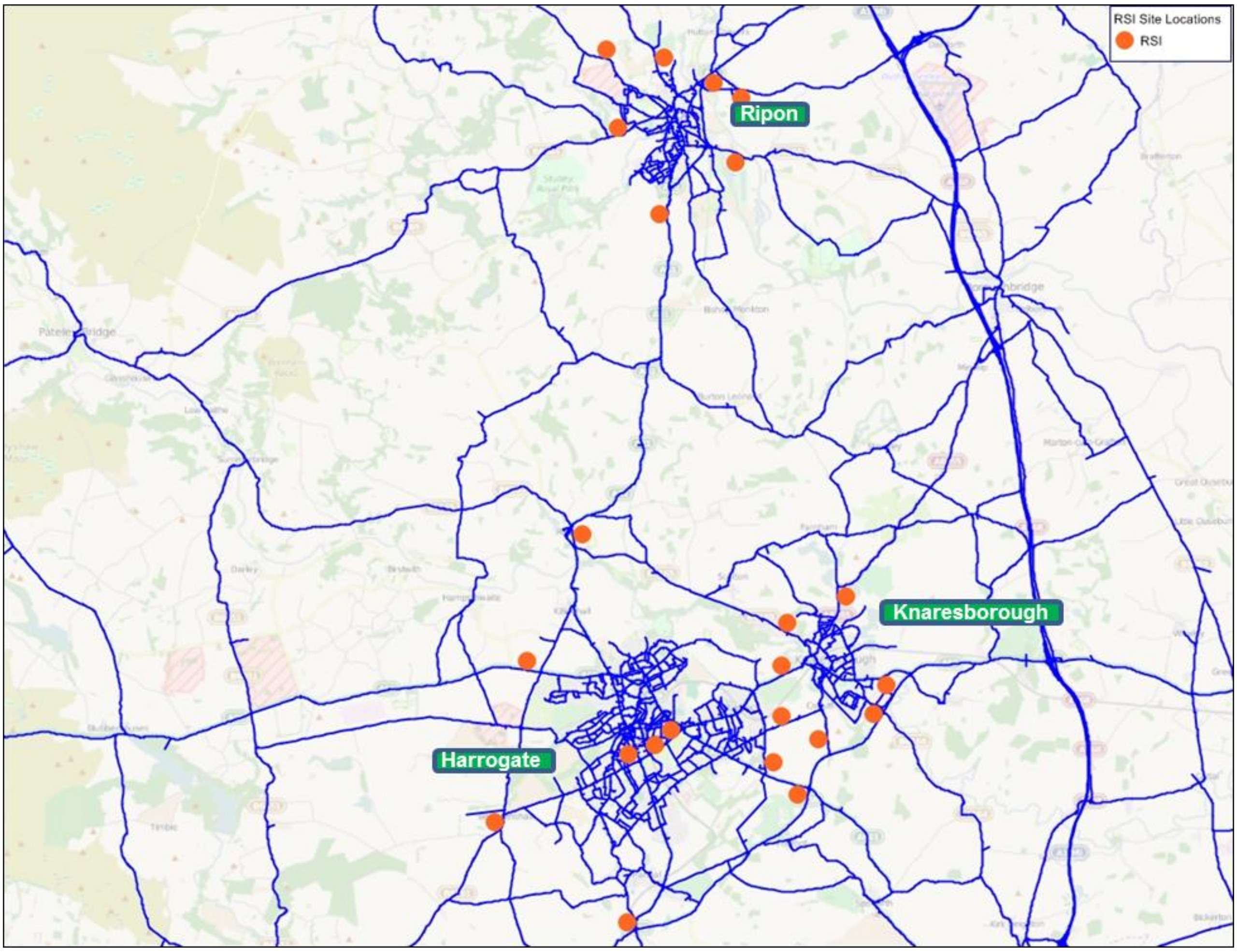
5. Calibration and Validation Data

5.1 Traffic Counts at Roadside Interview Sites

Roadside Interview Surveys (RSIs) were conducted at 23 different sites across four screenlines within the study area in March and April 2015. Each site was surveyed in the inbound direction for a 12 hour period (7:00 – 19:00) on a neutral weekday (Tuesday, Wednesday or Thursday). The RSI questionnaire was designed to capture a variety of information from the road user either directly at the survey site or via a reply paid postcard questionnaire. A copy of the questionnaire can be found in **Appendix A**.

The data collection report for this project, which was jointly published by Jacobs and Sky High in March 2015, describes the RSI process including all applied standards in more detail. **Figure 5-1** below shows the locations of the individual RSI sites, while overleaf provides detailed location information for each individual site.

Figure 5-1 RSI Site Locations



Map data © OpenStreetMap contributors

Table 5-1 RSI Site Locations

Site ID	Location Description	Interview Direction	Screenline	Survey Date
150005 – 1	A61 West Park,Harrogate	N	P	17/03/15
50005 – 2	A61 Station Parade, Harrogate	S	P	17/03/15
50005 – 3	A59 Skipton Road, Harrogate (Centre)	N	P	24/03/15
50005 – 4	A59 Skipton Road, Harrogate (NW)	E	A	18/03/15
50005 – 5	A59 Harrogate Road, Knaresborough (SW)	NE	B	26/03/15
50005 – 6	Forest Moor Road, Harrogate	E	B	26/03/15
50005 – 7	B6165 Ripley Road, Knaresborough	SE	B	24/03/15
50005 – 8	A6055 Boroughbridge Road, Scriven, Knaresborough	S	B	24/03/15
50005 – 9	A59 York Road, Knaresborough (west)	W	B	25/03/15
50005 – 10	B6164 Grimbald Crag Way, Knaresborough	NW	B	25/03/15
50005 – 11	B6163 Thistle Hill, Knaresborough	N	B	25/03/15
50005 – 12	A661 Wetherby Road, Harrogate	NW	A	19/03/15
50005 – 13	A61 Harrogate Road, Harrogate	N	A	18/03/15
50005 – 14	B161 Otley Road (Snuff's Wood), Beckwithshaw	NE	A	18/03/15
50005 – 15	A61 Harrogate Road, Ripon (south)	N	E	12/03/15
50005 – 16	B6265 Studley Road, Ripon	E	E	11/03/15
50005 – 17	Kirkby Road, Ripon	SE	E	11/03/15
50005 – 18	A6108, Palace Road, Ripon	S	E	10/03/15
50005 – 19	A61, Hutton Bank, Ripon	SW	E	10/03/15
50005 – 20	B6265, Boroughbridge Road, Ripon	NW	E	11/03/15
50005 – 21	Dishforth Road, near Sharow	W	E	10/03/15
50005 – 22	A61, Ripon Road, Ripley	S	E	12/03/15
50005 – 23	Forest Lane, Harrogate	N	A	19/03/15

5.2 Traffic Counts for Matrix Estimation and Model Validation

The following data was collected on-site as part of the base model development and is summarised in **Appendix B**.

- RSI Surveys at 23 locations within the study area (see **Section 5-1**)
- Manual Classified Counts (MCC) surveys at 46 locations conducted bidirectional at all 23 RSI sites during the same timeframe
- Automated Traffic Count (ATC) surveys at 149 temporary sites collected over a 14 day period during between 18th of April and 6th of May 2015
- Automated Traffic Count (ATC) surveys at 14 permanent sites distributed across 6 different locations averaged over a 14 day period in April / May 2015
- Traffic Flow Data System (TRADS) flows for 5 sites in the vicinity of the A1, collected during April 2015.
- Additional traffic flows downloaded from C2WEB, a database providing traffic count information for major roads across different regions

Temporary ATC data was recorded by using tube counters. Permanent ATC and TRADS sites data is recorded by the use of loops in-built to the carriageway surface. A 5 day average count was calculated for each site.

5.3 Screenlines

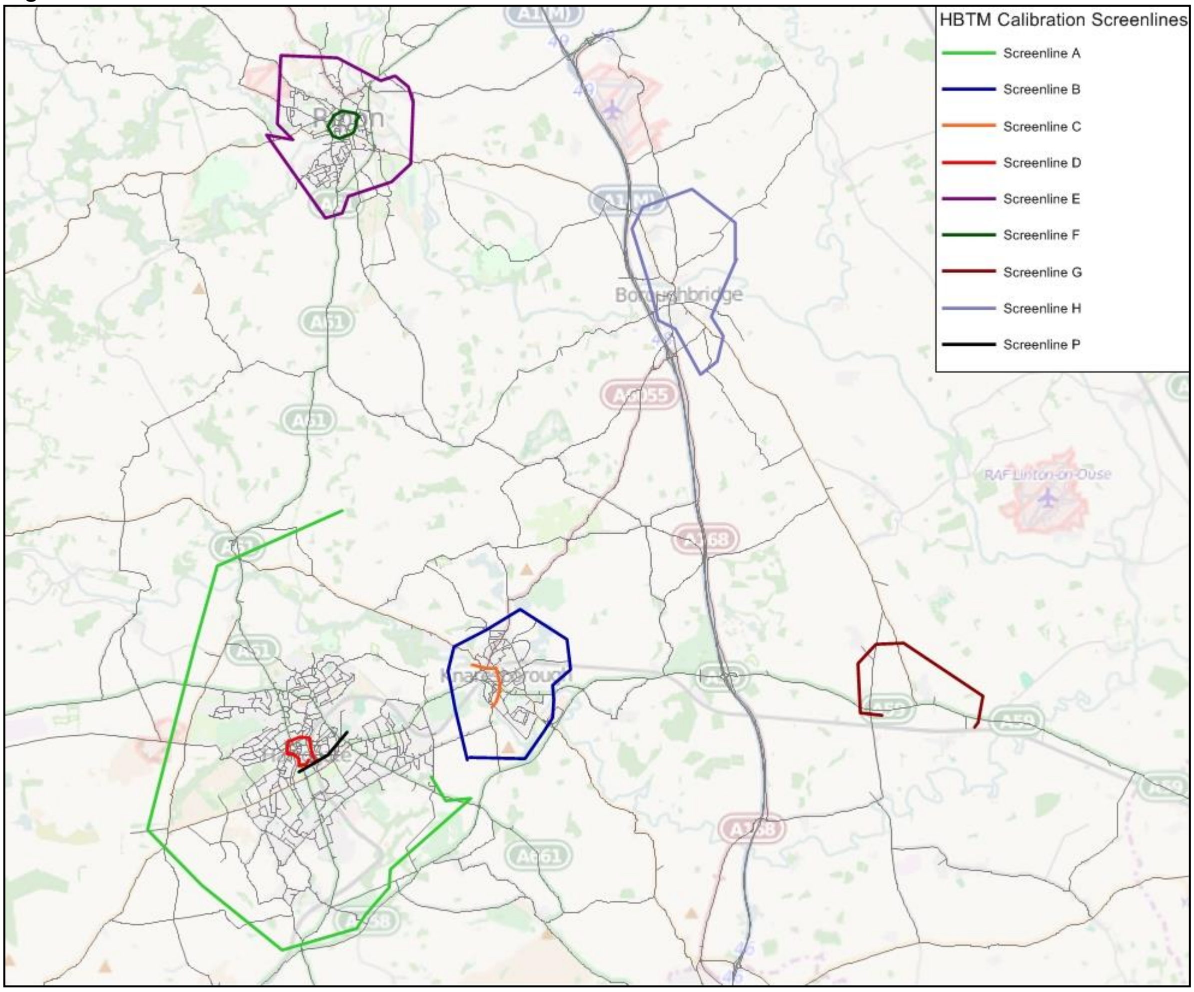
Fourteen bi-directional screenlines were constructed using the traffic count information outlined in **Section 5.2** to capture the total flow of vehicles within and around the study area. Out of these screenlines, nine (A to H & P) were used for calibrating the transport model, while the remaining seven (I, J, M, N and O) were applied for validation purposes. **Table 5-2** describes the purpose and location of each screenline in more detail, while **Figure 5-2** and **Figure 5-3** overleaf show the detailed location and shape of both, calibration and validation screenlines.

Table 5-2 Screenline Overview

Name	Location Description	Screenline Purpose	Number of Links
A	Harrogate Outer Cordon	Calibration	9
B	Knaresborough Outer Cordon	Calibration	9
C	Knaresborough Inner Codon	Calibration	6
D	Harrogate Inner Cordon	Calibration	11
E	Ripon Outer Cordon	Calibration	12
F	Ripon Inner Cordon	Calibration	12
G	Hammerton Cordon	Calibration	6
H	Boroughbridge Cordon	Calibration	7
I	Parallel to A1 (west side) from Junction 47 to Junction 49	Validation	9
J	Ripon Centre Access from South	Validation	6
M	Harrogate Centre Access from South – East	Validation	9
N	Harrogate Centre Access from North	Validation	6
O	Knaresborough Centre Access from West	Validation	8
P	Harrogate Centre Access from South (A61 only)	Calibration	2

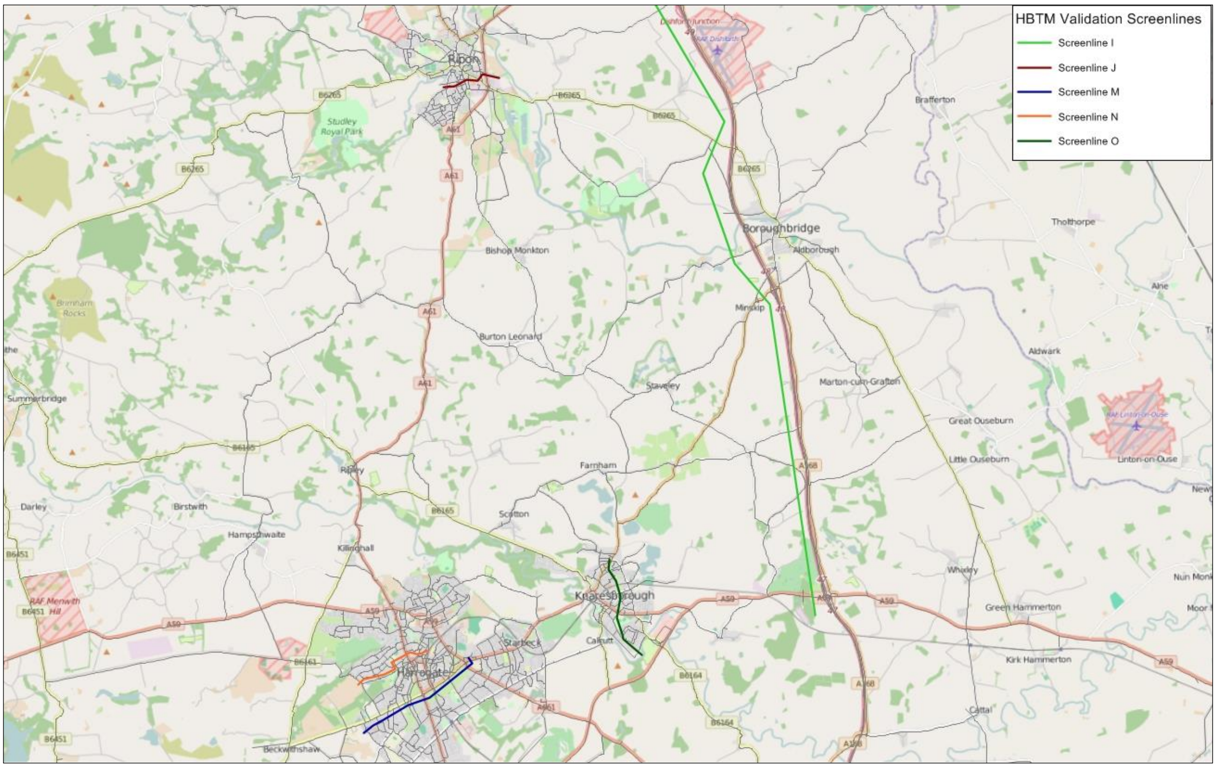
The number of links outlined in **Table 5-2** is the maximum number of links in one of the two directions. The actual number of links considered for each screenline might sometimes be smaller for one of the directions due to the fact that some links are only one way roads. The count sites that were combined to form the screenlines are given in **Appendix B**.

Figure 5-2 Calibration Screenlines



Map data © OpenStreetMap contributors

Figure 5-3 Validation Screenlines



Map data © OpenStreetMap contributors

5.4 Seasonality Check

The model is designed to represent an average weekday. RSI surveys and MCCs have therefore been conducted only on Tuesdays, Wednesdays or Thursdays outside of school holiday periods. Temporary ATC data collection was undertaken during a two week period in April and May 2015, however, all data collected on Monday the 4th of May 2015 has been excluded as it was a bank holiday. Results from permanent ATC count sites have been averaged over a two week period also excluding any school or public holidays. All data recorded between the 23rd and 26th of April 2015 have also been excluded from the final dataset to eliminate potential negative influences caused by the Harrogate Spring Flower Show.

In May 2015 TRADS data for five sites along the A1, as well as C2Web data for several key roads within the study area have been downloaded for all available months between January 2012 and May 2015 have been downloaded as shown in Appendix B. For each site, monthly 24hr Average Annual Weekday Total (AAWT) flow was calculated and averaged to accurately represent the traffic situation on an average day. Comparing the individual results for each month against each other showed only a small variance of AAWT flows once bank holidays and school holidays were disregarded. The average traffic flows resulting from this process were therefore assumed to be robust enough to be taken forward, especially considering that these data are only used for reference purposes rather than actual model calibration or validation.

5.5 Journey Time Surveys for Calibration and Validation

Eleven routes were identified for Journey Time Survey (JTS) data collection, out of which nine have been observed through traditional methods, while Trafficmaster Data has been used for the remaining two. The reason for this was that two additional routes were added after surveys had been undertaken, in order to increase model robustness. This was especially required on East-West movements within Harrogate, North South journeys bypassing the town and along the A1, as these areas were not included within the original survey routes. Using Trafficmaster rather than conducting a time- and cost-intensive resurveying was therefore agreed as suitable way to collect the missing data between Jacobs and the client.

A map of all these routes is provided in **Figure 5-4**.

The agreed methodology was to survey the routes on any Tuesday to Thursday (inclusive), avoiding bank holidays and the school holidays. Each JTS for each route was carried out bidirectional with the individual runs being spread over at least two days between April 21st and April 30th 2015.

The method for collecting the surveyed journey time data was using both, a Moving Observer Methodology, alongside with gathering GPS data from vehicles. Data was captured using suitable GPS devices enabled to capture, as a minimum, location data within 1 second intervals within a 10 metre radius.

A minimum of 6 runs per route for each direction, for each time period (as shown below) were required.

- AM Peak 08:00-09:00;
- Interpeak 11:00-12:00; and
- PM Peak 17:00-18:00.

Surveys of journey routes were applied after the peak period analysis which found the final modelled PM peak hour to be 16:45-17:45. It was agreed with NYCC to use the AM and PM peak hour JTS results as planned, as the collected dataset was considered strong and robust enough to represent afternoon traffic, even with slightly amended times. The routes and dates of collection are given in **Table 5-3**, while **Figure 5-4** provides a graphical overview of the surveyed journey routes.

Table 5-3 Journey Time Survey Routes

No	Start and End Points	Major Roads Travelled	Direction	Method
1	Bond End / High Bond End, to A61/A658 Roundabout	B6165, A61,	NB / SB	Moving Observer
2	A61 / A658 Roundabout to A59 / A658 Roundabout, Knaresborough	A658	NB / SB	Moving Observer
3	A1(M) J47 / A59 Roundabout to A59 / B6161 Roundabout	A59	EB / WB	Moving Observer
4	Empress Roundabout to A61 / Dreighton Road Junction	A661	NB / SB	Moving Observer
5	A61 / Follifoot Road Junction to A59 / Forest Lane Junction	Follifoot Road, Pannal Road, Rudding Lane, Forest Lane	EB / WB	Moving Observer
6	A61 / Hookstone Road / Leadhall Lane to A6055 / Farnham Lane Junction	Hookstone Road, Hookstone Drive, Hookstone Chase, Forest Moor Road, B6163, A59, A6055	EB / WB	Moving Observer
7	A61 / Harrogate Road Roundabout to A61 / Shambles Lane Junction	A61	NB / SB	Moving Observer
8	A61 in Wormald Green to B6265 in Bridge Hewick	A61, Harrogate Road, Water Skellgate, Bondgate Green, B6265	EB / WB	Moving Observer
9	Harrogate Road / Grove Lane	Harrogate Road,	EB / WB	Moving

	Junction to Disforth Road in Sharow	Market Place, North Street, North Road, Sharow Lane, Disforth Road		Observer
10	Empress Roundabout to A61 / Killinghall Road Junction	York Place, Otley Road, B6161	EB / WB	Trafficmaster
20	A61 / Shambles Lane Junction to B1224 / A168 / Deighton Road Roundabout	A59, A1(M), B1224	NB / SB	Trafficmaster

Each JTS route was subdivided into a number of timing points located at key points along the route. An average time for each section of the route was calculated, the summation of which provided the total route time to which the model output would be compared.

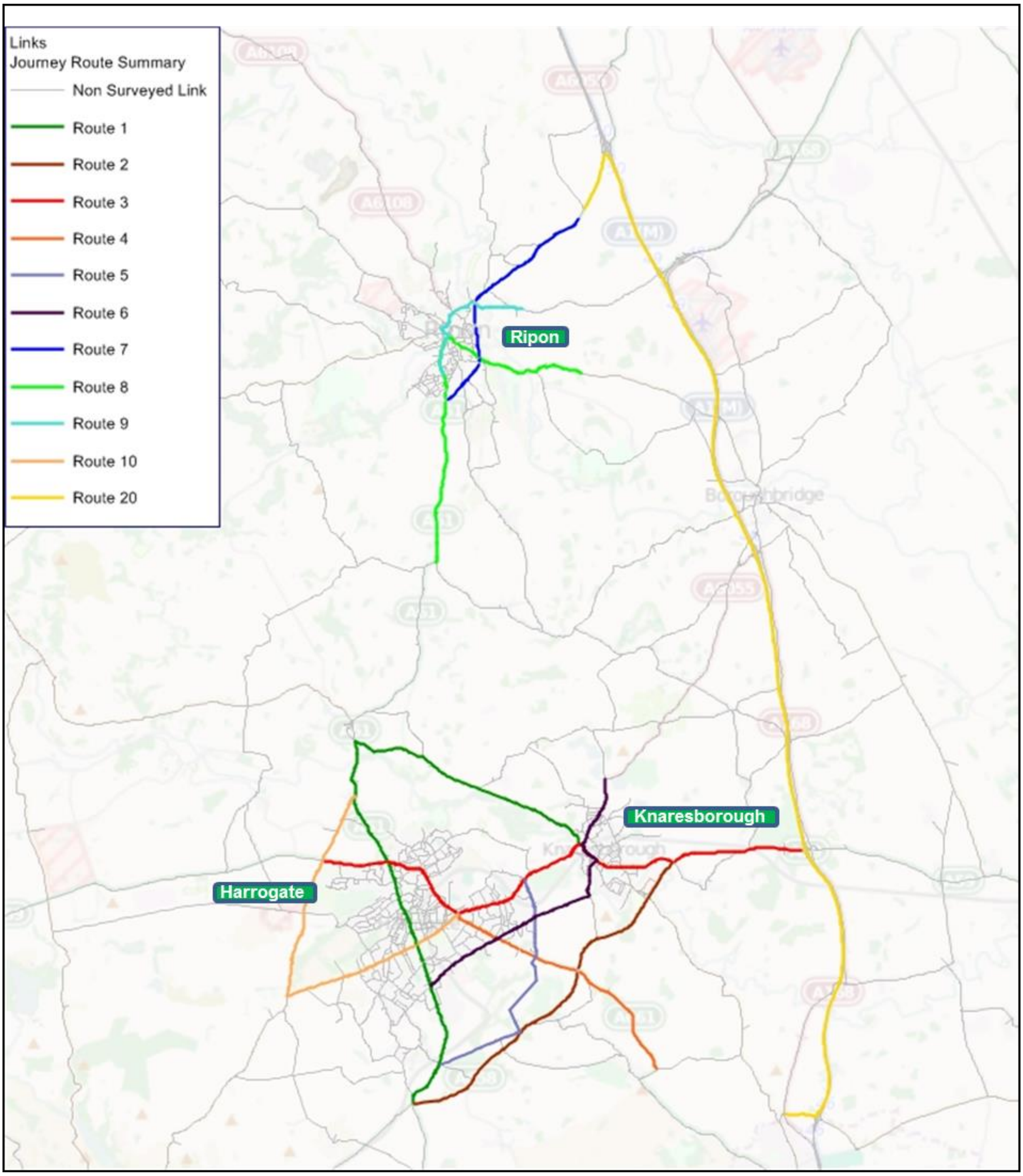
Robustness of the observed journey time surveys was analysed by using standard deviation, a measure describing the dispersion of a dataset around the mean. From the standard deviation a coefficient of variation was calculated which compares the mean to the standard deviation in percentage format. WebTAG states that the coefficient of variation percentage should ideally be around 15% or under to show a relatively stable set of survey results. The coefficients of variation for all journey times are presented below in **Table 5-4**. This shows that the majority of routes are below 15% with a few slightly above. Of those which are above 15%, route 5 shows a large amount of variation, this is due to the fact that route 5 passes along a number of side streets in Harrogate, crossing key strategic roads via junctions' without signals. Therefore the delay at these crossing points will vary largely between runs.

Table 5-4 Journey Time Coefficient of Variation Table

Journey	AM	PM
Route1 OB	13%	4%
Route1 IB	8%	4%
Route2 OB	4%	11%
Route2 IB	18%	13%
Route3 OB	9%	11%
Route3 IB	8%	11%
Route4 OB	6%	18%
Route4 IB	18%	13%
Route5 OB	13%	21%
Route5 IB	26%	29%
Route6 OB	6%	7%
Route6 IB	5%	14%
Route7 OB	26%	4%
Route7 IB	5%	7%
Route8 OB	8%	13%
Route8 IB	17%	7%
Route9 OB	9%	8%
Route9 IB	11%	16%

For the two journey routes based on traffic master, average travel times were determined by multiplying the average traffic master speed for the respective time period by the modelled link length. The result of this calculation represented the overall travel time used for model calibration and validation.

Figure 5-4 JT Survey Routes



Map data © OpenStreetMap contributors

6. Network Development

6.1 Junctions

As outlined in **Section 4.9** all junctions within the detailed model area and on journey survey routes were coded individually based upon geometries and signal timings to give a realistic simulation of the delay in the network.

There are three types of junction coding within the model: priority, signalised and roundabouts. The capacity of each was calculated under the following methodologies:

- Priority junctions – calculation according to Highway Capacity Manual (HCM) 2000;
- Signalised junctions - calculation according to HCM 2000; and
- Roundabouts – calculation according to TRL / Kimber equations.

Each junction in the model area was assessed for open turn movements and correct geometries. This was conducted primarily using aerial photography, Google Streetmap and local knowledge. A check of major flow priority was undertaken to ensure that delays were applied to the minor arms of priority junctions, and that the majority of green time went to the main movement for signalised junctions.

The majority of signalised junctions were coded based upon the specification data provided by NYCC. However, in cases where signal data could not be provided, cycle times were coded based on observed major and minor movements, local knowledge and signal patterns derived from junctions with a similar layout within the model. **Table 6-1** outlines all modelled junctions where cycle times have been estimated, using Google Street View and local knowledge of the major movements.

Table 6-1 Estimated Signals timings

Number	Junction Location	Junction Details
1	Harrogate	Station Parade / Victoria Avenue
2	Harrogate	Skipton Road / Woodfield Road / King's Road
3	Harrogate	Otley Road / Harlow Pines
4	Harrogate	Skipton Road / Westmoreland Avenue
5	Pannal	Princess Royal Way / The Carr Leeds Road / Follifoot Road / Pannal Bank

The signalised junctions were coded as either nodes or main nodes, depending on the complexity of the junction and movements involved.

6.2 Link Coding

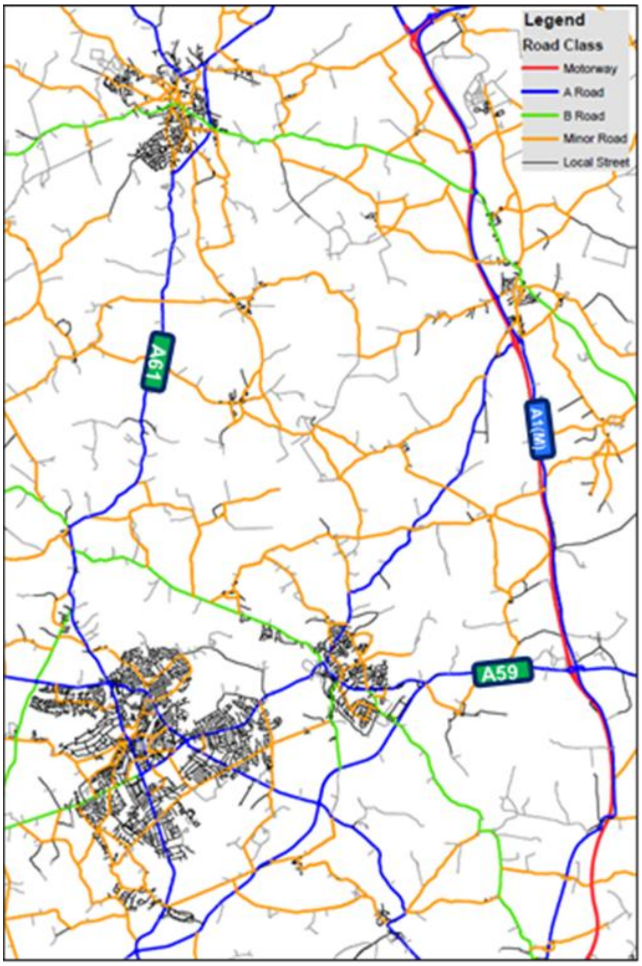
Network data geometry and classification was taken from the Ordnance Survey dataset; the Integrated Transport Network (ITN). The ITN attributes were reviewed for validity and updated where necessary. ITN provides the following information:

- Link Lengths;
- Road Link Classification - Motorway, A road, B road, minor road, local street, alley, pedestrianised streets, private road – publicly accessible, private road – restricted access;

- Road link types - Dual carriageway, single carriageway, slip road, roundabout, traffic island, traffic island at junction, enclosed traffic area; and
- Routing information - No turn, mandatory turn, no entry, access prohibited to (specified vehicle types), access limited to (specified vehicle types), height restrictions, fords, mini roundabouts, traffic calming, gate, tolls, bridge over road, firing range, through route, severe turn.

Figure 6-1 provides the example ITN road network, classified as described above, within the Harrogate Borough area.

Figure 6-1 ITN Road Network



WebTAG unit M3.1 §2.9.2 details the requirements for capacity restraint as follows:

"In models of congested areas, capacity restraint should be applied throughout the fully modelled area. Capacity restraint may be applied by the use of either:

- *link-based speed/flow or flow/delay relationships; or*
- *flow/delay modelling of junctions; or*
- *a combination of both."*

WebTAG unit M3.1 Appendix D further details the speed/flow relationships appropriate in various link areas as presented within **Table 6-2**.

Table 6-2 Application of Speed Flow Relationship to Network Coding

Area type	Separate light and heavy vehicle speeds	Link or route or network relationships?	Major junction delays included or excluded?
Rural	Yes	Link	Should be modelled separately
Urban	No	Network	Included
Small Town	No	Route	Should be modelled separately
Suburban	Yes	Route	Should be modelled separately

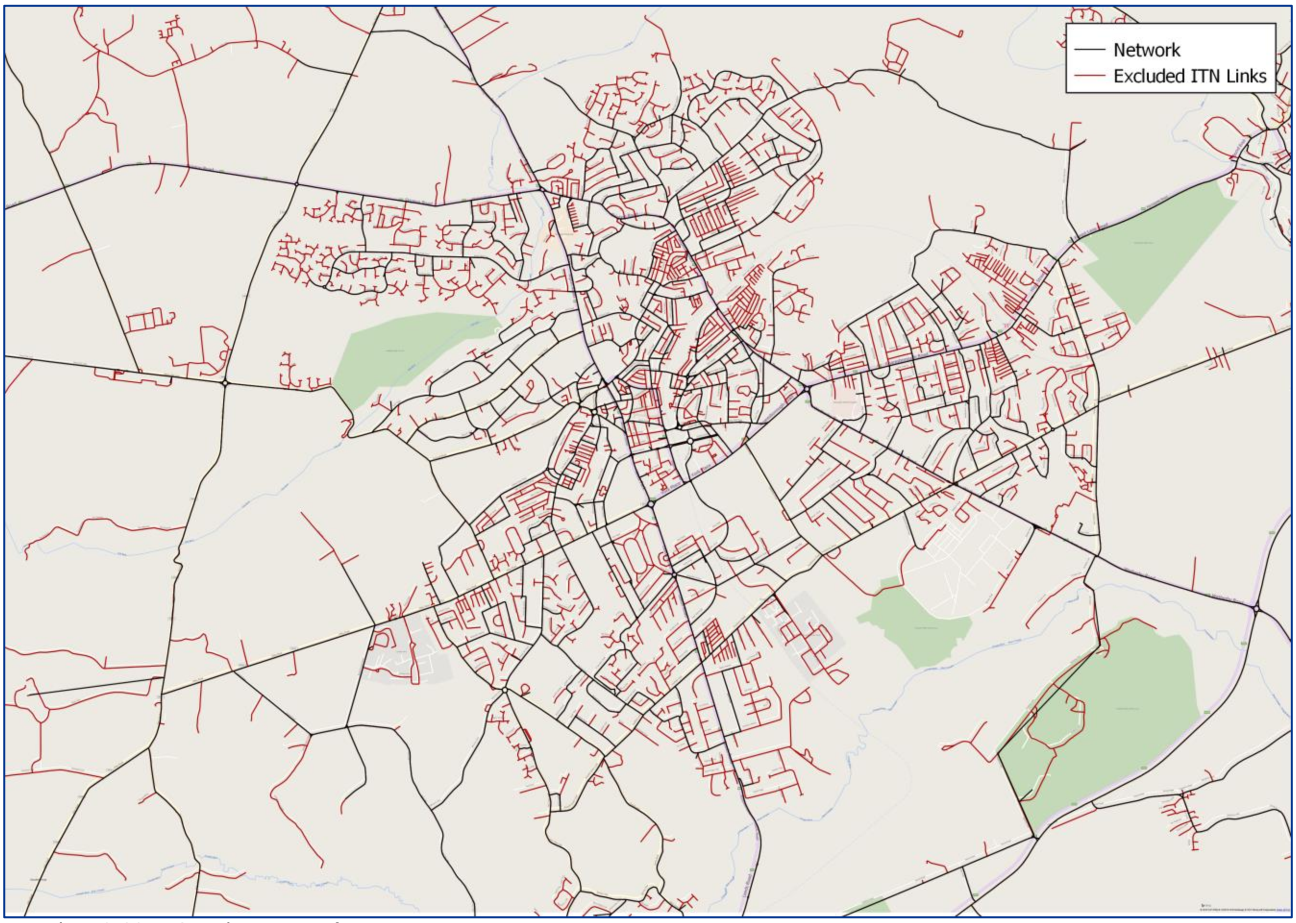
Urban Areas are defined by towns with a population greater than 70,000 or where the speed limits are typically set at 40mph or less. Accordingly, the majority of the detailed model area of Harrogate, Knaresborough and Ripon is defined as urban, the rest of the fully modelled area is either small town or rural in nature.

Banned turning movements, one-way street information, pedestrian only zones, HGV and weight restrictions, speed restrictions, number of lanes and road types were checked and adjusted where required to create an accurate base network model.

Link lengths were checked by selecting random paths in the model and comparing them with online journey planning software distance outputs.

A cross check between road type, location and assigned speed flow relationship was made to highlight any obvious mistakes when importing from ArcGIS, e.g. motorway speed flow relationships on urban links etc.

Figure 6-2 Current Network and Excluded ITN Links



Map data © 2015 Google. Terms of Use

As the ITN and Trafficmaster data sets include all roads, the network was simplified by removing multiple links, leaving the network shown in **Figure 6-2**.

Within the detailed area of the model this was completed by retaining any link which represented roads which are to be affected by the scheme. The assessment of this was based on the expanded observed matrix being assigned to a fix speed network, any links with greater than 200 vehicles per hour (as indicated in DMRB guidance). This network was then reviewed using local knowledge of NYCC and HBC to ensure no low trafficked but important links were wrongly excluded.

With regards to the external area of the model, the Network Analyst tool within ArcGIS was used to determine the fastest routes between all OD pairs based on the network's spatial location and a uniquely configured data model. These fastest routes, which were mostly made up of motorways and major A roads, were then used to select the ITN links were to be kept.

7. Trip Matrix Development

7.1 Theory Overview

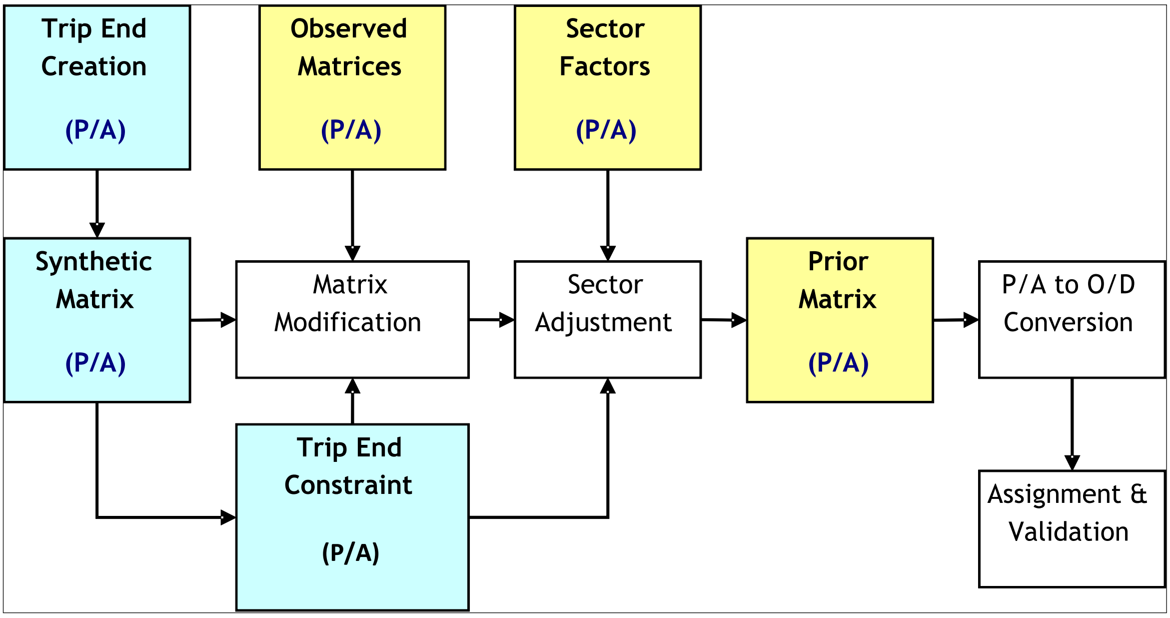
Transport models are composed of two elements: the road network (representing the supply), and the trips that travel on that network (the demand). **Section 6** explained how the current network has been developed and **Section 4** presented the calculation of the assignment model parameters and other key features of the model. The purpose of this section is to set out the methodology by which demand matrices were developed.

WebTAG unit M2 Appendix B sets out an approach to the development of prior matrices based upon synthetic matrices, using trip end estimations from local demographic information. These are then adjusted and modified to fit observed trip patterns taken from the survey data and constrained to trip end estimates. The methodology used to build the prior matrices integrates elements of both surveyed and synthesised data in order to produce production/attraction (P/A) matrices that directly produce Origin/Destination (O/D) prior matrices for assignment and is summarised in **Figure 7-1**. Each step of the process is detailed later in this section.

Prior matrix development was carried out using a system of tools and procedures within the VISUM software platform. The process comprises six main stages:

- **Synthetic Trip End Creation:** Using a combination of the 2011 Census, NTEM and employment databases to produce population and jobs data from which trip ends are derived for each modelled zone utilising Jacobs's JTREND program;
- **Synthetic Trip Distribution:** The distribution trips using a gravity model to create synthetic P/A matrices where the mean trip length of trips are calibrated to National Travel Survey trip length distributions;
- **Observed Matrix Development:** The development of expanded observed P/A matrices through roadside interview data on watertight cordons and screenlines subjected to treatment for bias and double counting;
- **Matrix Modification:** The statistical merging of observed and synthetic models and constraining to synthetic trip end totals (where appropriate);
- **Prior Matrix Validation:** The comparison of the above steps in line with Guidance set out in **Section 3** to assess the need for Matrix Estimation;
- **Sector Adjustment:** where prior matrix validation does not match observed screenline flows, adjustments at a sector level will be made appropriate where appropriate. The success of this stage determines the extent of matrix estimation required.

Figure 7-1 Prior Matrix Development Procedure

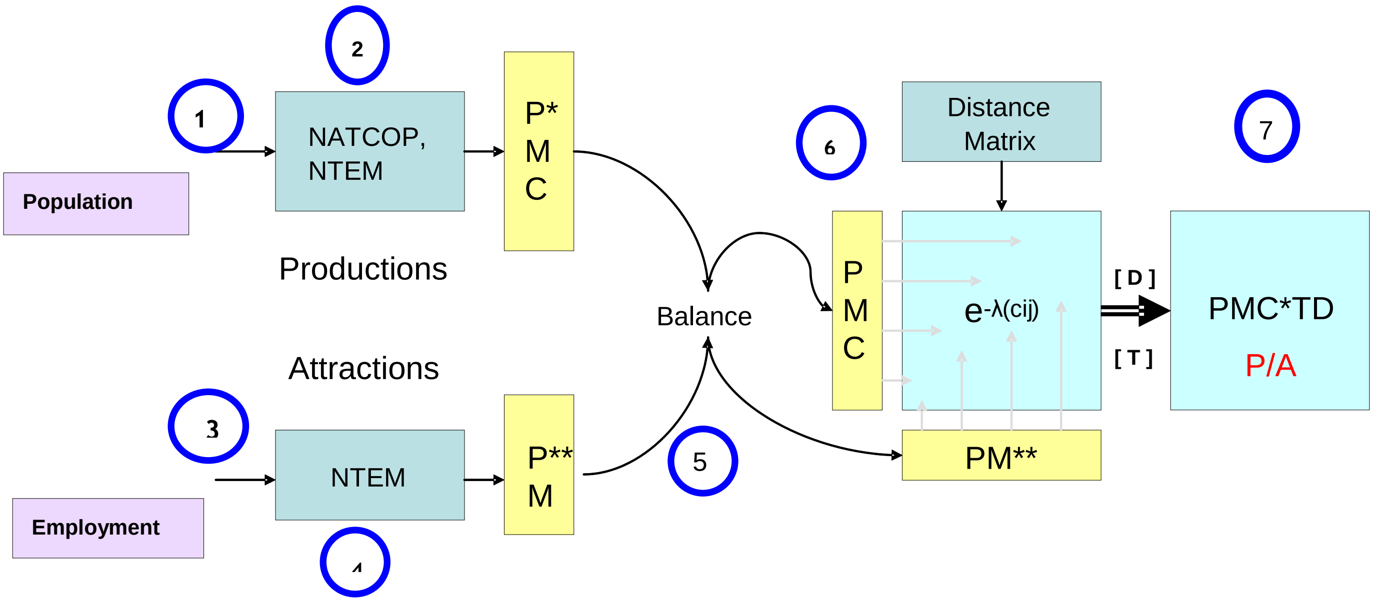


The final output of the process was a consistent set of P/A and O/D matrices that can be used in assignment and validation.

7.2 Synthetic Matrix Creation

With respect to the HDTM we define a synthetic matrix to be a matrix that has been constructed using demographic information associated with the model area. There are several distinct processes involved in creating the base year synthetic matrices, which are presented in **Figure 7-2**.

Figure 7-2 Overview of Synthetic Matrix Creation Process



P = Purpose M = Mode C = Car Availability T=Time of Day D=Direction (P/A)

* Home Based Work, Home Based Employers Business, HBED, HBS, HBO ** HBW, HBED, NHBEB, NHBO

1. **Create Population Data:** Derive population data for all zones from 2011 Census and NTEM;
2. **Generate Productions:** Run population estimates in each zone through NATCOP (National Car Ownership Programme) and apply NTEM trip rates to the outputs to create production trip ends by purpose, mode and car availability using Jacobs JTREND software;
3. **Create Employment Data:** Derive employment information from Census data and Bluesheep (an employment database) for all zones;
4. **Generate Attractions and NHB (Non-Home Based) Trips:** Apply NTEM trip rates to employment data to create attraction trip ends by purpose and mode;
5. **Balance Productions and Attractions:** Produce balanced trip end matrices whereby the total attractions are the same as the total productions for each purpose and mode;
6. **Distribution of Trip Ends to create Synthetic Matrices**: Distribute the trips using a negative exponential cost function (e-λ(cij)) based on zone-to-zone distances for each O/D pair and adjust for appropriate intra-zonal trip making; and
7. **Create Synthetic Assignment Matrices:** Factor the distributed matrices by direction and time of day using factors derived from NTEM.

Population and household data was taken from the socio-economic information supplied in the 2011 Census. The smallest area measurement in this dataset is the COA and these were aggregated / disaggregated where necessary to match the model zone layout and to produce definitive demographic data for each zone within the model. The zonal population information was segmented into 11 NTEM person types (**Table 7-1**) and 8 household types (**Table 7-2)** and run through the DfT's NATCOP programme to produce demographic information for each zone segmented into 88 traveller types based on age, employment status, household type and car availability.

Table 7-1 NTEM Zonal Person Type Categorisation

Person Type	Description
1	Children (0-15)
2	Males in Full Time Employment (16 to 64)
3	Males in Part Time Employment (16 to 64)
4	Male Students (16 to 64)
5	Males Not in Employment / Students (16 to 64)
6	Males 65+
7	Females in Full Time Employment (16 to 64)
8	Females in Part Time Employment (16 to 64)
9	Female Students (16 to 64)
10	Females Not in Employment / Students (16 to 64)
11	Females 65+

Table 7-2 NTEM Zonal Household Type Categorisation

Household Type	Description
1	1 Adult Household with no Car
2	1 Adult Household with one or more Cars
3	2 Adult Household with no Car
4	2 Adult Household with one Car
5	2 Adult Household with two or more Cars
6	3+ Adult Household with no Car
7	3+ Adult Household with one Car
8	3+ Adult Household with two or more Cars

Employment data has been derived from a combination of NTEM and Bluesheep data (a business database giving the coordinates of employers with information on industry type and number of employers) collected in 2013. The latter dataset was used to apportion employment data into the modelled zones, based on 15 job type categories given in NTEM in **Table 7-3**.

Table 7-3 NTEM Zonal Employment Type Categorisation

Employment Type	Description
E01	Total jobs
E02	Total Households
E03	Primary and Secondary Education
E04	Higher Education
E05	Adult/Other Education
E06	Hotels, camp sites etc.
E07	Retail Trade
E08	Health/Medical
E09	Services (business and other)

E10	Industry, construction and transport
E11	Restaurants and bars
E12	Recreation and sport
E13	Agriculture and fishing
E14	Business and not above
E15	Holiday Homes

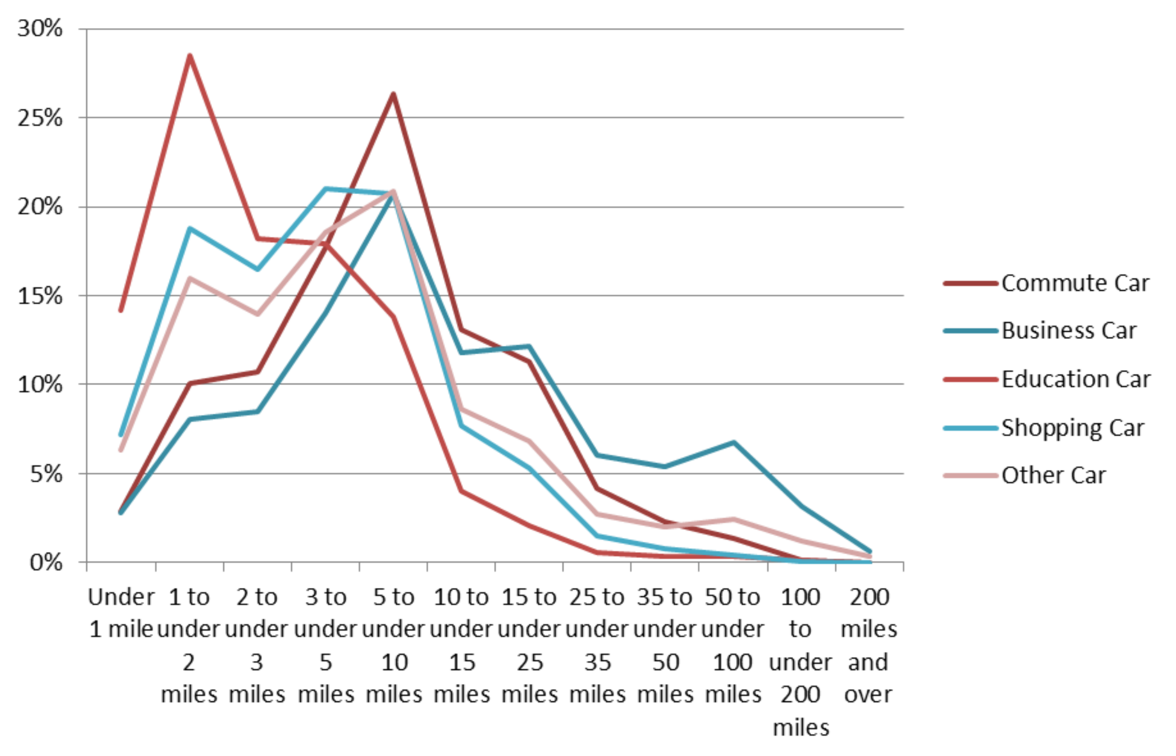
Prior to use in the model, the jobs and population data had to be adjusted, using NTEM datasets and local data for the modelled area, to grow base information to a 2015 estimate (taking account of changing household sizes, an ageing population, new housing schemes within the modelled area etc). NTEM trip rates were then applied to population estimates by car availability in order to derive the number of trips per week originating in each zone by purpose and car availability (see **Section 4.6** for the description of the segmentation used in this model). Similarly, NTEM trip rates had to be applied to each of the job types to generate attraction rates. The result was a set of 24hour trip ends by purpose and car availability. The 24 hour trip ends were split by mode according to proportions included within the NTEM datasets.

The productions and attractions for car drivers and car passengers have been balanced to ensure that the total productions match the total attractions within set balancing areas. For home-based trip purposes the attractions were adjusted to productions only. For non-home based trip purposes, the productions were then derived from these balanced home-based attractions. Further NTEM factors have also been applied to the trip ends to split them out by time of day.

7.3 Synthetic Matrix Distribution

Initially, daily productions and attractions were distributed by the negative exponential cost function (**Figure 7-2**) using cost matrices for each zone pairing by purpose and mode combination. These were then compared against both National Travel Survey (NTS) trip length distributions (latest 2002-2013) for all user classes to demonstrate the level of fit against national travel patterns. The model lambdas have been calibrated to provide the best fit to mean trip lengths. **Figure 7-3** presents the NTS distances by purpose.

Figure 7-3 NTS Car Trip Length Distributions 2002-2013



Intra-zonal costs were assumed to be half the value of the average of the three lowest distances within each zone. For example, if the three shortest distances from a given zone to other zones in the network are 3 km, 5 km, and 10 km, then the intra-zonal distances would be taken to be trips with lengths of 3 km or less (mean of 6 divided by 2). Intra-zonal trips would then be apportioned across all NTS distance bandings that are equal to or lower than the derived intra-zonal distance. This had a negligible effect on the internal zones, where intra-zonal distances are very small, but it further improved the model's fit to longer distance trip making in the NTS and for large external model zones.

Once the 24 hour outbound P/A matrices had been developed as above, these were then split using NTEM factors by time of day and car availability to give the following matrices based on the segmentation given in **Section 4.6**.

- 7 Purposes: 5 home based and 2 non home based;
- 3 Mode: Car Driver and Passenger, Public Transport and Slow Modes;
- 3 Times of Day - AM (07:00 - 9:59), IP (10:00 - 15:59) and PM (16:00-18:59); and
- 4 Car availabilities: No Car, Part Car, One Car and Multiple Cars.

The above 252 outbound P/A matrices were then converted to O-D matrices through phi factors within NTEM to give return trips and combined and aggregated for use in matrix modification as detailed in **Section 7.6**. **Table 7-4** below presents the resultant mean trip lengths calculated by the synthetic trip distribution against National Travel Survey averages. These show an exact match against observed values ensuring a robust distribution of trips within the assignment.

Table 7-4 Synthetic Distribution Vs National Travel Survey

Journey Purpose	Omnitrans	NTS	Lambda
Home other	17.76	17.76	0.12
Home shop	9.67	9.67	0.18
Non Home Based Work	16.05	16.05	0.10
Non Home Based Other	17.76	17.76	0.10
Home employer business	33.14	33.14	0.06
Home education	6.65	6.65	0.24
Home work	16.05	16.05	0.12

7.4 Observed Matrix Creation

Observed matrices from the Roadside Interviews (RSI) identified within **Section 5.1** have been used to adjust the synthetic matrices so they better reflect the demand for travel in the base year of 2015.

Observed matrices are constructed using data from three sources:

- Roadside Interviews (RSIs): Containing origin and destination information by purpose, mode, time of day and car occupancy as well as a intended return time;
- Manual Classified Counts (MCCs): Situated at each RSI site containing volumetric data classified by mode over 12 hours to expand the interviewed sample from the RSI data to the full survey day; and
- Automated Traffic Count (ATCs): Containing volumetric information for a 2-week period to normalise the survey data to an average weekday count.

RSI observations have been screened to ensure that all are suitable, provide logical movements, and with the correct level of definition and details. Return times, or any other missing data were synthesised, where possible or practical to do so, with confidence intervals applied to these datasets.

The ATC and MCC data was used to expand the screened data, and where 2-way surveys are not used, data for the other direction was transposed.

All of the expanded and normalised RSI data has been merged and grouped into cordons (where possible) along the edges of the Detailed Study Area in order to capture as many trips as possible. This was then supplemented by some RSI sites within the cordon, close to where it is envisaged that the relief road options could join the network, to ensure these options can be modelled during Phase 2 of the work. This merged RSI data was then filtered according to the DfT's approved approach used in ERICA whereby any trips between a single origin, destination, purpose and time of day that crosses multiple RSI cordons, is adjusted to remove potential double counting.

Three types of errors are found within the RSI survey data. These are called Response Bias, Survey Bias and Postcard Bias:

- Response bias occurs where the respondent gives information that they believe the interviewer wants to hear rather than their actual trip data;

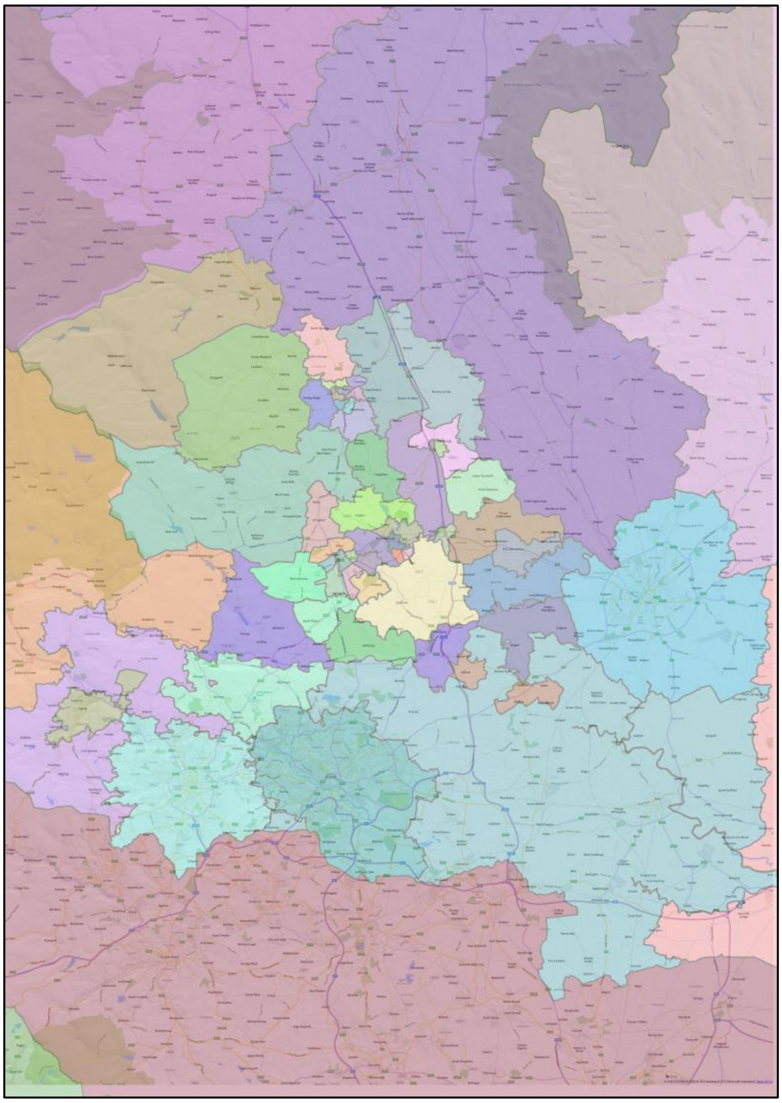
- Survey Bias comes from interviewing respondents only on certain roads, rather than a broad range of independent users; and

- Postcard Bias occurs when respondents forget details of their trip data because they are filling in the survey at a later date, after their trip has been completed.

Response bias and survey bias (including postcard survey bias) were accounted for by defining a confidence interval for each observation based on ERICA guidelines factors such as interview type, expansion factor, data age and other quality attributes. Biases associated with postcard surveys have been accounted for by applying a wider confidence interval to this data, meaning that it therefore had less influence in the construction of the observed matrices.

One problem with developing observed matrices is *lumpiness* in the data, whereby survey expansion causes a small number of zone-to-zone movements to have all of the expanded trips in them. In order to counter this, the merged RSI data has been used in model development at a disaggregate sector level, before being combined with the synthetic matrices. This *lumpy* zone system consists of 67 zones as is shown below in **Figure 7-4**.

Figure 7-4 Lumpy zoning system



7.5 Goods Vehicle Matrix Creation

Observed Goods Vehicle (GV) matrices were derived in a similar fashion to the car matrices, by taking RSI data and expanding it out to daily and average weekday levels.

However, in this state they were not detailed enough to be used directly in model construction. The majority of GV trips use motorways or trunk routes where it is difficult to site an RSI and consequently, relatively few GV trips are captured. Therefore, GV matrices used the synthetic matrices for Non-Home Based Employer's Business (NHBEB) trips as a starting point, as LGV and HGV matrices are likely to have trip ends in similar locations to employer's business trips.

The synthetic NHBEB matrices were scaled separately by goods vehicle type (LGV and HGV) and time period to match the level of trip making observed in the traffic counts (ATCs split by MCC proportions).

In addition to the use of synthetic matrices, where available, Trafficmaster O-D data was also used to ensure goods vehicle distributions match observed distributions, although there was only limited coverage available. Once the synthetic matrices had been scaled down to observed trip levels, they were used to 'infill' the observed GV matrices to create composite matrices. These composite GV matrices were then run through matrix estimation to improve the fit of these matrices to observed traffic flows. This meant that the origin / destination of trips in the model were more accurate than if the RSI data has been used in isolation, especially for GVs where there are few observed counts.

7.6 Matrix Modification

The synthetic matrices provide a balanced set of trip ends that have been distributed according to trip end constraints and NTS distance bands. However, this distribution did not replicate the observed travel patterns. Similarly, observed matrices provided a more realistic representation of trip distribution, but did not accurately reflect the trip end totals as they represented only a sample of the trips.

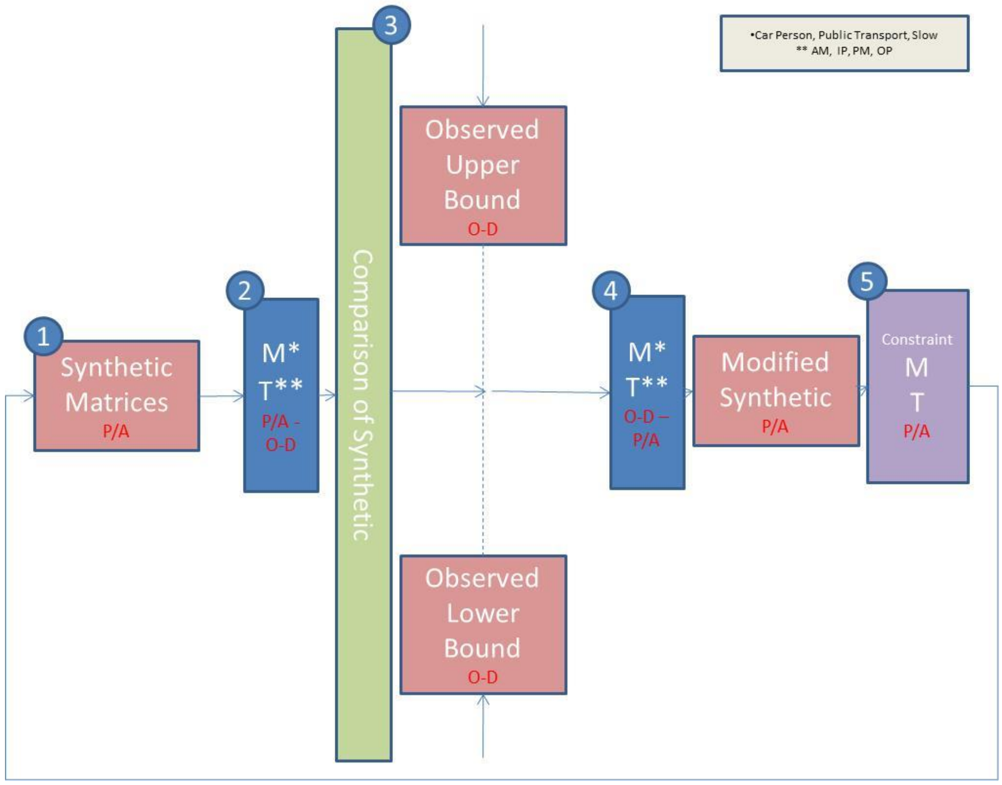
In order to reconcile the strengths and weaknesses between the two data sources, matrix modification was used. This involved adapting the synthetic matrices to include information from the observed matrices. The synthetic matrices were aggregated to a level consistent with the observed P/A matrices and adjusted so that they reflected the observed travel patterns derived from the Roadside Interview data.

Matrix modification was then undertaken at the lowest level of compatibility between both the synthetic matrices and observed matrices, this was by time period, purpose and mode of transport.

Figure 7-5 provides detail on the matrix modification key process steps as set out below:

1. **Synthetic Matrices**: Input synthetic matrices by purpose, mode, time of day, car availability and direction;
2. **Matrix Modification:** Synthetic matrices are compared with observed trips by P/A pair, where synthetic matrix value is within the bound, the synthetic value is retained. Exceedances are set at the observed matrix bound; and
3. **Trip End Constraint:** Trip end are compared by purpose, mode, time of day, car availability and direction to ensure compatibility with trip end targets.

Figure 7-5 Matrix Modification Process



Following the completion of matrix modification there was a set of matrices by purpose, mode, time of day, car availability and direction which were termed 'prior'.

WebTAG Unit M3.1 §8.1.3 states that the 'prior' matrices should be compared against the acceptability criteria as set out in **Section 7.3** where the fit of the model against screenlines will determine the quality of the modified matrices. §8.1.3 further states that where the prior matrices do not meet these acceptability criteria three options are available:

- Seek to improve the prior matrices through redevelopment;
- Seek to improve the fit to counts through network calibration; and
- Seek to improve the prior matrices through matrix estimation.

WebTAG Unit M3.1 §8.3.4 states that the effects of matrix estimation should be minimised therefore, improving the prior matrices and the fit of counts through redevelopment and network calibration respectively, was prioritised. Where the prior matrix did not meet the requirements as set out **Section 3** the prior matrices were adjusted manually at an aggregate sector level to improve model fit with the aim of removing the need for matrix estimation. The adjustment was based on comparing modelled traffic flows across screenlines against the observed screenline flow totals. A set of sector factors were adjusted iteratively until the screenline fit reached a suitable level of screenline validation. This was determined through professional judgment based on proximity to the Harrogate relief road scheme and other key movements. The sector factors were initially set to 1 and only adjusted marginally for each iteration. A constraint to trip ends and conformity with the matrix modification process as shown in **Figure 7-1** was maintained throughout.

The results of these factored prior matrix at a screenline level is detailed below in **Table 7-5** and

Table 7-6.

Table 7-5 Prior Matrix Screenline Comparison with Observed Flows AM Cars

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
A_Inbound	3,358	3,771	12%	6.9	No
B_Inbound	2,345	2,204	6%	3.0	Yes
C_Inbound	1,084	1,382	27%	8.5	No
D_Inbound	2,128	2,798	31%	13.5	No
E_Inbound	2,029	2,954	46%	18.5	No
F_Inbound	1,669	1,484	11%	4.7	No
G_Inbound	1,451	1,636	13%	4.7	No
H_Inbound	368	328	11%	2.1	Yes
P_Inbound	1,264	1,243	2%	0.6	Yes
A_Outbound	2,725	3,475	28%	13.5	No
B_Outbound	2,952	2,716	8%	4.4	No
C_Outbound	1,441	978	32%	13.3	No
D_Outbound	2,630	3,140	19%	9.5	No
E_Outbound	2,066	3,180	54%	21.7	No
F_Outbound	1,570	1,375	12%	5.1	No
G_Outbound	1,448	1,650	14%	5.1	No
H_Outbound	372	271	27%	5.6	No
P_Outbound	1,356	1,463	8%	2.8	Yes
Overall	32,258	36,048	12%	20.5	No

Table 7-6 Prior Matrix Screenline Comparison with Observed Flows PM Cars

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
A_Inbound	3,226	3,867	20%	10.8	No
B_Inbound	3,517	2,863	19%	11.6	No
C_Inbound	1,417	1,291	9%	3.4	Yes
D_Inbound	2,652	2,607	2%	0.9	Yes
E_Inbound	2,449	3,260	33%	15.2	No
F_Inbound	1,805	1,446	20%	8.9	No
G_Inbound	1,747	1,852	6%	2.5	Yes
H_Inbound	440	297	33%	7.5	No
P_Inbound	1,578	1,678	6%	2.5	Yes
A_Outbound	3,974	3,830	4%	2.3	Yes
B_Outbound	2,722	2,568	6%	3.0	Yes
C_Outbound	1,362	1,149	16%	6.0	No
D_Outbound	3,035	2,468	19%	10.8	No
E_Outbound	2,300	3,222	40%	17.5	No
F_Outbound	2,089	1,395	33%	16.6	No
G_Outbound	1,792	1,897	6%	2.4	Yes
H_Outbound	406	259	36%	8.1	No
P_Outbound	1,646	1,655	1%	0.2	Yes

Overall	38,159	37,604	1%	2.8	Yes

This highlights that the prior matrix development process results in an assignment that is relatively close to the observed in many cases and shows that the matrix development process produced results that were overall fairly representative with overall totals within 5% summing over all screenlines. However, the prior matrices do not meet the WebTAG criteria; therefore further work was undertaken on the network and demand matrices to improve the model results, which is detailed in the following sections.

8. Network Calibration and Validation

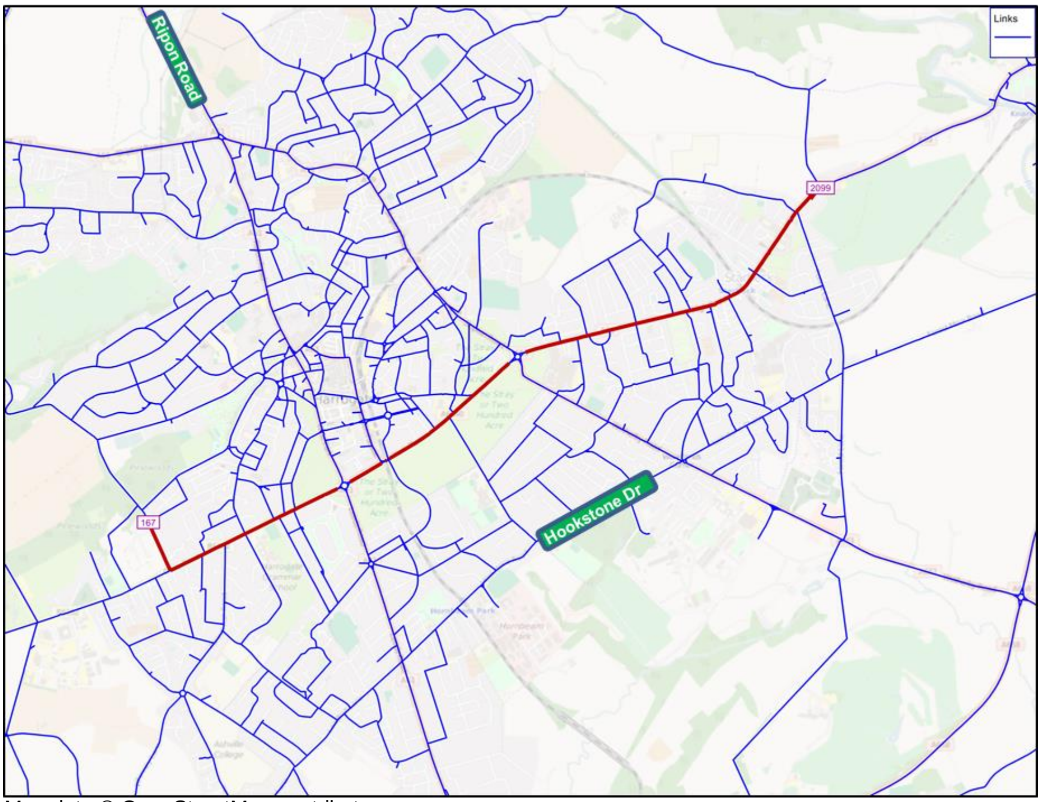
8.1 Network Calibration

An initial prior trip matrix was assigned to the network for both time periods (AM & PM) and routing, link travel times and turn movement delays were assessed.

Routing checks were carried out using the 'Flow Bundle' and 'Shortest Path Search' functions. A 'Flow Bundle' is a form of selective link analysis which shows the origin and destination of traffic from a single point on the network, while a 'Shortest Path Search' calculates the minimum cost route from a selected origin and destination. This ensured that all network restrictions, such as one-way streets, were operating correctly and that traffic volumes were suitable for the link type. This enabled any network corrections to be made to better reflect observed traffic movements. One such network change was to globally reduce the capacity and speed limits of most urban roads within the centre of Harrogate, Knaresborough and Ripon to account for delays caused by pedestrian movements and cars pulling in or out. 'Flow Bundle' analysis was also used on all major road links to identify any rat running occurring within the model and subsequently also to implement further network changes forcing people to use the main roads rather than side streets if required.

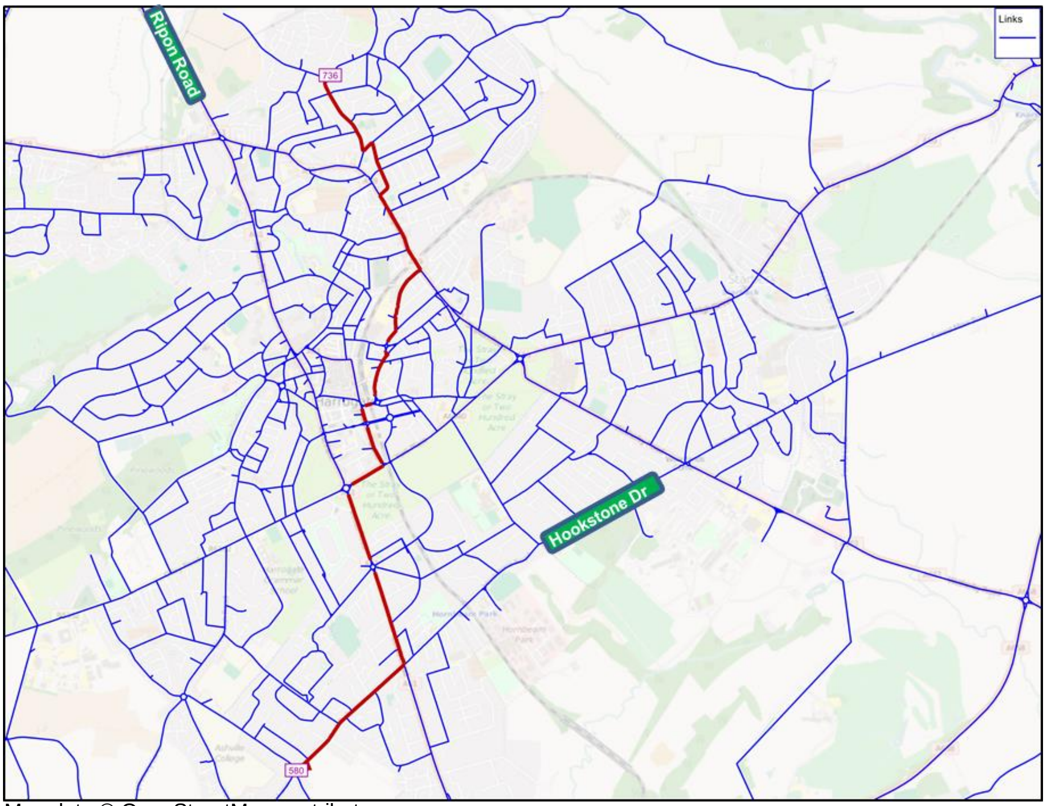
Figure 8-1 to **Figure 8-3** to provide some examples of 'Shortest Path Search' analysis for the Commute user class during the AM peak. The routing between two selected nodes can be displayed like this in VISUM and therefore, allows easy examination whether the most obvious route is taken. Thorough checking of the routing has been undertaken in line with Jacobs CRAV (Check, Review, Approve and Verify) process. The figures below detail a selection of the routing checks undertaken on the model to highlight that no obviously unrealistic movements are occurring.

Figure 8-1 Shortest Path Analysis – Harrogate East to West



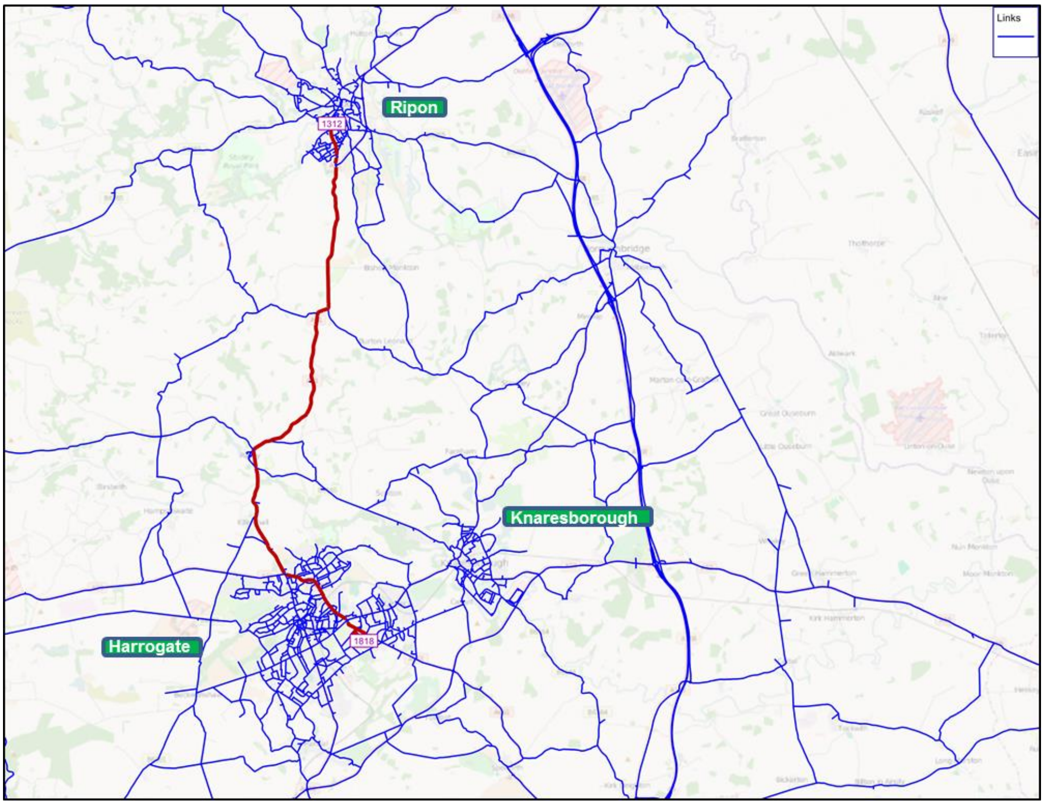
Map data © OpenStreetMap contributors

Figure 8-2 Shortest Path Analysis – Harrogate North to South



Map data © OpenStreetMap contributors

Figure 8-3 Shortest Path Analysis – Harrogate to Ripon



Map data © OpenStreetMap contributors

Delays at junctions were examined and where possible compared to the journey time survey data. One junction that required modification was the give way junction on Wetherby Road, Forest Lane and Rudding Lane. The initial coding, which was based on general standards applied within the model, assumed a critical gap value of 4 for all turns made at this junction. This caused high delays for all turns from the side streets onto Wetherby Road, which were not accurately represented within the Journey Time Surveys of Route 5. The critical gap value for these turns had therefore been reduced to 2.5 for left turns and straight on movements, while 3 was chosen as the most accurate value to represent right turns onto Wetherby Road. These amendments were based on the assumption that drivers require less time for these movements reducing overall junction delay.

Other examples of retrospective network changes are all major roundabouts within the study area. By comparing turn delays and travel times through these junctions with the actual journey times surveyed, not enough delay was being produced using the standard junction coding to account for accelerating, decelerating and lane changes. As a result, the Kimber– Hollis C-Factor, which is a constant used for delay calculations within VISUM, has been set to 10 for all main node roundabouts to add additional delay to all movements.

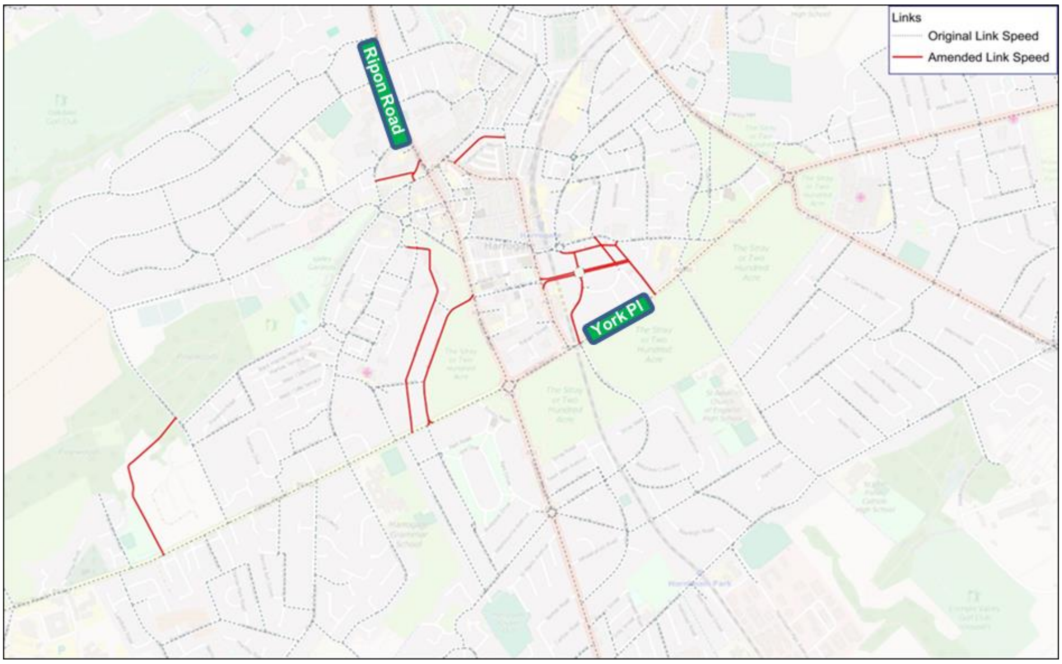
Further changes made to junctions within the model include both, adjusting the major flow and closing turns for certain vehicles. The latter was for example required if a road had to be closed for HGVs, or if the road layout does not allow for certain turns being made due to general conditions or visibility restrictions.

Major flow is a measure used in VISUM to code and represent right of way regulations at junctions. At priority junctions, all movements not following the major flow of the junction need to stop and give way if required, which causes delay and potentially even rerouting. As part of the initial network review, it was determined that the major flow at some junctions within the model was coded incorrectly, as the wrong arms had to give way. This was especially the case at junctions where the major movement was not straight ahead and these junctions have therefore been changed if appropriate.

Link travel times were examined compared to the observed journey time data. In general the travel times within the city centres were too fast, while those on major rural road links were too slow. The model journey times could not be matched to the observed without alteration of link speeds and type. Especially due to peak time queuing in town centres and at a value lower than the actual speed limit to accurately represent delays within the area caused by on street parking etc. In contrast, travel times on major road links between towns, for example, on the A59, A61 and A658, had to be increased from the default value to 60mph or 70mph respectively, as JTS indicated travel along these links being much quicker than originally modelled.

To prevent rat running on side roads within the network on links that in reality would be unattractive due to reduced capacity due to on street parking and delays caused by both, parking cars and pedestrians crossing the street, adjustments to free flow link speeds were required in some cases. For example, free flow link speeds had to be reduced to values as small as 16kmh (10 mph) to accurately represent the traffic situations in Harrogate, Knaresborough and Ripon. **Figure 8-4** shows all links where free flow speed had been set to 16 kmh in Harrogate Centre, as outlined above.

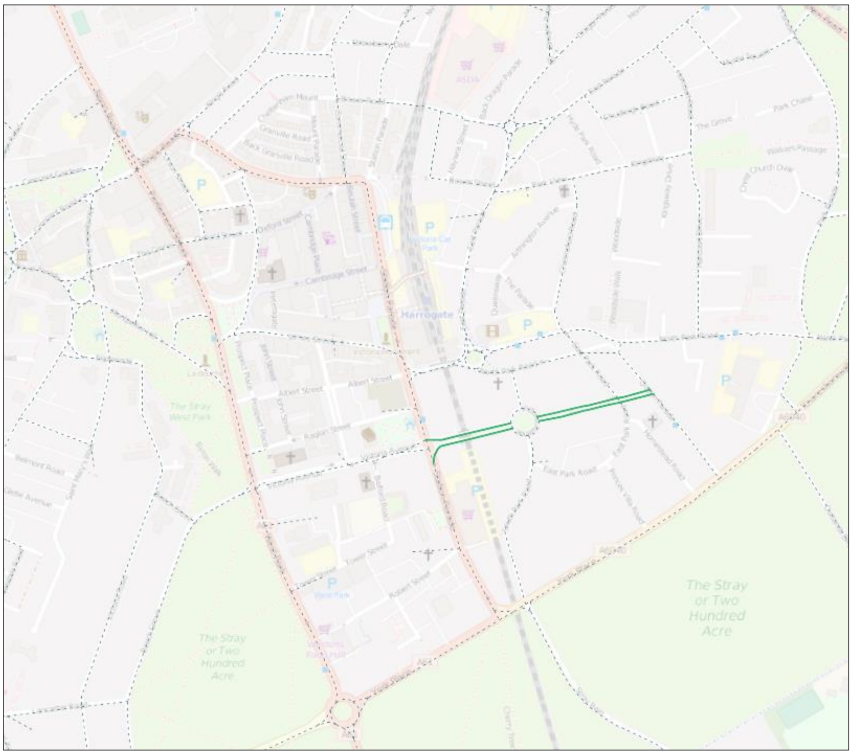
Figure 8-4 Side Roads with Link Speeds Reduced to 16 kmh in Harrogate Town Centre



Map data © OpenStreetMap contributors

One example for this change is Victoria Avenue in Harrogate, which is located as displayed in **Figure 8-5**. This road has very narrow lanes and is constrained by cars parking on both sides as shown in **Figure 8-6** below. This road was originally coded with a free flow speed of 36 kmh, which was considered as being too fast and therefore changed to 16 kmh to reflect that this road will effectively operate with just a single lane in places.

Figure 8-5 Location of Victoria Avenue within Harrogate



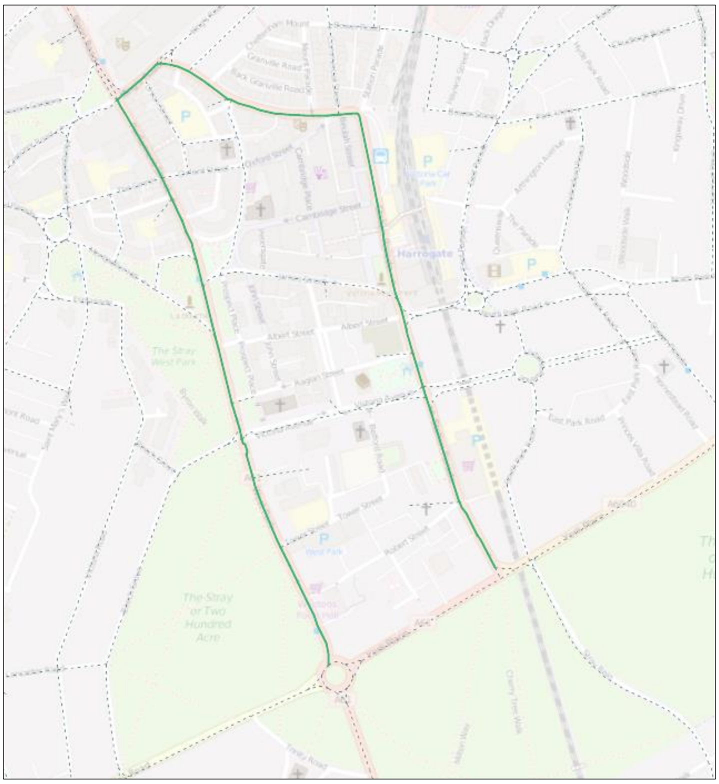
Map data © OpenStreetMap contributors

Figure 8-6 Traffic Situation on Victoria Avenue

Map data © 2015 Google. Terms of Use

Another example for retroactive changes to link speeds is the A61 within the centre of Harrogate, in both Northbound (Parliament Street) and Southbound (Station Parade) direction. Since both of these streets are both, main access roads to the town centre and major shopping locations, free flow speeds had to be amended here as well to accurately represent the traffic situation indicated by the measured journey times. Rather than being coded as 48kmh (30mph) as proposed by TrafficMaster, both roads have been set to 32 kmh (20mph) to account for congestion and stop and go movements. **Figure 8-7** shows the location of these particular roads, while **Figure 8-8** provides at example of the congested street.

Figure 8-7 Section of the A61 within Harrogate Town Centre



Map data © OpenStreetMap contributors

Figure 8-8 Traffic Situation on A61 Parliament Street

Map data © 2015 Google. Terms of Use

9. Route Choice Calibration and Validation

9.1 Route Choice

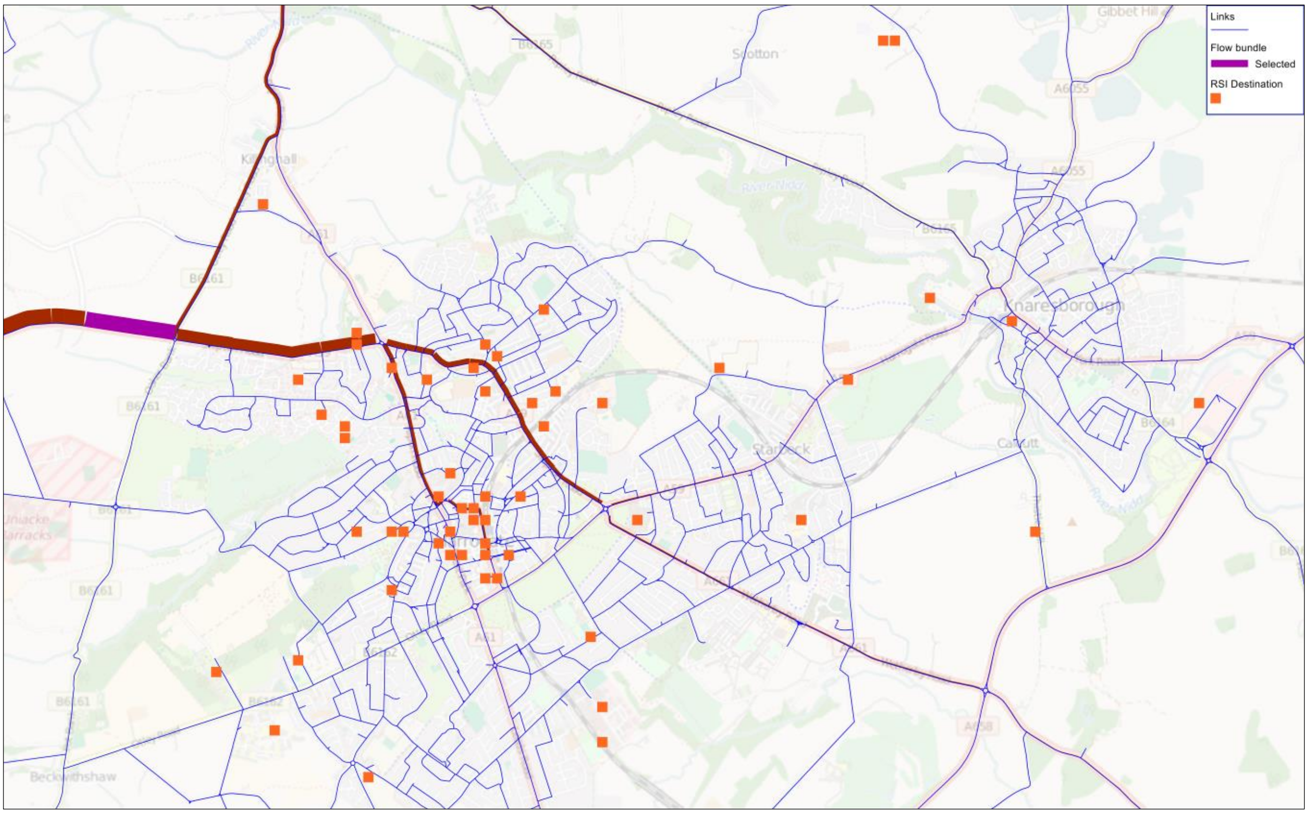
The modelled routes within the model depend upon:

- Appropriateness of zone size and location of zone connectors;
- Accuracy of network coding;
- Accuracy of link and junction delay which is a direct result of speed flow relationship and junction coding; and
- Accuracy of demand which will influence the time taken to travel along links and through junctions.

When all of the above has been considered the final route choice is dependent upon the generalised cost formulations, which are explained in **Section 4.8**.

The route choice check is twofold: to examine demand matrix through the distribution, and examine the network coding through level of flow on each link type. Tests were carried out on the base model to ensure traffic was routing appropriately on the network from a single origin point. The VISUM analysis tool ‘Flow Bundle’ was used to carry out these tests. It is a form of selective link analysis which shows the origin and destination of traffic from a single point on the network. Examples from the morning peak base model are given in **Figure 9-1** and **Figure 9-2** below.

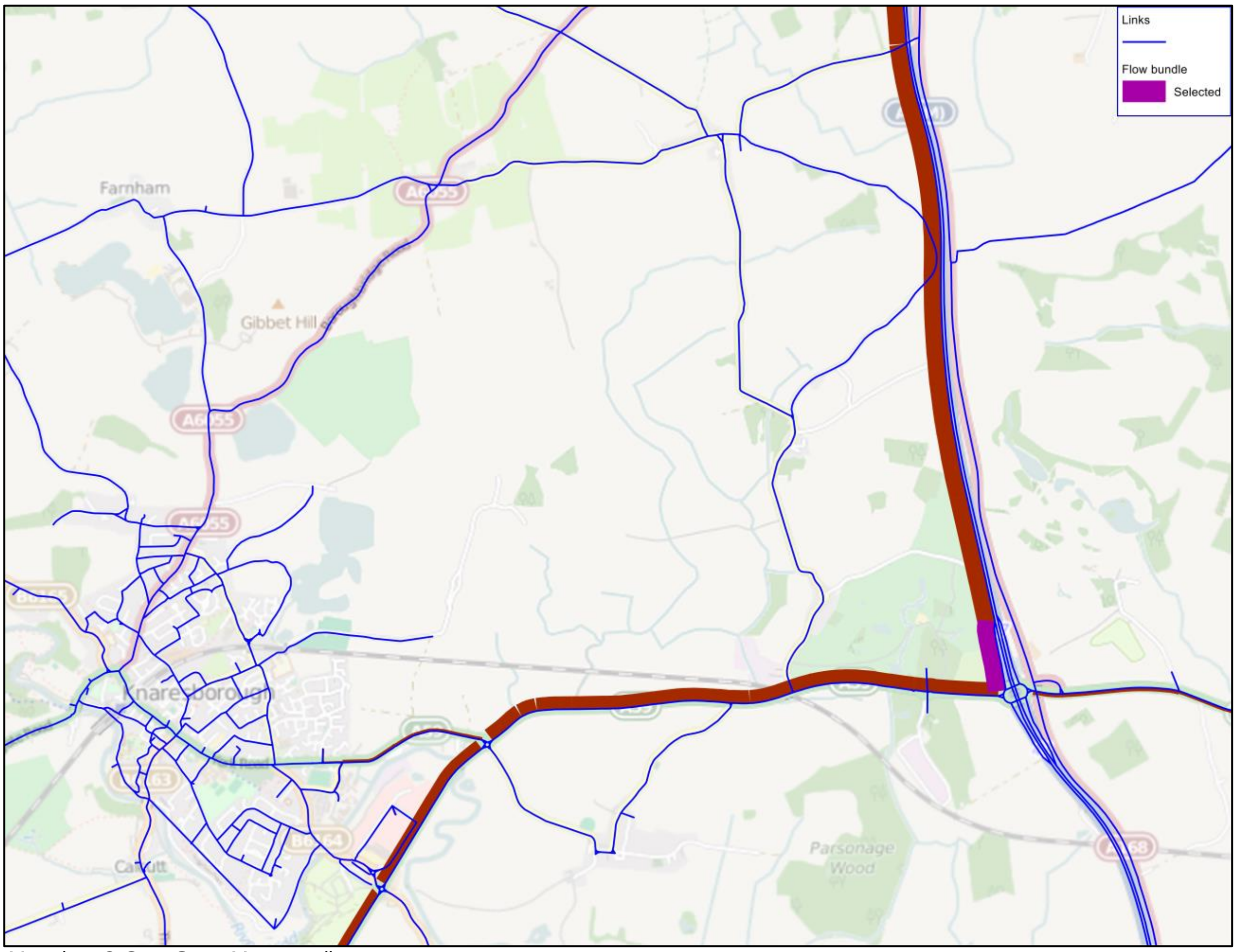
Figure 9-1 Select Link Analysis in Harrogate



Map data © OpenStreetMap contributors

Figure 9-1 shows the routing of vehicles approaching Harrogate from the West on the A59 Skipton Road in red. The traffic flow on this link appears to be reasonable, as modelled O & D pairs are distributed similarly to those determined in the RSIs at this site, with the surveyed destinations being shown in orange. Route choice appears to be sensible as well with the O&D majority of trips being destined for the centre of Harrogate, which is accessed mainly via the A59 and A61. Trips towards Knaresborough, Ripon and the A1 northbound however, avoid the city centre by routing via Killinghall and either the B6165 Ripley Road for Knaresborough or the A61 for Ripon.

Figure 9-2 Select Link Analysis of A1 West of Knaresborough



Map data © OpenStreetMap contributors

The traffic situation between Knaresborough and the A1 is displayed in **Figure 9-2**. Route choices appear to be sensible in this area as well since no rat running takes place and traffic is using the A69 Southern Bypass before joining the A59 on all Northbound journeys. Since the Bypass is also used by all vehicles travelling from Southern Harrogate and Pannal to the North via Knaresborough and the A1, the route choices within the model can be assumed to be fit for purpose as traffic is forced to stay on main roads without crossing town centres.

10. Trip Matrix Calibration and Validation

10.1 Sector Analysis

Matrix Estimation was required to achieve an acceptable level of fit. To check the differences in trip totals and vehicle kilometres travelled between the modified and base matrices during the first and final Matrix Estimation run, model zones were aggregated into 36 sectors (the same sectors as used for prior matrix adjustment), with comparisons made on a sector-by-sector basis. These 36 sectors have been scaled down further to a 12 x 12 sector system to speed up the analysis process and provide a better overview of key figures within the model. This final scaled sector system is shown in **Figure 10-1** and **Figure 10-2** below.

Figure 10-1 HDTM Model Main Sectors

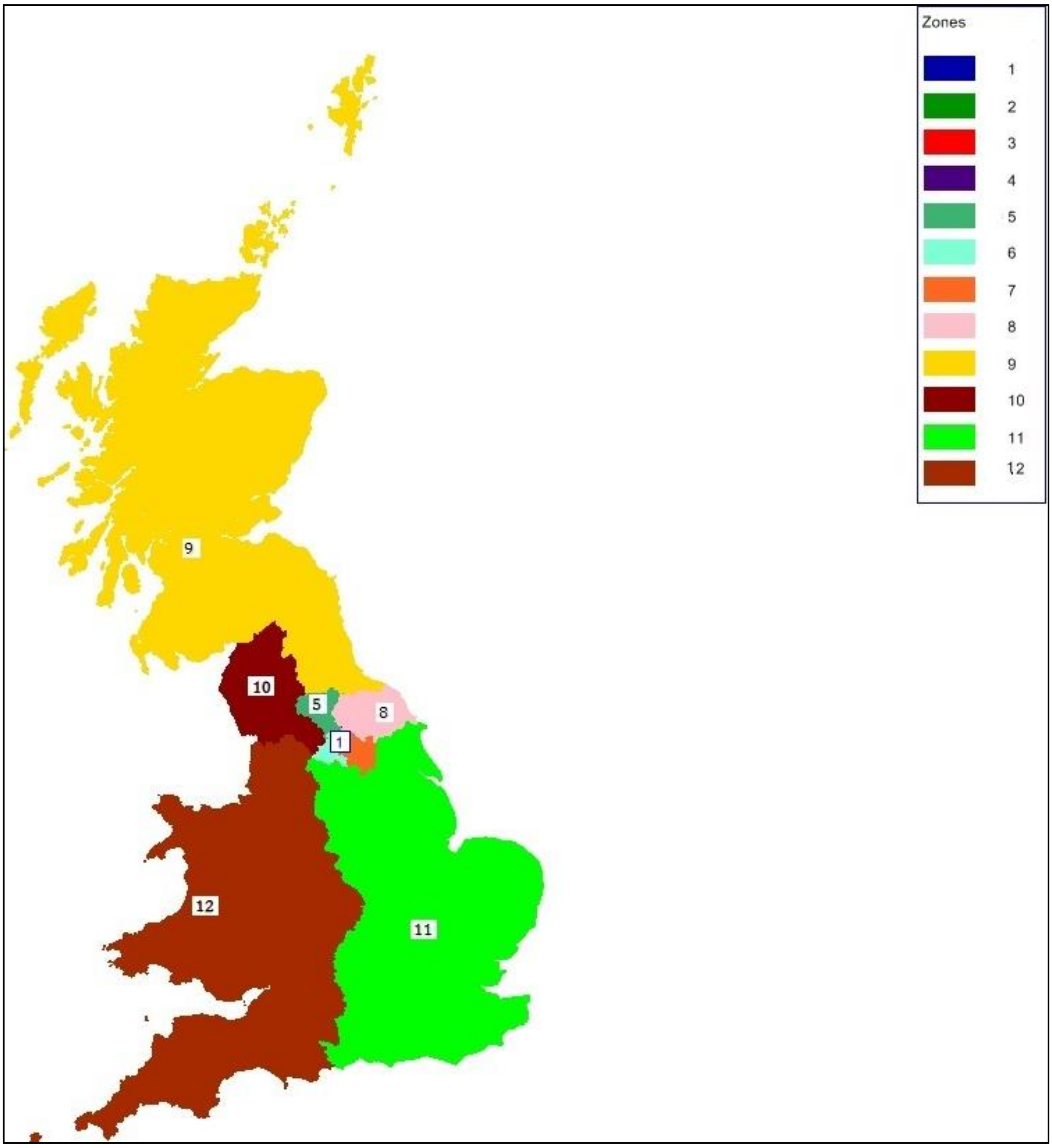


Figure 10-2 HDTM Model Main Sectors – Zoomed In

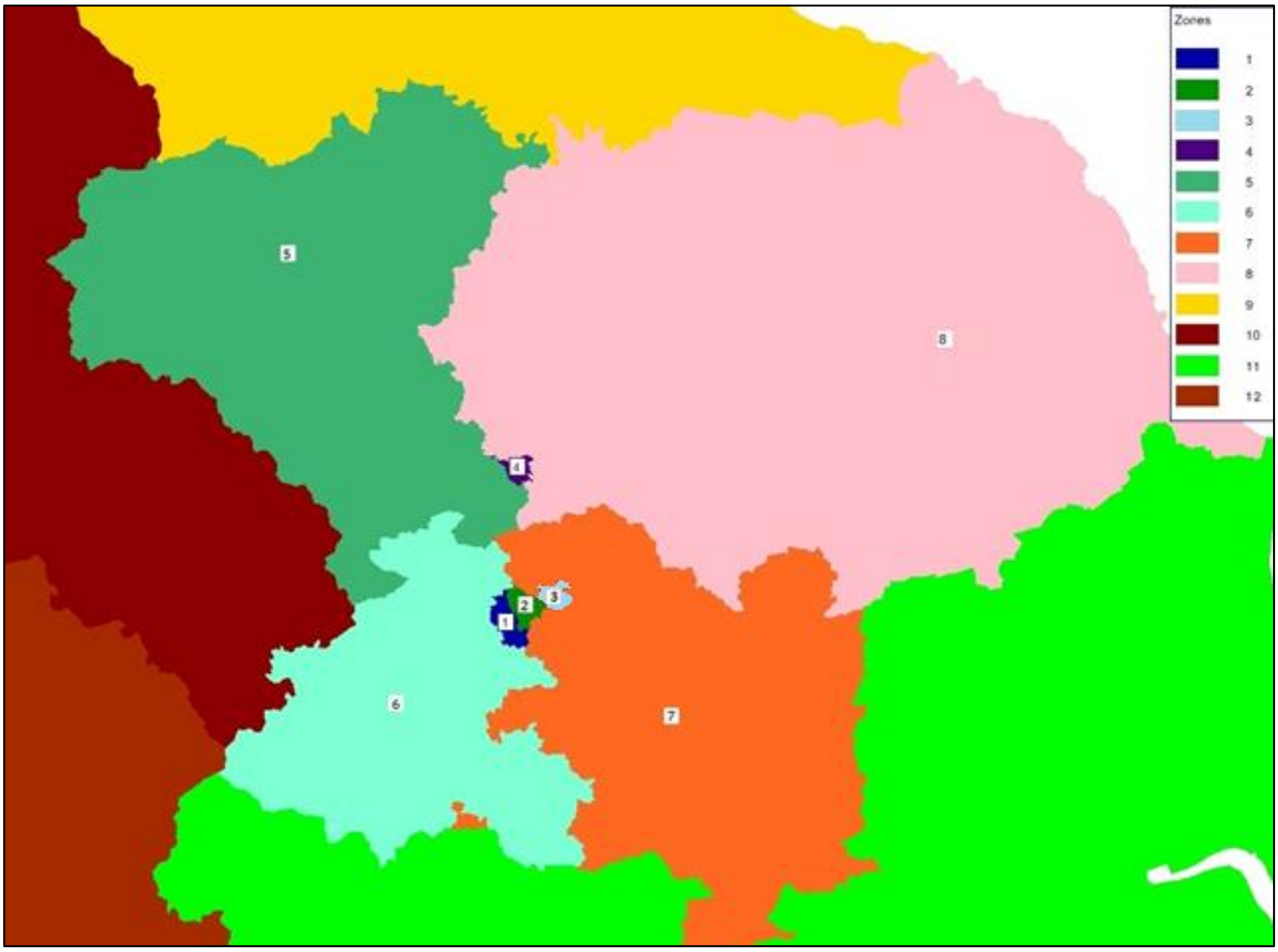


Table 10-1 HDTM Model Main Sectors – Detailed Description

Sector Nr	Sector Description
1	Harrogate West
2	Harrogate East
3	Knaresborough
4	Ripon
5	North Western Buffer Area
6	South Western Buffer Area
7	South Eastern Buffer Area
8	North Eastern Buffer Area
9	North East England and Scotland
10	North West England
11	South East of England and London
12	South West of England and Wales

A sense check of the vehicle kilometres travelled between the prior and base matrices was undertaken and revealed that the final trip length distribution within the model changes only marginally for most user classes. As shown in **Table 10-2** below, the biggest change occurs for LGVs and HGV's. Although the changes are relatively high, they can still be accepted as LGV/HGV matrices are based on limited traffic master information and synthetic demand, rather than observed values. Therefore with the LGV and HGV we would expect the prior matrix performance to be less accurate and that ME will need to be used to a greater extent, which is standard practice and due to the relatively low levels of goods vehicles within the area we don't expect this to be an issue.

Table 10-2 Changes in Modelled Trip Length Distribution Prior vs Final Matrices

		Prior		Final		Abs. Difference		Perc. Difference	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
AM	Car Business	38.4	30.3	38.1	29.5	-0.3	-0.8	-1%	-3%
	Car Commute	34.8	17.4	34.8	17.3	0.0	-0.1	0%	-1%
	Car Other	33.9	15.6	34.0	15.6	0.1	0.0	0%	0%
	LGV	50.7	50.6	51.8	47.0	1.0	-3.5	2%	-7%
	HGV	38.5	30.3	38.6	30.2	0.1	-0.1	0%	0%
PM	Car Business	44.3	39.8	44.0	39.4	-0.3	-0.4	-1%	-1%
	Car Commute	38.2	27.2	38.1	27.2	-0.1	0.0	0%	0%
	Car Other	36.9	23.5	36.8	23.4	-0.1	0.0	0%	0%
	LGV	52.5	51.9	57.1	53.0	4.6	1.0	9%	2%
	HGV	72.1	53.2	84.2	58.6	12.1	5.3	17%	10%

Table 10-3 and **Table 10-4** show the percentage difference in trips for the user class 'Car Commute' between prior and post ME matrices for both the morning and evening peak. Data displayed within the green coloured cells represents the fully observed sector to sector movements, tables for the remaining 4 user classes (Car Business, Car Other, LGV & HGV) are provided in **Appendix C**. The difference in matrix demand must be at least 100 trips and greater than 5% to be shown in the tables.

As can be seen in the tables, between the AM prior and post matrices the significant changes do not occur within the fully observed range. Only a single observed movement between zones 7 and 2 is above the 5% / 100 vehicle threshold, this being 112 vehicles and therefore only slightly over. Therefore the integrity of the surveyed data is maintained during the matrix estimation process.

In the PM prior and post matrices there is less overall change with most movements being below the 5% / 100 vehicle threshold. There are two observed movements between zones 6 / 7 and zone 3. Which represent the buffer areas around Knaresborough travelling into Knaresborough. These values are just above the 100 vehicle threshold (111 and 143 vehicles).

Table 10-3 Scaled Sector to Sector Percentage Differences Car Commute Prior vs. Post – AM

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	-24% (-349)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%
2	-31% (-228)	0%	0%	0%	0%	-40% (-185)	0%	0%	0%	0%	0%	0%	-6%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	-11% (-215)	0%	0%	0%	0%	0%	0%	0%	-1%
6	0%	0%	0%	0%	0%	-11% (-1261)	-11% (-480)	0%	0%	0%	-11% (-3172)	0%	-3%
7	0%	-22% (-112)	0%	0%	0%	-11% (-491)	-10% (-201)	0%	0%	0%	-11% (-1280)	0%	-5%
8	0%	0%	0%	0%	0%	0%	0%	-11% (-622)	0%	0%	-11% (-110)	0%	-2%
9	0%	0%	0%	0%	0%	0%	0%	0%	-11% (-41077)	0%	0%	0%	-1%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	-11% (-3141)	0%	-11% (-118)	-2%
11	0%	0%	0%	0%	0%	-11% (-3172)	-11% (-1250)	0%	0%	0%	-11% (-151646)	-11% (-558)	-4%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	-11% (-118)	-11% (-479)	-11% (-103672)	-3%
Sum	-5%	-2%	0%	0%	-1%	-6%	-3%	-1%	-1%	-2%	-5%	-3%	-2%

Table 10-4 Scaled Sector to Sector Percentage Differences Car Commute Prior vs. Post – PM

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	-9% (-117)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
2	+33% (226)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	+55% (109)	0%	0%	0%	0%	0%	0%	0%	0%	5%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	+65% (111)	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
7	0%	0%	+78% (143)	0%	0%	0%	0%	0%	0%	0%	0%	0%	7%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum	2%	0%	12%	5%	0%	0%	0%	0%	0%	0%	0%	0%	2%

10.2 Regression Analysis

The Robustness of the matrix estimation process was tested through regression analysis in order to determine the interdependency of variables, confidence intervals and standard errors between prior and post matrices. **Table 10-5** describes the results of this regression analysis with A being the X Value, B being the Y Value and R^2 representing the coefficient of correlation of the regression line.

Table 10-5 Regression Analysis Results

			Matrix			Row Totals			Column Totals		
Period	Purpose	Mode	A	B	R^2	A	B	R^2	A	B	R^2
AM	Commute	Car	0.00	1.13	1.00	-0.08	1.13	1.00	-2.17	0.90	0.99
AM	Business	Car	0.00	1.08	1.00	-0.36	1.10	0.99	-0.63	1.14	0.84
AM	Other	Car	0.00	1.22	1.00	0.00	1.23	0.99	-6.55	0.96	0.97
AM		LGV	0.01	0.99	0.83	0.28	1.17	0.94	0.25	0.78	0.86
AM		HGV	0.00	0.26	1.00	0.07	0.27	0.97	-0.75	4.79	0.90
PM	Commute	Car	0.00	0.98	1.00	-1.30	0.98	1.00	-1.72	1.05	1.00
PM	Business	Car	0.00	0.97	1.00	-0.17	0.97	1.00	-1.50	1.24	0.94
PM	Other	Car	0.00	0.94	1.00	-1.31	0.94	1.00	-10.06	1.31	0.99
PM		LGV	0.01	0.83	0.82	0.12	1.05	0.97	0.25	0.95	0.80
PM		HGV	0.00	0.12	0.83	0.16	0.05	0.30	1.27	3.62	0.07

As shown above, the coefficient of variation is always close or equal to 1 for the overall matrix indicating a high degree of interdependency between prior and post matrices. Given that the car matrices consist of both, observed and synthetic values, high R^2 values indicate logical changes. With A values being close to 0 and the slope being close to 1, the overall regression line for the total matrix can be assumed to be linear and almost passing through the origin most of the times.

A similar conclusion can be drawn from the standard error values shown in **Table 10-6** below, as the values for both A and B are close to 0 for all scenarios and a linear relationship can therefore be assumed.

Table 10-6 Regression Analysis Standard Error

			Matrix		Row Totals		Column Totals	
Period	Purpose	Mode	A	B	A	B	A	B
AM	Commute	Car	0.002	0.000	1.747	0.003	3.711	0.006
AM	Business	Car	0.001	0.000	0.401	0.007	1.317	0.030
AM	Other	Car	0.003	0.000	2.959	0.009	3.307	0.010
AM		LGV	0.001	0.002	0.353	0.018	0.444	0.019
AM		HGV	0.000	0.000	0.062	0.003	0.410	0.094
PM	Commute	Car	0.002	0.000	0.755	0.001	2.676	0.004
PM	Business	Car	0.000	0.000	0.197	0.003	1.024	0.018
PM	Other	Car	0.001	0.000	0.556	0.001	4.107	0.008
PM		LGV	0.001	0.001	0.178	0.012	0.421	0.028

PM		HGV	0.000	0.000	0.034	0.004	0.480	0.808

The 95% confidence interval represents the area into which 95% of all values fall. Hence, a small confidence interval indicates that all values are close to the mean and no major outliers exist. **Table 10-7** shows the confidence intervals that have been calculated for the matrix estimation process and again shows that the process can be considered very robust as the final total matrix confidence intervals are comparatively small.

Table 10-7 Regression Analysis 95% Confidence Interval

			Matrix		Row Totals		Column Totals	
Period	Purpose	Mode	A	B	A	B	A	B
AM	Commute	Car	0 - 0.01	1.13 - 1.13	-3.51 - 3.36	1.12 - 1.13	-9.47 - 5.14	0.89 - 0.91
AM	Business	Car	0 - 0	1.08 - 1.08	-1.14 - 0.43	1.08 - 1.11	-3.22 - 1.96	1.08 - 1.2
AM	Other	Car	0 - 0.01	1.22 - 1.22	-5.82 - 5.82	1.21 - 1.24	-13.06 - -0.04	0.95 - 0.98
AM		LGV	0.01 - 0.01	0.98 - 0.99	-0.42 - 0.97	1.13 - 1.2	-0.63 - 1.12	0.74 - 0.82
AM		HGV	0 - 0	0.26 - 0.26	-0.05 - 0.19	0.26 - 0.27	-1.56 - 0.05	4.6 - 4.97
PM	Commute	Car	0 - 0	0.18 - 0.18	0 - 0.04	0.13 - 0.22	0.04 - 0.15	0.15 - 0.44
PM	Business	Car	0 - 0	0.98 - 0.98	-2.78 - 0.19	0.98 - 0.98	-6.98 - 3.55	1.04 - 1.06
PM	Other	Car	0 - 0	0.97 - 0.97	-0.56 - 0.21	0.96 - 0.97	-3.51 - 0.51	1.2 - 1.28
PM		LGV	0 - 0	0.94 - 0.94	-2.4 - -0.21	0.94 - 0.94	-18.14 - -1.98	1.29 - 1.32
PM		HGV	0.01 - 0.01	0.83 - 0.84	-0.23 - 0.47	1.03 - 1.08	-0.58 - 1.08	0.89 - 1

10.3 Convergence

The criteria for convergence are given in **Section 3.6**. The duality gap and relative deviation were examined for the HDTM base model. The results are shown below in **Table 10-8** for both the AM and PM models.

Table 10-8 Model Convergence

Movement Type	AM	PM
Number of assignment iterations to convergence	6	8
GAP Value Achieved (Criteria <0.1)	0.00000501	0.00000126
GEH between turning flows in current and previous assignment <=1 (Criteria 0.95)	0.955	0.965
GEH between turning flows in current and smoothed ICA assignment <=1 (Criteria 0.95)	0.988	0.994
Relative GAP between ICA wait time and VDF wait time is <=0.05 (Criteria 0.9)	0.971	0.984

The HDTM base AM and PM models both achieve a good level of convergence, fulfilling the WebTAG criteria within 6 and 8 outer iterations respectively. It can be seen that the model performs well on proximity whereby we can be satisfied that all users can find their minimum cost through the network. In addition the stability indicators with high proportion of flows changing with a GEH less than 1 providing confidence the model shows stable and repeatable results.

11. Assignment Calibration and Validation

11.1 Screenlines

Screenlines are used to assess how closely the volume of modelled traffic replicates observed traffic over a wider area of the model. They are placed on the network where traffic has little option for route choice, e.g. a railway or river crossing, and therefore must cross that point. **Section 3.2** provides further details of how screenlines were developed for the HDTM model.

It should be noted that the guidance for screenlines is steered towards strategic highway models which generally have large flows. Due to the urban nature of the HDTM study area, these guidelines are being applied to smaller flows than normal and so a GEH function has also been included with a guideline target to be below 4 as per DMRB guidance.

The comparison between observed and modelled flows for car only and total screenlines are given in **Table 11-1** to

Analysing non-compliant links in the figures above shows that this occurs in Ripley on screenline A and the High Street in Knaresborough on screenline C. Both of these aspects might be related to zoning issues with all traffic for one zone using the same road to reach the connector rather than splitting up accordingly. However, for screenline D outbound all non-compliant links are on minor roads.

Table 11-4.

Table 11-1 Screenline Comparison with Observed Flows AM Cars

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
A_Inbound	3,358	3,564	6%	3.5	Yes
B_Inbound	2,345	2,199	6%	3.1	Yes
C_Inbound	1,084	1,122	3%	1.1	Yes
D_Inbound	2,128	2,186	3%	1.3	Yes
E_Inbound	2,029	2,130	5%	2.2	Yes
F_Inbound	1,669	1,615	3%	1.3	Yes
G_Inbound	1,451	1,438	1%	0.3	Yes
H_Inbound	368	370	1%	0.1	Yes
P_Inbound	1,264	1,271	1%	0.2	Yes
A_Outbound	2,725	2,943	8%	4.1	No
B_Outbound	2,952	2,825	4%	2.4	Yes
C_Outbound	1,441	1,307	9%	3.6	Yes
D_Outbound	2,630	2,087	21%	11.2	No
E_Outbound	2,066	2,177	5%	2.4	Yes
F_Outbound	1,570	1,475	6%	2.4	Yes
G_Outbound	1,448	1,444	0%	0.1	Yes
H_Outbound	372	347	7%	1.3	Yes
P_Outbound	1,356	1,341	1%	0.4	Yes
Overall	32,258	31,841	1%	2.3	Yes

Within the AM Car only results, a general good level of fit can be seen across the screenlines with the overall screenline flow being within 1% of the observed. 16 of the 18 screenlines meet the applied standards fulfilling the criteria of “all or nearly all”.

The screenlines which don’t meet the required guidelines are generally very close to the requirements with the total difference rarely exceeding a few hundred vehicles which is within the expected variance of daily flow in an urban area.

The exception to this is screenline D outbound which has a 21% difference between the observed and modelled screenline. This represents traffic leaving the centre of Harrogate, but not the wider Harrogate area, due to A outbound, which cordons the whole of Harrogate, not having the same level of difference.

This difference in observed/modelled trips for these internal movements can be seen as a weakness within the model, but it is important to note that screenline P, which represents the main North/South movements through Harrogate is very close to the observed and so the main strategic movements are correct, therefore the differences account for more minor routes developed from synthetic movements.

Table 11-2 Screenline Comparison with Observed Flows PM Cars

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
A_Inbound	3,226	3,412	6%	3.2	Yes
B_Inbound	3,517	3,337	5%	3.1	Yes
C_Inbound	1,417	1,319	7%	2.6	Yes
D_Inbound	2,652	2,557	4%	1.9	Yes
E_Inbound	2,449	2,579	5%	2.6	Yes
F_Inbound	1,805	1,713	5%	2.2	Yes
G_Inbound	1,747	1,716	2%	0.7	Yes
H_Inbound	440	453	3%	0.6	Yes
P_Inbound	1,578	1,520	4%	1.5	Yes
A_Outbound	3,974	4,140	4%	2.6	Yes
B_Outbound	2,722	2,543	7%	3.5	Yes
C_Outbound	1,362	1,279	6%	2.3	Yes
D_Outbound	3,035	2,664	12%	7.0	No
E_Outbound	2,300	2,412	5%	2.3	Yes
F_Outbound	2,089	1,932	8%	3.5	Yes
G_Outbound	1,792	1,744	3%	1.1	Yes
H_Outbound	406	409	1%	0.1	Yes
P_Outbound	1,646	1,659	1%	0.3	Yes
Overall	38,159	37,388	2%	4.0	Yes

The PM Car only results a show similar good level of fit across the screenlines. In this case, only a single screenline doesn’t meet the criteria and that is reasonably close to the requirement. So the PM screenlines can be seen to be very robust, with an overall screenline flow within 2% of the observed and with only 1 of 18 screenlines not meeting the required GEH criteria, overall the guidance of “All of nearly all” is fully achieved.

Table 11-3 Screenline Comparison with Observed Flows AM All Vehicles

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline

A_Inbound	4,032	4,241	5%	3.3	Yes
B_Inbound	2,785	2,632	5%	2.9	Yes
C_Inbound	1,350	1,354	0%	0.1	Yes
D_Inbound	2,612	2,607	0%	0.1	Yes
E_Inbound	2,567	2,675	4%	2.1	Yes
F_Inbound	2,045	1,885	8%	3.6	Yes
G_Inbound	1,806	1,771	2%	0.8	Yes
H_Inbound	445	422	5%	1.1	Yes
P_Inbound	1,603	1,626	1%	0.6	Yes
A_Outbound	3,292	3,593	9%	5.1	No
B_Outbound	3,500	3,355	4%	2.5	Yes
C_Outbound	1,751	1,554	11%	4.8	No
D_Outbound	3,247	2,623	19%	11.5	No
E_Outbound	2,559	2,720	6%	3.1	Yes
F_Outbound	1,920	1,786	7%	3.1	Yes
G_Outbound	1,819	1,784	2%	0.8	Yes
H_Outbound	467	403	14%	3.1	Yes
P_Outbound	1,588	1,582	0%	0.1	Yes
Overall	39,386	38,613	2%	3.9	Yes

For the AM All vehicle results, in general the observed inbound results are all within guidance. In the outbound direction the screenlines which do not meet guidance are generally close apart from screenline D due to the same rationale described in the Car Only section. Despite a number of screenlines not meeting guidance when considering all vehicles, the overall screenline flow is still within 2% of the observed.

By analysing the individual links which make up the three noncompliant screenlines, we can see where the differences in flow are occurring. **Figure 11-1** to **Figure 11-3** below show the results of this analysis.

Figure 11-1 Screenline A Outbound AM All Vehicles Link Compliancy

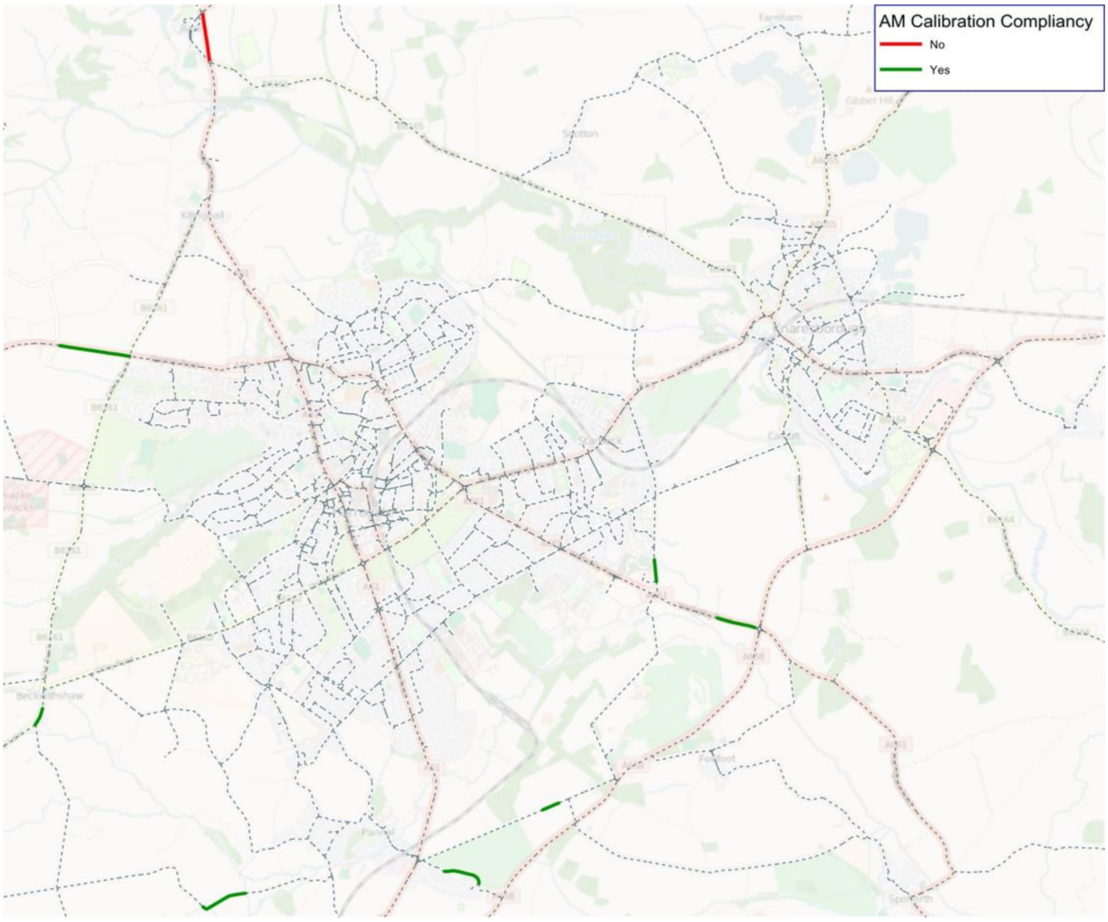


Figure 11-2 Screenline C Outbound AM All Vehicles Link Compliancy

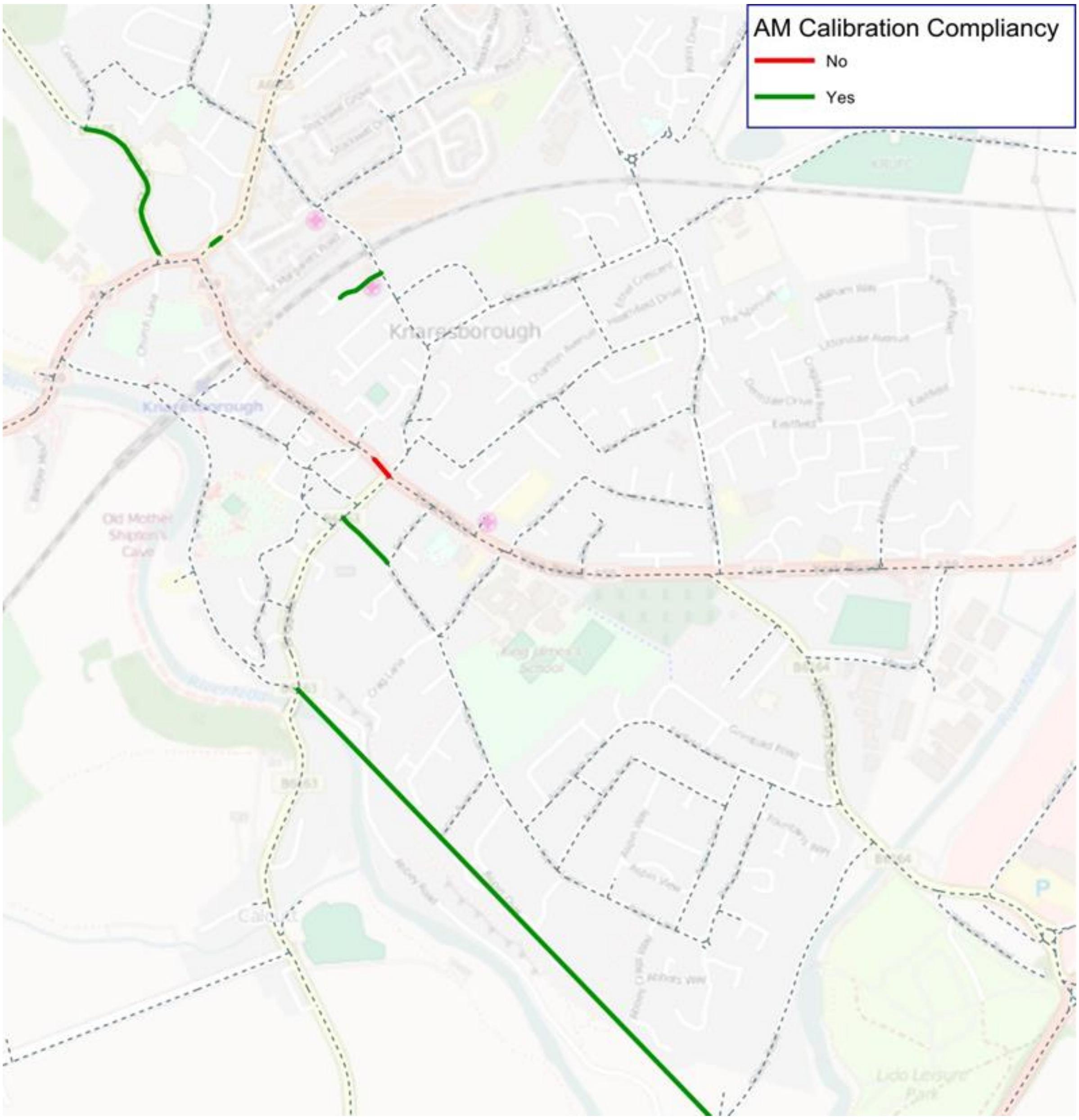
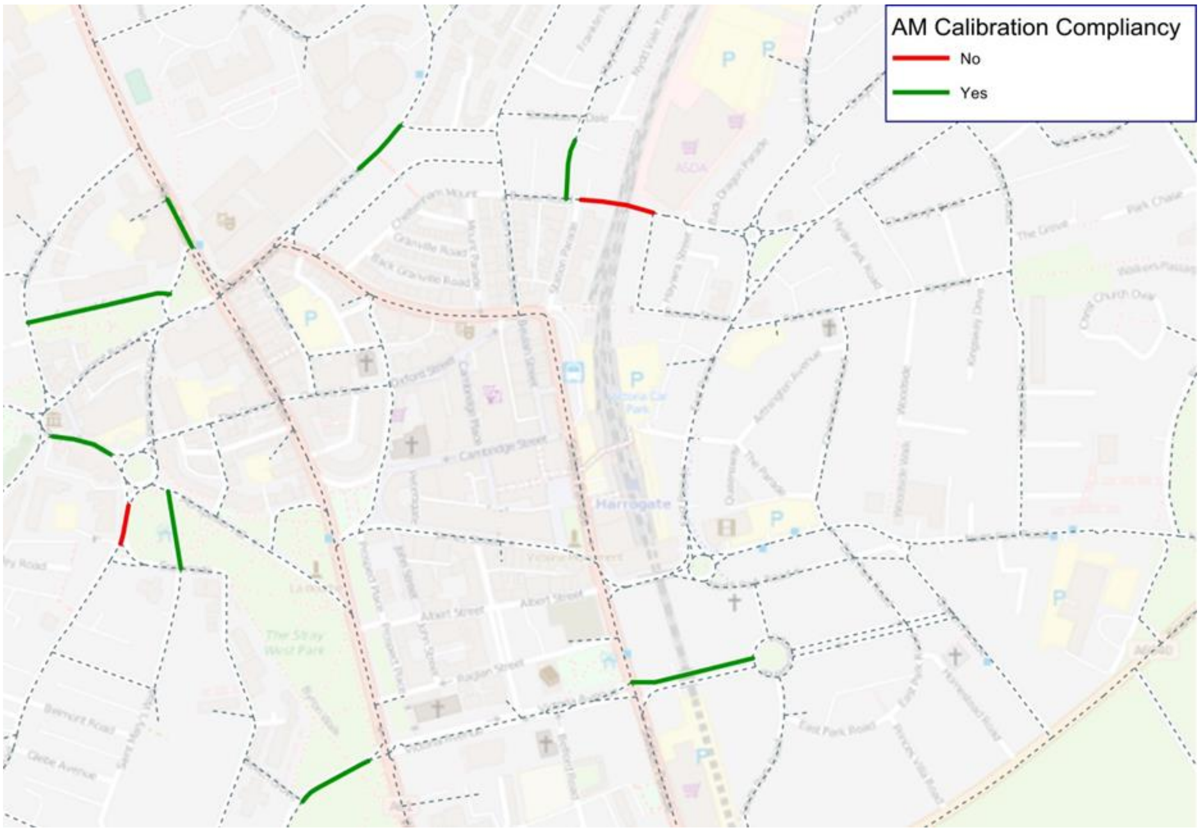


Figure 11-3 Screenline D Outbound AM All Vehicles Link Compliancy



Analysing non-compliant links in the figures above shows that this occurs in Ripley on screenline A and the High Street in Knaresborough on screenline C. Both of these aspects might be related to zoning issues with all traffic for one zone using the same road to reach the connector rather than splitting up accordingly. However, for screenline D outbound all non-compliant links are on minor roads.

Table 11-4 Screenline Comparison with Observed Flows PM All Vehicles

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
A_Inbound	3,636	3,847	6%	3.4	Yes
B_Inbound	3,917	3,767	4%	2.4	Yes
C_Inbound	1,582	1,442	9%	3.6	Yes
D_Inbound	2,998	2,861	5%	2.5	Yes
E_Inbound	2,812	3,018	7%	3.8	Yes
F_Inbound	2,005	1,857	7%	3.4	Yes
G_Inbound	2,005	1,917	4%	2.0	Yes
H_Inbound	497	485	2%	0.5	Yes
P_Inbound	1,732	1,679	3%	1.3	Yes
A_Outbound	4,460	4,681	5%	3.3	Yes
B_Outbound	3,020	2,856	5%	3.0	Yes
C_Outbound	1,536	1,417	8%	3.1	Yes
D_Outbound	3,405	2,964	13%	7.8	No

E_Outbound	2,668	2,844	7%	3.3	Yes
F_Outbound	2,328	2,098	10%	4.9	No
G_Outbound	2,048	1,953	5%	2.1	Yes
H_Outbound	452	440	3%	0.6	Yes
P_Outbound	1,806	1,837	2%	0.7	Yes
Overall	42,909	41,963	2%	4.6	Yes

For the PM All vehicle results, screenline F outbound does not meet guidance, however, it is very close to a GEH of 4 and does meet the criteria at the Car Only level, with slight differences in the LGV and HGV flows pushing the GEH just above 4.

In general the level of fit is good despite not meeting the full guidance, with an overall difference in flow of 2%. It is further noted that the level of fit as shown at an individual link level is high as shown within **Figure 11-6** and **Figure 11-5** below.

Figure 11-4 Screenline D Outbound PM All Vehicles Link Compliancy

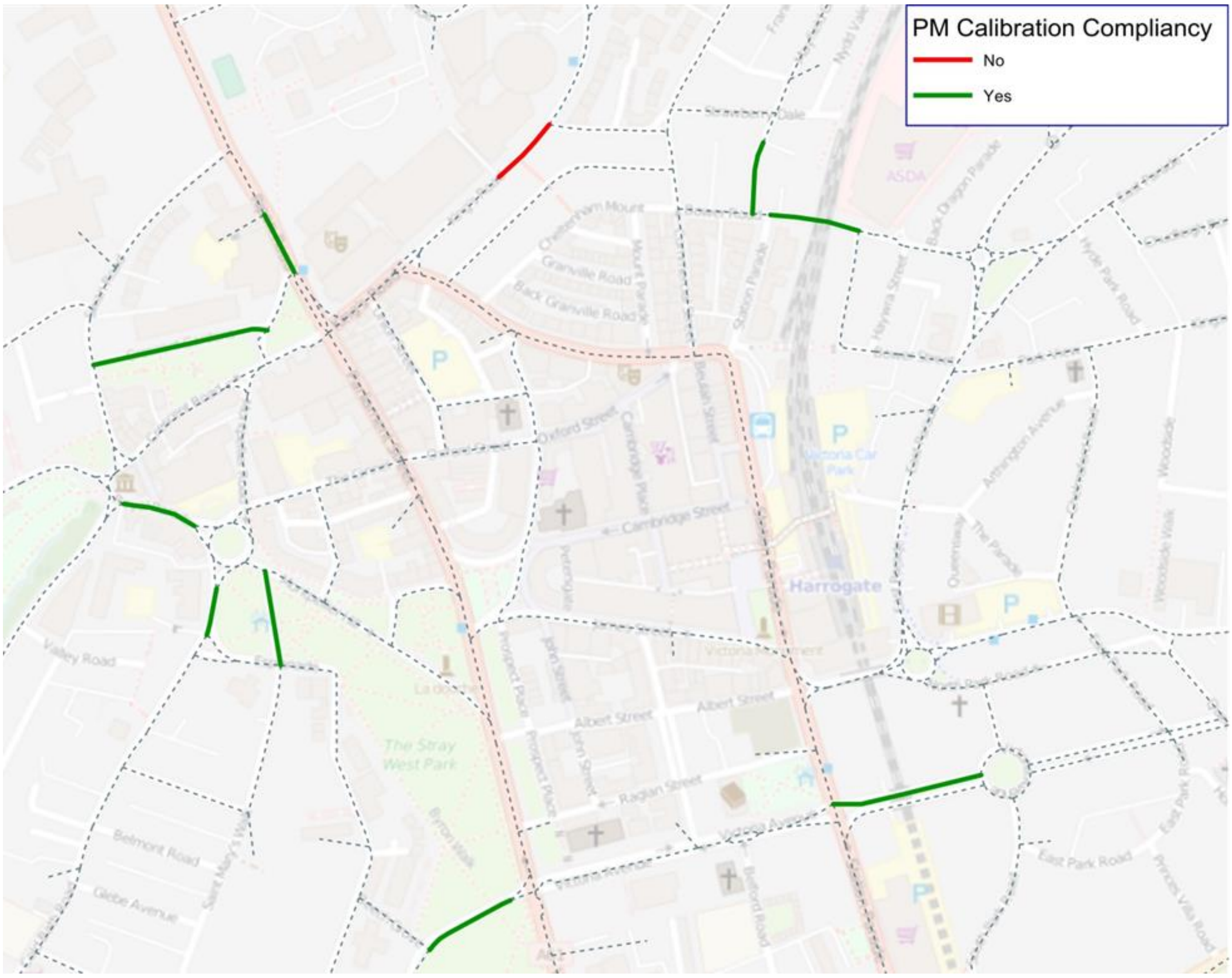
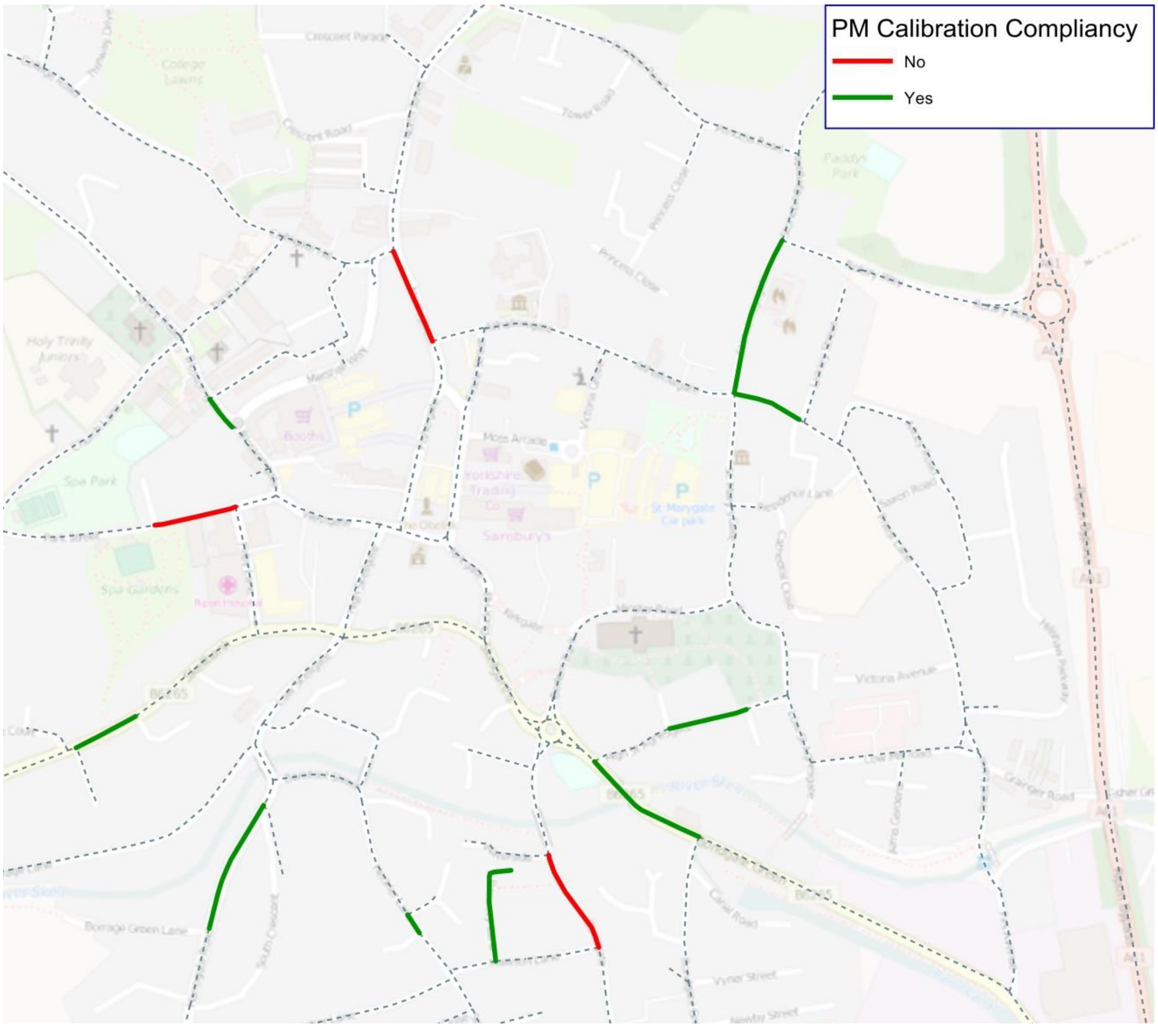


Figure 11-5 Screenline F Outbound PM All Vehicles Link Compliancy



The figures above show that all major roads are compliant for calibration screenlines in the PM peak and discrepancies between observed and modelled flows are only occurring on minor road links within the city centres of Harrogate and Ripon.

11.2 Assignment Calibration

Calibration of traffic flows on links occurs during the Matrix Modification process. The purpose is to ensure that modelled link flows match observed link flows on those counts selected for calibration purposes.

The comparison between observed and modelled link flows for total vehicles and cars only are given in **Table 11-5** and **Table 11-6**.

Full link calibration details are presented in **Appendix D**.

Table 11-5 Calibration Link Flow Comparison with Observed Flows AM (Cars and Total Vehicle)

All Link Calibration Sites	Car Only	Total Vehicles
No. within DMRB Flow criteria	133	131
No. within GEH of 5	111	110
% within DMRB Flow criteria	91.10%	89.73%
% within GEH of 5	76.03%	75.34%
Compliant (WebTAG guideline is 85%)	93.84%	92.47%

Table 11-6 Calibration Link Flow Comparison with Observed Flows PM (Cars and Total Vehicle)

All Link Calibration Sites	Car Only	Total Vehicles
No. within DMRB Flow criteria	131	128
No. within GEH of 5	108	107
% within DMRB Flow criteria	89.73%	87.67%
% within GEH of 5	73.97%	73.29%
Compliant (WebTAG guideline is 85%)	91.78%	90.41%

The above table's show a good level of calibration at the individual link level within the model, the model calibration exceeds the WebTAG criteria in both the AM and PM scenarios for both car only and all vehicle results.

Therefore the model can be considered robust at the individual link flow calibration level, fully meeting guidance.

11.3 Assignment Validation

The validation of the model is measured by comparing modelled flows to observed flows on links and comparison of modelled journey times to observed journey times.

11.4 Screenline Validation

Screenline validation uses the screenlines which were not used within the calibration process and therefore were not used as part of the matrix estimation procedure. They therefore provide an additional health check of the flows within the model.

Note that TAG unit M3.1 states in Section 8.3.16 that in can be difficult to achieve validation in some larger models, especially in congested areas, without significant change to the prior observed matrices. In this case the matrix integrity should be respected and a lower level of validation reported.

This advice has been followed in the building of the HDTM model for the screenline and link count validation.

The comparison between these screenlines for observed and modelled cars and all vehicles are given in **Table 11-7** to **Table 11-10**.

Table 11-7 Screenline Validation Comparison AM Cars

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
I Inbound	1,762	1,544	12%	5.4	No
J Inbound	716	739	3%	0.8	Yes
M Inbound	2,776	1,983	29%	16.3	No
N Inbound	1,339	810	40%	16.1	No
O Inbound	910	884	3%	0.9	Yes
I Outbound	1,592	1,514	5%	2.0	Yes
J Outbound	663	725	9%	2.3	Yes
M Outbound	3,050	2,865	6%	3.4	Yes
N Outbound	643	355	45%	12.9	No
O Outbound	700	753	8%	2.0	Yes
Overall	14,152	12,172	14%	17.3	No

For the AM car validation, screenlines J and O Inbound and I, J, M and O Outbound are all within the required guidelines. Screenline I inbound, despite not meeting the criteria is very close to the guidelines. The larger differences occur on screenlines M and N, this is due to the fact that these screenlines are predominantly made up of smaller non-strategic roads in the centre of Harrogate which cover a lot of short internal trips and made up of synthetic trips.

Table 11-8 Screenline Validation Comparison PM Cars

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
I Inbound	1,942	1,837	5%	2.4	Yes
J Inbound	878	957	9%	2.6	Yes
M Inbound	2,912	2,608	10%	5.8	No
N Inbound	810	684	16%	4.6	No
O Inbound	875	943	8%	2.2	Yes
I Outbound	2,061	1,741	16%	7.3	No
J Outbound	881	970	10%	2.9	Yes
M Outbound	3,313	2,553	23%	14.0	No
N Outbound	1,103	786	29%	10.3	No
O Outbound	892	953	7%	2.0	Yes
Overall	15,667	14,032	10%	13.4	No

For the PM car validation, screenlines I, J, and O Inbound and J and O outbound are all within the required guidelines. Screenlines M inbound, N inbound and I outbound are very close to the guidelines. The larger differences again occur on screenlines M and N outbound for similar reasons to the AM.

Table 11-9 Screenline Validation Comparison AM All Vehicles

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
I Inbound	2,231	1,915	14%	6.9	No
J Inbound	888	895	1%	0.2	Yes
M Inbound	3,470	2,468	29%	18.4	No
N Inbound	1,581	948	40%	17.8	No
O Inbound	1,100	1,073	2%	0.8	Yes
I Outbound	1,989	1,881	5%	2.5	Yes
J Outbound	780	879	13%	3.4	Yes
M Outbound	3,631	3,248	11%	6.5	No
N Outbound	801	461	42%	13.5	No
O Outbound	855	938	10%	2.8	Yes
Overall	17,327	14,706	15%	20.7	No

The screenline validation for AM All vehicles generally follows the same pattern as with Car Only with the same screenlines meeting and not meeting guidance for the same rationale. An assessment of individual link compliancy has also been undertaken for all non-compliant screenlines on an all vehicle basis in order to identify all links that do not meet WebTAG guidance. **Figure 11-6** to **Figure 11-10** highlights this analysis.

Figure 11-6 Screenline I Inbound AM All Vehicles Link Compliancy

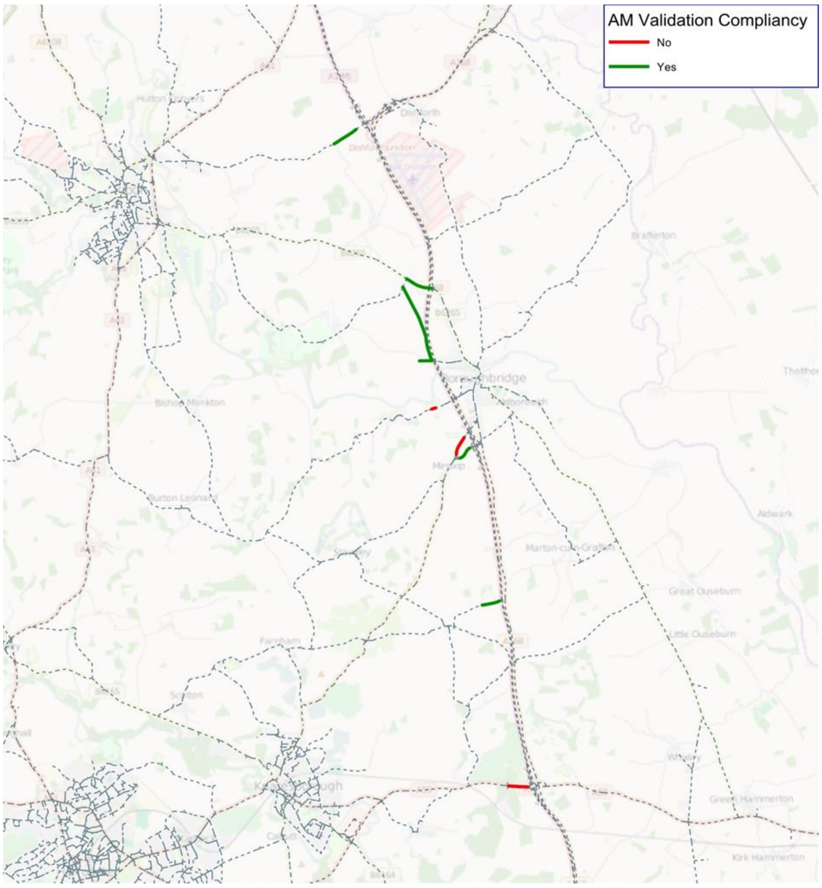


Figure 11-7 Screenline M Inbound AM All Vehicles Link Compliancy

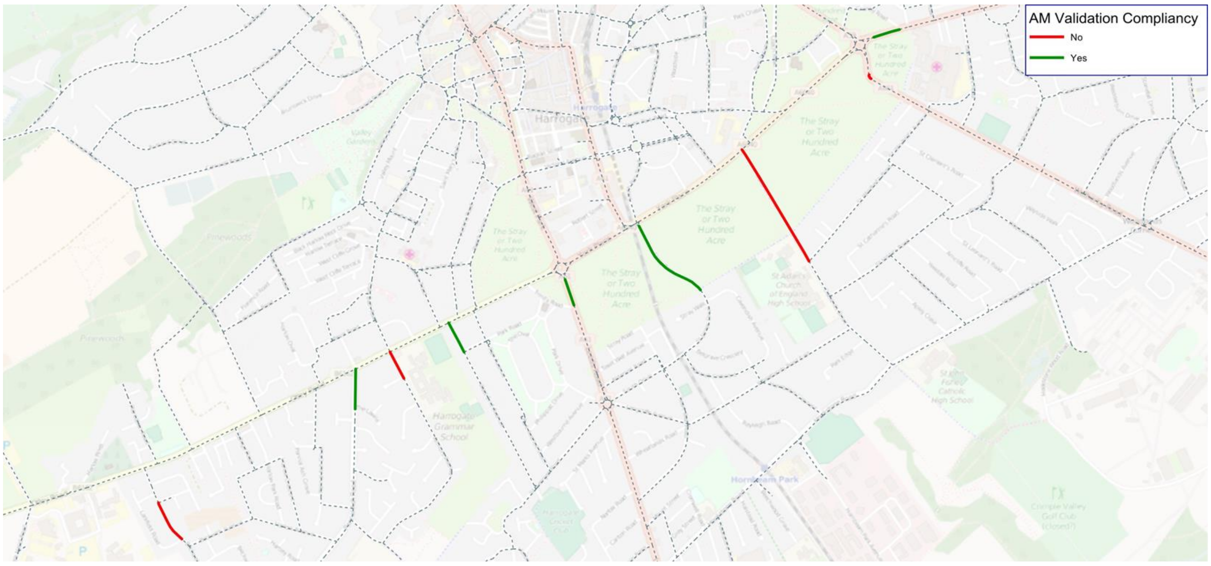


Figure 11-8 Screenline N Inbound AM All Vehicles Link Compliancy

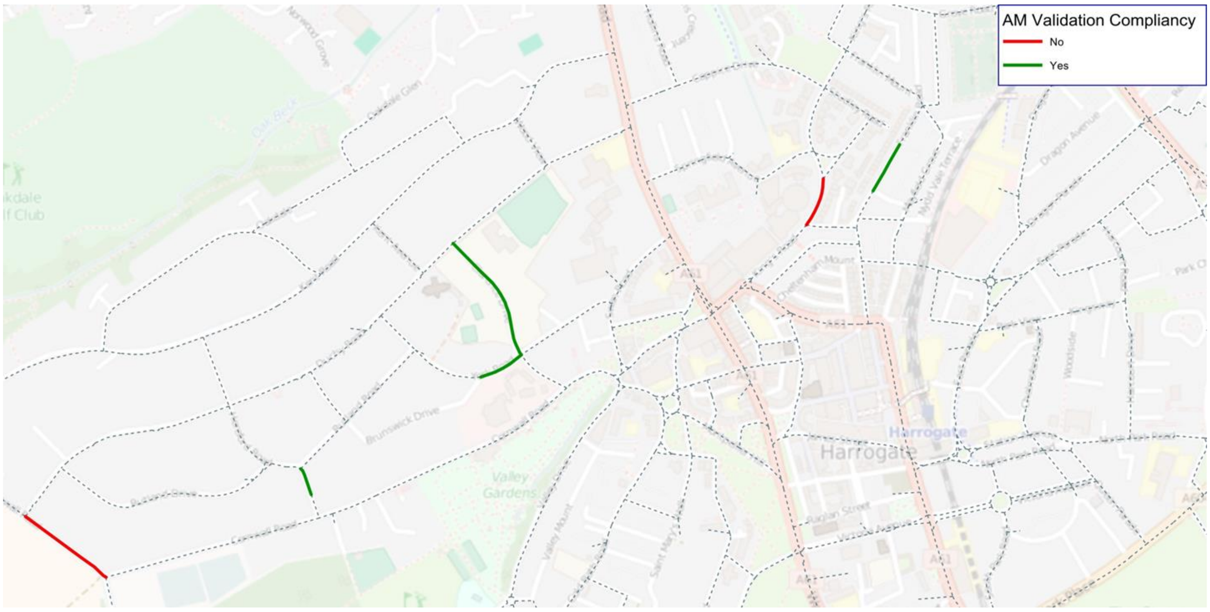


Figure 11-9 Screenline M Outbound AM All Vehicles Link Compliancy

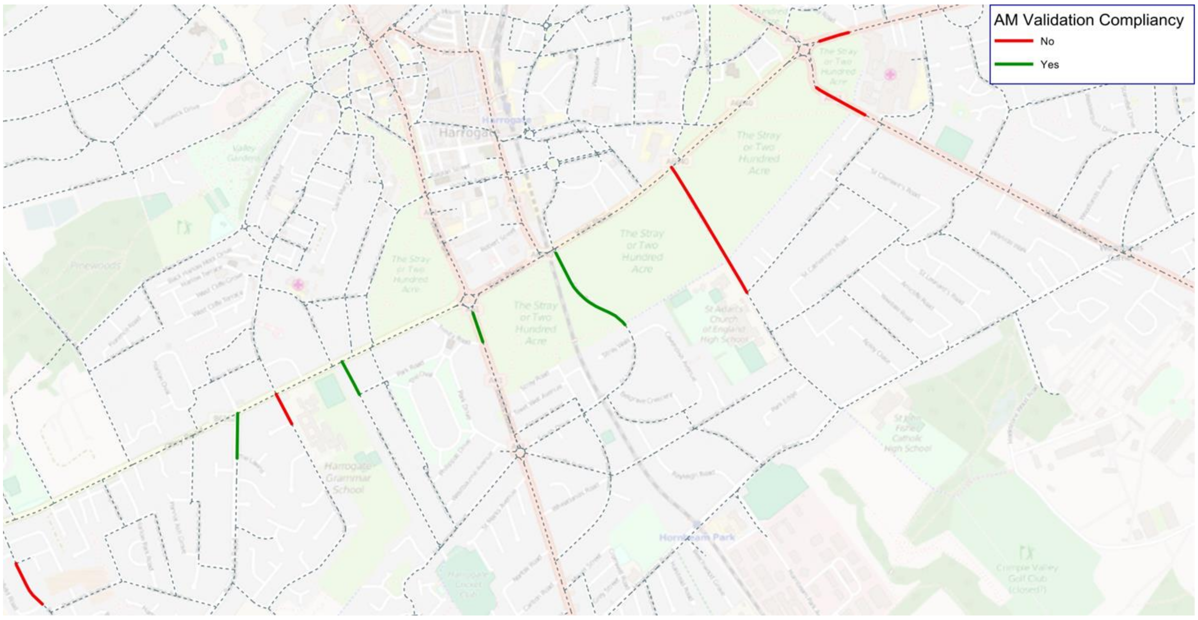
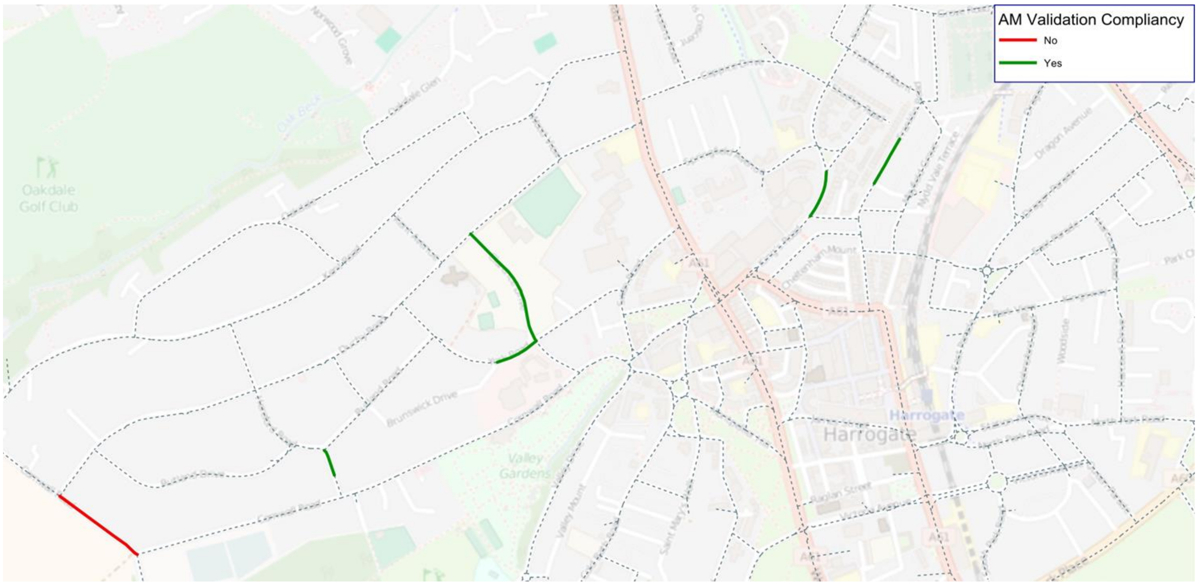


Figure 11-10 Screenline N Outbound AM All Vehicles Link Compliancy



The figures above show that in screenlines I and M a number of keys roads do not fully meet the WebTAG criteria, which can be considered a weakness in this area of the model. Regarding the A661 Wetherby Road in Harrogate, flows in both directions are slightly too low as shown by a GEH of 6.1 in the outbound and 6.8 in the inbound direction. Flows on the A59 Knaresborough Road are also modelled too high as shown by a GEH of 11.0 in the outbound direction for screenline M. Analysing the differences on both of these points, it can be concluded that the overall traffic flow leaving the centre of Harrogate is modelled correctly, however, more vehicles are taking the A59 than the A61, which can be seen as a weakness of the model that might be related to zoning issues. The A59 does also not meet criteria for inbound traffic on the A59 close to Junction 47 on the A1 as shown by a GEH of 10.8 on screenline I. Although this might be another weakness of the model, it should be noted that both, bidirectional traffic flows on the A1 and screenline G in Kirk Hammerton are WebTAG compliant.

Table 11-10 Screenline Validation Comparison PM All Vehicles

Screenline	Observed Flow	Modelled Flow	% Diff	GEH	In Guideline
I Inbound	2,223	2,098	6%	2.7	Yes
J Inbound	955	1,041	9%	2.7	Yes
M Inbound	3,216	2,847	11%	6.7	No
N Inbound	903	735	19%	5.9	No
O Inbound	969	1,064	10%	3.0	Yes
I Outbound	2,381	2,044	14%	7.2	No
J Outbound	977	1,077	10%	3.1	Yes
M Outbound	3,721	2,874	23%	14.7	No
N Outbound	1,204	854	29%	10.9	No
O Outbound	984	1,065	8%	2.5	Yes
Overall	17,532	15,699	10%	14.2	No

The screenline validation for PM All vehicles generally follows the same pattern as with Car Only with the same screenlines meeting and not meeting guidance for the same rationale. Analysing compliancy of individual links for all vehicles in the PM scenario has identified the links marked as red in **Figure 11-11** to **Figure 11-15** not meeting guidance.

Figure 11-11 Screenline M Inbound PM All Vehicles Link Compliancy

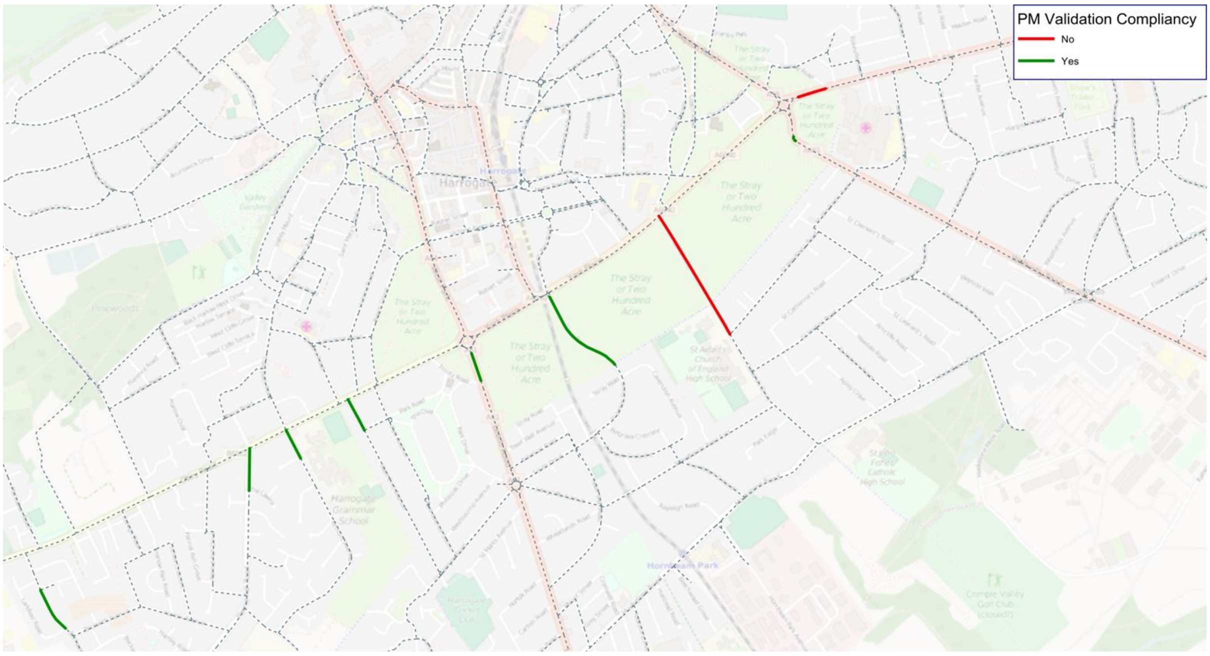


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Figure 11-12 Screenline N Inbound PM All Vehicles Link Compliancy

Figure 11-13 Screenline I Outbound PM All Vehicles Link Compliancy

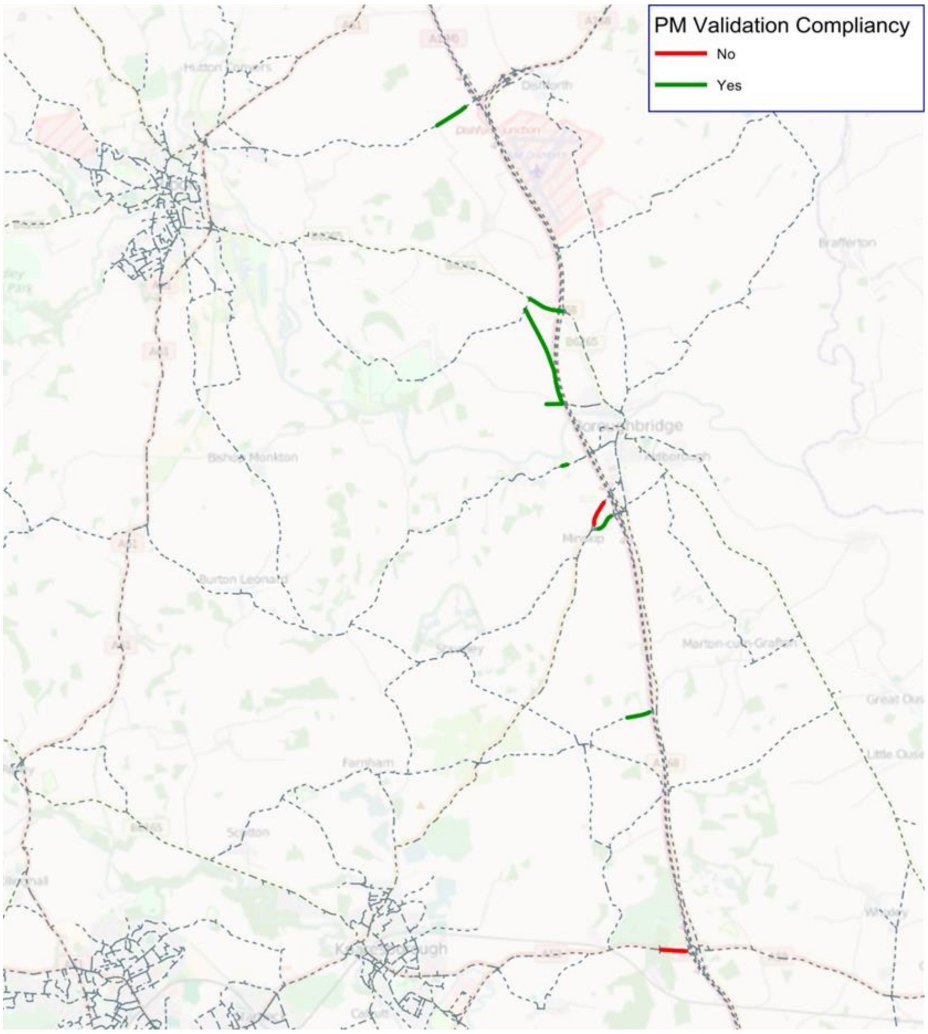

Figure 11-14 Screenline M Outbound PM All Vehicles Link Compliancy

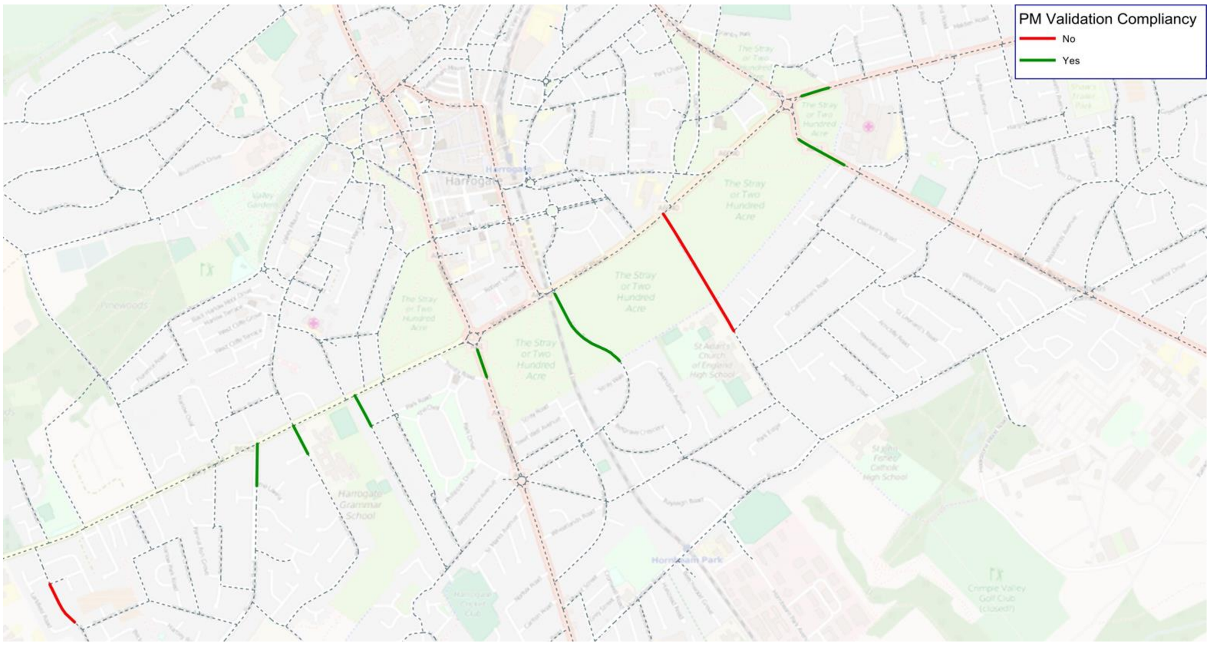

Figure 11-15 Screenline N Outbound PM All Vehicles Link Compliancy

Regarding non-compliant links on strategic roads for the PM peak, the existing pattern is similar to the AM peak. Inbound flows on the A59 in Harrogate are too low as shown in **Figure 11-11** and through a GEH of 7.4. In addition, outbound flows on the A59 on screenline I are too high with the A1 and screenline G being modelled correctly.

11.5 Link Flow Validation

Link flow validation uses pre-selected count sites that have not been used at any stage during model construction. It provides an additional ‘snapshot’, following successful link flow calibration, of how well traffic flows match recorded count data.

The comparison between observed and modelled link flows for total vehicles and cars only are given in

and **Table 11-12**.

Full link validation details are presented in **Appendix E.**

Table 11-11 Validation Link Flow Comparison with Observed Flows PM (Cars and Total Vehicle)

All Link Validation Sites (10 sites)	Car Only	Total Vehicles
No. within DMRB Flow criteria	63	59
No. within GEH of 5	36	35
% within DMRB Flow criteria	82.76%	73.56%
% within GEH of 5	47.37%	46.05%
Compliant (WebTAG guideline is 85%)	82.89%	77.63%

Table 11-12 Validation Link Flow Comparison with Observed Flows PM (Cars and Total Vehicle)

All Link Validation Sites (10 sites)	Car Only	Total Vehicles
No. within DMRB Flow criteria	66	64
No. within GEH of 5	44	43
% within DMRB Flow criteria	83.91%	80.46%
% within GEH of 5	57.89%	56.58%
Compliant (WebTAG guideline is 85%)	86.84%	84.21%

The above table’s show that the link flow validation doesn’t quite meet the full WebTAG criteria in all cases although it is close. As with noted earlier in this section the decision has been made to maintain the integrity of the observed matrices rather than further adjust them to bring the validation links into guidance. The screenline validation section highlights that is predominantly the side roads which cover smaller internal movements which do not validate, whereas a good level of fit can be seen on the strategic roads. As such the model can be deemed WebTAG compliant and fit for purpose.

11.6 Journey Time Validation

Journey time validation is used to assess how well the model replicates surveyed journey times on the highway network. DMRB criteria on journey route validation stipulates that modelled end-to-end journey times should be within either 15% or one minute of the corresponding observed survey route, in at least 85% of cases. The outputs for the HDTM journey routes are given below in **Table 11-13** and **Table 11-14**.

Full link validation details are presented in **Appendix F** and **Appendix G**.

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Table 11-13 Validation Journey Times Comparison with Observed Times AM

Route	Direction	Observed	Modelled	Difference	Perc Difference	DfT Compliant
Route_1	OB	1783	1640	143	8%	Yes
	IB	2057	1765	292	14%	Yes
Route_2	OB	484	522	-38	-8%	Yes
	IB	620	536	84	14%	Yes
Route_3	OB	1749	1743	6	0%	Yes
	IB	1949	1723	226	12%	Yes
Route_4	OB	611	661	-50	-8%	Yes
	IB	1058	906	152	14%	Yes
Route_5	OB	538	617	-79	-15%	Yes
	IB	715	657	58	8%	Yes
Route_6	OB	1058	1215	-157	-15%	Yes
	IB	1393	1228	165	12%	Yes
Route_7	OB	397	366	31	8%	Yes
	IB	393	388	5	1%	Yes
Route_8	OB	707	798	-91	-13%	Yes
	IB	757	851	-94	-12%	Yes
Route_9	OB	504	528	-24	-5%	Yes
	IB	613	601	12	2%	Yes
Route_10	OB	1285	1260	25	2%	Yes
	IB	1449	1293	156	11%	Yes
Route_20	OB	1608	1371	237	15%	Yes
	IB	1662	1591	71	4%	Yes
% Of Routes within WebTAG Guidance (Guideline is 85%)						**100.00%**

Table 11-14 Validation Journey Times Comparison with Observed Times PM

Route	Direction	Observed	Modelled	Difference	Perc Difference	DfT Compliant
Route_1	OB	2058	2082	-24	-1%	Yes
	IB	1812	1793	19	1%	Yes
Route_2	OB	546	554	-8	-1%	Yes
	IB	549	554	-5	-1%	Yes
Route_3	OB	2057	1780	277	13%	Yes
	IB	1956	1745	211	11%	Yes
Route_4	OB	685	711	-26	-4%	Yes
	IB	846	898	-52	-6%	Yes
Route_5	OB	565	573	-8	-1%	Yes
	IB	626	645	-19	-3%	Yes
Route_6	OB	1267	1234	33	3%	Yes
	IB	1280	1382	-102	-8%	Yes
Route_7	OB	349	387	-38	-11%	Yes
	IB	346	424	-78	-23%	No
Route_8	OB	756	831	-75	-10%	Yes
	IB	721	854	-133	-18%	No
Route_9	OB	502	528	-26	-5%	Yes
	IB	629	613	16	3%	Yes
Route_10	OB	1448	1314	134	9%	Yes
	IB	1483	1304	179	12%	Yes
Route_20	OB	1553	1521	32	2%	Yes
	IB	1638	1411	227	14%	Yes
% Of Routes within WebTAG Guidance (Guideline is 85%)						**90.91%**

As can be seen the DMRB journey time criteria are met in both the AM and PM scenarios with 100% for AM and 91% for PM of routes within the required guidance. This shows that the model overall is satisfactorily replicating the time it takes to travel along the key routes through the Harrogate, Ripon, Knaresborough and immediate surrounding area and therefore is representing the correct level of delay observed during the surveys.

This criteria is important to show, due to one of the key model purposes being for the testing of relief roads around the town centres. It is therefore crucial that the journey times are modelled correctly and so confidence can be had in any rerouting results produced in further work.

Within the AM the criteria is met on all routes in both directions, while within the PM the criteria is not met on Route 7 Inbound, and Route 8 Inbound. Route 8 is close to the observed being within 3% of the guidance. However, Route 7 is a bit further out showing a 23% difference from the observed.

Overall the model shows a good level of fit to the observed journey times and meets the DMRB guidance, with those routes not within guidance being generally very close.

11.7 Conclusion

The HDTM meets the full WebTAG guidance for calibration, journey time and assignment validation criteria, overall the model can be considered robust and fit for purpose. It should be noted that the WebTAG criteria was developed primarily for strategic highway modelling and so is specifically designed for the smaller urban links which have made up parts of HDTM calibration/validation process. Therefore DMRB criteria have been used for screenlines, which is more suited to the smaller flow present in the modelled area.

Full WebTAG criteria is met for both *Car Only* and *All Vehicle* assessments of the screenline and individual link calibration and the journey time validation, the latter being important given the proposed future uses of the model. The individual link validation has not quite met the full criteria in all cases although it is very close.

For validation screenlines, although not all meet the required guidance those that do are generally close apart from screenlines M and N which is due to the fact these are made up of a significant number of smaller side streets in Harrogate.

WebTAG guidance has been followed with regards to not compromising the integrity of the observed matrices in order to meet full validation guidance, therefore a lower level of validation has been reported.

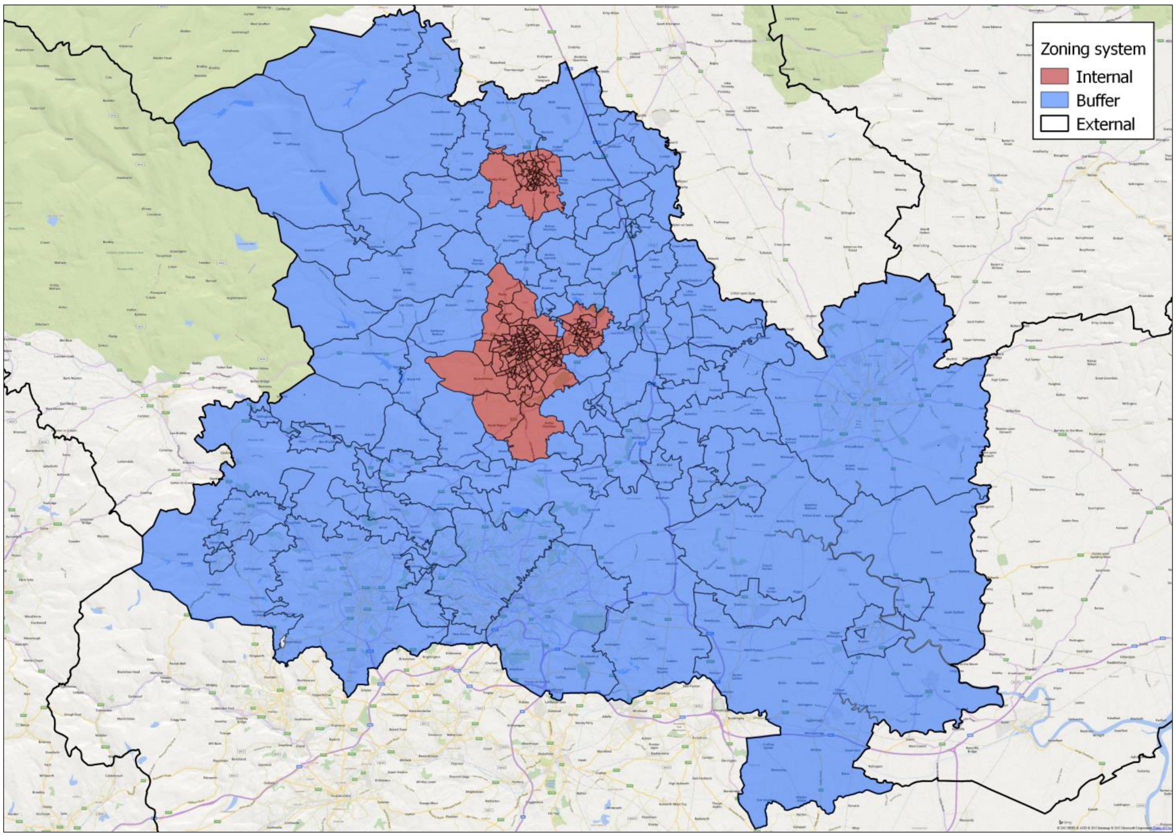
12. Summary

12.1 Summary of Model Development

The HDTM model has been developed for the purposes of testing land use and relief road options around the Harrogate, Knaresborough and Ripon areas.

A zone structure has been created to model in sufficient detail the town centres and surrounding areas to allow for a suitable representation of the current land usage. The zone structure is detailed below in Table 12-1.

Figure 12-1 HDTM Zone Structure



Map data © GeoBasis-DE/BKG (© 2009), Google, Inst. Geogr. Nacional. Terms of Use

Road Side Interview, Classified count and Journey time surveys were undertaken in April 2015 in order to collect a suitable level of base data to inform the model. This has been supplemented with available local ATC and C2Web data where available.

The model demand has been built using both observed and synthetic demand matrices. The former being based on the roadside interview data and the latter being based on 2011 Census and NTEM data. These matrices have then been combined to produce AM and PM Peak 2015 demand.

The model network has been constructed using ITN and Trafficmaster data with a 3 tier approach:

- Detailed model area with full junction coding (Harrogate, Knaresborough and Ripon)
- Buffer area with link capacity restraint and key junctions coded (surrounding area)
- External network with no detailed coding (Rest of UK)

The network has been adjusted in order to calibrate the assignment in order to successfully replicate narrow heavily parked lanes and observed junction delay in a realistic fashion

Matrix estimation has been used at a mini-screenline level in order to improve the demand and achieve the required levels of calibration/validation. The matrix estimation results are within the WebTAG guidance for pre and post demand change in the observed areas except for a single movement in the AM and two movements in the PM which have a change of just slightly over 100 vehicles.

12.2 Summary of Standards Achieved

The model standards achieved are summarised below in Table 12-1

Table 12-1 Model Standards Summary

Criteria	AM Car	AM All	PM Car	PM All
Screenline Calibration (Nearly All)	16 of 18	15 of 18	17 of 18	16 of 18
Link Flow Calibration (Guidance >85%)	93.84%	92.47%	91.78%	90.41%
Screenline Validation (Nearly All)	6 of 10	5 of 10	5 of 10	5 of 10
Link Flow Validation (Guidance >85%)	82.89%	77.63%	86.84%	84.21%
Journey Time Validation (Guidance >85%)	100%		90.91%	

12.3 Assessment of Fitness for Purpose

The model assignment has met the required convergence criteria for both AM and PM which shows that the model has achieved an acceptable level of stability.

It should be noted that the WebTAG criteria was developed primarily for strategic highway modelling and so is specifically designed for the smaller urban links which have made up parts of HDTM calibration/validation process. To this end HMRB guidance has been used at the screenline level which is more suitable for smaller levels of traffic flow.

The model meets full WebTAG calibration criteria, for both *Car Only* and *All Vehicles*, and also meets WebTAG guidance for the journey time validation, the latter being important given the proposed future uses of the model. The screenline/count validation has not quite met the full criteria in all cases although it is very close to guidelines. WebTAG guidance has been followed with regards to not compromising the observed demand in order to accommodate validation screenlines/counts and instead a lower level has been reported

A non-technical version of this document has been produced and is available on the Harrogate Borough Council website and the North Yorkshire County Council website if applicable.

Appendix A – Questionnaire and Postcard Layout

Surveyor Initials

Site Location

- ❑ 150005-01 A.61 West Park, Harrogate
- ❑ 150005-02 A.61 Station Parade, Harrogate
- ❑ 150005-03 A.59 Skipon Road, Harrogate (centre)
- ❑ 150005-04 A.59 Skipton Road, Harrogate (NW)
- ❑ 150005-05 A.59 Harrogate Road, Knarebrough (SW)
- ❑ 150005-06 Forrest Moor Road, Harrogate
- ❑ 150005-07 B.6165 Ripley Road, Knaresborough
- ❑ 150005-08 A.6055 Boroughbridge Road, Scriven, Knaresborough
- ❑ 150005-09 A.59 York Road, Knaresborough (west)
- ❑ 150005-10 B.6164 Grimbald Crag Way, Knaresborough
- ❑ 150005-11 B6163 Thistle Hill, Knaresborough
- ❑ 150005-12 A.661 Wetherby Road, Harrogate
- ❑ 150005-13 A.61 Harrogate Road, Harrogate (near Pannal)
- ❑ 150005-14 B.6161 Otley Road (Snuff's Wood), Beckwithshaw
- ❑ 150005-15 A.61 Harrogate Road, Ripon (south)
- ❑ 150005-16 B.6265 Studley Road, Ripon
- ❑ 150005-17 Kirkby Road, Ripon
- ❑ 150005-18 A.6108 Palace Road, Ripon
- ❑ 150005-19 A.61 Huton Bank, Ripon
- ❑ 150005-20 B.6265 Boroughbridge Road, Ripon
- ❑ 150005-21 Dishforth Road, near Sharow
- ❑ 150005-22 A.61 Ripon Road, Ripley
- ❑ 150005-23 Forest Lane, Harrogate

Introduction Text

- ❑ Proceed
- ❑ Refused

Q1. Would you please tell me the full address you have come from? Postcode

House Name/Number/Organisation

Street

Town

County

Q2. What was your reason for being there?

- ❑ Home
- ❑ Hotel / Holiday Home
- ❑ Usual Workplace
- ❑ Employers Business
- ❑ Education
- ❑ Shopping / Using Services
- ❑ Collect / Deliver Goods
- ❑ Escort - School
- ❑ Escort - Work
- ❑ Refused
- ❑ Other (specify)

Q3. Would you please tell me the full address you are going to now? Postcode

House Name/Number/Organisation

Street

Town

County

Q4. What is your reason for going there?

- ❑ Home
- ❑ Hotel / Holiday Home
- ❑ Usual Workplace
- ❑ Employers Business
- ❑ Education
- ❑ Shopping / Using Services
- ❑ Collect / Deliver Goods
- ❑ Escort - School
- ❑ Escort - Work
- ❑ Refused
- ❑ Other (specify)

Q5. Vehicle Type

- ❑ Car/Taxi
- ❑ Light goods vehicle
- ❑ OGV1 (Rigid, 2-3 axles)
- ❑ OGV2 (Articulated, 3+ axles)
- ❑ Buses / Coaches
- ❑ Motorcycles
- ❑ Pedal Cycle
- ❑ Other (specify)

Q6. Occupancy (including driver)

(must be superior to 1)

Q7. What is the time of your Reverse Trip?

MOISTEN HERE

MOSTEN HERE

MOISTEN HERE

Serial No -

If you want to enter our £100 prize draw, please give your name and daytime phone number

Name ____________________

Phone Number ____________________

1. Please provide full address you have just come from (incl. Postcode) (Last stop on Journey)

Name of Shop/Building ____________________

House Number and Street ____________________

____

District/Town ____________________

County ____________________ Postcode ____________________

2. Reason for being there?

1.Home ☐ 2.Holiday Home/Hotel ☐ 3.Work (usual workplace) ☐ 4.On employer's Business ☐ 5.Education ☐

6.Shopping ☐ 7.Personal Business ☐ 8.Visiting Friend/Family ☐ 9 Social/Recreational ☐ 10.Other ☐

3. Please provide full address you are going to. (incl. Postcode) (Next stop on Journey)

Name of Shop/Building ____________________

House Number and Street ____________________

____

District/Town ____________________

County ____________________ Postcode ____________________

4. Reason for being there?

1.Home ☐ 2.Holiday Home/Hotel ☐ 3.Work (usual workplace) ☐ 4.On employer's Business ☐ 5.Education ☐

6.Shopping ☐ 7.Personal Business ☐ 8.Visiting Friend/Family ☐ 9 Social/Recreational ☐ 10.Other ☐

5. What type of vehicle were you driving? 1. Car/Taxi ☐ 2. LGV(Van) ☐

3. HGV upto 3 axle rigid ☐ 4. HGV 4> axle rigid or articulated ☐ 5. Other (please state) ☐ ____________

6. How many passengers were in your vehicle? ____________

7. How often do you make this journey?

A. First time ☐ B. 3 or less times per month ☐ C. 1 to 2 times per week ☐

D. 3 to 5 times per week ☐ E. More then 5 times per week ☐

8. How many vehicles are owned by your household? ____________

9. If this is a return trip, what time do you expect to return? Time ____________
(or the time you made outbound trip)

Appendix B – Traffic Count Locations and Types

In the tables below, the sites are coded as follows:

- Black: Used for Matrix Estimation / Calibration
- Red: Used for Validation
- Blue: Not used for Calibration or Validation and therefore only considered for referencing purposes and as a base for comparison.

Table 1 Temporary ATC Site Locations

Site ID	Location	Screenline
150007-01	A61 West Park, Harroagte	P
150007-02	A61 Station Parade, Harrogate	P
150007-03	A59 Skipon Road, Harrogate (centre)	P
150007-04	A59 Skipton Road, Harrogate (NW)	A
150007-05	A59 Harrogate Road, Knarebrough(SW)	B
150007-06	Forrest Moor Road, Harrogate	B
150007-07	B6165 Ripley Road, Knaresborough	B
150007-08	A6055 Boroughbridge Road, Scriven, Knaresborough	B
150007-09	A59 York Road, Knaresborough (west)	B
150007-10	B6164 Grimbald Crag Way, Knaresborough	B
150007-11	B6163 Thistle Hill, Knaresborough	B
150007-12	A661 Wetherby Road, Harrogate	A
150007-13	A61 Harrogate Road, Harrogate (near Pannal)	A
150007-14	B6161 Otley Road (Snuff's Wood), Beckwithshaw	A
150007-15	A61 Harrogate Road, Ripon (south)	E
150007-16	B6265 Studley Road, Ripon	E
150007-17	Kirkby Road, Ripon	E
150007-18	A6108 Palace Road, Ripon	E
150007-19	A61 Huton Bank, Ripon	E
150007-20	B6265 Boroughbridge Road, Ripon	E
150007-21	Dishforth Road, near Sharow	E
150007-22	A61 Ripon Road, Ripley	A
150006-23	Forest Lane, Harrogate	A
150007-24	Pannal Road, Harrogate	A
150007-25	Drury Lane, Harrogate	A
150007-26	Brackenthwaite Lane, Harrogate	A
150007-27	Greengate Lane, Knaresborough	B
150007-28	Grimbald Crag Close, Knaresborough	B
150007-29	Berrygate Lane, Sharrow	E
150007-30	Galphay Lane, Ripon	E
150007-31	Knaresborough Road, Ripon	E
150007-32	Littlethorpe Road, Littlethorpe	E
150007-33	Abbey Road, Knaresborough (Site 1)	C
150007-34	Windsor Lane, Knaresborough	C
150007-35	A59 York Place, Knaresborough	C
150007-36	Wincup Avenue, Knaresborough	C
150007-37	Ash Tree Road, Knaresborough	C
150007-38	St Margaret's Road, Knaresborough	C

Site ID	Location	Screenline
150007-39	A6065 Boroughbridge Rd, Knaresborough	C
150007-40	B6165 High Bond End, Knaresborough	C
150007-41	Victoria Avenue, Harrogate	D
150007-42	St Mary's Walk, Harrogate	D
150007-43	Beech Grove, Harrogate	D
150007-44	Station Bridge, Harrogate	D
150007-45	Bower Road, Harrogate	D
150007-46	Belford Road, Harrogate	D
150007-47	Mayfield Grove, Harrogate	D
150007-48	King's Road, Harrogate (Site 1)	D
150007-49	A61 Ripon Road, Harrogate	D
150007-50	Crescent Garden, Harrogate	D
150007-51	Crescent Road, Harrogate	D
150007-52	Royal Pararde, Harrogate	D
150007-53	Cold Bath Road, Harrogate	D
150007-54	Bloomsgate, Ripon	F
150007-55	Park Street, Ripon (Site 1)	F
150007-56	B6265 Mallorie Park Drive, Ripon	F
150007-57	Harrogate Road, Ripon (Centre)	F
150007-58	Heckler Lane, Ripon	F
150007-59	Mawson Lane, Ripon	F
150007-60	Bondgate, Ripon (Site 1)	F
150007-61	B6265 Bondgate Green, Ripon (Site 1)	F
150007-62	High Saint Agnesgate, Ripon	F
150007-63	Priest Lane, Ripon (Site 1)	F
150007-64	Stonebridgegate, Ripon	F
150007-65	North Street, Ripon (Site 1)	F
150007-66	A59 New Road, near Whixley	G
150007-67	Station Road, near Kirk Hammerton	G
150007-68	A59 York Road, Kirk Hammerton	G
150007-69	B6265, Whixley	G
150007-70	Station Road, Whixley	G
150007-71	High Street, Whixley	G
150007-72	B6265 Leeming Lane, Kirby Hill	H
150007-73	Skelton Road, Langthorpe	H
150007-74	Roecliffe Lane, Boroughbridge	H
150007-75	Grafton Lane, near Aldborough	H
150007-76	Dunsforth Road, Aldborough	H
150007-77	Helperby Lane, near Milby	H
150007-78	Boroughbridge Road, Kirby Hill	H
150007-79	Cocklakes Lane, near Dishforth Airfield	H
150007-80	Dishforth Road, near Dishforth	I
150007-81	A59 York Road, near Flaxby	I
150007-82	Marton Lane, Arkendale	I
150007-83	A.6055 Aldborough Gate, near Boroughbridge	I

Site ID	Location	Screenline
150007-84	Weatherby Road, near Boroughbridge	I
150007-85	Bar Lane, Roecliffe	I
150007-86	Skelton Road, Langthorpe	I
150007-87	Moor Lane, Kirby Hill	I
150007-88	B.6265, Kirby Hill	I
150007-89	Harrogate Road, Ripon (South)	J
150007-90	Southgate, Ripon	J
150007-91	Bondgate, Ripon (Site 2)	J
150007-92	Bondgate Green Lane, Ripon	J
150007-93	B.6265 Bondgate Green, Ripon (Site 2)	J
150007-94	Priest Lane, Ripon (Site 2)	J
150007-95	Park Street, Ripon (Site 2)	K
150007-96	Kirkby Road, Ripon (Centre)	K
150007-97	College Road, Ripon (Centre)	K
150007-98	North Street, Ripon (Site 2)	L
150007-99	Princess Road, Ripon	L
150007-100	Magdalen's Road, Ripon	L
150007-101	Stray Rein, Harrogate	M
150007-102	Oatlands Drive, Harrogate	M
150007-103	Pannel Ash Road, Harrogate	M
150007-104	Arthur's Avenue, Harrogate	M
150007-105	West End Avenue, Harrogate	M
150007-106	A61 Leeds Road, Harrogate	M
150007-107	A661 Wetherby Road, Harrogate	M
150007-108	A59 Knaresborough Road, Harrogate	M
150007-109	Beckwith Avenue, Harrogate	M
150007-110	King's Road, Harrogate (Site 2)	N
150007-111	Franklin Road, Harrogate	N
150007-112	Cornwall Road, Harrogate	N
150007-113	Cornwall Road, Harrogate	N
150007-114	York Road, Harrogate	N
150007-115	Clarence Drive, Harrogate	N
150007-116	Swan Road, Harrogate	N
150007-117	Abbey Road, Knaresborough (Site 2)	O
150007-118	Aspin Lane, Knaresborough	O
150007-119	Aspin Park Drive, Knaresborough	O
150007-120	King James Road, Harrogate	O
150007-121	Stockwell Lane, Knaresborough	O
150007-122	Stockwell Drive, Knaresborough	O
150007-123	Blind Lane, Knaresborough	O
150007-124	A6055 Boroughbridge Road , Knaresborough	O
150007-125	B.6265 Studley Road, Ripon	E
150007-126	Whitecliffe Lane, Ripon	Additional
150007-127	Clotherholme Road, Ripon	Additional
150007-128	A661 Wetherby Road, Harrogate	A

Site ID	Location	Screenline
150007-129	Forest Lane, Harrogate (South of A59)	Additional
150007-130	Ruding Lane, Harrogate	Additional
150007-131	Hookstone Chase, Harrogate	Additional
150007-132	Lancaster Park Road, Harrogate	Additional
150007-133	South Drive, Harrogate	Additional
150007-134	Hookstone Road, Harrogate	Additional
150007-135	Leadhall Lane, Harrogate	Additional
150007-136	Pannal Bank	Additional
150007-137	Burn Bridge Lane	Additional
150007-138	Howhill Road	Additional
150007-139	Beckwith Head Road, Harrogate	Additional
150007-140	Penny Pot Lane, Harrogate	Additional
150007-141	Skipton Road, Harrogate	Additional
150007-142	Crowberry Drive, Harrogate	Additional
150007-143	Norwich Drive, Harrogate	Additional
150007-144	Harewood Road, Harrogate	Additional
150007-145	B6161 Otley Road, Harrogate	Additional
150007-146	A61 Ripon Road, Harrogate	Additional
150007-147	Bilton Lane, Bilton	Additional
150007-148	Woodfield Road, Bilton	Additional
150007-149	Grove Road, Harrogate	Additional

Table 2 Permanent ATC Site Location

Site No	Location	Screenline
1	St Marygate, Ripon	F
2	Wetherby Road, Boroughbridge	H
3	Ripon Bypass, South of Rotary Way, Ripon	J
4	Ripon Bypass, North of Rotary Way, Ripon	L
5	Mallorie Park Drive, Ripon	K
6	Skipton Road, Harrogate	N

Table 3 TRADS Site Locations

Site No	Location	Count Direction	Dates Available	Screenline
1	A1(M), J48 Access	Northbound	May 2014 – March 2015	Additional
2	A1(M), J48 Access	Southbound	May 2014 – March 2015	Additional
3	A1(M), Through J47	Northbound	January 2012 – November 2013	Additional
4	A1(M), Walshford	Northbound	January 2012 – November 2013	Additional
5	A1(M), Walshford	Southbound	January 2012 – October 2013	Additional

Table 4 C2WEBSite Locations

Site No	Location	Dates Available	Screenline
1	A61, North of Killinghall	July, August & September 2013	Additional
2	A61 Leeds Road, South of A658 Roundabout	January 2014 – March 2015	Additional
3	A59, Green Hammerton - East	Various Months between 2013 and March 2015	Additional

The temporary and permanent ATC sites, as well as the C2WEB locations are all bi-directional. The TRADS sites listed are one direction only.

Appendix C Matrix Estimation Results

Table 1 **Scaled Sector to Sector Percentage Difference Car Business Prior Vs Post – AM**

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-7% (-157)	0%	-1%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	-7% (-2221)	0%	0%	0%	-1%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	-7% (-151)	0%	0%	-1%
11	0%	0%	0%	0%	0%	-7% (-151)	0%	0%	0%	0%	-7% (-9054)	0%	-1%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-7% (-5278)	-1%
Sum	0%	0%	0%	0%	0%	-1%	0%	0%	-1%	-1%	-1%	-1%	0%

Table 2 **Scaled Sector to Sector Percentage Difference Car Business Prior Vs Post – PM**

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 3 Scaled Sector to Sector Percentage Difference Car Other Prior Vs Post – AM

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	-13% (-112)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
2	-62% (-757)	-25% (-249)	0%	0%	0%	-57% (-288)	0%	0%	0%	0%	0%	0%	-12%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	-18% (-294)	0%	0%	0%	0%	0%	0%	0%	-2%
6	0%	0%	0%	0%	0%	-18% (-1662)	-17% (-443)	0%	0%	0%	-18% (-4131)	0%	-4%
7	0%	0%	0%	0%	0%	-18% (-532)	-16% (-181)	0%	0%	0%	-18% (-1322)	0%	-4%
8	0%	0%	0%	0%	0%	0%	0%	-18% (-1170)	0%	0%	0%	0%	-1%
9	0%	0%	0%	0%	0%	0%	0%	0%	-18% (-47275)	0%	0%	0%	-1%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	-18% (-3943)	0%	0%	-1%
11	0%	0%	0%	0%	0%	-18% (-4192)	-18% (-1126)	0%	0%	0%	-18% (-184584)	-18% (-387)	-6%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-18% (-331)	-18% (-125324)	-3%
Sum	-5%	-3%	0%	0%	-2%	-9%	-4%	-1%	-1%	-1%	-6%	-3%	-3%

Table 4 Scaled Sector to Sector Percentage Difference Car Other Prior Vs Post – PM

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	+43% (121)	+25% (104)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	+63% (147)	0%	0%	0%	0%	0%	0%	0%	0%	5%
5	0%	0%	0%	0%	+6% (132)	0%	0%	0%	0%	0%	0%	0%	1%
6	0%	0%	0%	0%	0%	+6% (836)	+6% (229)	0%	0%	0%	+6% (2090)	0%	2%
7	0%	0%	+57% (142)	0%	0%	+6% (245)	+8% (105)	0%	0%	0%	+6% (671)	0%	6%
8	0%	0%	0%	0%	0%	0%	0%	+6% (430)	0%	0%	0%	0%	1%
9	0%	0%	0%	0%	0%	0%	0%	0%	+6% (24311)	0%	0%	0%	1%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	+6% (1996)	0%	+6% (107)	1%
11	0%	0%	0%	0%	0%	+6% (2077)	+6% (571)	0%	0%	0%	+6% (92881)	+6% (597)	2%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	+6% (359)	+6% (63304)	1%
Sum	4%	2%	5%	5%	1%	2%	2%	1%	1%	1%	2%	2%	2%

Table 5 **Scaled Sector to Sector Percentage Difference LGV Prior Vs Post – AM**

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 6 **Scaled Sector to Sector Percentage Difference LGV Prior Vs Post – PM**

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 7 **Scaled Sector to Sector Percentage Difference HGV Prior Vs Post – AM**

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	+286% (244)	0%	0%	0%	0%	+287% (606)	0%	48%
7	0%	0%	0%	0%	0%	+286% (112)	0%	0%	0%	0%	+295% (265)	0%	48%
8	0%	0%	0%	0%	0%	0%	0%	+287% (145)	0%	0%	0%	0%	24%
9	0%	0%	0%	0%	0%	0%	0%	0%	+287% (8731)	0%	0%	0%	24%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	+287% (590)	0%	0%	24%
11	0%	0%	0%	0%	0%	+287% (604)	+294% (208)	0%	0%	0%	+287% (35604)	+287% (285)	96%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	+287% (323)	+287% (20755)	48%
Sum	0%	0%	0%	0%	0%	72%	25%	24%	24%	24%	96%	48%	26%

Table 8 **Scaled Sector to Sector Percentage Difference HGV Prior Vs Post – PM**

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Appendix D Individual Link Calibration

Table 1 – Post AM

Screenline Number	Count Reference	Description	Observed Flow	Modelled Flow	Actual Difference	ABS Perc. Difference	GEH Statistics	DMRB Compliance
1	AI1	SKIPTON ROAD	435	402	-33	7.56%	1.6	Yes
1	AI10	RIPON ROAD	706	865	159	22.53%	5.7	No
1	AI2	WETHERBY ROAD	580	690	110	19.03%	4.4	No
1	AI3	HARROGATE ROAD	627	691	64	10.15%	2.5	Yes
1	AI4	OTLEY ROAD	542	478	-64	11.84%	2.8	Yes
1	AI5	FOREST LANE	237	262	25	10.45%	1.6	Yes
1	AI6	PANNAL ROAD	133	115	-18	13.66%	1.6	Yes
1	AI7	DRURY LANE	63	41	-22	34.80%	3.0	Yes
1	AI8	BRACKENTHWAITE LANE	35	20	-15	43.02%	2.9	Yes
1	AO1	SKIPTON ROAD	418	375	-43	10.24%	2.1	Yes
1	AO10	RIPON ROAD	513	746	233	45.43%	9.3	No
1	AO2	WETHERBY ROAD	681	716	35	5.08%	1.3	Yes
1	AO3	HARROGATE ROAD	442	470	28	6.29%	1.3	Yes
1	AO4	OTLEY ROAD	260	245	-15	5.78%	0.9	Yes
1	AO5	FOREST LANE	163	243	80	49.50%	5.7	Yes
1	AO6	PANNAL ROAD	181	145	-36	19.87%	2.8	Yes
1	AO7	DRURY LANE	51	0	-51	100.00%	10.1	Yes
1	AO8	BRACKENTHWAITE LANE	16	3	-13	81.17%	4.2	Yes
2	BI1	HARROGATE ROAD	267	302	35	12.91%	2.0	Yes
2	BI2	FOREST MOOR ROAD	377	339	-38	10.06%	2.0	Yes
2	BI3	RIPLEY ROAD	231	213	-18	7.70%	1.2	Yes
2	BI4	BOROUGHBRIDGE ROAD	380	333	-47	12.38%	2.5	Yes
2	BI5	YORK ROAD	282	222	-60	21.16%	3.8	Yes
2	BI6	GRIMBALD CRAG WAY	358	365	7	2.00%	0.4	Yes
2	BI7		324	308	-16	4.88%	0.9	Yes
2	BI8	GREENGATE LANE	80	102	22	26.77%	2.3	Yes
2	BI9	GRIMBALD CRAG CLOSE	46	15	-31	67.65%	5.7	Yes
2	BO1	HARROGATE ROAD	545	658	113	20.69%	4.6	No
2	BO2	FOREST MOOR ROAD	523	388	-135	25.83%	6.3	No
2	BO3	RIPLEY ROAD	309	326	17	5.66%	1.0	Yes
2	BO4	BOROUGHBRIDGE ROAD	232	218	-14	6.06%	0.9	Yes
2	BO5	YORK ROAD	300	307	7	2.17%	0.4	Yes
2	BO6	GRIMBALD CRAG WAY	540	446	-94	17.40%	4.2	Yes
2	BO7	BLATCHINGTON ROAD	176	137	-39	21.94%	3.1	Yes
2	BO8	GREENGATE LANE	77	90	13	16.80%	1.4	Yes
2	BO9	GRIMBALD CRAG	250	255	5	2.08%	0.3	Yes

		CLOSE						
3	CI1		12	0	-12	100.00%	4.9	Yes
3	CI2	WINDSOR LANE	221	179	-42	18.87%	2.9	Yes
3	CI3	HIGH STREET	459	446	-13	2.84%	0.6	Yes
3	CI5	ASH TREE ROAD	12	15	3	22.55%	0.7	Yes
3	CI7	BOROUGHBRIDGE ROAD	212	274	62	29.43%	4.0	Yes
3	CI8	HIGH BOND END	169	208	39	23.35%	2.9	Yes
3	CO1		9	0	-9	100.00%	4.3	Yes
3	CO2	WINDSOR LANE	210	260	50	24.02%	3.3	Yes
3	CO3	HIGH STREET	495	326	-169	34.18%	8.4	No
3	CO5	ASH TREE ROAD	33	86	53	162.93%	6.9	Yes
3	CO7	BOROUGHBRIDGE ROAD	321	288	-33	10.31%	1.9	Yes
3	CO8	HIGH BOND END	373	347	-26	6.98%	1.4	Yes
4	DI1	VICTORIA AVENUE	63	59	-4	5.75%	0.5	Yes
4	DI10	CRESCENT GARDENS	46	23	-23	50.52%	4.0	Yes
4	DI11	CRESCENT ROAD	607	586	-21	3.41%	0.8	Yes
4	DI12	COLD BATH ROAD	204	231	27	13.48%	1.9	Yes
4	DI2		24	50	26	109.37%	4.3	Yes
4	DI3	BEECH GROVE	113	144	31	27.79%	2.8	Yes
4	DI5	BOWER ROAD	261	241	-20	7.70%	1.3	Yes
4	DI6	VICTORIA AVENUE	47	36	-11	23.05%	1.7	Yes
4	DI7	MAYFIELD GROVE	52	60	8	15.82%	1.1	Yes
4	DI8	KING'S ROAD	278	213	-65	23.25%	4.1	Yes
4	DI9	RIPON ROAD	435	543	108	24.87%	4.9	No
4	DO1	VICTORIA AVENUE	188	109	-79	41.96%	6.5	Yes
4	DO10	CRESCENT GARDENS	15	0	-15	100.00%	5.6	Yes
4	DO11	ROYAL PARADE	485	412	-73	15.02%	3.4	Yes
4	DO12	COLD BATH ROAD	535	689	154	28.81%	6.2	No
4	DO2	BLATCHINGTON ROAD	27	0	-27	100.00%	7.4	Yes
4	DO3	BEECH GROVE	147	81	-66	44.95%	6.2	Yes
4	DO5	BOWER ROAD	531	291	-240	45.21%	11.8	No
4	DO7	MAYFIELD GROVE	158	84	-74	46.98%	6.8	Yes
4	DO8	KING'S ROAD	200	125	-75	37.40%	5.9	Yes
4	DO9	RIPON ROAD	344	296	-48	13.92%	2.7	Yes
5	EI1	HARROGATE ROAD	457	602	145	31.59%	6.3	No
5	EI11	BERRYGATE LANE	19	0	-19	100.00%	6.1	Yes
5	EI12	GALPHAY LANE	24	35	11	42.98%	1.9	Yes
5	EI13	KNARESBOROUGH ROAD	60	34	-26	43.53%	3.8	Yes
5	EI14	LITTLETHORPE ROAD	27	0	-27	100.00%	7.4	Yes
5	EI15	STUDLEY ROAD	109	118	9	7.80%	0.8	Yes
5	EI2	STUDLEY ROAD	142	148	6	4.21%	0.5	Yes
5	EI3	KIRKBY ROAD	76	68	-8	10.92%	1.0	Yes
5	EI4	PALACE ROAD	242	232	-10	4.01%	0.6	Yes
5	EI5	HUTTON BANK	369	317	-52	13.99%	2.8	Yes
5	EI6	BOROUGHBRIDGE ROAD	320	334	14	4.51%	0.8	Yes
5	EI7	DISHFORTH ROAD	183	242	59	32.19%	4.0	Yes

5	EO1	HARROGATE ROAD	491	632	141	28.72%	6.0	No
5	EO11	BERRYGATE LANE	28	0	-28	100.00%	7.4	Yes
5	EO12	GALPHAY LANE	13	20	7	54.22%	1.7	Yes
5	EO13	KNARESBOROUGH ROAD	54	22	-32	59.17%	5.2	Yes
5	EO14	LITTLETHORPE ROAD	19	0	-19	100.00%	6.1	Yes
5	EO15	STUDLEY ROAD	97	109	12	12.08%	1.2	Yes
5	EO2	STUDLEY ROAD	136	126	-10	7.14%	0.8	Yes
5	EO3	KIRKBY ROAD	68	53	-15	21.53%	1.9	Yes
5	EO4	PALACE ROAD	253	287	34	13.46%	2.1	Yes
5	EO5	HUTTON BANK	406	392	-14	3.42%	0.7	Yes
5	EO6	BOROUGHBRIDGE ROAD	344	373	29	8.52%	1.5	Yes
5	EO7	DISHFORTH ROAD	159	163	4	2.50%	0.3	Yes
6	FI1	BLOSSOMGATE	122	109	-13	10.68%	1.2	Yes
6	FI10	PRIEST LANE	69	16	-53	76.93%	8.2	Yes
6	FI11	STONEBRIDGEGATE	185	275	90	48.73%	5.9	Yes
6	FI12	NORTH STREET	161	173	12	7.52%	0.9	Yes
6	FI2	PARK STREET	235	194	-41	17.32%	2.8	Yes
6	FI3	SKELLBANK	162	183	21	13.29%	1.6	Yes
6	FI4	HARROGATE ROAD	259	270	11	4.12%	0.7	Yes
6	FI5	HECKLER LANE	40	38	-2	5.54%	0.4	Yes
6	FI6	BREWERY LANE	3	0	-3	100.00%	2.5	Yes
6	FI7	BONDGATE	138	127	-11	7.65%	0.9	Yes
6	FI8	BONDGATE GREEN	296	230	-66	22.22%	4.1	Yes
6	FO1	BLOSSOMGATE	181	161	-20	10.90%	1.5	Yes
6	FO10	PRIEST LANE	62	15	-47	75.75%	7.6	Yes
6	FO11	STONEBRIDGEGATE	100	197	97	96.50%	7.9	Yes
6	FO12	NORTH STREET	114	54	-60	52.67%	6.6	Yes
6	FO2	PARK STREET	268	169	-99	36.98%	6.7	Yes
6	FO3	SKELLBANK	128	191	63	49.48%	5.0	Yes
6	FO4	HARROGATE ROAD	201	207	6	3.07%	0.4	Yes
6	FO5	HECKLER LANE	28	72	44	157.99%	6.2	Yes
6	FO6	BREWERY LANE	11	0	-11	100.00%	4.7	Yes
6	FO7	BONDGATE	87	65	-22	25.23%	2.5	Yes
6	FO8	BONDGATE GREEN	341	310	-31	9.10%	1.7	Yes
6	FO9	HIGH ST AGNESGATE	49	34	-15	31.31%	2.4	Yes
7	GI1	BLATCHINGTON ROAD	589	615	26	4.33%	1.0	Yes
7	GI2	STATION ROAD	66	56	-10	15.09%	1.3	Yes
7	GI3	YORK ROAD	480	585	105	21.88%	4.6	No
7	GI4	BLATCHINGTON ROAD	225	96	-129	57.32%	10.2	No
7	GI5	BLATCHINGTON ROAD	71	36	-35	49.27%	4.8	Yes
7	GI6	HIGH STREET	20	50	30	153.73%	5.1	Yes
7	GO1		549	615	66	12.07%	2.7	Yes
7	GO2	STATION ROAD	97	60	-37	37.94%	4.1	Yes
7	GO3	YORK ROAD	537	582	45	8.28%	1.9	Yes
7	GO4		168	97	-71	42.34%	6.2	Yes
7	GO5		76	64	-12	15.45%	1.4	Yes
7	GO6	HIGH STREET	21	26	5	23.93%	1.0	Yes

8	HI1	LEEMING LANE	111	61	-50	45.11%	5.4	Yes
8	HI2	SKELTON ROAD	39	66	27	69.83%	3.7	Yes
8	HI3	ROECLIFFE LANE	110	132	22	19.83%	2.0	Yes
8	HI4	GRAFTON LANE	8	17	9	125.25%	2.7	Yes
8	HI5	BLATCHINGTON ROAD	11	19	8	66.12%	1.9	Yes
8	HI6	HELPERBY LANE	62	31	-31	50.40%	4.6	Yes
8	HI7	BLATCHINGTON ROAD	26	44	18	67.35%	3.0	Yes
8	HO1	LEEMING LANE	130	59	-71	54.49%	7.3	Yes
8	HO2	SKELTON ROAD	25	32	7	26.75%	1.3	Yes
8	HO3	ROECLIFFE LANE	123	183	60	48.30%	4.8	Yes
8	HO4	GRAFTON LANE	6	6	0	3.31%	0.1	Yes
8	HO5		11	17	6	59.02%	1.7	Yes
8	HO6	HELPERBY LANE	42	27	-15	35.32%	2.5	Yes
8	HO7		35	23	-12	35.15%	2.3	Yes
16	PI1	WEST PARK STREET	704	707	3	0.43%	0.1	Yes
16	PI2	SKIPTON ROAD	560	564	4	0.69%	0.2	Yes
16	PO1	STATION PARADE	771	703	-68	8.77%	2.5	Yes
16	PO2	SKIPTON ROAD	586	638	52	8.90%	2.1	Yes

Table 2 – Post PM

Screenline Number	Count Reference	Description	Observed Flow	Modelled Flow	Actual Difference	ABS Perc. Difference	GEH Statistics	DMRB Compliance
1	AI1	SKIPTON ROAD	530	428	-102	19.28%	4.7	No
1	AI10	RIPON ROAD	737	970	233	31.62%	8.0	No
1	AI2	WETHERBY ROAD	637	707	70	11.04%	2.7	Yes
1	AI3	HARROGATE ROAD	608	639	31	5.08%	1.2	Yes
1	AI4	OTLEY ROAD	266	251	-15	5.61%	0.9	Yes
1	AI5	FOREST LANE	205	242	37	18.12%	2.5	Yes
1	AI6	PANNAL ROAD	163	114	-49	30.13%	4.2	Yes
1	AI7	DRURY LANE	65	38	-27	41.11%	3.7	Yes
1	AI8	LANE	16	23	7	46.86%	1.7	Yes
1	AO1	SKIPTON ROAD	518	447	-71	13.64%	3.2	Yes
1	AO10	RIPON ROAD	764	1023	259	33.99%	8.7	No
1	AO2	WETHERBY ROAD	898	888	-10	1.09%	0.3	Yes
1	AO3	HARROGATE ROAD	648	731	83	12.83%	3.2	Yes
1	AO4	OTLEY ROAD	508	523	15	2.95%	0.7	Yes
1	AO5	FOREST LANE	330	334	4	1.25%	0.2	Yes
1	AO6	PANNAL ROAD	220	182	-38	17.19%	2.7	Yes
1	AO7	DRURY LANE	61	0	-61	100.00%	11.1	Yes
1	AO8	BRACKENTHWAITE LANE	29	12	-17	58.20%	3.7	Yes
2	BI1	HARROGATE ROAD	473	557	84	17.87%	3.7	Yes
2	BI2	FOREST MOOR ROAD	517	364	-153	29.65%	7.3	No
2	BI3	RIPLEY ROAD	380	274	-106	27.89%	5.9	No
2	BI4	BOROUGHBRIDGE ROAD	324	295	-29	8.87%	1.6	Yes
2	BI5	YORK ROAD	443	422	-21	4.73%	1.0	Yes

2	BI6	GRIMBALD CRAG WAY	606	535	-71	11.78%	3.0	Yes
2	BI7		409	446	37	9.01%	1.8	Yes
2	BI8	GREENGATE LANE	112	196	84	75.18%	6.8	Yes
2	BI9	GRIMBALD CRAG CLOSE	253	248	-5	2.04%	0.3	Yes
2	BO1	HARROGATE ROAD	442	550	108	24.31%	4.8	No
2	BO2	FOREST MOOR ROAD	562	390	-172	30.63%	7.9	No
2	BO3	RIPLEY ROAD	274	295	21	7.61%	1.2	Yes
2	BO4	BOROUGHBRIDGE ROAD	335	262	-73	21.77%	4.2	Yes
2	BO5	YORK ROAD	353	323	-30	8.55%	1.6	Yes
2	BO6	GRIMBALD CRAG WAY	460	455	-5	1.12%	0.2	Yes
2	BO7	BLATCHINGTON ROAD	179	105	-74	41.50%	6.2	Yes
2	BO8	GREENGATE LANE	70	77	7	10.33%	0.8	Yes
2	BO9	GRIMBALD CRAG CLOSE	46	86	40	87.34%	4.9	Yes
3	CI1		13	0	-13	100.00%	5.2	Yes
3	CI2	WINDSOR LANE	214	168	-46	21.54%	3.3	Yes
3	CI3	HIGH STREET	475	520	45	9.36%	2.0	Yes
3	CI5	ASH TREE ROAD	32	51	19	60.57%	3.0	Yes
3	CI7	BOROUGHBRIDGE ROAD	314	292	-22	7.05%	1.3	Yes
3	CI8	HIGH BOND END	368	288	-80	21.77%	4.4	Yes
3	CO1		19	0	-19	100.00%	6.1	Yes
3	CO2	WINDSOR LANE	192	276	84	43.58%	5.5	Yes
3	CO3	HIGH STREET	555	397	-158	28.52%	7.3	No
3	CO5	ASH TREE ROAD	21	18	-3	15.94%	0.8	Yes
3	CO7	BOROUGHBRIDGE ROAD	295	276	-19	6.42%	1.1	Yes
3	CO8	HIGH BOND END	279	312	33	11.70%	1.9	Yes
4	DI1	VICTORIA AVENUE	110	121	11	10.37%	1.1	Yes
4	DI10	CRESCENT GARDENS	35	3	-32	91.44%	7.3	Yes
4	DI11	CRESCENT ROAD	603	631	28	4.69%	1.1	Yes
4	DI12	COLD BATH ROAD	264	337	73	27.53%	4.2	Yes
4	DI2		35	72	37	108.63%	5.1	Yes
4	DI3	BEECH GROVE	81	127	46	57.37%	4.5	Yes
4	DI5	BOWER ROAD	546	347	-199	36.50%	9.4	No
4	DI6	VICTORIA AVENUE	78	155	77	97.60%	7.1	Yes
4	DI7	MAYFIELD GROVE	182	154	-28	15.59%	2.2	Yes
4	DI8	KING'S ROAD	265	201	-64	24.03%	4.2	Yes
4	DI9	RIPON ROAD	453	409	-44	9.74%	2.1	Yes
4	DO1	VICTORIA AVENUE	181	127	-54	29.70%	4.3	Yes
4	DO10	CRESCENT GARDENS	23	0	-23	100.00%	6.8	Yes
4	DO11	ROYAL PARADE	667	633	-34	5.14%	1.3	Yes
4	DO12	COLD BATH ROAD	488	510	22	4.46%	1.0	Yes
4	DO2	BLATCHINGTON ROAD	47	14	-33	69.89%	5.9	Yes
4	DO3	BEECH GROVE	157	120	-37	23.67%	3.2	Yes
4	DO5	BOWER ROAD	357	331	-26	7.39%	1.4	Yes

4	DO7	MAYFIELD GROVE	160	82	-78	48.59%	7.1	Yes
4	DO8	KING'S ROAD	352	260	-92	26.19%	5.3	Yes
4	DO9	RIPON ROAD	603	587	-16	2.63%	0.7	Yes
5	EI1	HARROGATE ROAD	554	699	145	26.07%	5.8	No
5	EI11	BERRYGATE LANE	13	0	-13	100.00%	5.1	Yes
5	EI12	GALPHAY LANE	16	22	6	39.00%	1.4	Yes
5	EI13	KNARESBOROUGH ROAD	57	47	-10	18.04%	1.4	Yes
5	EI14	LITTLETHORPE ROAD	19	2	-17	89.59%	5.3	Yes
5	EI15	STUDLEY ROAD	135	141	6	4.73%	0.5	Yes
5	EI2	STUDLEY ROAD	170	161	-9	5.29%	0.7	Yes
5	EI3	KIRKBY ROAD	72	55	-17	23.43%	2.1	Yes
5	EI4	PALACE ROAD	317	227	-90	28.34%	5.4	Yes
5	EI5	HUTTON BANK	479	531	52	10.94%	2.3	Yes
5	EI6	BOROUGHBRIDGE ROAD	435	465	30	6.92%	1.4	Yes
5	EI7	DISHFORTH ROAD	183	229	46	25.33%	3.2	Yes
5	EO1	HARROGATE ROAD	564	751	187	33.20%	7.3	No
5	EO11	BERRYGATE LANE	15	0	-15	100.00%	5.4	Yes
5	EO12	GALPHAY LANE	30	27	-3	9.01%	0.5	Yes
5	EO13	KNARESBOROUGH ROAD	60	16	-44	73.52%	7.2	Yes
5	EO14	LITTLETHORPE ROAD	24	0	-24	100.00%	6.9	Yes
5	EO15	STUDLEY ROAD	126	116	-10	8.26%	0.9	Yes
5	EO2	STUDLEY ROAD	173	140	-33	18.88%	2.6	Yes
5	EO3	KIRKBY ROAD	87	96	9	9.91%	0.9	Yes
5	EO4	PALACE ROAD	266	306	40	15.12%	2.4	Yes
5	EO5	HUTTON BANK	433	403	-30	6.98%	1.5	Yes
5	EO6	BOROUGHBRIDGE ROAD	332	355	23	7.08%	1.3	Yes
5	EO7	DISHFORTH ROAD	190	202	12	6.07%	0.8	Yes
6	FI1	BLOSSOMGATE	91	90	-1	0.61%	0.1	Yes
6	FI10	PRIEST LANE	65	48	-17	26.28%	2.3	Yes
6	FI11	STONEBRIDGEGAT E	174	193	19	10.61%	1.4	Yes
6	FI12	NORTH STREET	219	247	28	13.03%	1.9	Yes
6	FI2	PARK STREET	219	182	-37	17.06%	2.6	Yes
6	FI3	SKELLBANK	159	168	9	5.47%	0.7	Yes
6	FI4	HARROGATE ROAD	297	295	-2	0.78%	0.1	Yes
6	FI5	HECKLER LANE	50	57	7	13.86%	0.9	Yes
6	FI6	BREWERY LANE	3	0	-3	100.00%	2.6	Yes
6	FI7	BONDGATE	137	107	-30	22.07%	2.7	Yes
6	FI8	BONDGATE GREEN	390	326	-64	16.37%	3.4	Yes
6	FO1	BLOSSOMGATE	252	241	-11	4.55%	0.7	Yes
6	FO10	PRIEST LANE	70	51	-19	27.23%	2.5	Yes
6	FO11	STONEBRIDGEGAT E	174	238	64	37.09%	4.5	Yes
6	FO12	NORTH STREET	185	93	-92	49.71%	7.8	Yes
6	FO2	PARK STREET	288	175	-113	39.33%	7.5	No
6	FO3	SKELLBANK	159	246	87	54.52%	6.1	Yes
6	FO4	HARROGATE ROAD	292	348	56	19.03%	3.1	Yes
6	FO5	HECKLER LANE	50	80	30	58.97%	3.7	Yes

6	FO6	BREWERY LANE	23	0	-23	100.00%	6.7	Yes
6	FO7	BONDGATE	192	92	-100	52.15%	8.4	No
6	FO8	BONDGATE GREEN	339	331	-8	2.44%	0.5	Yes
6	FO9	HIGH ST AGNESGATE	63	37	-26	41.46%	3.7	Yes
7	GI1	BLATCHINGTON ROAD	710	757	47	6.63%	1.7	Yes
7	GI2	STATION ROAD	103	79	-24	23.50%	2.5	Yes
7	GI3	YORK ROAD	640	634	-6	0.89%	0.2	Yes
7	GI4	BLATCHINGTON ROAD	187	135	-52	28.00%	4.1	Yes
7	GI5	BLATCHINGTON ROAD	88	59	-29	33.10%	3.4	Yes
7	GI6	HIGH STREET	18	52	34	184.99%	5.7	Yes
7	GO1		714	694	-20	2.79%	0.8	Yes
7	GO2	STATION ROAD	85	74	-11	12.82%	1.2	Yes
7	GO3	YORK ROAD	624	737	113	18.01%	4.3	No
7	GO4		253	131	-122	48.20%	8.8	No
7	GO5		92	78	-14	15.36%	1.5	Yes
7	GO6	HIGH STREET	23	30	7	27.99%	1.3	Yes
8	HI1	LEEMING LANE	159	95	-64	40.34%	5.7	Yes
8	HI2	SKELTON ROAD	34	64	30	88.72%	4.3	Yes
8	HI3	ROECLIFFE LANE	127	143	16	12.25%	1.3	Yes
8	HI4	GRAFTON LANE	9	17	8	83.04%	2.1	Yes
8	HI5	BLATCHINGTON ROAD	13	45	32	255.48%	6.0	Yes
8	HI6	HELPERBY LANE	54	26	-28	51.92%	4.4	Yes
8	HI7	BLATCHINGTON ROAD	44	63	19	44.49%	2.7	Yes
8	HO1	LEEMING LANE	127	60	-67	52.58%	6.9	Yes
8	HO2	SKELTON ROAD	31	45	14	45.46%	2.3	Yes
8	HO3	ROECLIFFE LANE	119	169	50	42.11%	4.2	Yes
8	HO4	GRAFTON LANE	8	15	7	94.26%	2.2	Yes
8	HO5		14	39	25	170.75%	4.8	Yes
8	HO6	HELPERBY LANE	72	36	-36	49.87%	4.9	Yes
8	HO7		36	45	9	25.73%	1.4	Yes
16	PI1	WEST PARK STREET	954	878	-76	7.97%	2.5	Yes
16	PI2	SKIPTON ROAD	624	642	18	2.85%	0.7	Yes
16	PO1	STATION PARADE	997	934	-63	6.29%	2.0	Yes
16	PO2	SKIPTON ROAD	649	725	76	11.69%	2.9	Yes

Appendix E Individual Link Validation

Table 1 – Post AM

Screenline Number	Count Reference	Description	Observed Flow	Modelled Flow	Actual Difference	ABS Perc. Difference	GEH Statistics	DMRB Compliance
9	II10		276	313	37	13.31%	2.1	Yes
9	II2	DISHFORTH ROAD	166	245	79	47.91%	5.5	Yes
9	II3		868	629	-239	27.50%	8.7	No
9	II4	MARTON LANE	52	14	-38	73.31%	6.7	Yes
9	II5	ALDBOROUGH GATE	139	212	73	52.21%	5.5	Yes
9	II6		135	27	-108	79.99%	12.0	No
9	II7	BAR LANE	106	29	-77	72.70%	9.4	Yes
9	II8		16	59	43	268.74%	7.0	Yes
9	II9	MOOR LANE	4	16	12	344.52%	4.0	Yes
9	IO10		279	321	42	15.04%	2.4	Yes
9	IO2	DISHFORTH ROAD	150	169	19	12.61%	1.5	Yes
9	IO3	BLATCHINGTON ROAD	769	704	-65	8.42%	2.4	Yes
9	IO4	MARTON LANE	53	29	-24	45.58%	3.8	Yes
9	IO5	ALDBOROUGH GATE	156	152	-4	2.69%	0.3	Yes
9	IO6	BLATCHINGTON ROAD	94	20	-74	78.69%	9.8	Yes
9	IO7	BAR LANE	67	11	-56	83.50%	8.9	Yes
9	IO8		21	81	60	286.98%	8.4	Yes
9	IO9	MOOR LANE	3	27	24	676.13%	6.0	Yes
10	JI1	HARROGATE ROAD	255	278	23	9.10%	1.4	Yes
10	JI2	SOUTHGATE	36	43	7	20.92%	1.2	Yes
10	JI3	BONDGATE	137	127	-10	7.48%	0.9	Yes
10	JI4	BONDGATE GREEN LANE	54	67	13	24.43%	1.7	Yes
10	JI5	BONDGATE GREEN	230	188	-42	18.33%	2.9	Yes
10	JI6	PRIEST LANE	4	36	32	700.13%	7.0	Yes
10	JO1	HARROGATE ROAD	209	215	6	3.03%	0.4	Yes
10	JO2	SOUTHGATE	48	101	53	108.28%	6.1	Yes
10	JO3	BONDGATE	78	53	-25	32.37%	3.1	Yes
10	JO4	BONDGATE GREEN LANE	58	12	-46	79.24%	7.8	Yes
10	JO5	BONDGATE GREEN	264	325	61	22.97%	3.5	Yes
10	JO6	PRIEST LANE	6	19	13	228.98%	3.8	Yes
11	KI1	PARK STREET	274	283	9	3.12%	0.5	Yes
11	KI2	KIRKBY ROAD	83	129	46	55.96%	4.5	Yes
11	KI3	COLLEGE ROAD	124	25	-99	79.85%	11.5	Yes
11	KO1	PARK STREET	274	170	-104	38.07%	7.0	No
11	KO2	KIRKBY ROAD	101	165	64	63.85%	5.6	Yes
11	KO3	COLLEGE ROAD	20	0	-20	100.00%	6.4	Yes
12	LI1	NORTH STREET	367	124	-243	66.20%	15.5	No
12	LI2	PRINCESS ROAD	72	166	94	130.21%	8.6	Yes
12	LI3	MAGDALEN'S ROAD	26	11	-15	57.32%	3.4	Yes

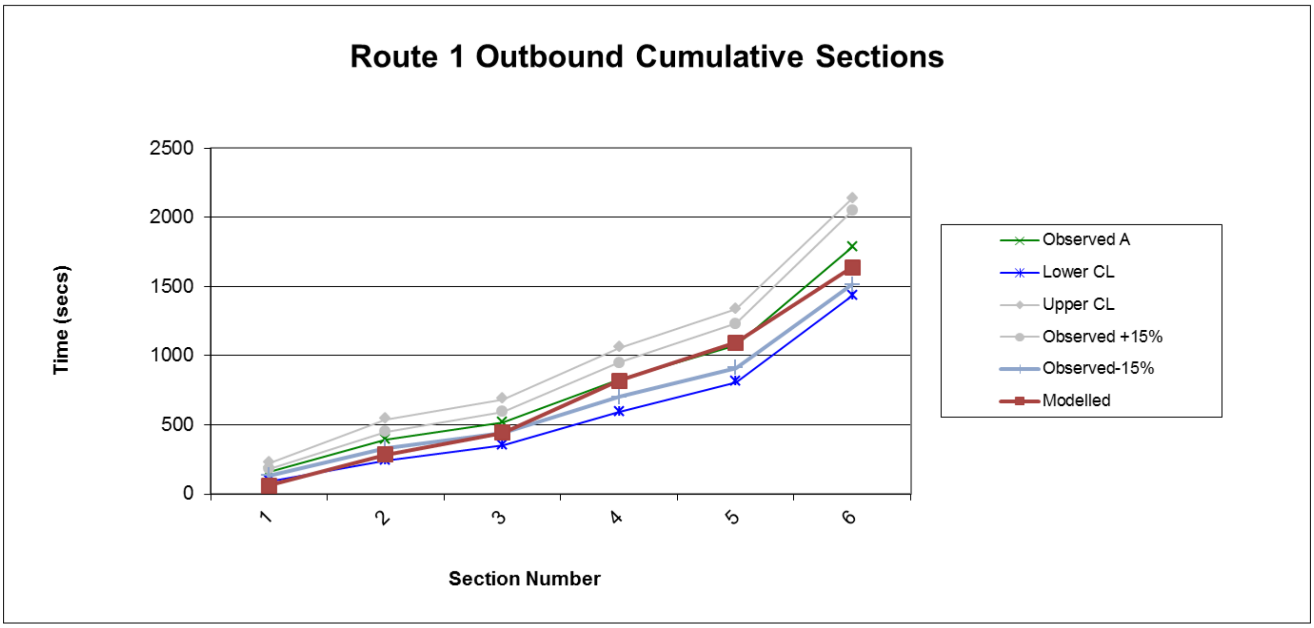
12	LO1	NORTH STREET	318	226	-92	29.02%	5.6	Yes
12	LO3	MAGDALEN'S ROAD	52	129	77	147.10%	8.1	Yes
13	MI1	STRAY REIN	17	0	-17	100.00%	5.8	Yes
13	MI2	OATLANDS DRIVE	260	74	-186	71.51%	14.4	No
13	MI3	PANNAL ASH ROAD	200	168	-32	15.94%	2.3	Yes
13	MI4	ARTHURS AVENUE	164	24	-140	85.35%	14.4	No
13	MI5	WEST END AVENUE	68	19	-49	72.25%	7.5	Yes
13	MI6	LEEDS ROAD	616	544	-72	11.74%	3.0	Yes
13	MI7	WETHERBY ROAD	576	411	-165	28.59%	7.4	No
13	MO7	WETHERBY ROAD	593	433	-160	27.03%	7.1	No
13	MI8	KNARESBOROUGH ROAD	623	576	-47	7.56%	1.9	Yes
13	MI9	BECKWITH ROAD	252	167	-85	33.68%	5.9	Yes
13	MO1	STRAY REIN	58	24	-34	58.70%	5.3	Yes
13	MO2	OATLANDS DRIVE	429	378	-51	11.89%	2.5	Yes
13	MO3	PANNAL ASH ROAD	265	301	36	13.74%	2.2	Yes
13	MO4	ARTHURS AVENUE	200	37	-163	81.49%	15.0	No
13	MO5	WEST END AVENUE	65	107	42	63.36%	4.5	Yes
13	MO6	LEEDS ROAD	594	505	-89	15.03%	3.8	Yes
13	MO8	KNARESBOROUGH ROAD	572	937	365	63.87%	13.3	No
13	MO9	BECKWITH ROAD	274	143	-131	47.72%	9.0	No
14	NI1	KING'S ROAD	509	413	-96	18.82%	4.5	Yes
14	NI2	FRANKLIN ROAD	85	12	-73	85.83%	10.5	Yes
14	NI3	CORNWALL ROAD	471	200	-271	57.53%	14.8	No
14	NI4	HEREFORD ROAD	95	99	4	3.80%	0.4	Yes
14	NI5	YORK ROAD	74	45	-29	39.18%	3.8	Yes
14	NI6	CLARENCE DRIVE	105	41	-64	61.11%	7.5	Yes
14	NO1	KING'S ROAD	189	188	-1	0.58%	0.1	Yes
14	NO2	FRANKLIN ROAD	23	0	-23	100.00%	6.7	Yes
14	NO3	CORNWALL ROAD	197	59	-138	70.11%	12.2	No
14	NO4	HEREFORD ROAD	55	58	3	6.26%	0.5	Yes
14	NO5	YORK ROAD	93	48	-45	48.18%	5.3	Yes
14	NO6	CLARENCE DRIVE	86	2	-84	97.68%	12.7	Yes
15	OI1	ABBEY ROAD	5	0	-5	100.00%	3.2	Yes
15	OI2	ASPIN LANE	129	60	-69	53.64%	7.1	Yes
15	OI3	ASPIN PARK DRIVE	105	109	4	3.44%	0.4	Yes
15	OI4	YORK ROAD	174	349	175	101.04%	10.9	No
15	OI5	STOCKWELL LANE	90	24	-66	73.46%	8.8	Yes
15	OI6	STOCKWELL DRIVE	47	8	-39	82.94%	7.4	Yes
15	OI7	BLIND LANE	11	29	18	156.92%	3.9	Yes
15	OI8	BOROUGHBRIDGE ROAD	348	305	-43	12.43%	2.4	Yes
15	OO1	ABBEY ROAD	9	0	-9	100.00%	4.4	Yes
15	OO2	ASPIN LANE	78	31	-47	60.07%	6.3	Yes
15	OO3	ASPIN PARK DRIVE	73	32	-41	56.45%	5.7	Yes
15	OO4	YORK ROAD	148	317	169	114.23%	11.1	No
15	OO5	STOCKWELL LANE	103	76	-27	26.47%	2.9	Yes
15	OO6	STOCKWELL DRIVE	35	7	-28	79.93%	6.1	Yes
15	OO7	BLIND LANE	12	18	6	46.75%	1.5	Yes
15	OO8	BOROUGHBRIDGE ROAD	241	272	31	12.80%	1.9	Yes

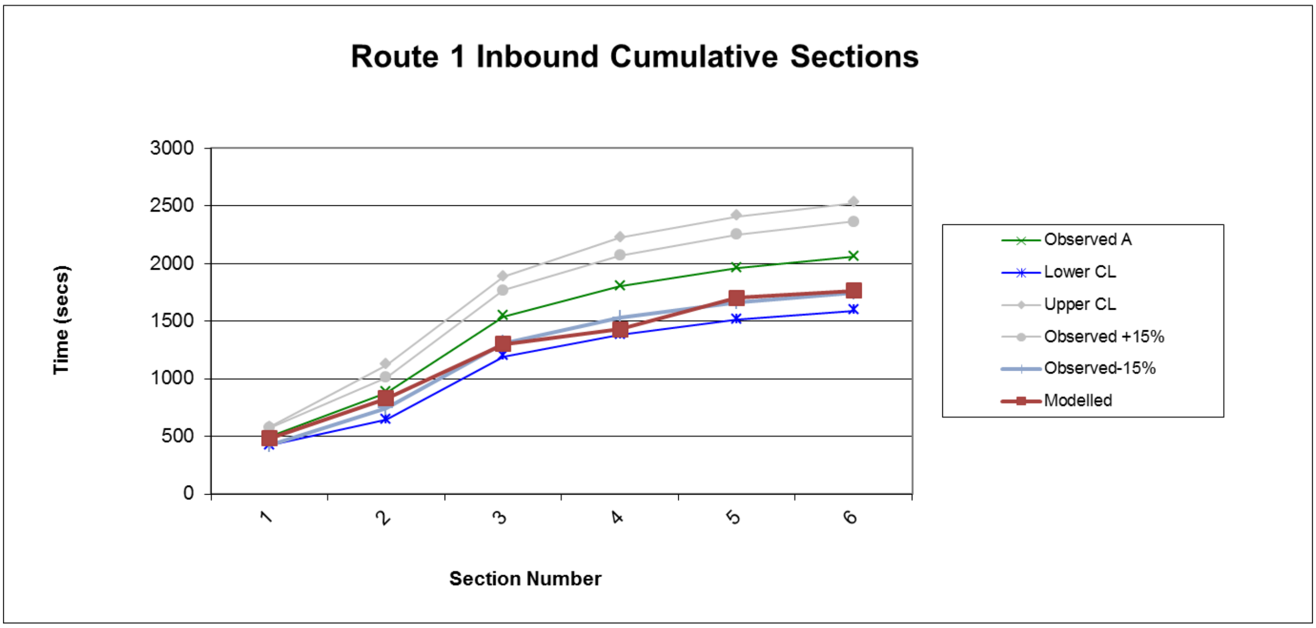
Table 2 – Post PM

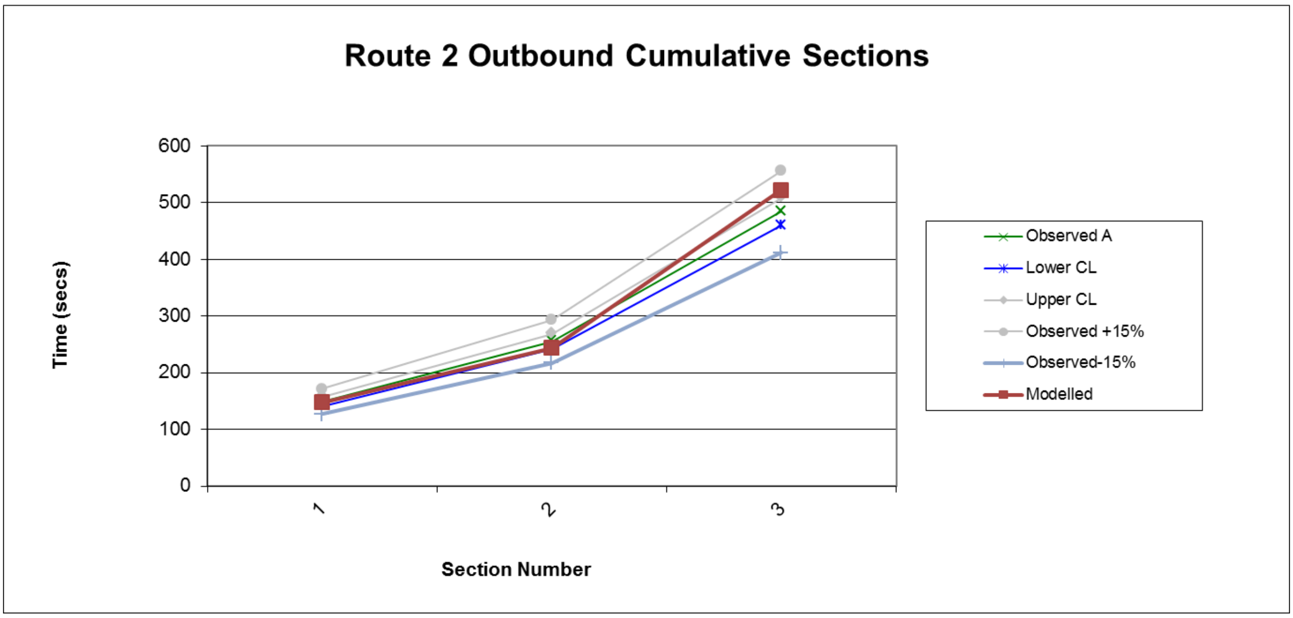
Screenline Number	Count Reference	Description	Observed Flow	Modelled Flow	Actual Difference	ABS Perc. Difference	GEH Statistics	DMRB Compliance
9	II10		344	431	87	25.34%	4.4	Yes
9	II2	DISHFORTH ROAD	176	236	60	34.45%	4.2	Yes
9	II3		891	833	-58	6.51%	2.0	Yes
9	II4	MARTON LANE	63	20	-43	68.23%	6.7	Yes
9	II5	ALDBOROUGH GATE	195	199	4	2.30%	0.3	Yes
9	II6		167	10	-157	94.00%	16.7	No
9	II7	BAR LANE	82	30	-52	63.54%	7.0	Yes
9	II8		20	61	41	201.85%	6.4	Yes
9	II9	MOOR LANE	5	17	12	269.86%	3.8	Yes
9	IO10		294	342	48	16.33%	2.7	Yes
9	IO2	DISHFORTH ROAD	182	205	23	12.71%	1.7	Yes
9	IO3	BLATCHINGTON ROAD	1068	808	-260	24.36%	8.5	No
9	IO4	MARTON LANE	52	56	4	7.77%	0.5	Yes
9	IO5	ALDBOROUGH GATE	171	179	8	4.52%	0.6	Yes
9	IO6	BLATCHINGTON ROAD	162	29	-133	82.12%	13.6	No
9	IO7	BAR LANE	105	24	-81	77.13%	10.1	Yes
9	IO8		22	83	61	282.07%	8.5	Yes
9	IO9	MOOR LANE	5	15	10	200.00%	3.2	Yes
10	JI1	HARROGATE ROAD	300	308	8	2.57%	0.4	Yes
10	JI2	SOUTHGATE	48	91	43	89.59%	5.2	Yes
10	JI3	BONDGATE	142	112	-30	20.99%	2.6	Yes
10	JI4	BONDGATE GREEN LANE	61	55	-6	10.22%	0.8	Yes
10	JI5	BONDGATE GREEN	320	322	2	0.67%	0.1	Yes
10	JI6	PRIEST LANE	7	69	62	953.36%	10.2	Yes
10	JO1	HARROGATE ROAD	293	377	84	28.56%	4.6	Yes
10	JO2	SOUTHGATE	65	115	50	77.66%	5.3	Yes
10	JO3	BONDGATE	173	74	-99	57.23%	8.9	Yes
10	JO4	BONDGATE GREEN LANE	67	44	-23	34.15%	3.1	Yes
10	JO5	BONDGATE GREEN	276	339	63	22.74%	3.6	Yes
10	JO6	PRIEST LANE	7	21	14	204.89%	3.8	Yes
11	KI1	PARK STREET	220	281	61	27.85%	3.9	Yes
11	KI2	KIRKBY ROAD	64	109	45	70.15%	4.8	Yes
11	KI3	COLLEGE ROAD	81	31	-50	61.49%	6.6	Yes
11	KO1	PARK STREET	294	177	-117	39.70%	7.6	No
11	KO2	KIRKBY ROAD	168	247	79	47.46%	5.5	Yes
11	KO3	COLLEGE ROAD	46	0	-46	100.00%	9.6	Yes
12	LI1	NORTH STREET	415	170	-245	59.07%	14.3	No
12	LI2	PRINCESS ROAD	91	111	20	21.54%	2.0	Yes
12	LI3	MAGDALEN'S ROAD	27	120	93	337.08%	10.8	Yes
12	LO1	NORTH STREET	401	275	-126	31.46%	6.9	No
12	LO3	MAGDALEN'S ROAD	78	134	56	72.49%	5.5	Yes
13	MI1	STRAY REIN	33	0	-33	100.00%	8.1	Yes

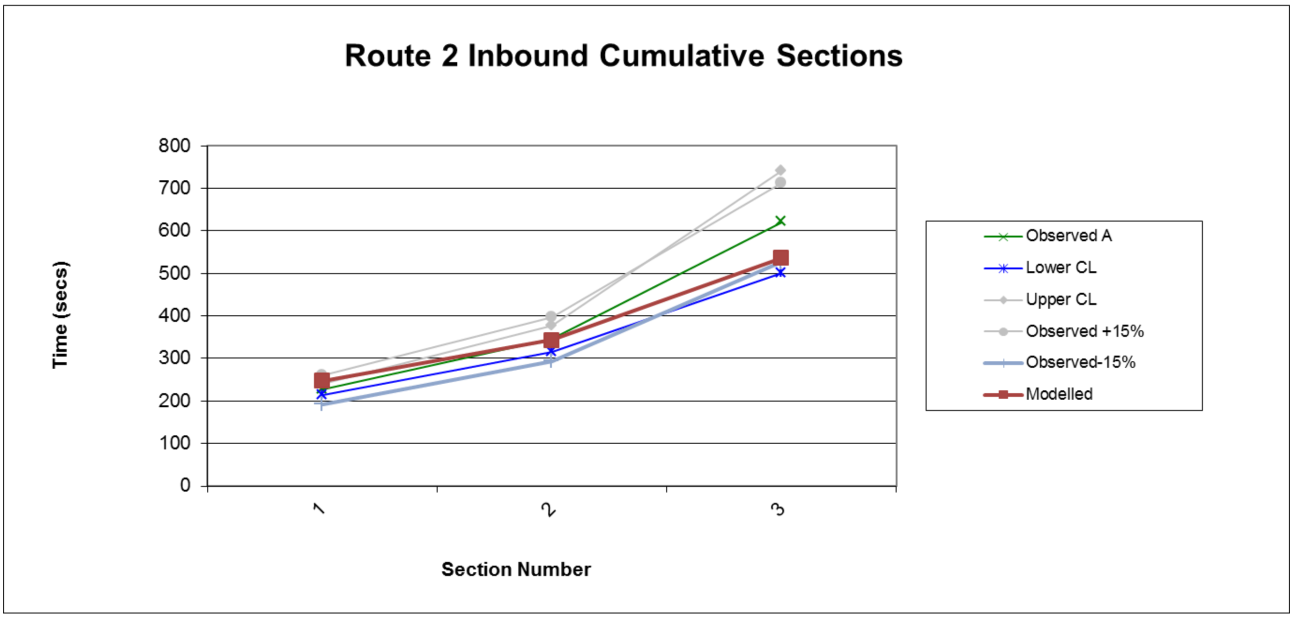
13	MI2	OATLANDS DRIVE	340	169	-171	50.35%	10.7	No
13	MI3	PANNAL ASH ROAD	232	229	-3	1.13%	0.2	Yes
13	MI4	ARTHURS AVENUE	94	77	-17	18.12%	1.8	Yes
13	MI5	WEST END AVENUE	52	72	20	38.48%	2.5	Yes
13	MI6	LEEDS ROAD	642	726	84	13.14%	3.2	Yes
13	MI7	WETHERBY ROAD	607	505	-102	16.74%	4.3	No
13	MO7	WETHERBY ROAD	641	558	-83	12.89%	3.4	Yes
13	MI8	KNARESBOROUGH ROAD	718	579	-139	19.36%	5.5	No
13	MI9	BECKWITH ROAD	195	251	56	28.96%	3.8	Yes
13	MO1	STRAY REIN	46	116	70	154.75%	7.8	Yes
13	MO2	OATLANDS DRIVE	456	212	-244	53.55%	13.4	No
13	MO3	PANNAL ASH ROAD	304	211	-93	30.65%	5.8	Yes
13	MO4	ARTHURS AVENUE	110	31	-79	71.91%	9.4	Yes
13	MO5	WEST END AVENUE	86	20	-66	76.69%	9.0	Yes
13	MO6	LEEDS ROAD	560	534	-26	4.67%	1.1	Yes
13	MO8	KNARESBOROUGH ROAD	796	727	-69	8.70%	2.5	Yes
13	MO9	BECKWITH ROAD	314	144	-170	54.12%	11.2	No
14	NI1	KING'S ROAD	312	265	-47	15.10%	2.8	Yes
14	NI2	FRANKLIN ROAD	19	0	-19	100.00%	6.2	Yes
14	NI3	CORNWALL ROAD	279	158	-121	43.38%	8.2	No
14	NI4	HEREFORD ROAD	50	142	92	186.13%	9.4	Yes
14	NI5	YORK ROAD	83	60	-23	27.98%	2.8	Yes
14	NI6	CLARENCE DRIVE	67	59	-8	12.09%	1.0	Yes
14	NO1	KING'S ROAD	476	390	-86	18.12%	4.1	Yes
14	NO2	FRANKLIN ROAD	63	0	-63	100.00%	11.3	Yes
14	NO3	CORNWALL ROAD	346	256	-90	25.94%	5.2	Yes
14	NO4	HEREFORD ROAD	59	31	-28	47.39%	4.2	Yes
14	NO5	YORK ROAD	57	98	41	71.28%	4.6	Yes
14	NO6	CLARENCE DRIVE	101	11	-90	89.15%	12.1	Yes
15	OI1	ABBEY ROAD	12	0	-12	100.00%	5.0	Yes
15	OI2	ASPIN LANE	139	77	-62	44.61%	6.0	Yes
15	OI3	ASPIN PARK DRIVE	60	60	0	0.68%	0.1	Yes
15	OI4	YORK ROAD	178	434	256	144.03%	14.6	No
15	OI5	STOCKWELL LANE	107	47	-60	56.26%	6.9	Yes
15	OI6	STOCKWELL DRIVE	41	19	-22	53.32%	4.0	Yes
15	OI7	BLIND LANE	18	23	5	25.66%	1.0	Yes
15	OI8	BOROUGHBRIDGE ROAD	320	283	-37	11.54%	2.1	Yes
15	OO1	ABBEY ROAD	9	0	-9	100.00%	4.3	Yes
15	OO2	ASPIN LANE	131	113	-18	13.95%	1.7	Yes
15	OO3	ASPIN PARK DRIVE	69	78	9	13.38%	1.1	Yes
15	OO4	YORK ROAD	190	345	155	81.21%	9.5	No
15	OO5	STOCKWELL LANE	80	96	16	19.71%	1.7	Yes
15	OO6	STOCKWELL DRIVE	57	17	-40	70.24%	6.6	Yes
15	OO7	BLIND LANE	11	27	16	150.26%	3.7	Yes
15	OO8	BOROUGHBRIDGE ROAD	344	277	-67	19.52%	3.8	Yes

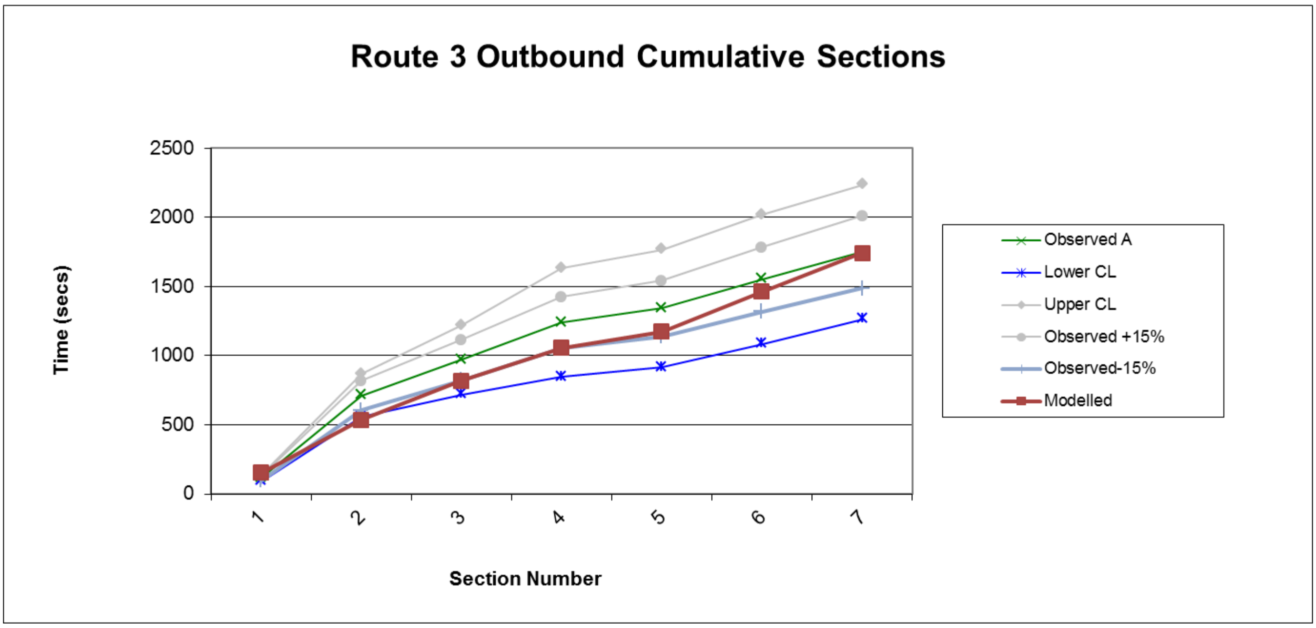
Appendix F – Individual Journey Time Graphs AM

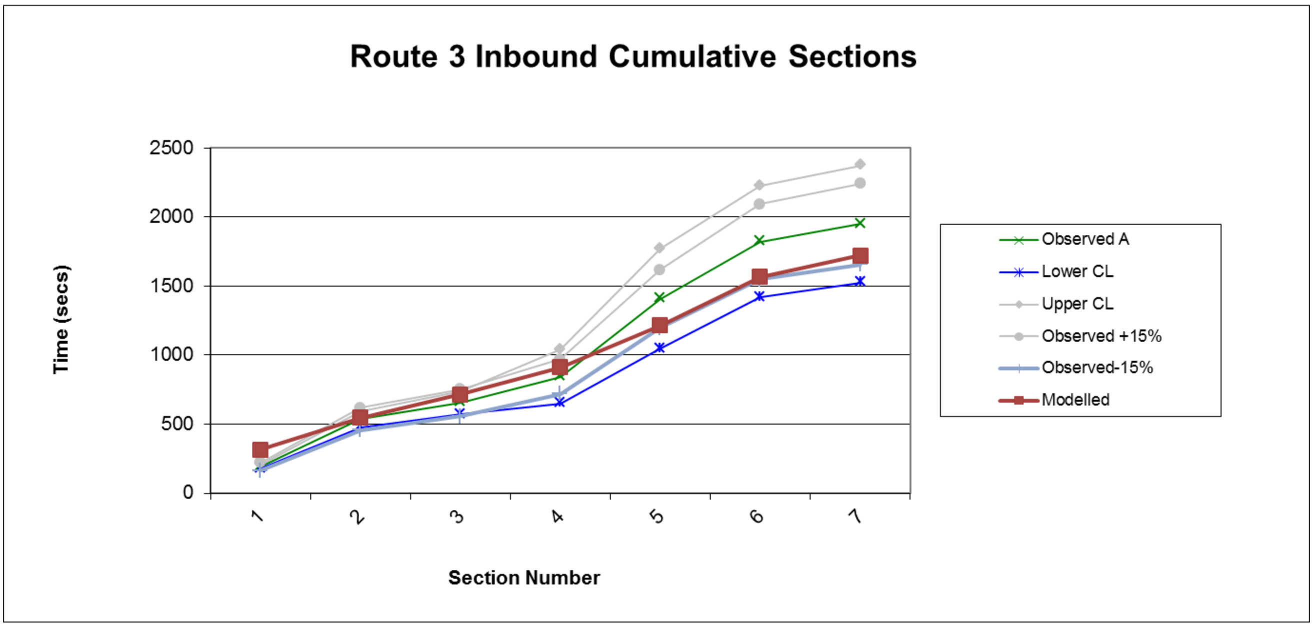


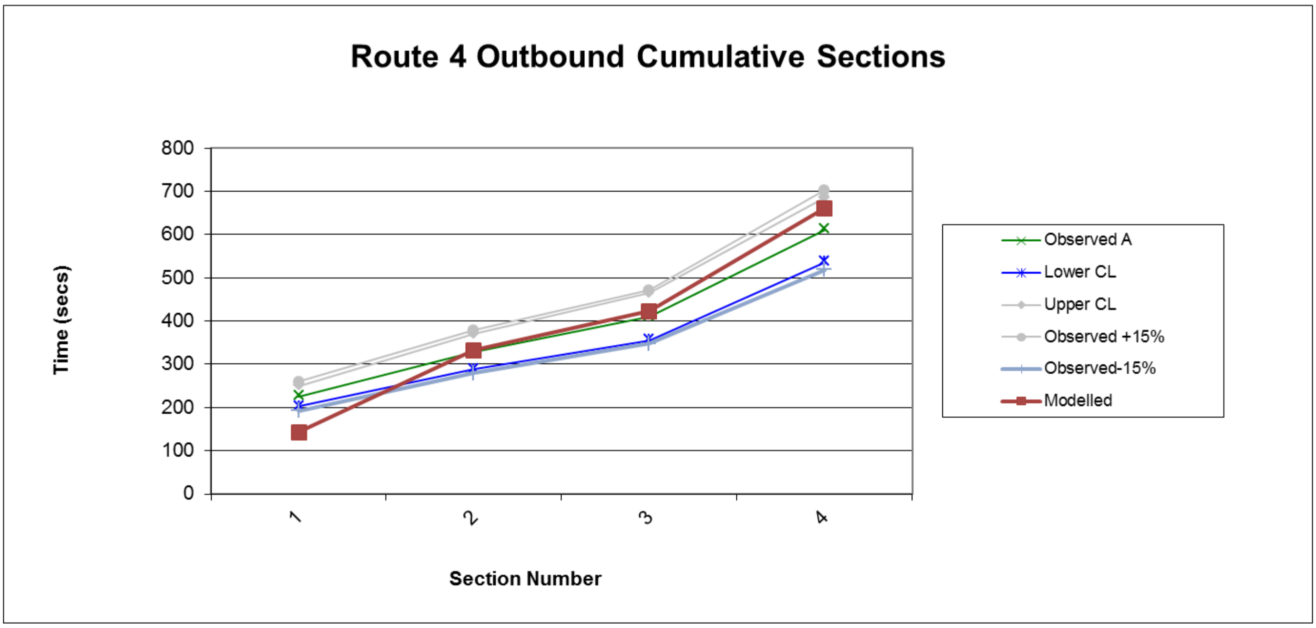


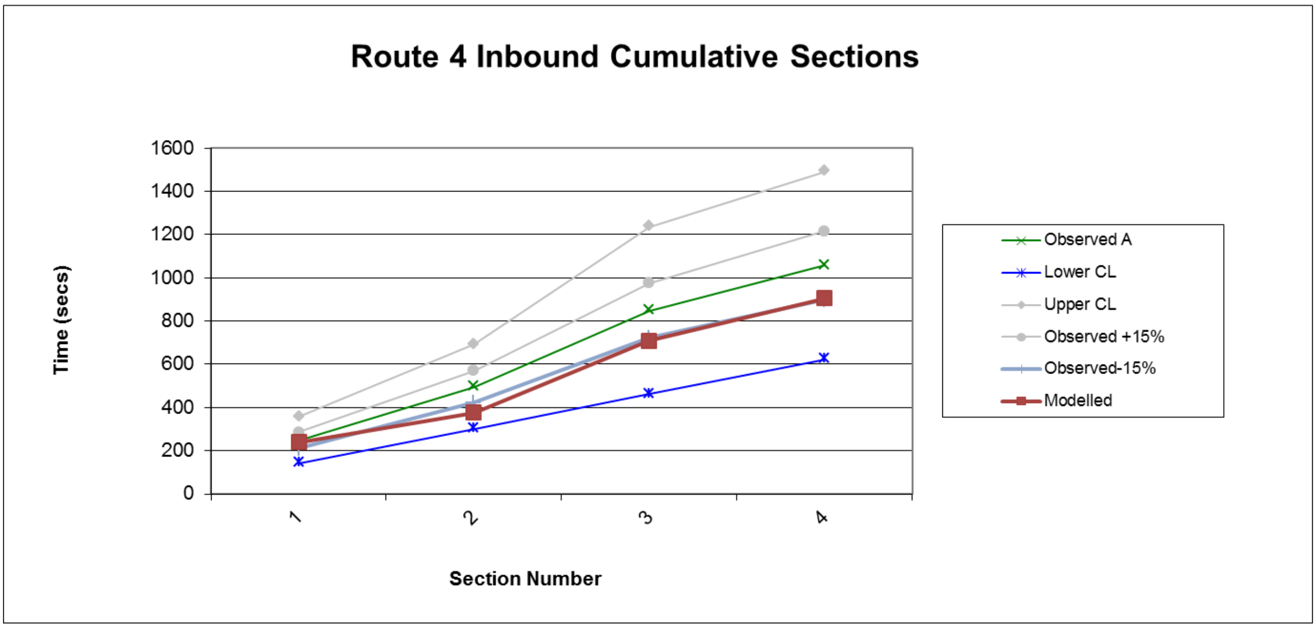

Route 2 Outbound Cumulative Sections
Time (secs)
600
500
400
300
200
100
0
1
2
3
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

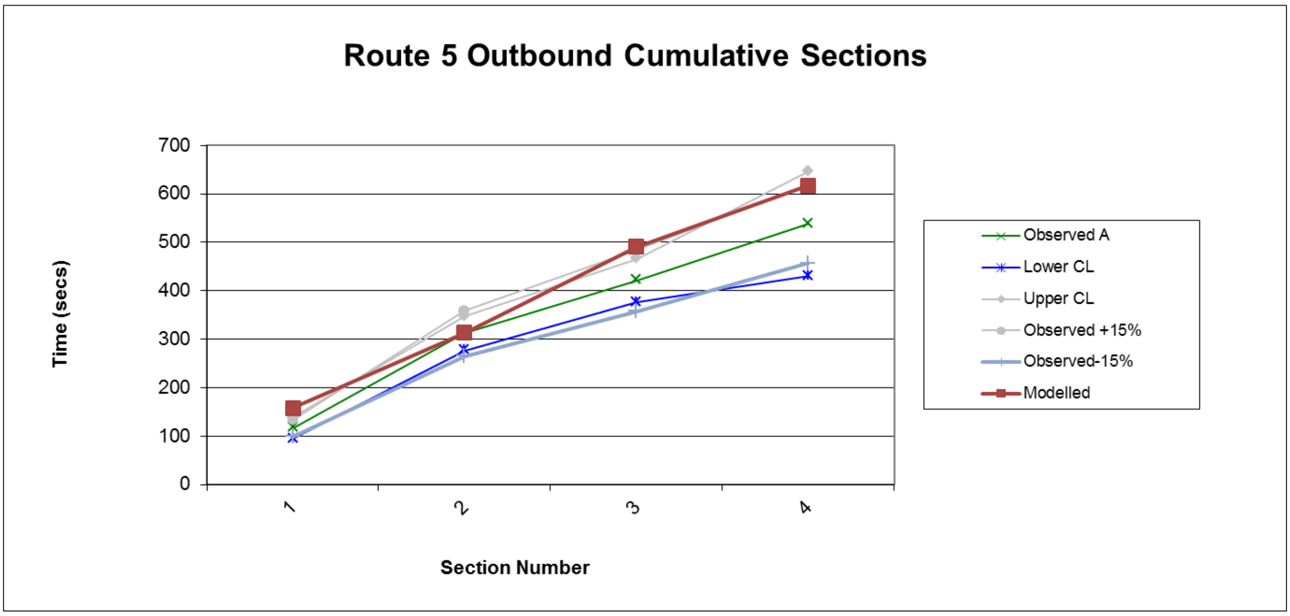

Route 2 Inbound Cumulative Sections
Time (secs)
800
700
600
500
400
300
200
100
0
1
2
3
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

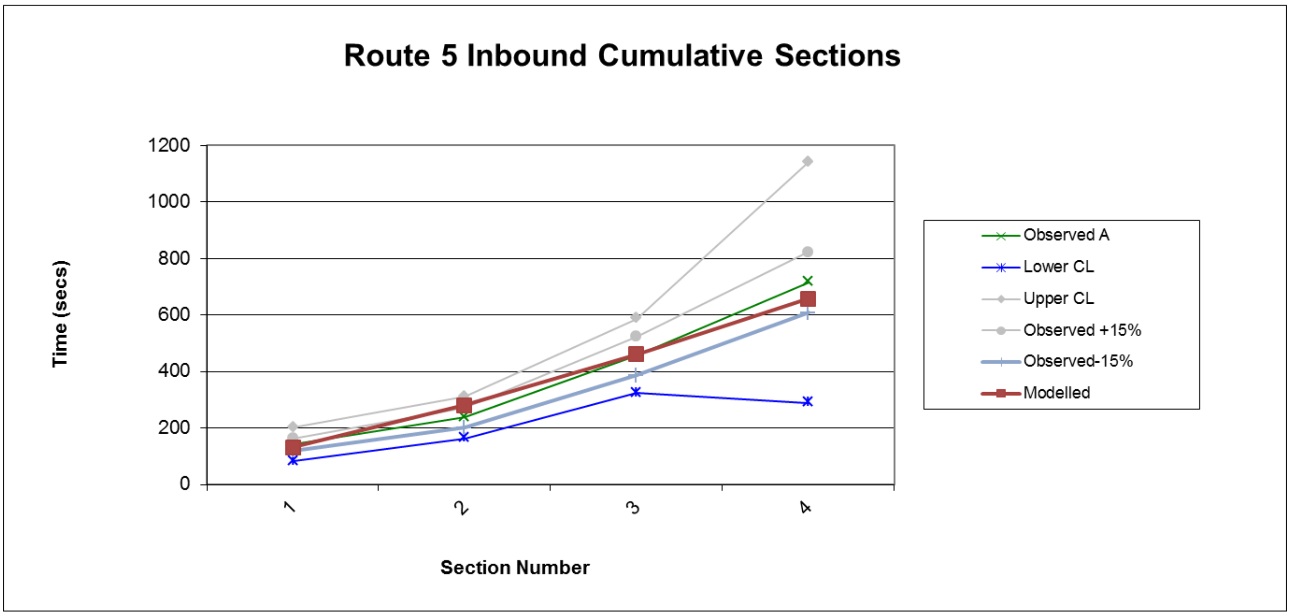

Route 3 Outbound Cumulative Sections
2500
2000
1500
1000
500
0
Time (secs)
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

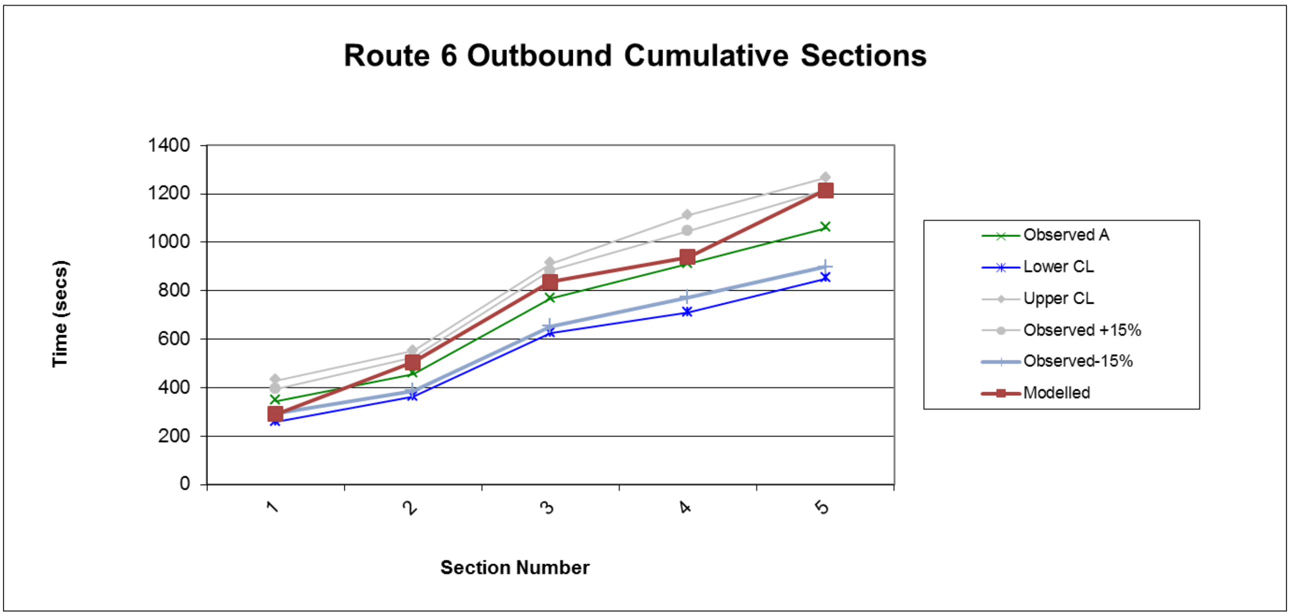

Route 3 Inbound Cumulative Sections
2500
2000
1500
1000
500
0
Time (secs)
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

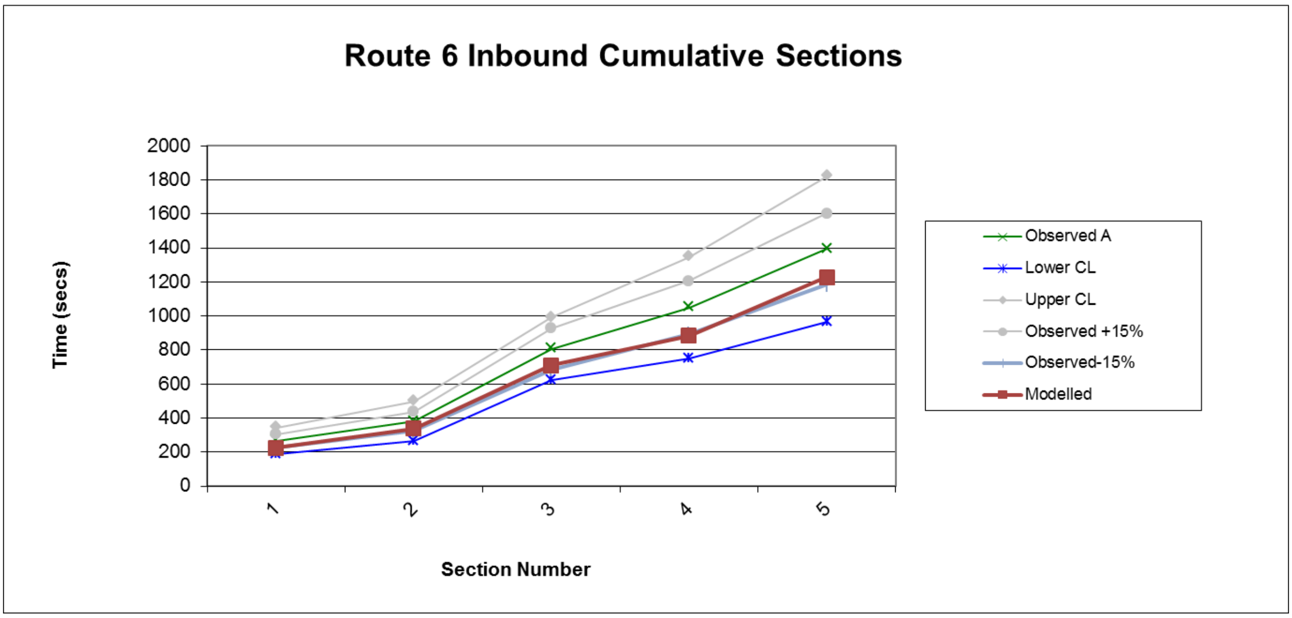

Route 4 Outbound Cumulative Sections
800
700
600
500
400
300
200
100
0
Time (secs)
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

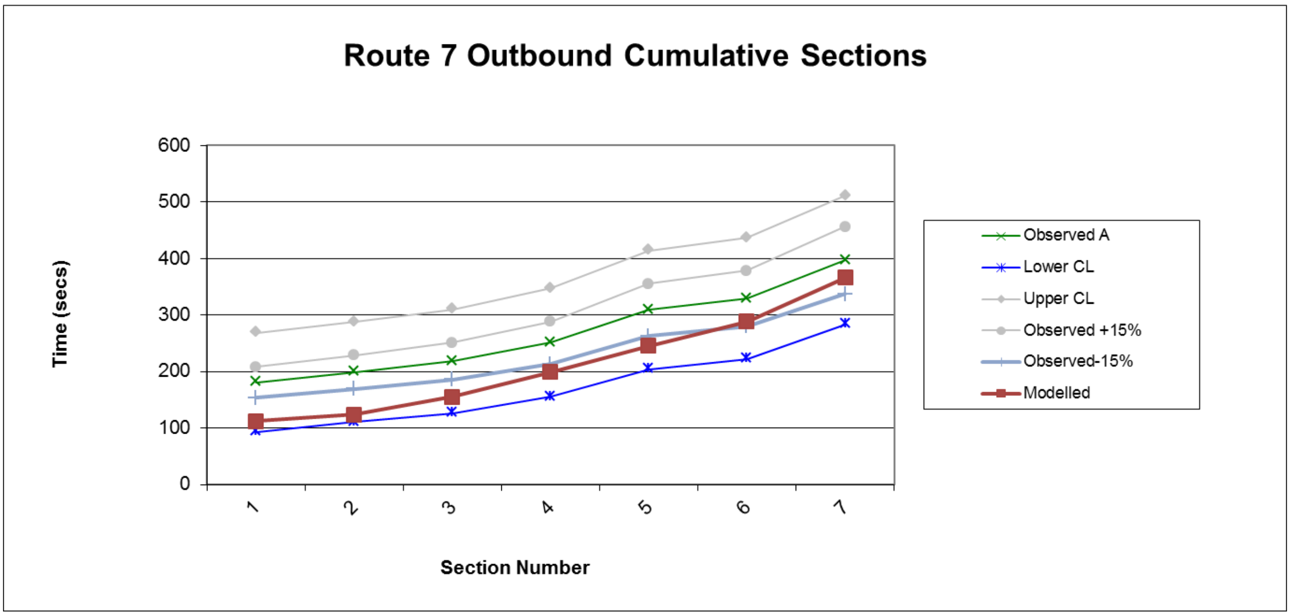

Route 4 Inbound Cumulative Sections
1600
1400
1200
1000
800
600
400
200
0
Time (secs)
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 5 Outbound Cumulative Sections
Time (secs)
700
600
500
400
300
200
100
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

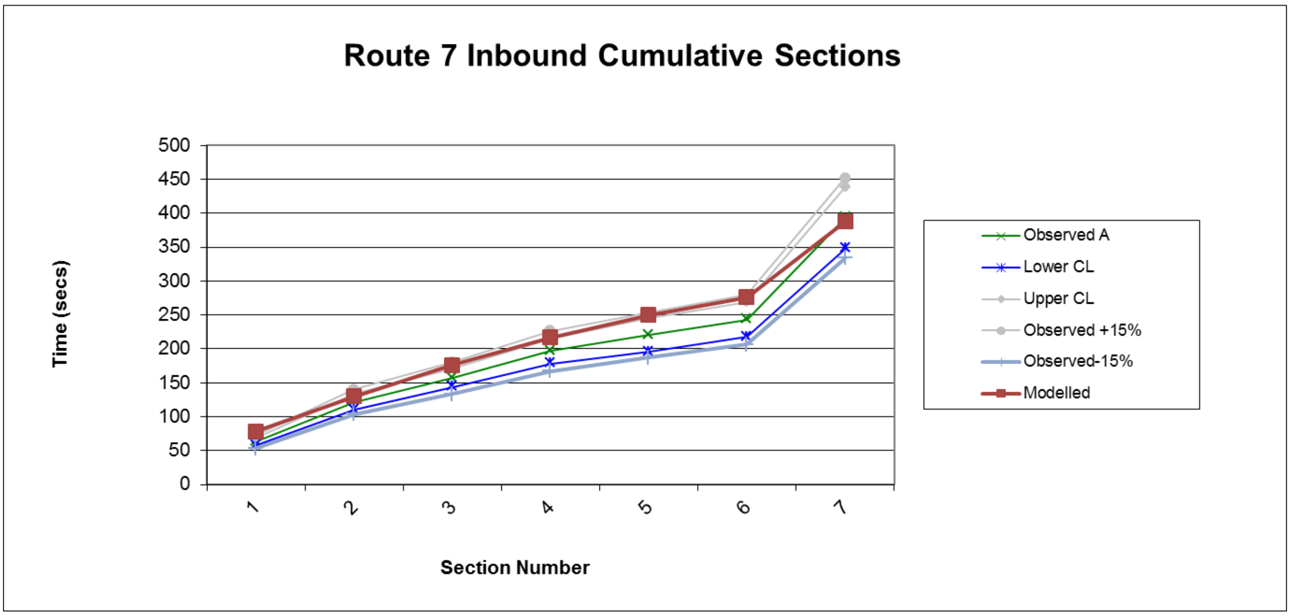

Route 5 Inbound Cumulative Sections
Time (secs)
1200
1000
800
600
400
200
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 6 Outbound Cumulative Sections
Time (secs)
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

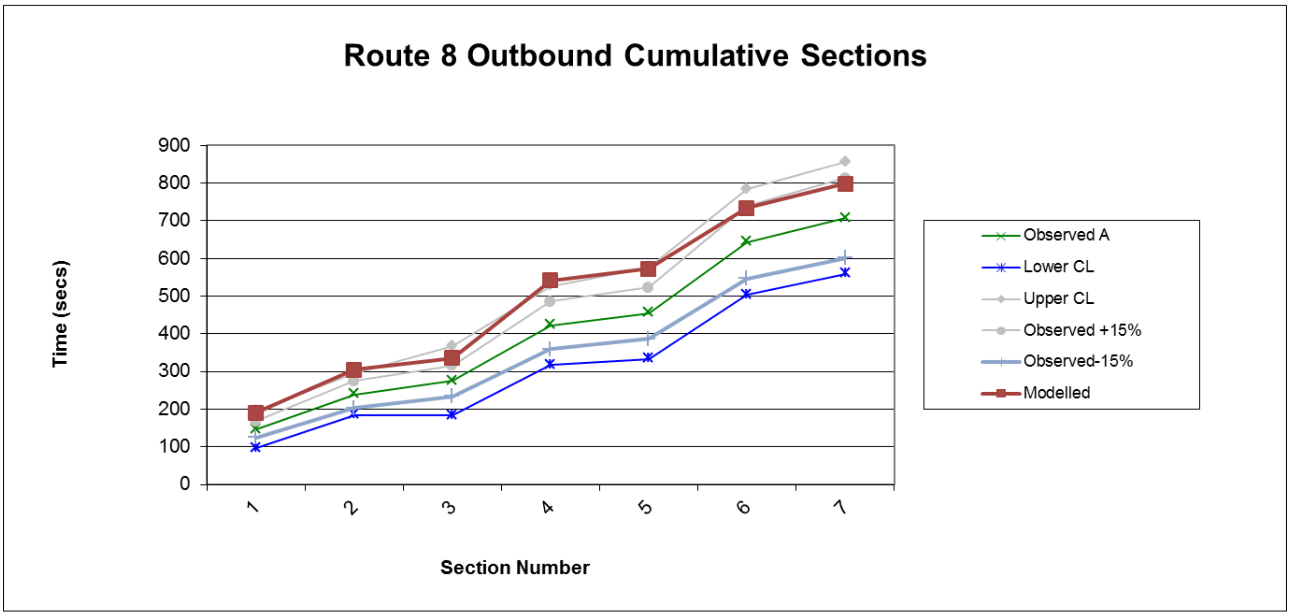

Route 6 Inbound Cumulative Sections
Time (secs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

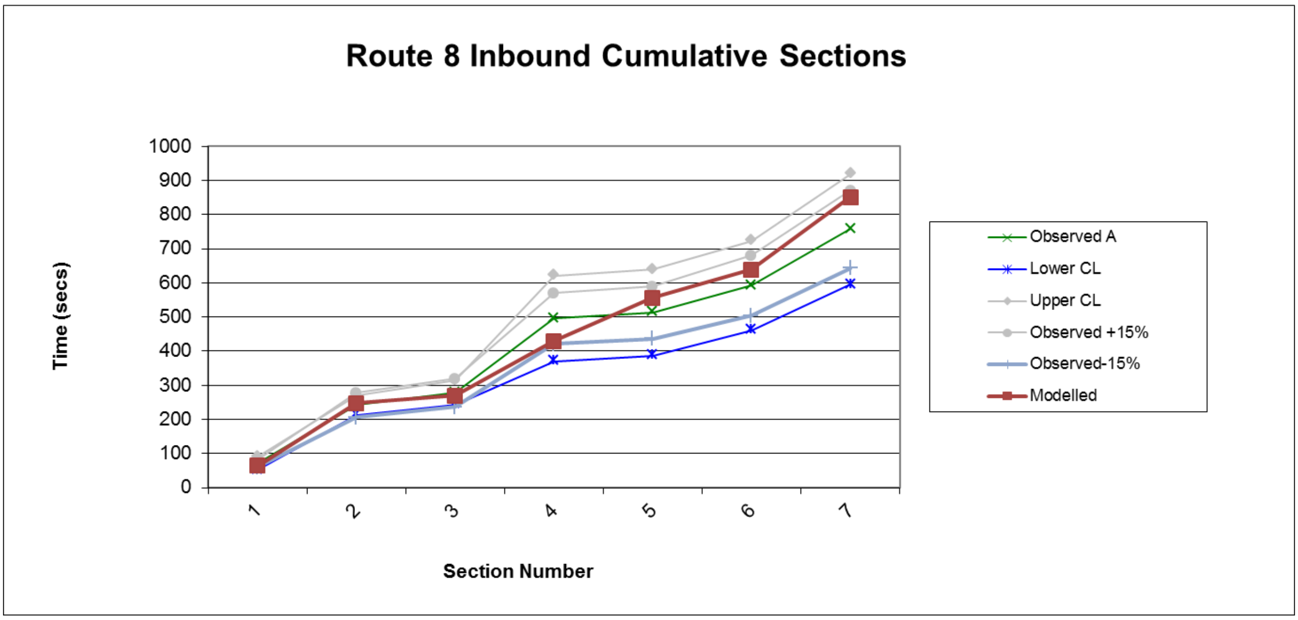


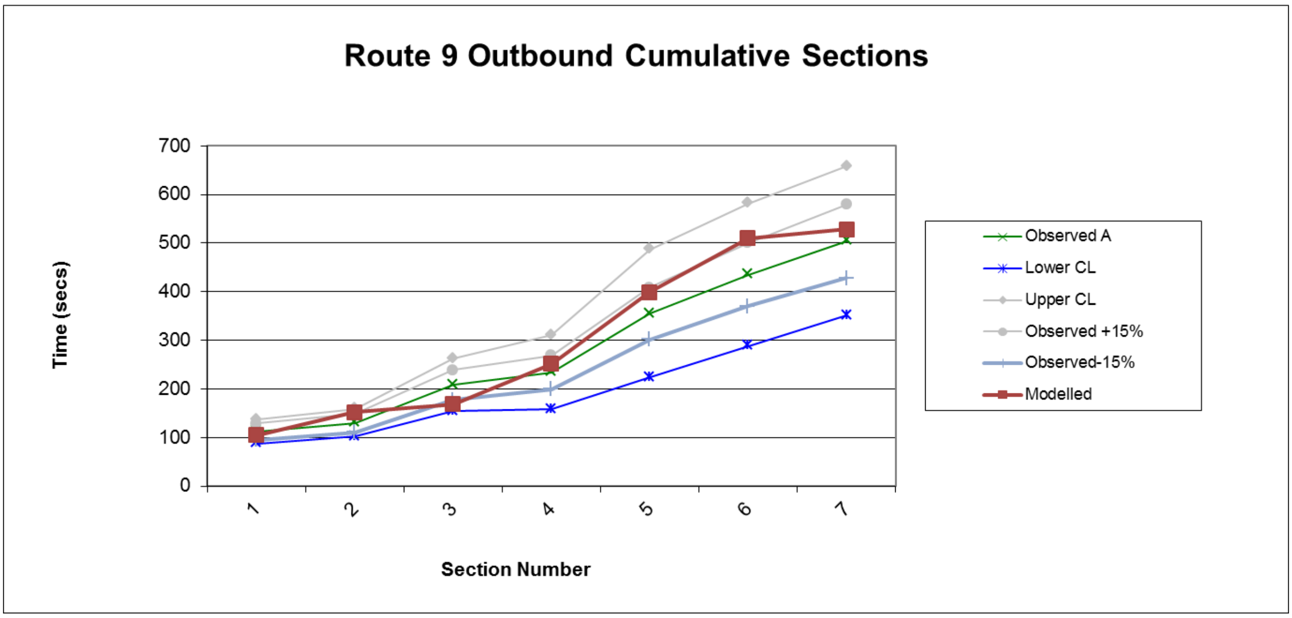
Route 7 Outbound Cumulative Sections
Time (secs)
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

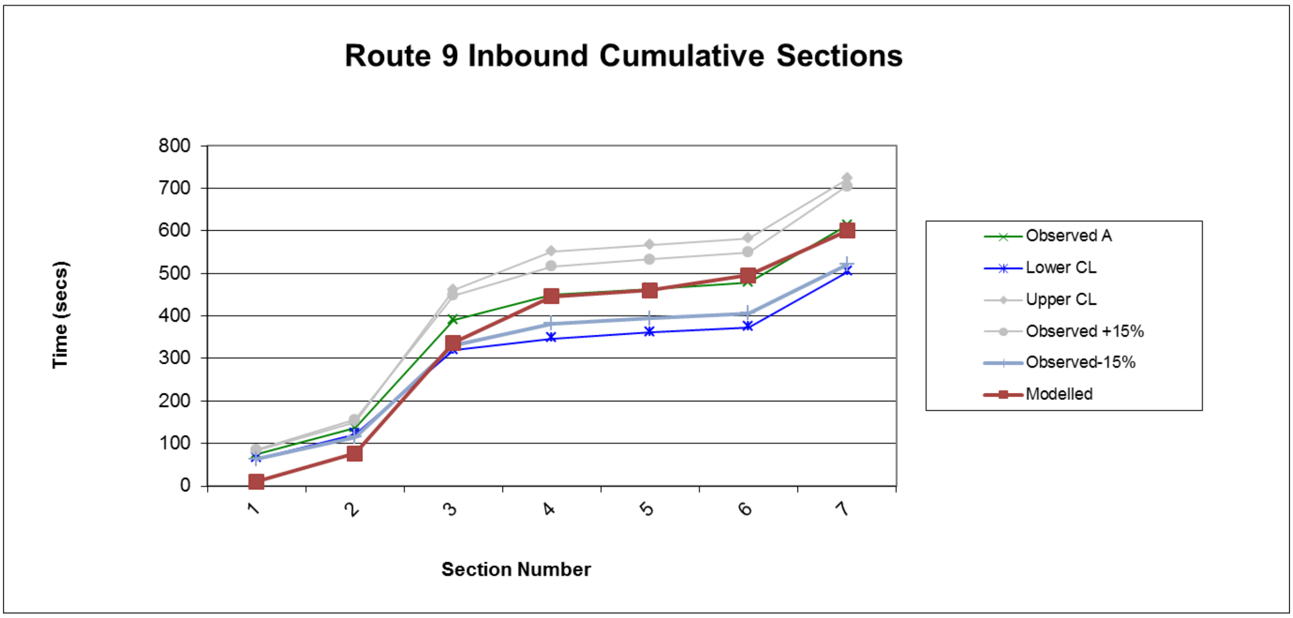


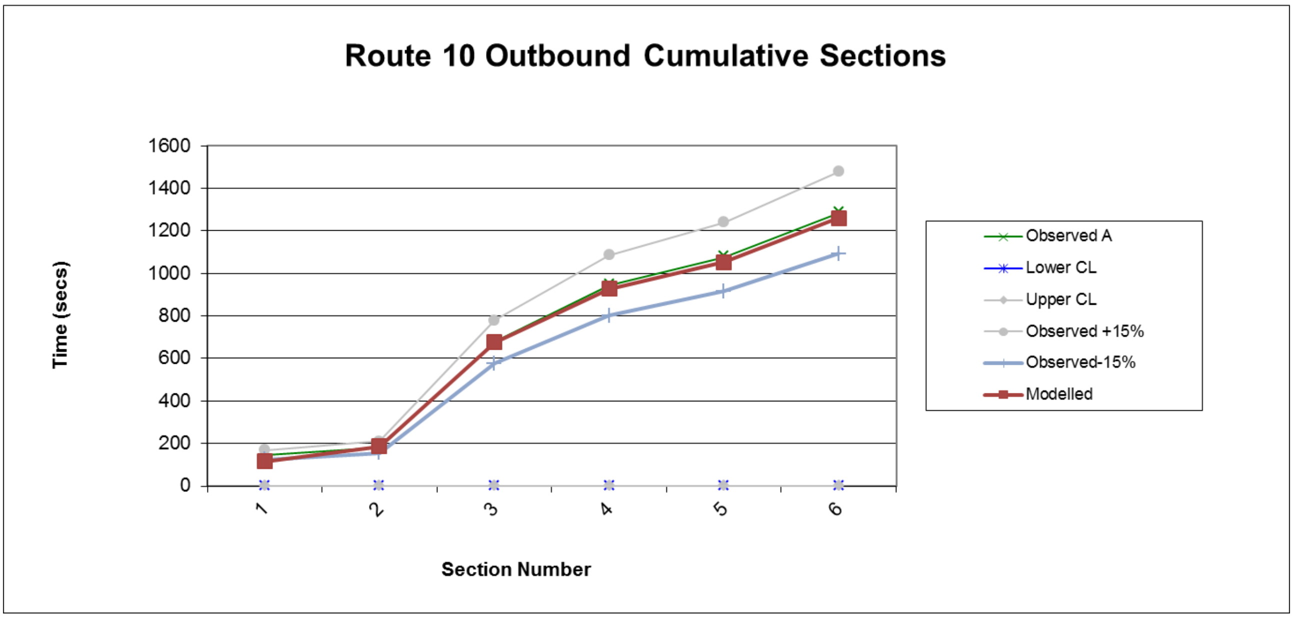
Route 7 Inbound Cumulative Sections
Time (secs)
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

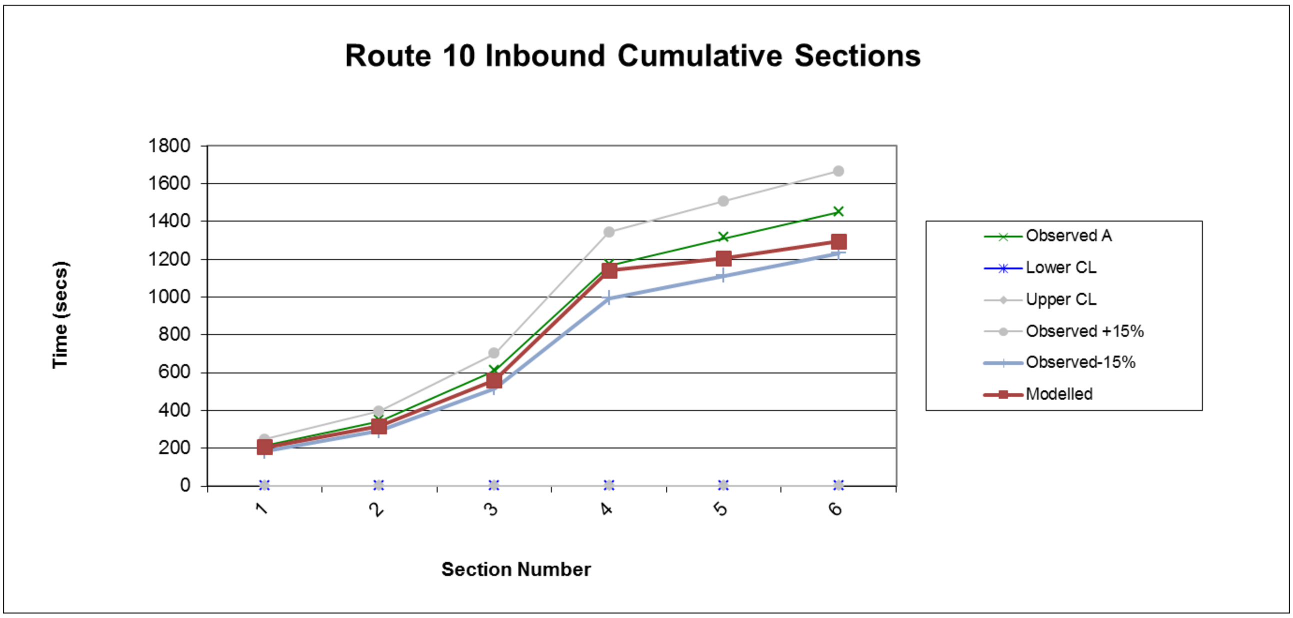

Route 8 Outbound Cumulative Sections
Time (secs)
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

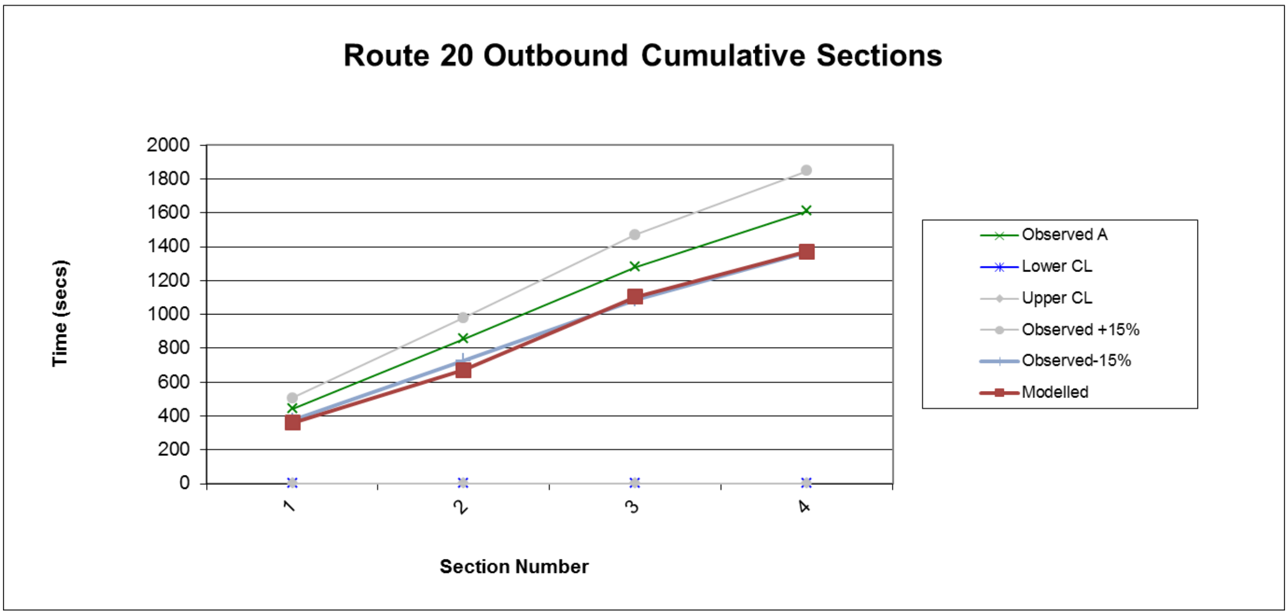

Route 8 Inbound Cumulative Sections
Time (secs)
1000
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

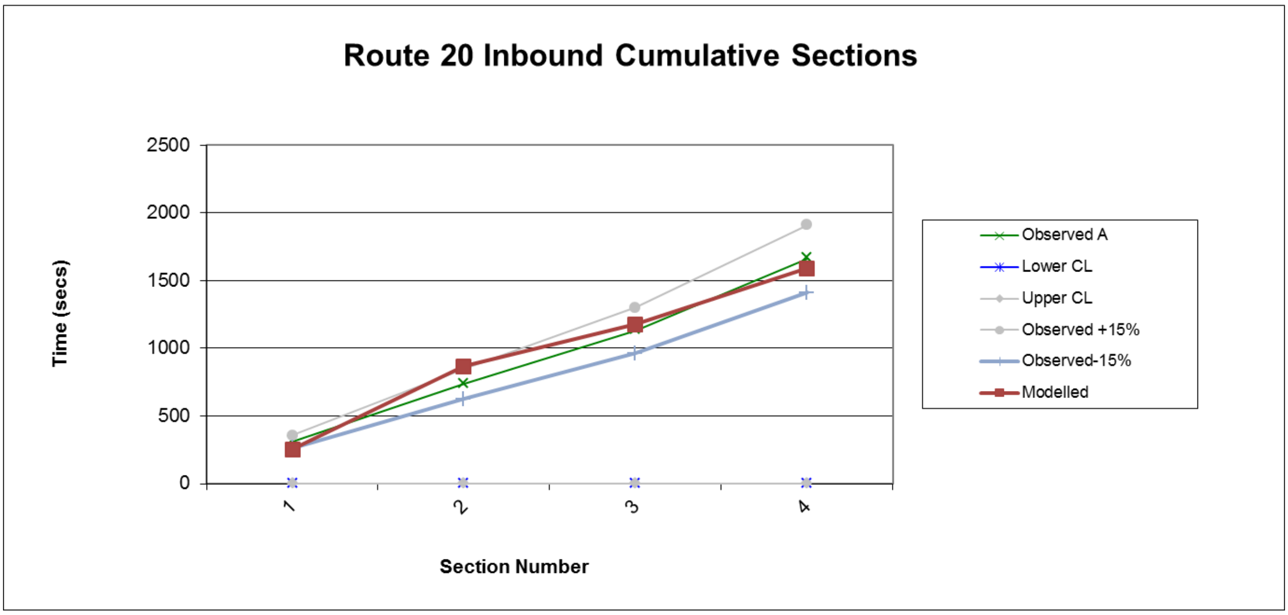

Route 9 Outbound Cumulative Sections
Time (secs)
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 9 Inbound Cumulative Sections
Time (secs)
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

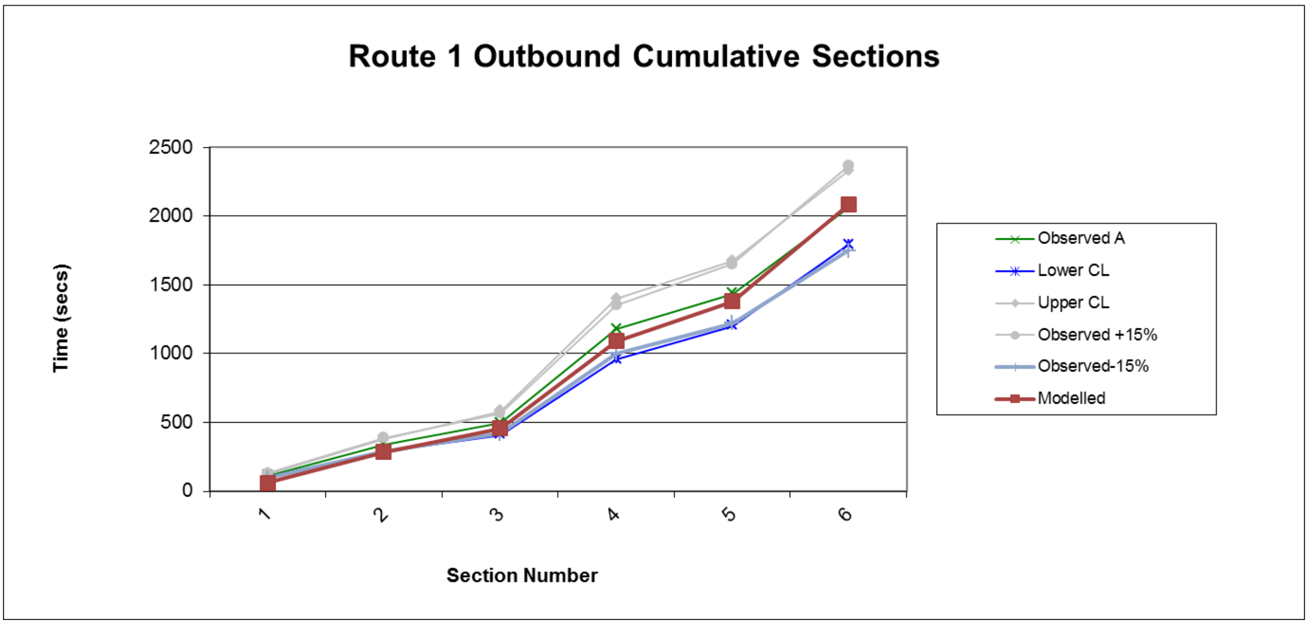

Route 10 Outbound Cumulative Sections
Time (secs)
0
200
400
600
800
1000
1200
1400
1600
1
2
3
4
5
6
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

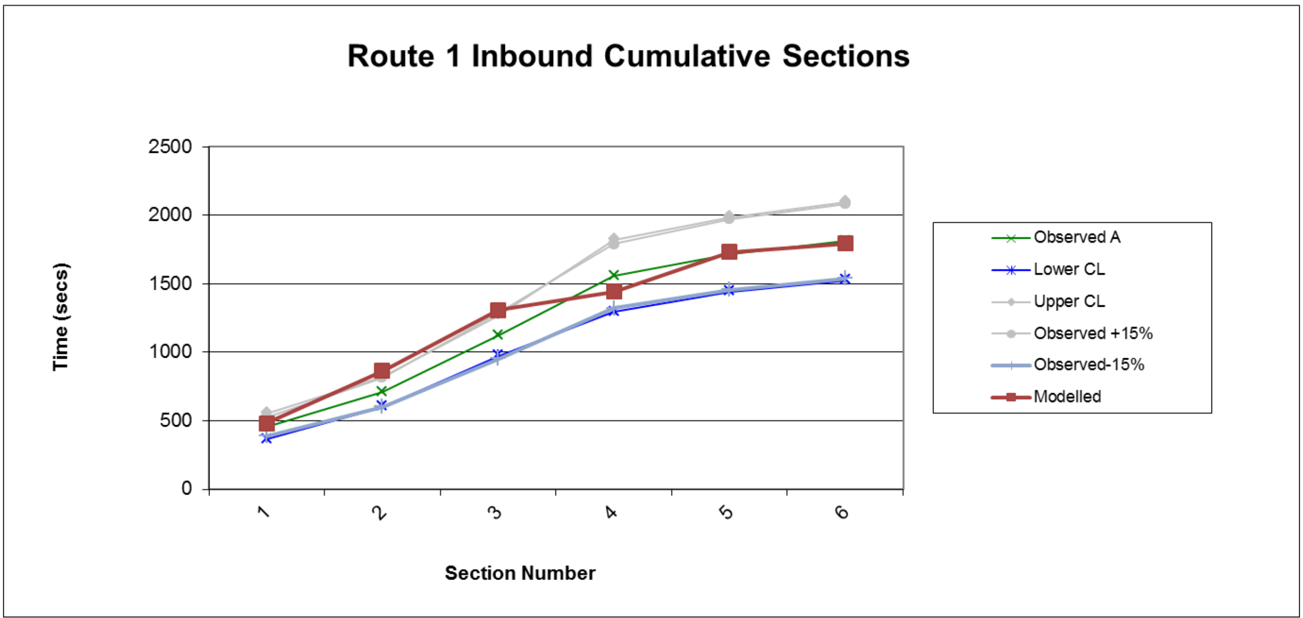

Route 10 Inbound Cumulative Sections
Time (secs)
0
200
400
600
800
1000
1200
1400
1600
1800
1
2
3
4
5
6
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

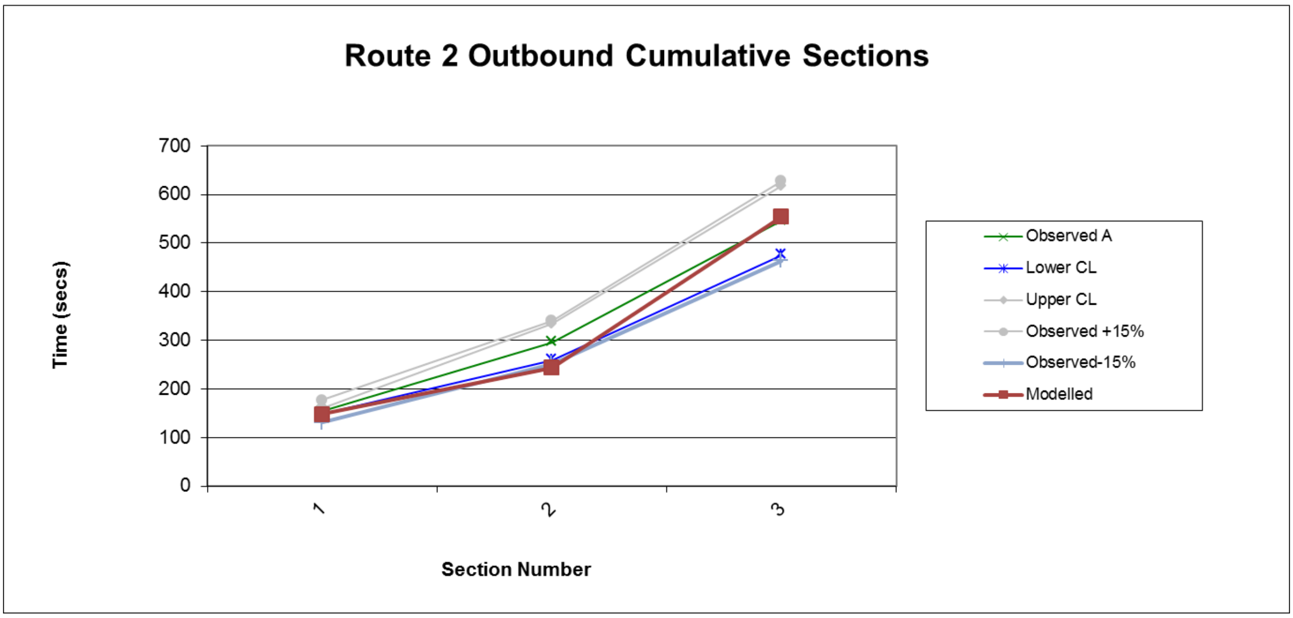

Route 20 Outbound Cumulative Sections
Time (secs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 20 Inbound Cumulative Sections
Time (secs)
2500
2000
1500
1000
500
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

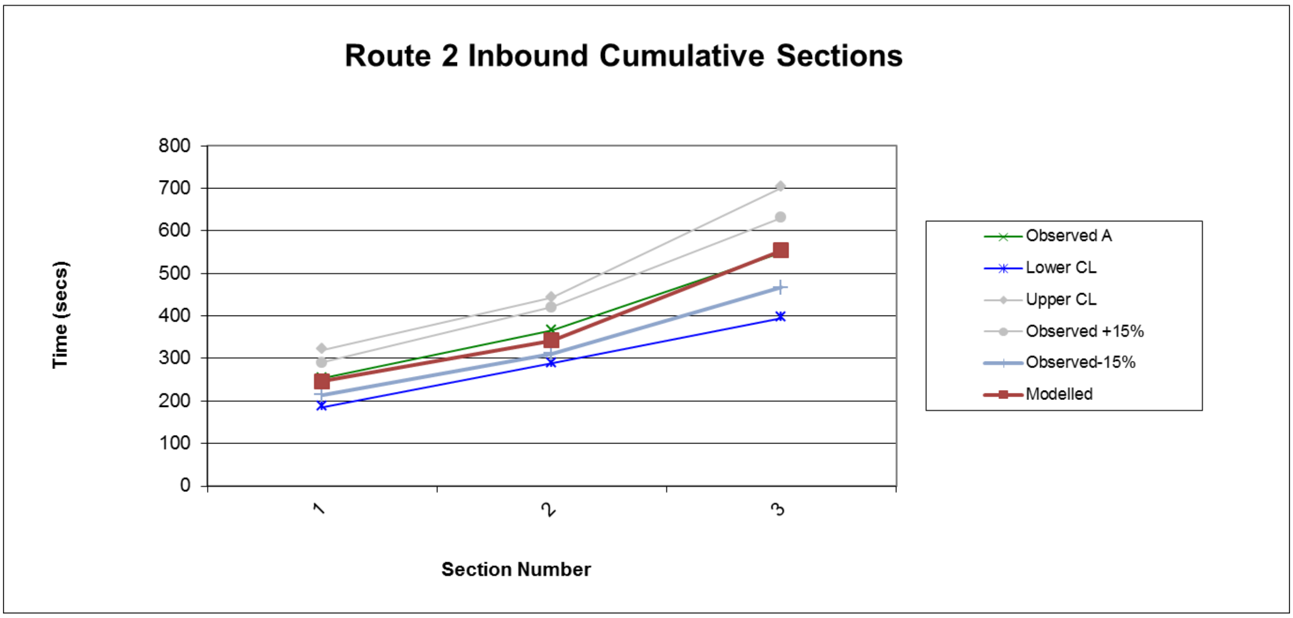
Appendix G – Individual Journey Time Graphs PM Peak



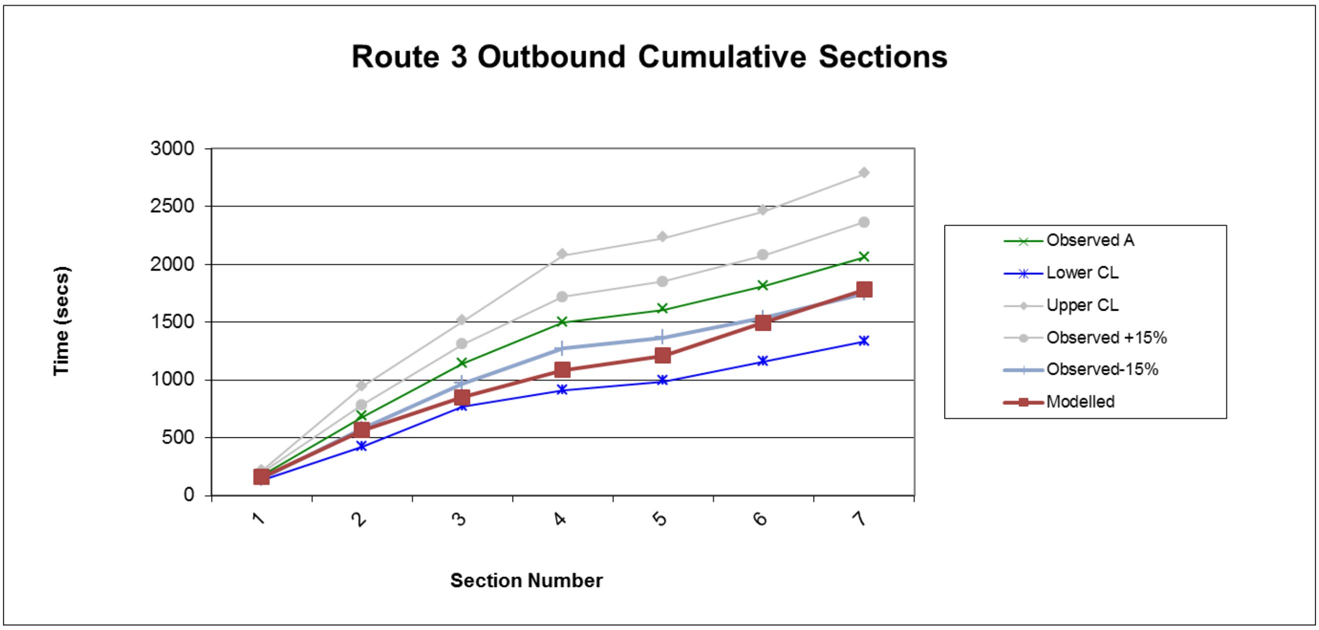


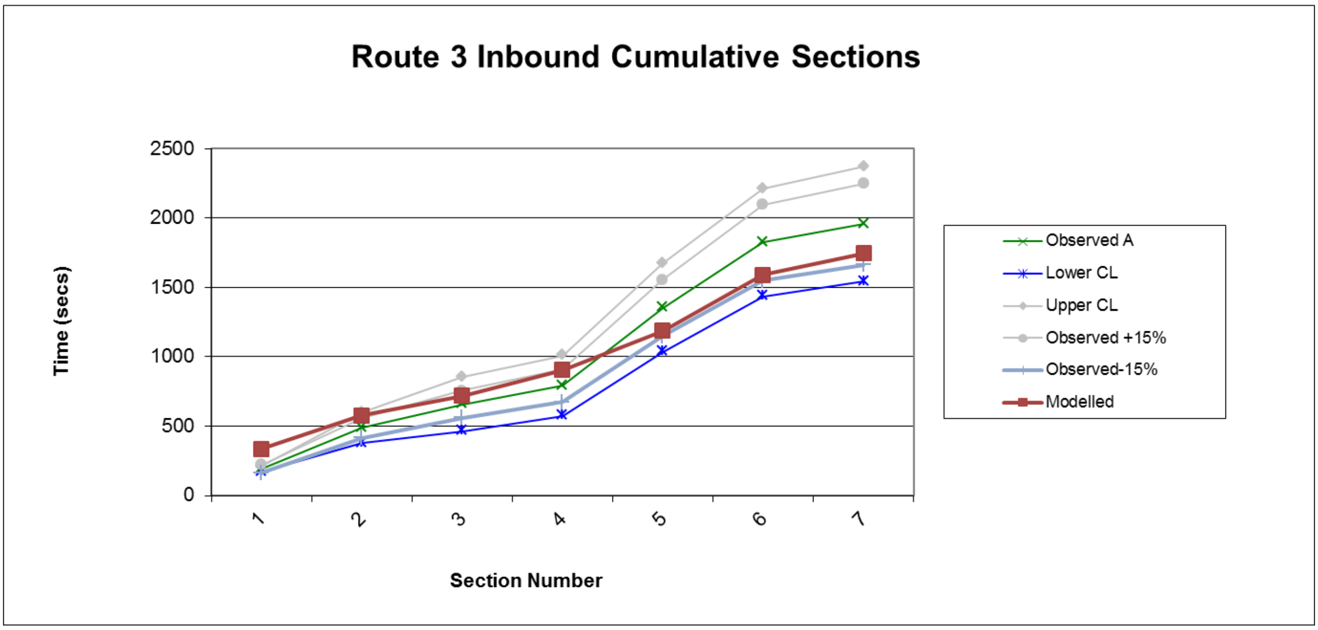


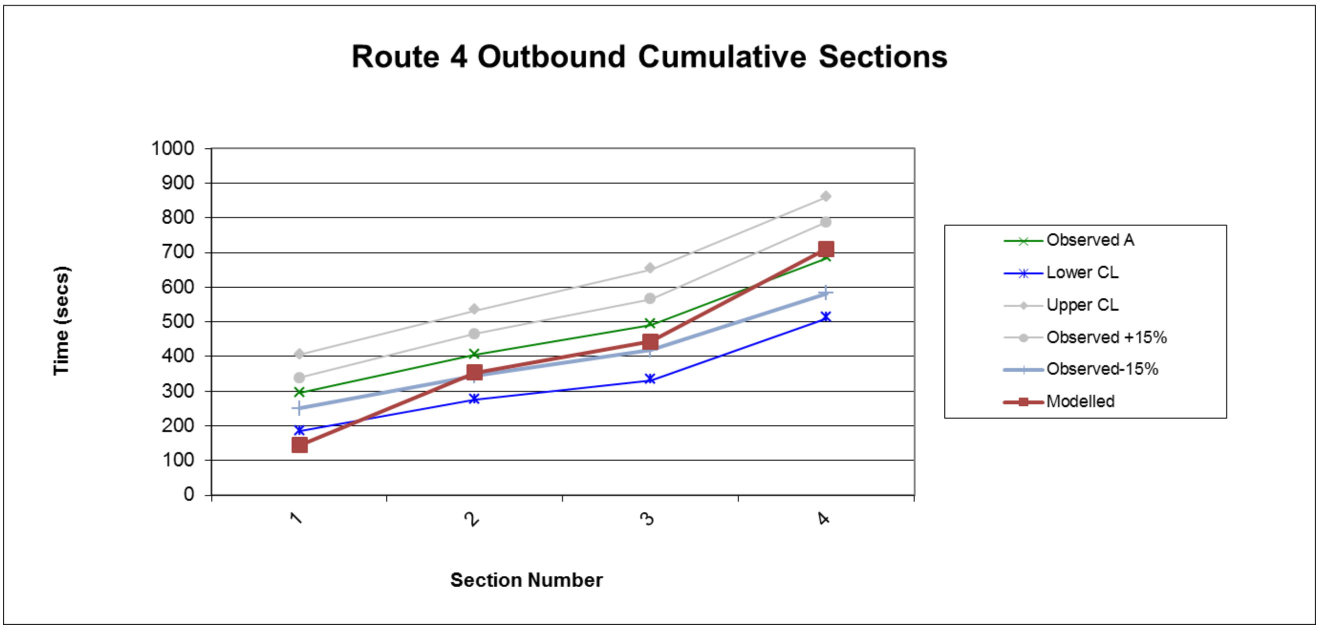
Route 2 Outbound Cumulative Sections
700
600
500
400
300
200
100
0
Time (secs)
1
2
3
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

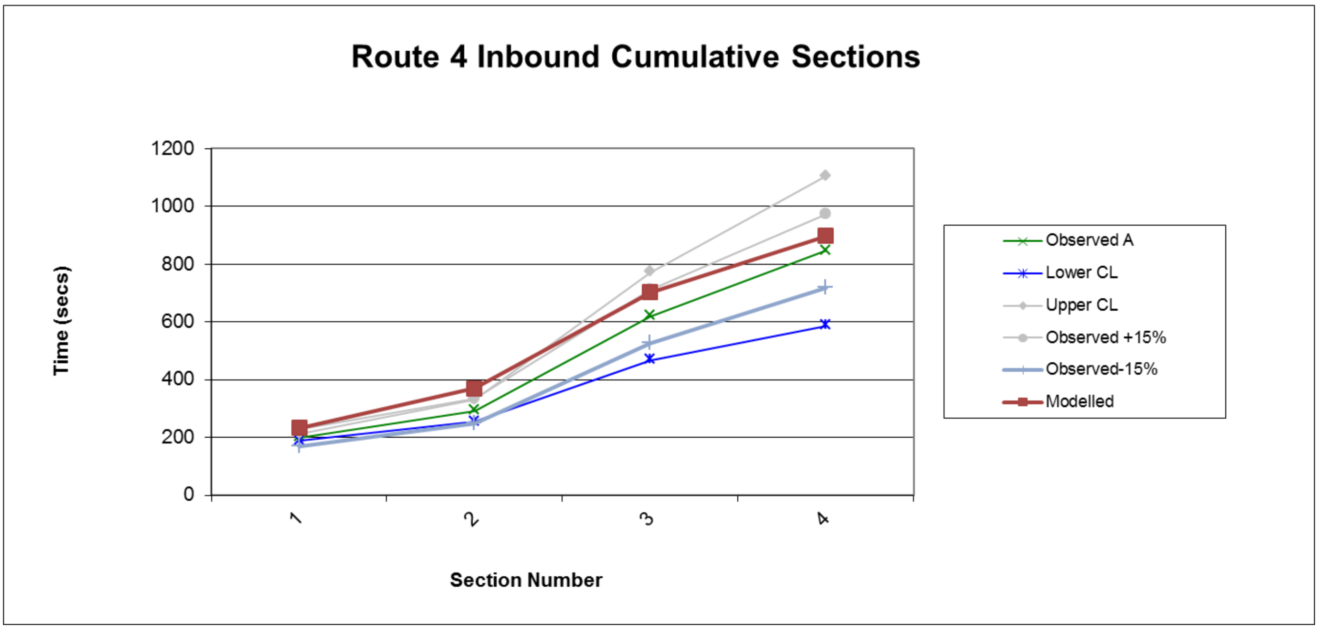


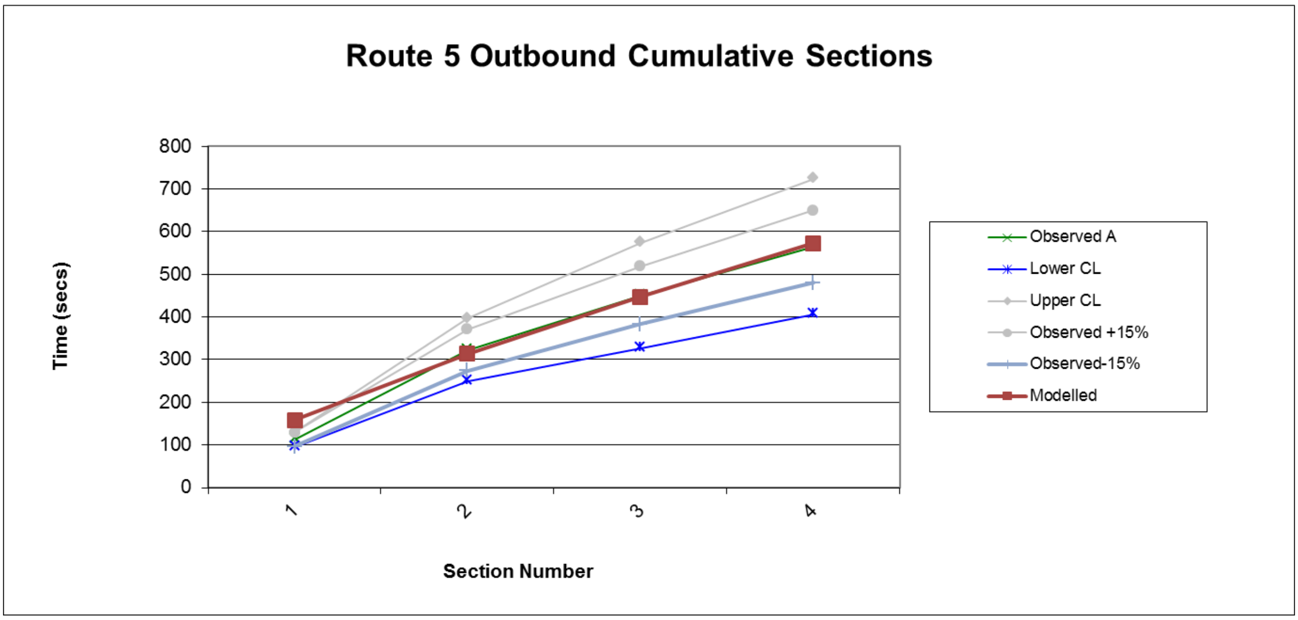
Route 2 Inbound Cumulative Sections
800
700
600
500
400
300
200
100
0
Time (secs)
1
2
3
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 3 Outbound Cumulative Sections
Time (secs)
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

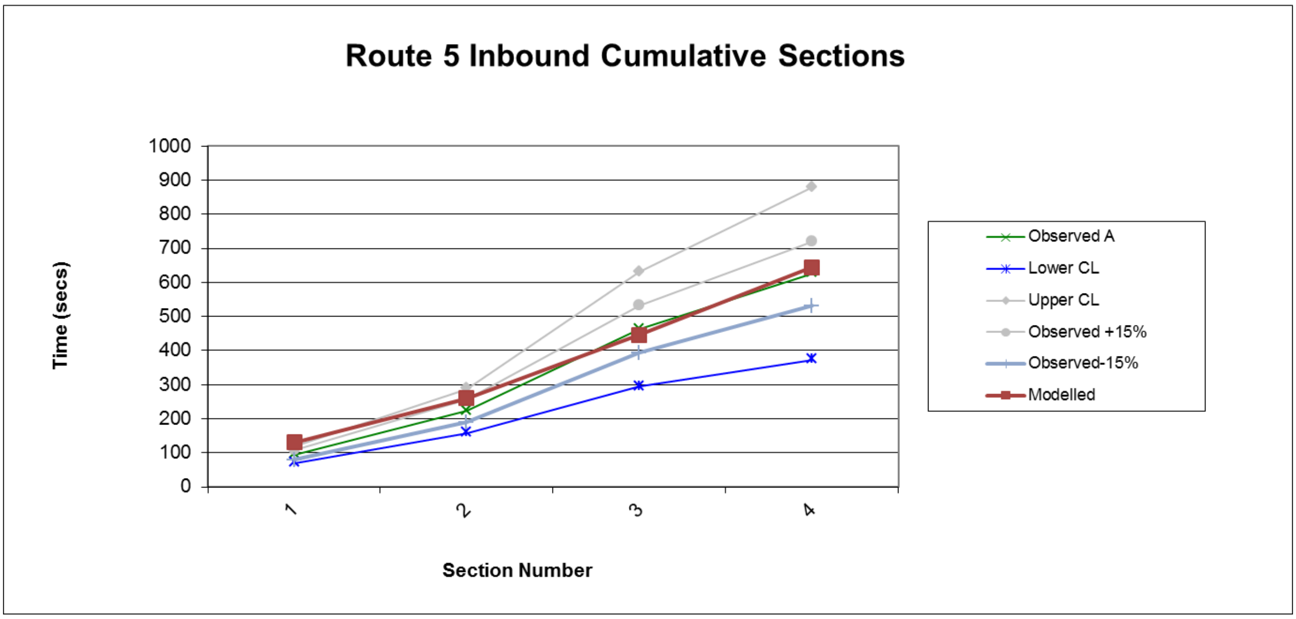

Route 3 Inbound Cumulative Sections
Time (secs)
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 4 Outbound Cumulative Sections
Time (secs)
1000
900
800
700
600
500
400
300
200
100
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

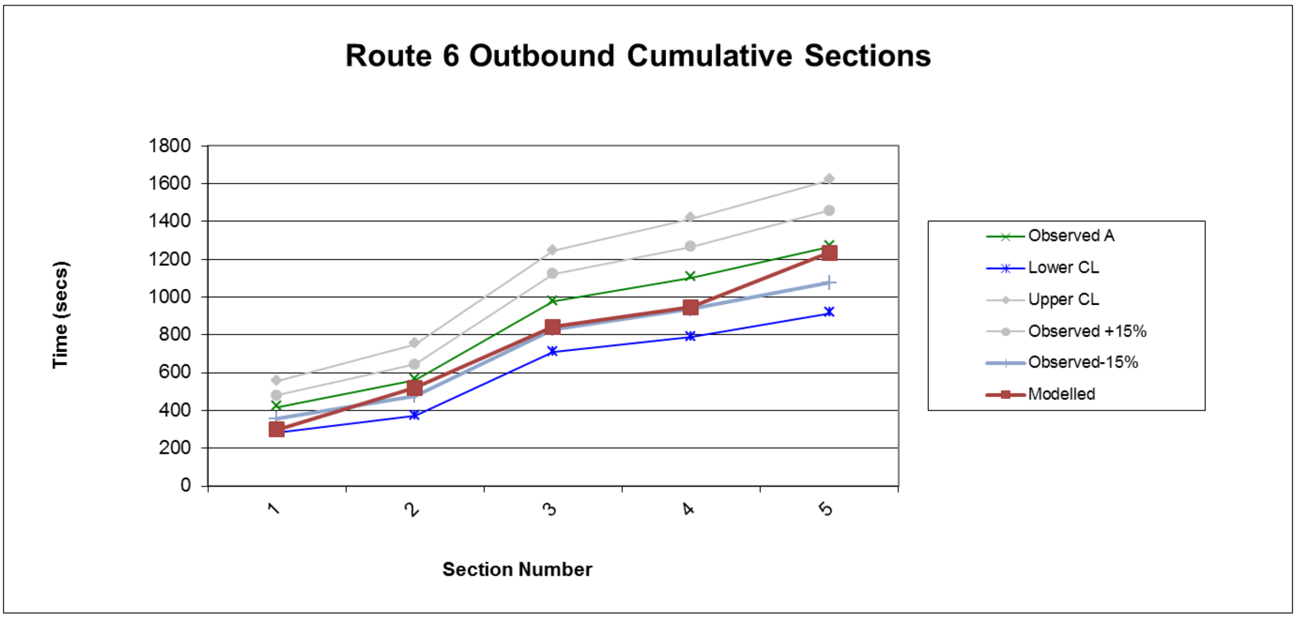

Route 4 Inbound Cumulative Sections
Time (secs)
1200
1000
800
600
400
200
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

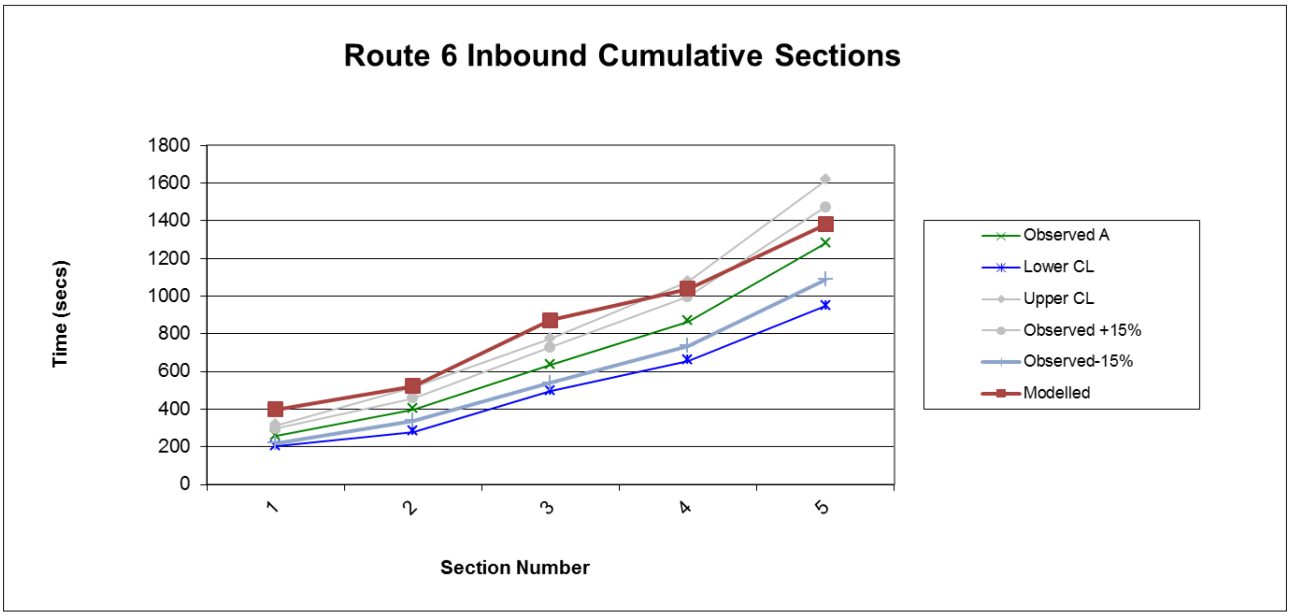


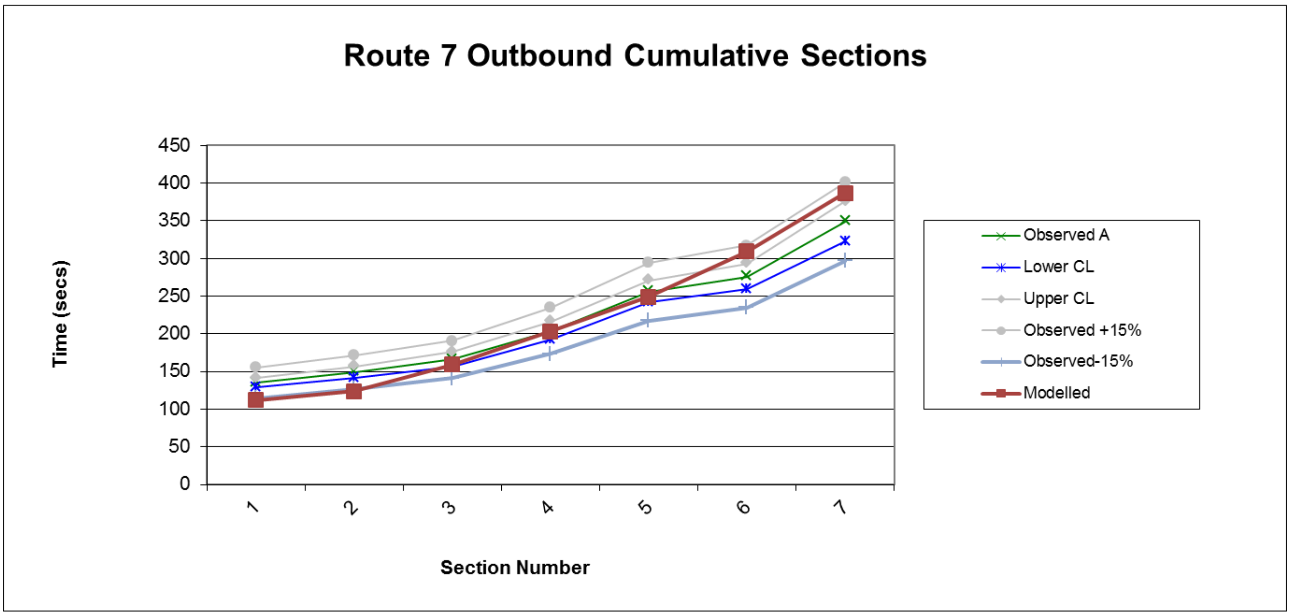
Route 5 Outbound Cumulative Sections
Time (secs)
800
700
600
500
400
300
200
100
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

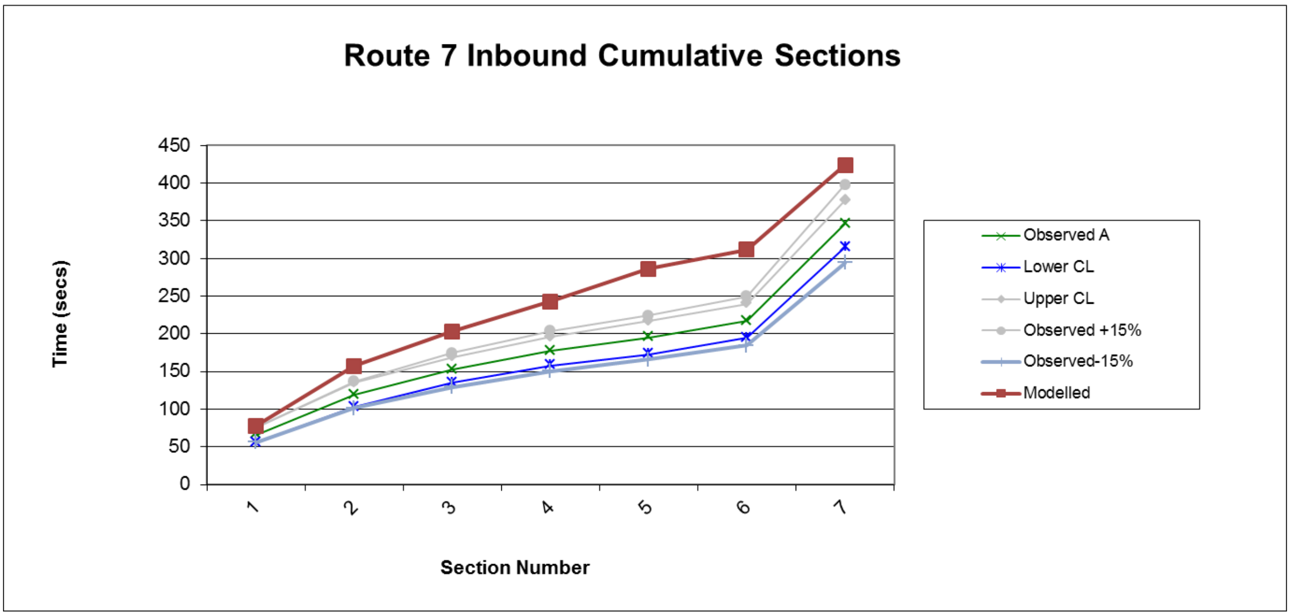


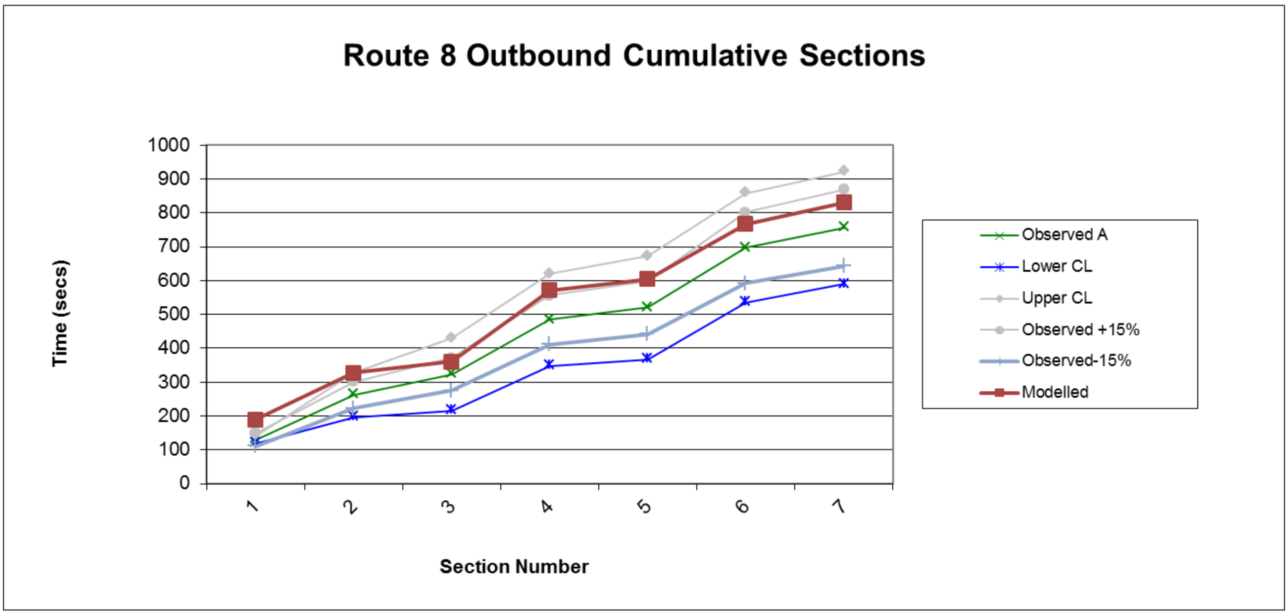
Route 5 Inbound Cumulative Sections
Time (secs)
1000
900
800
700
600
500
400
300
200
100
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 6 Outbound Cumulative Sections
Time (secs)
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

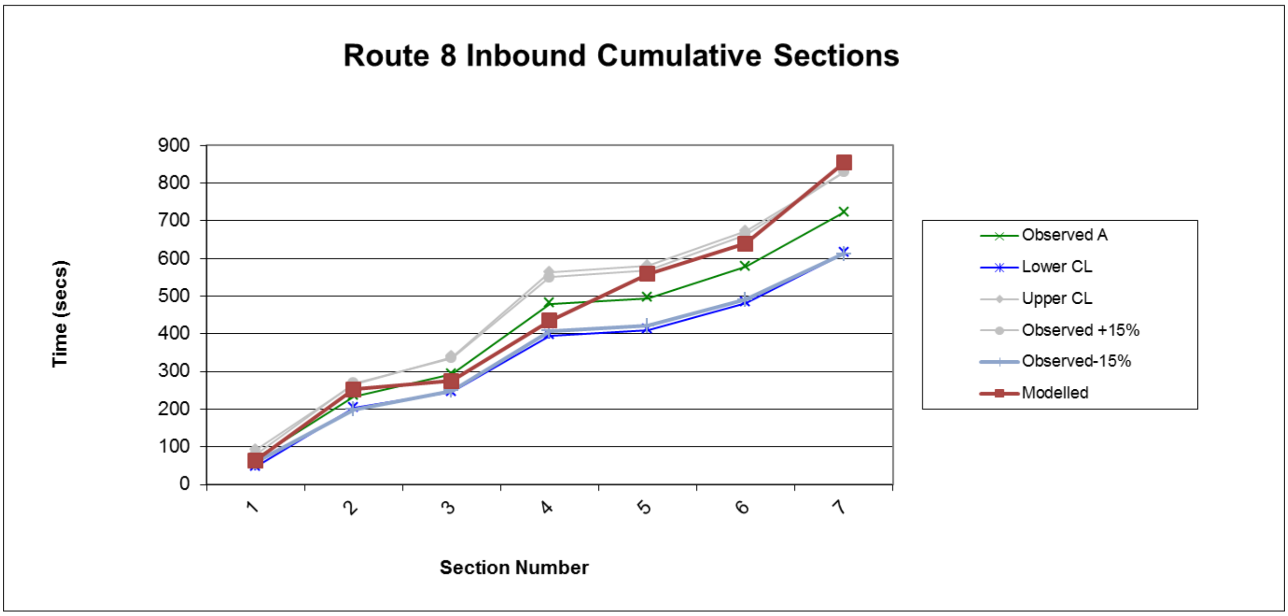

Route 6 Inbound Cumulative Sections
Time (secs)
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 7 Outbound Cumulative Sections
Time (secs)
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

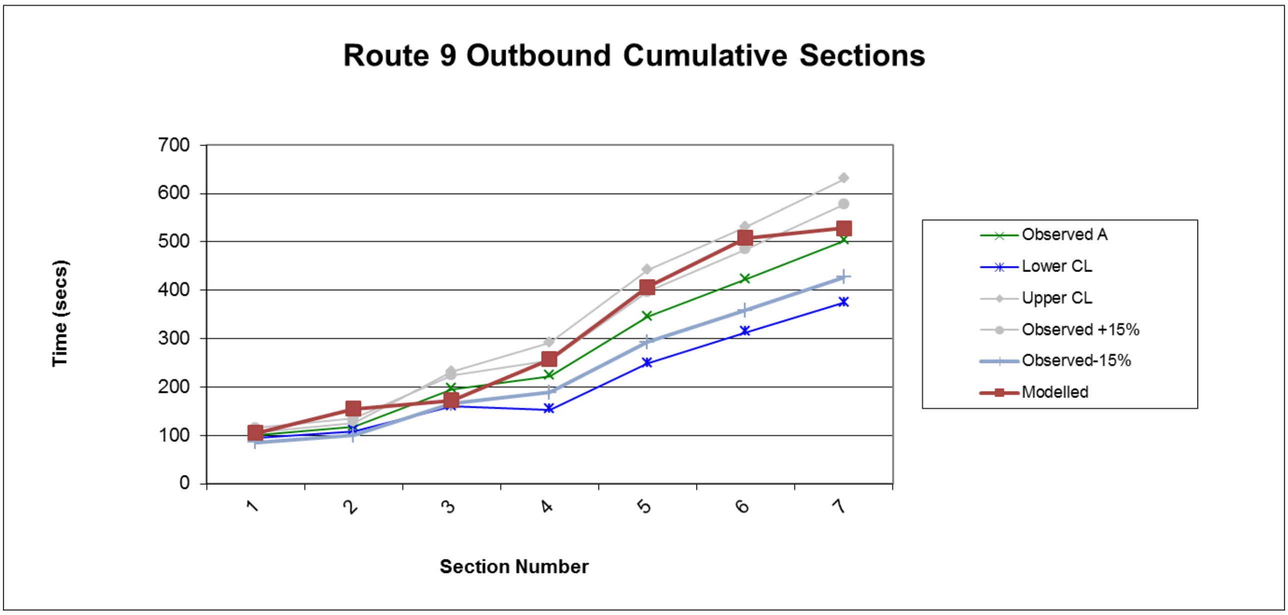

Route 7 Inbound Cumulative Sections
Time (secs)
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled



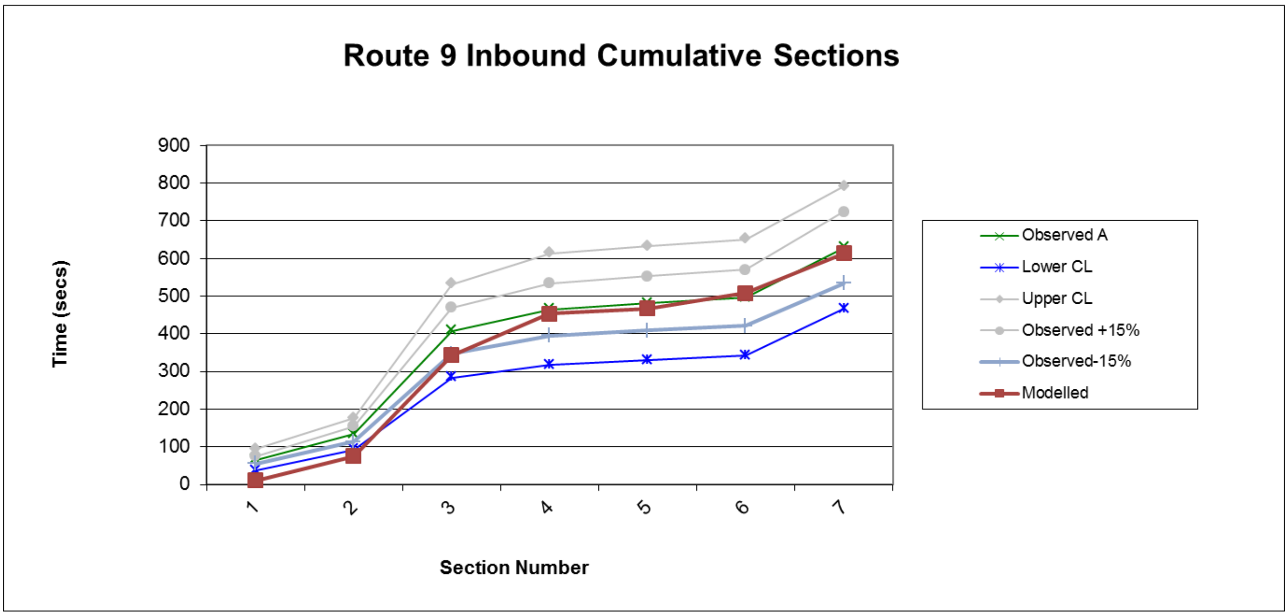
Route 8 Outbound Cumulative Sections
Time (secs)
1000
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled



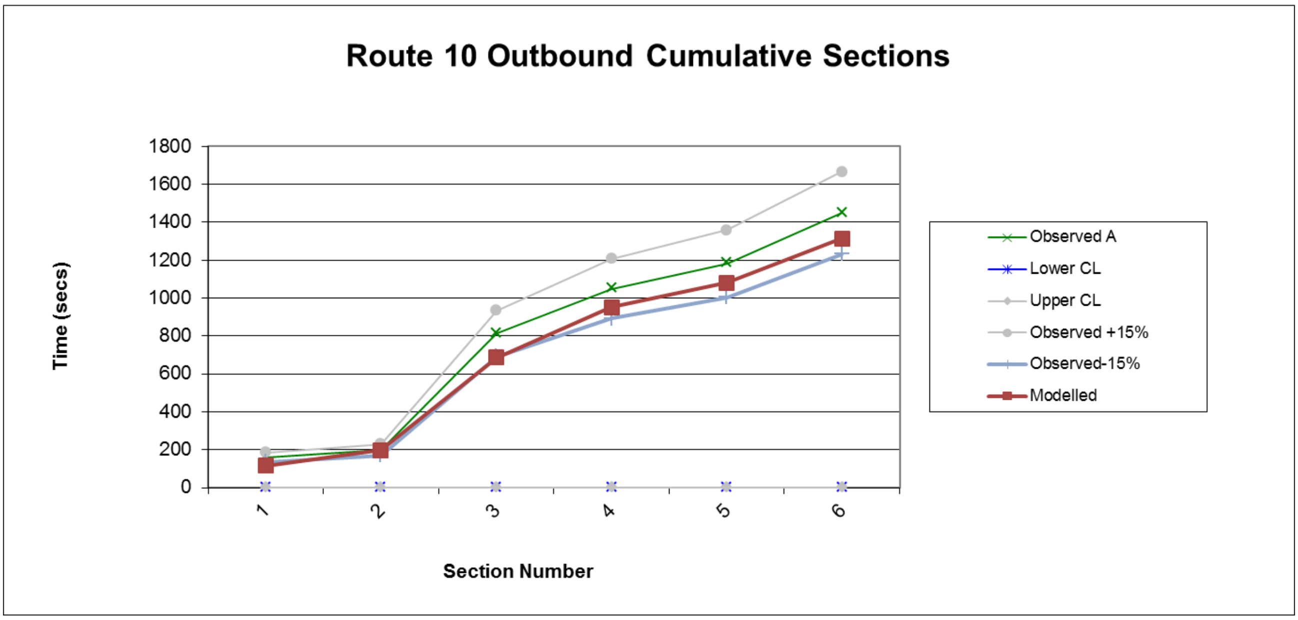
Route 8 Inbound Cumulative Sections
Time (secs)
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

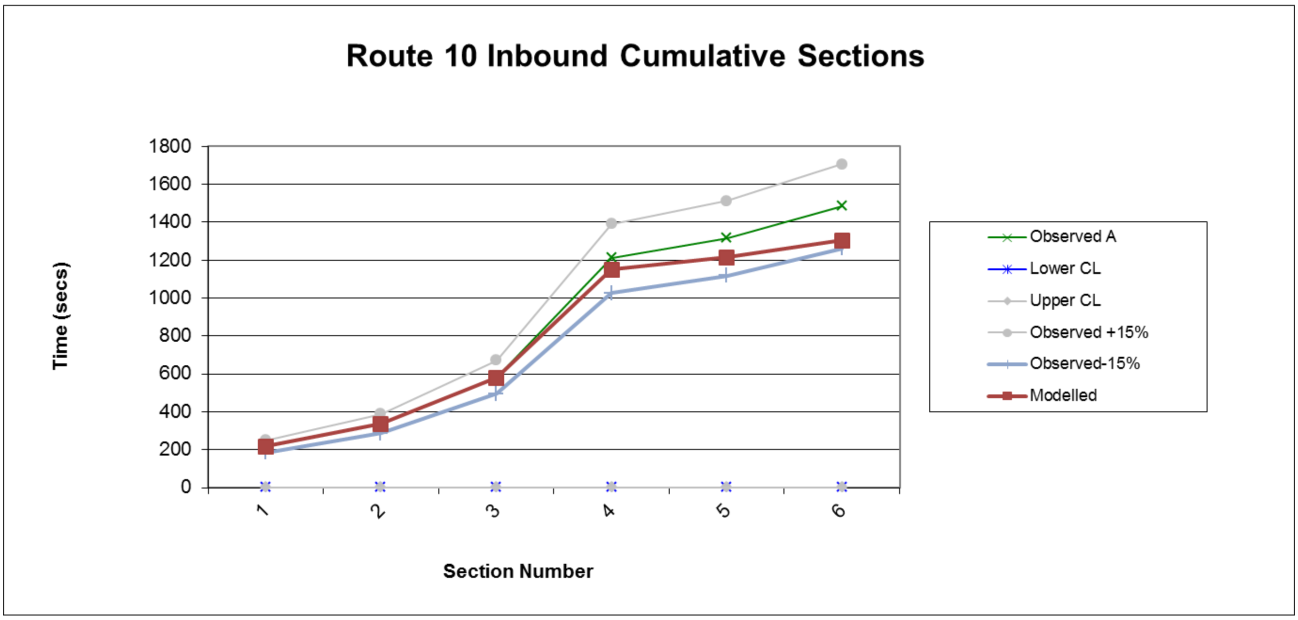


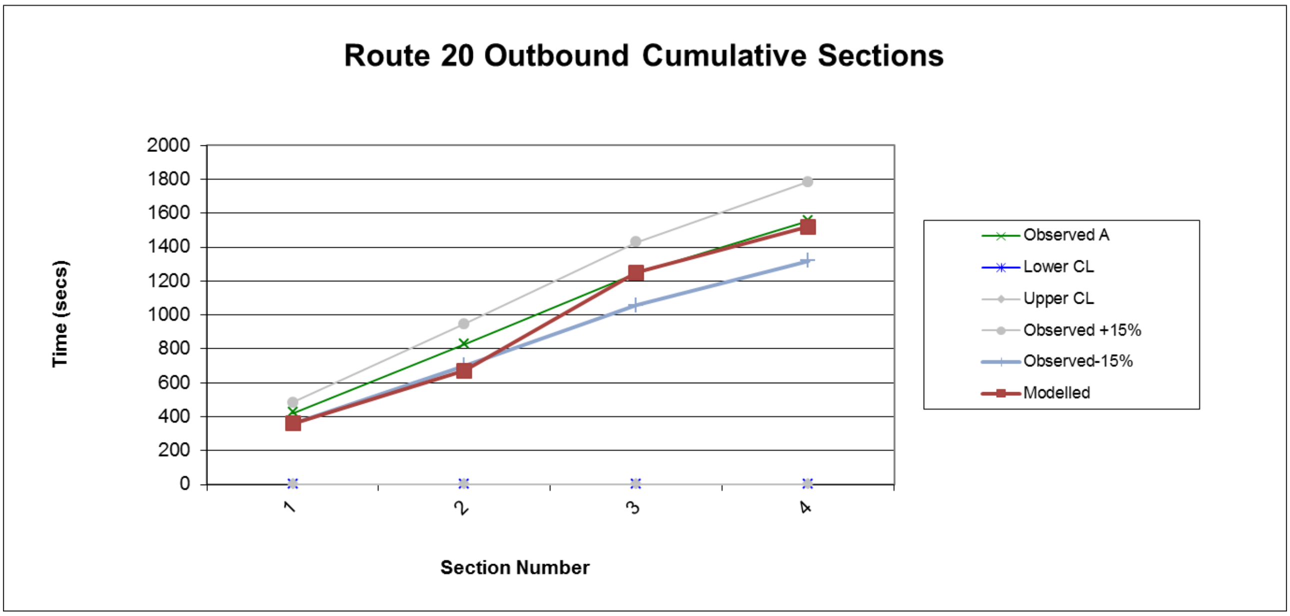
Route 9 Outbound Cumulative Sections
Time (secs)
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

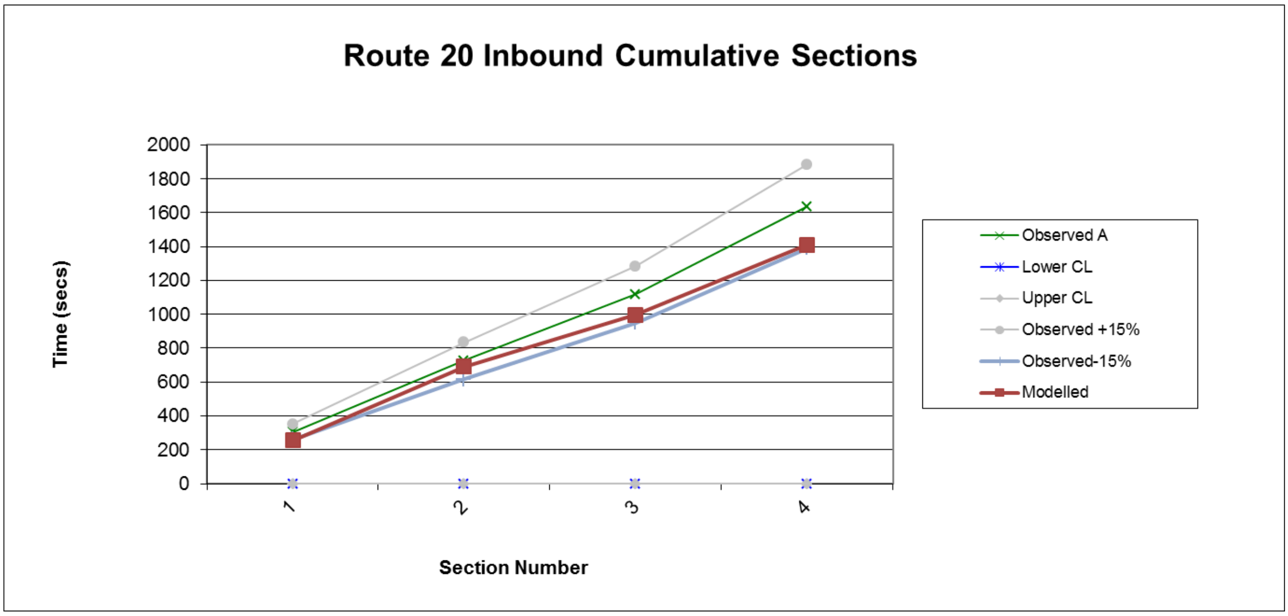


Route 9 Inbound Cumulative Sections
Time (secs)
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 10 Outbound Cumulative Sections
Time (secs)
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 10 Inbound Cumulative Sections
Time (secs)
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 20 Outbound Cumulative Sections
Time (secs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled


Route 20 Inbound Cumulative Sections
Time (secs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
Section Number
Observed A
Lower CL
Upper CL
Observed +15%
Observed-15%
Modelled

Appendix H – Speed Flow Curves

The speed flow curves used within the HBTM have been based upon the relationships detailed within WebTAG Unit 3.1 Appendix D. Which have been calculated in the following tables:

Figure 1 Rural Road Speed Flow Curves

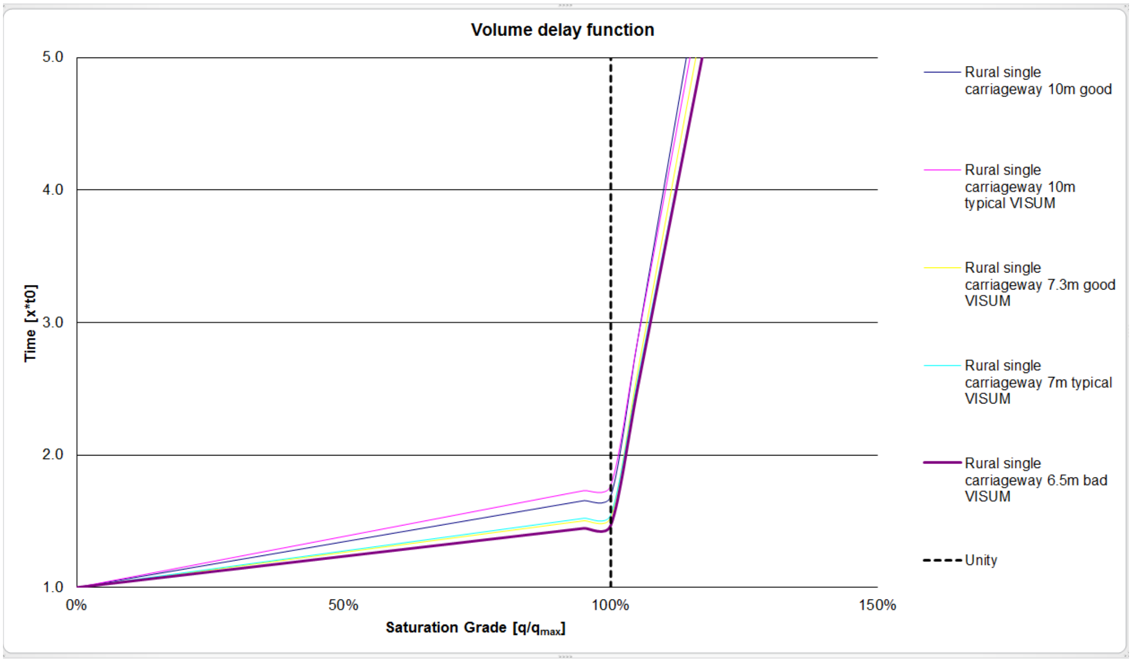


Figure 2 Motorway Speed Flow Curves

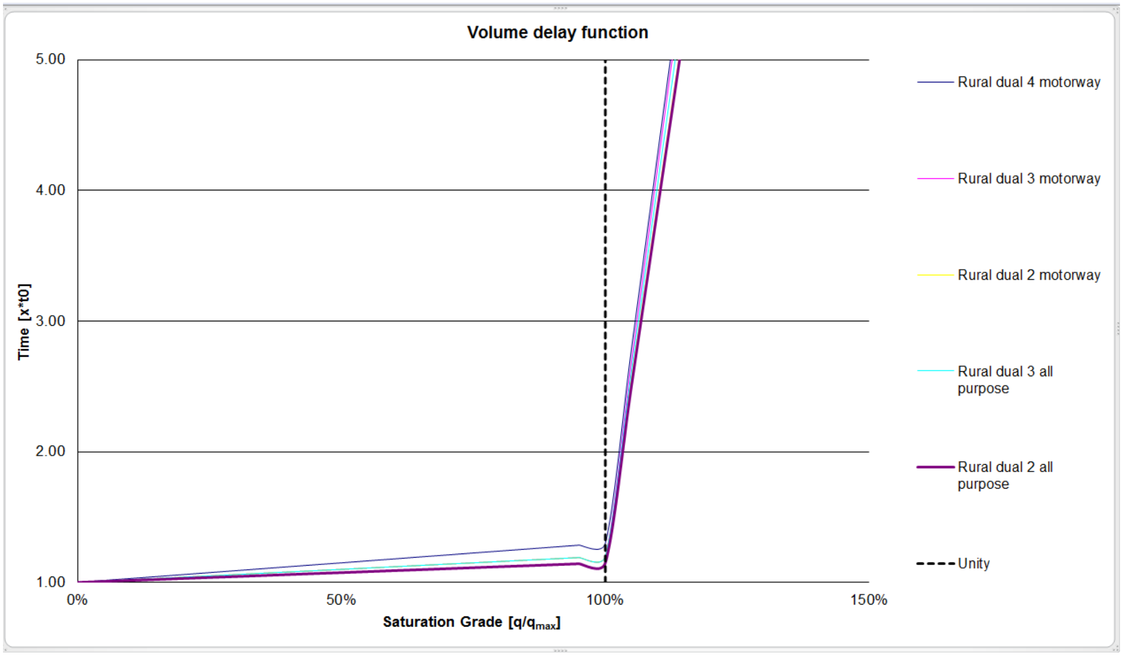


Figure 3 Urban Speed Flow Curves

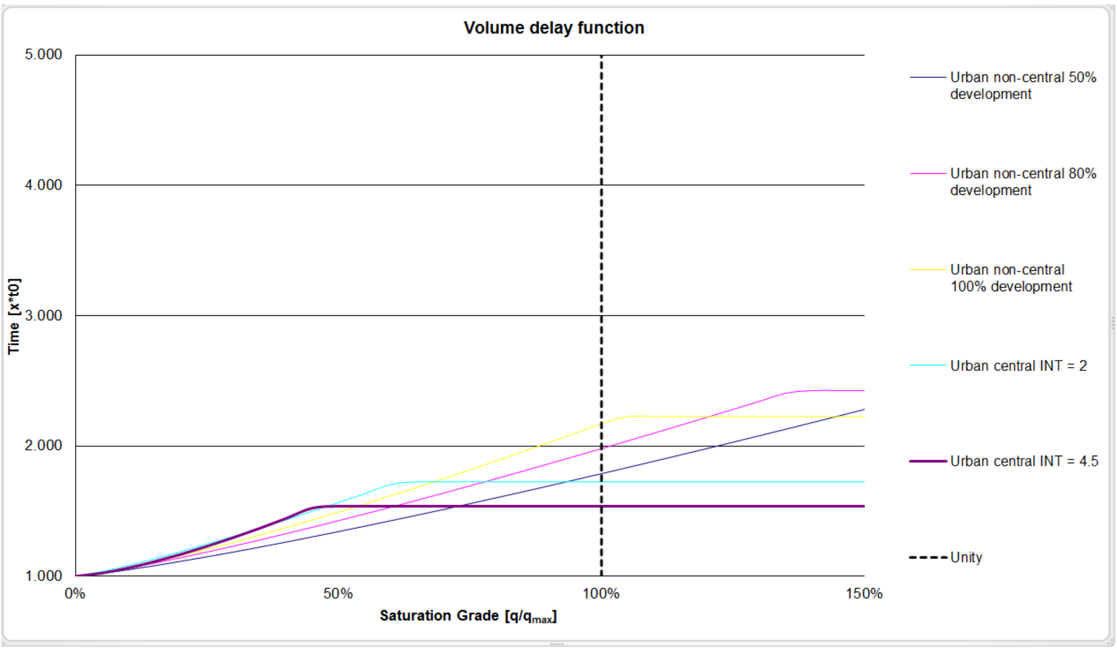


Figure 4 Small Town Speed Flow Curves

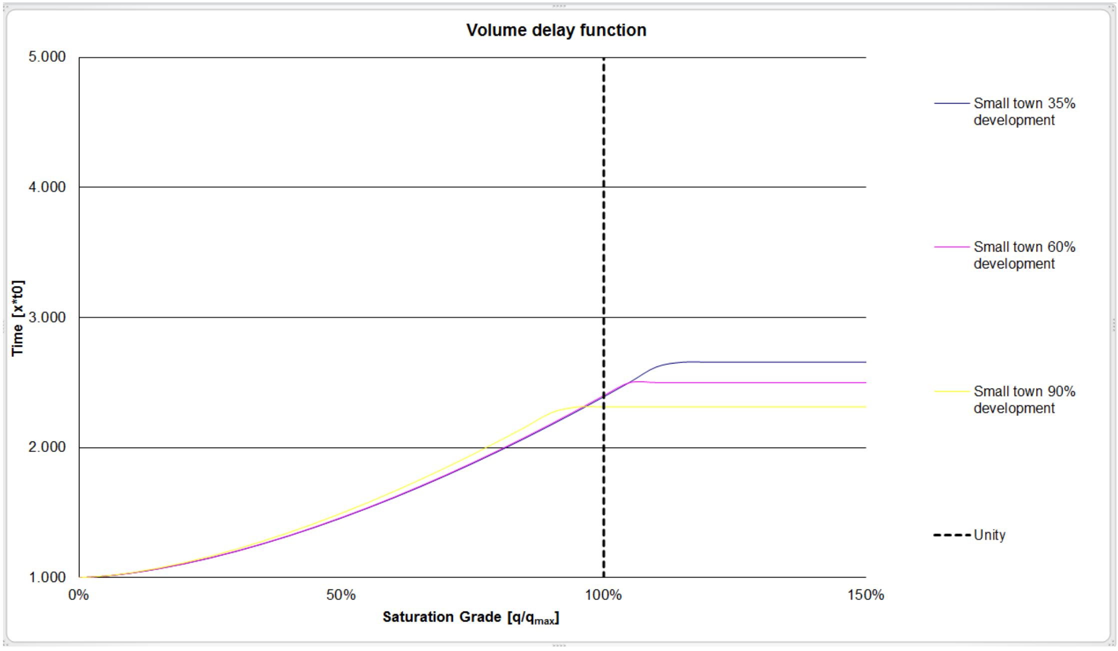
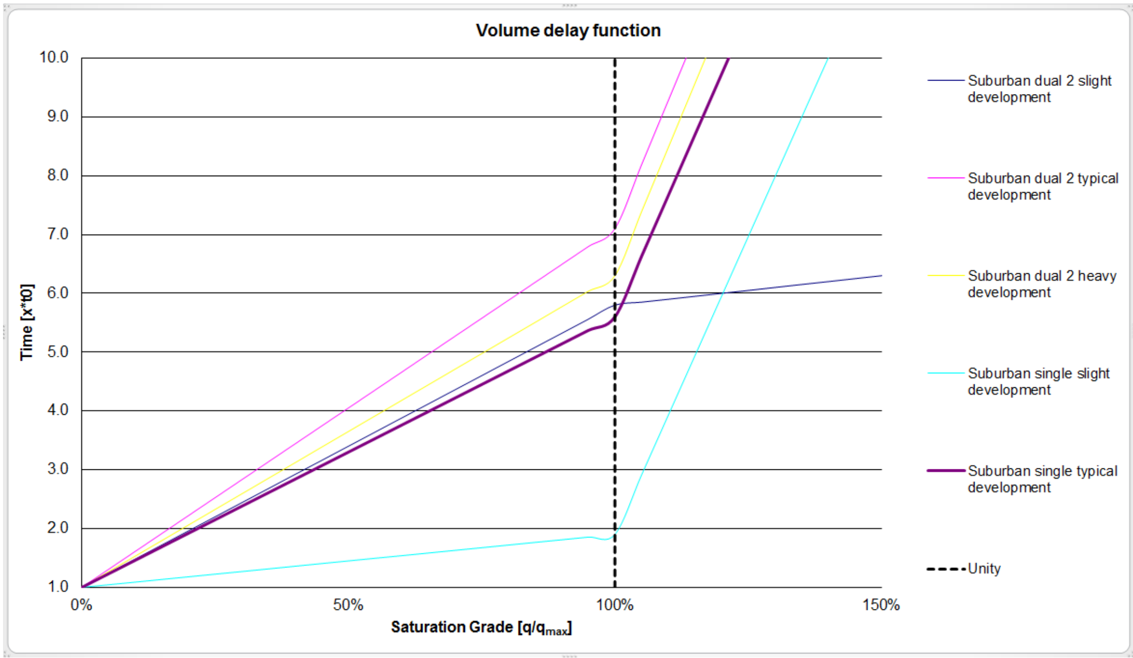


Figure 5 Suburban Speed Flow Curves



The formula used to calculate the speed flow curves within VISUM is detailed below:

Case 1: T Sys <> „HGV“

a) $sat < sat_{crit}$: $t_{Cur} = t_0 \cdot (1.0 + a \cdot sat)$

b) $sat \geq sat_{crit}$: $t_{Cur} = t_0 \cdot [1.0 + a \cdot sat_{crit} + b \cdot (sat - sat_{crit})]$

Case 2: T Sys = „HGV“

a) $sat < d$: $t_{Cur} = t_0 \cdot (1.0 + a_2 \cdot sat)$

b) $d \leq sat$ AND $sat < f$: $t_{Cur} = t_0 \cdot [1.0 + a_2 \cdot d + b_2 \cdot (sat - d)]$

c) $Else$: $t_{Cur} = t_0 \cdot [1.0 + a_2 \cdot d + b_2 \cdot (f - d) + d_2 \cdot (sat - f)]$

This translates into the following values to represent the speed flows curves taken from WebTAG guidance.

Table 5 WebTAG Speed Flow Curve Values

LinkType	Description	Formula Values							
		a	*b*	*c*	*d*	*a'*	*b'*	*d'*	*f*
0	Blocked opposite direction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	Rural dual 4 motorway	0.30	30.00	1.00	1.00	0.10	23.38	20.57	1.00
2	Rural dual 3 motorway	0.20	30.00	1.00	1.00	0.05	23.38	20.57	1.00
3	Rural dual 2 motorway	0.20	27.33	1.00	1.00	0.05	23.38	20.57	1.00
4	Rural dual 3 all purpose	0.20	28.67	1.00	1.00	0.05	23.38	20.57	1.00
5	Rural dual 2 all purpose	0.15	27.33	1.00	1.00	0.05	23.38	20.57	1.00
6	Rural single carriageway 10m good	0.69	23.38	1.00	1.00	0.10	23.38	20.57	1.00
7	Rural single carriageway 10m typical	0.77	21.76	1.00	0.80	0.10	21.76	6.19	1.00
8	Rural single carriageway 7.3m good	0.53	21.78	1.00	0.80	0.10	21.78	7.90	1.00
9	Rural single carriageway 7m typical	0.55	20.25	1.00	0.80	0.10	20.25	7.91	1.00

10	Rural single carriageway 6.5m bad	0.47	20.63	1.00	0.80	0.10	20.63	8.84	1.00
11	Suburban dual 2 slight development	4.80	1.00	1.00	0.85	0.05	21.00	20.00	1.00
12	Suburban dual 2 typical development	6.10	21.76	1.00	0.75	0.05	21.00	20.00	1.00
13	Suburban dual 2 heavy development	5.30	21.78	1.00	0.79	0.05	21.00	20.00	1.00
14	Suburban single slight development	0.90	20.25	1.00	0.97	0.05	21.00	20.00	1.00
15	Suburban single typical development	4.60	20.63	1.00	0.80	0.05	21.00	20.00	1.00
16	Suburban single heavy development	4.30	15.00	1.00	0.82	0.05	21.00	20.00	1.00
17	Urban non-central 50% development	0.79	1.20	1.00	N/A	N/A	N/A	N/A	N/A
18	Urban non-central 80% development	0.98	1.20	1.00	N/A	N/A	N/A	N/A	N/A
19	Urban non-central 100% development	1.17	1.25	1.00	N/A	N/A	N/A	N/A	N/A
20	Urban central INT = 2	1.30	1.20	1.00	N/A	N/A	N/A	N/A	N/A
21	Urban central INT = 4.5	1.60	1.40	1.00	N/A	N/A	N/A	N/A	N/A
22	Urban central INT = 9	2.50	1.35	1.00	N/A	N/A	N/A	N/A	N/A
23	Small town 35% development	1.39	1.60	1.00	N/A	N/A	N/A	N/A	N/A
24	Small town 60% development	1.40	1.60	1.00	N/A	N/A	N/A	N/A	N/A
25	Small town 90% development	1.50	1.60	1.00	N/A	N/A	N/A	N/A	N/A