Figure 1.2 2012 'City Centre' Model Coverage of the A465 Corridor

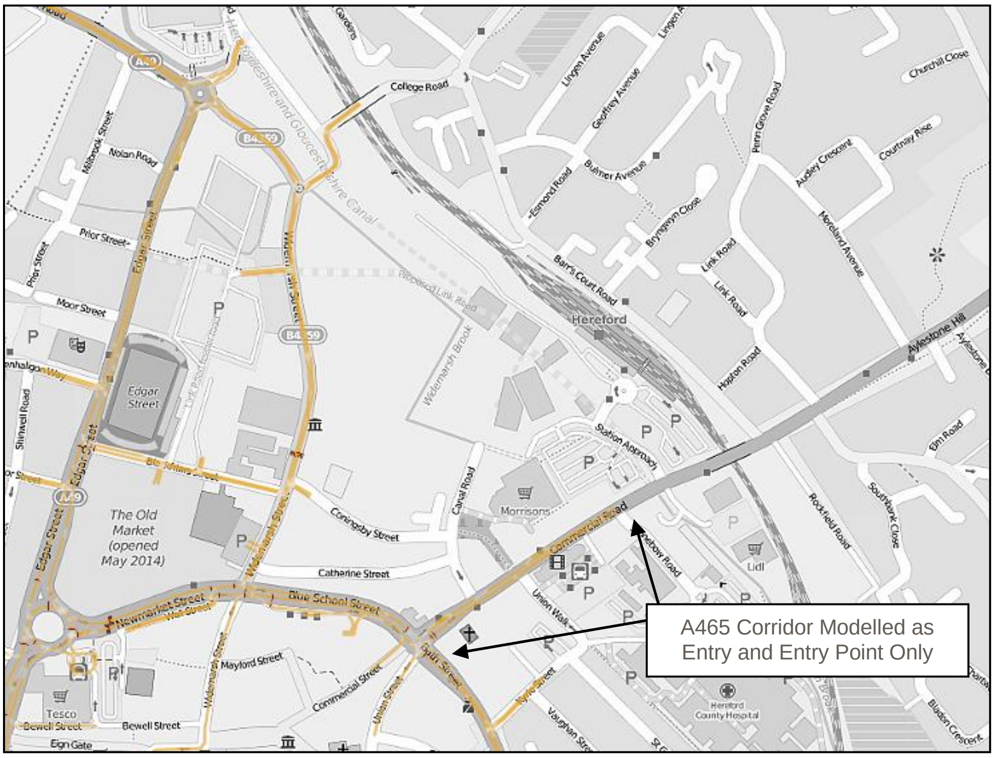


Figure 1.3 2014 Hereford Model Coverage including extension of the A465 Corridor

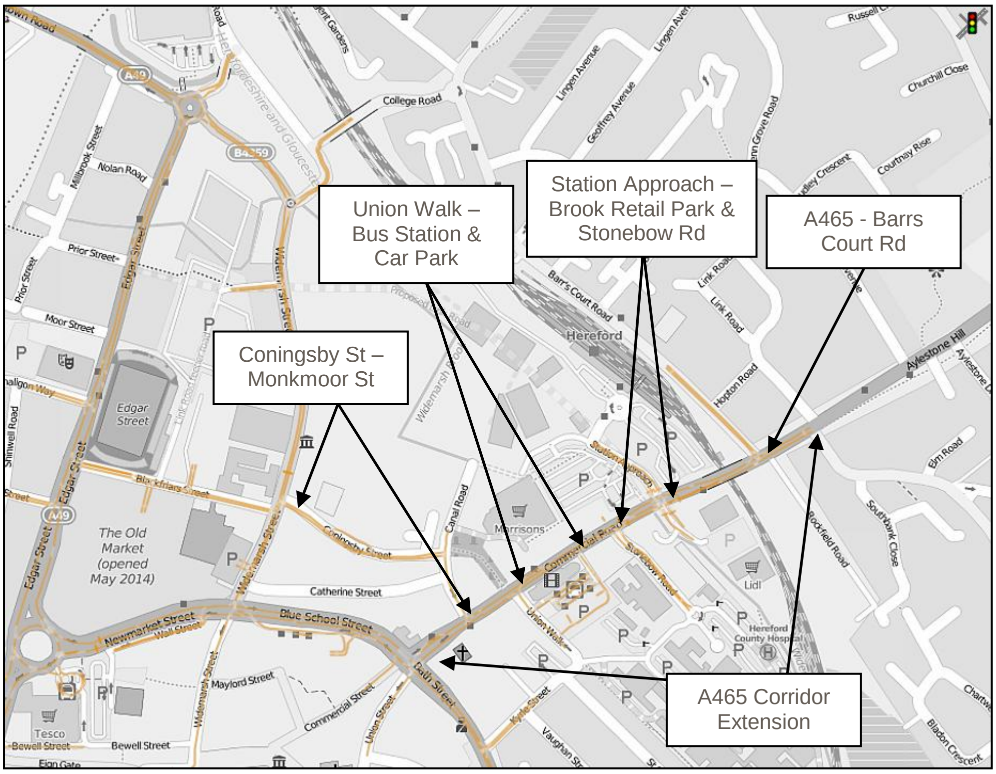
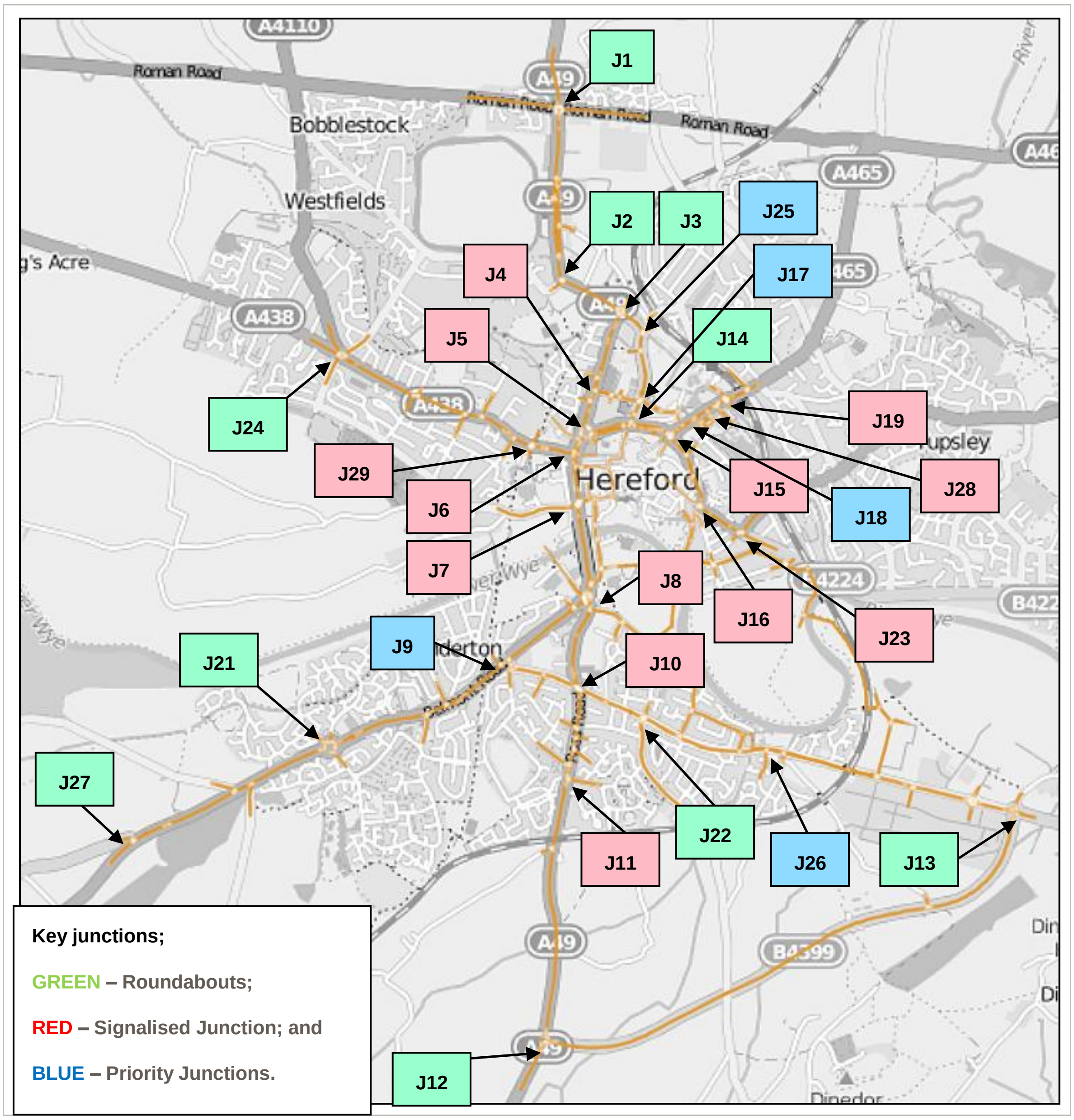


Figure 1.4 2014 Hereford Model Overall Coverage



1.5 There are three main arterial routes in the modelled area, as indicated in Figure 1.4.

i. A49 Strategic Road Network (SRN), running north to south through the model;

ii. A438 running northwest to southeast; and

iii. A465 running southwest to northeast.

1.6 The focus of the 2014 validation of the present year model is both the strategic road network in relation to junctions along the A49, and the local highway network. There are 30 junctions analysed within the model, 11 of which are of strategic importance along the A49, as indicated in Table 1.1.

1.7 Table 1.1 also contains definitions of each junction by type; traffic signals, roundabout and priority. It should be noted that over 40% of the modelled key junctions are signalised junctions, which indicates that the performance of the Hereford highway network is dependent on the management of traffic movements.

Table 1.1: Key Modelled Junctions

Key - GREEN – Roundabouts; RED – Signalised Junction; and BLUE – Priority Junctions

Junction	Location	Junction	Location
J1 (S1)	A49 / A4103 Roman Rd	J16 (S16)	A438 / St Owen St
J2 (S2)	A49 / Priory Place	J17 (HCC S5)	B4359 Widemarsh St / Blackfriars St / Coningsby St
J3 (S3)	A49 / Farriers Way / Newton Rd	J18 (HCC S7)	A465 Commercial Rd / Monkmoor St
J4 (S4)	A49 / Blackfriars St	J19 (HCC S8)	A465 / Station Approach / Brook Retail Park / Stonebow Rd
J5 (S5)	A49 / A438 Newmarket St	J20 (HCC S9)	A465 / Barrs Court Rd
J6 (S6)	A49 / A438 Eign St	J21 (2012 S1)	A465 / Abbotsmead Rd / Southolme Rd / Northolme Rd
J7 (S7)	A49 / Barton Rd / St Nicholas St	J22 (2012 S3)	Holme Lacy Rd / Chestnut Drive / Hoarwithy Rd
J8 (S8)	A49 / ASDA Junction	J23 (2012 S12)	A438 / Eign Rd
J9 (S9)	A465 / Walnut Tree Ave	J24 (2012 S23)	A438 / Yazor Rd / Wordsworth Rd / A110
J10 (S10)	A49 / Holme Lacy Rd / Walnut Tree Ave	J25 (2012 S28)	B4359 Widemarsh St / Newtown Rd
J11 (S11)	A49 / Bullingham Ln	J26 (2012 S36)	Holme Lacy Rd / St Clares Court
J12 (S12)	A49 / B4399	J27 (2012 S40)	A465 / B4349
J13 (S13)	B4399 / Chapel Rd / The Straight Mile	J28	A465 Commercial Rd / Union Walk
J14 (S14)	A438 / B4359 Widemarsh St	J29	A438 Eign St / Grimmer Rd
J15 (S15)	A438 / A465 Commercial Rd		

1.8 In order to develop an accurate representation of the traffic conditions throughout Hereford during the working day, the following time periods have been included in the model assessment:

- AM peak period (07:30-09:30), peak hour (08:00-09:00);
- Inter-peak period (11:30-13:30), peak hour (12:00-13:00); and
- PM peak period (16:30-18:30), peak hour (17:00-18:00).

1.9 The focus of the model evaluation is the peak hours within the above peak periods.

1.10 The VISSIM model has been developed to replicate, as far as feasible, the multi-modal interactions within Hereford, including:

1 Cars;

2 Light Goods Vehicles (LGVs);

3 Other Goods Vehicles Class 1 (OGV1) & Other Goods Vehicles 2 (OVG2); and

4 Public Service Vehicles (PSV);

1.11 The following document provides the evidence required to demonstrate that the Hereford VISSIM model is “fit for purpose” and has been developed in accordance with modelling best practice and Highway England applicable Department for Transport (DfT) Transport Appraisal Guidance (TAG), principally TAG Unit M3.1 – Highway Assignment Modelling.

1.12 This document contains references to the supporting Appendices, which is supplied as a separate document.

1.13 It is recommended that this document is reviewed and referenced to, as part of any subsequent application of the Hereford VISSIM model.

2 Data collection

INTRODUCTION

2.1 The following section provides an overview of the information collected for the model development, calibration and validation, including;

- Traffic counts;
- Queue counts; and
- Journey time data.

2.2 Each of the above data sets has been applied in the model development as either part of the model calibration or applied as an independent data set for model validation. Each data set is described in further detail below.

TRAFFIC COUNTS

Junction Turning Counts

2.3 The junction traffic volumes for 16 isolated junctions were collected, as part of the Present Year Validation model development process on the 12th November 2014, covering the key arterial routes within the modelled area – A49, A438 and A465 as mentioned in Section 1.4.

2.4 Supplementary to these counts, four additional junction counts were undertaken by Hereford City Council on the 22nd October 2014 and have also been taken into consideration for calibration purposes.

2.5 In addition to the junction count data collected in 2014, 2012 data has been used for calibration purposes for seven junctions that have low volumes or are situated on the edges of the VISSIM model.

2.6 The inclusion of the counts undertaken by Hereford City Council and the 2012 counts ensures that the Hereford VISSIM model is largely covered by survey locations, as shown in Figure 2.1, Figure 2.2 and Figure 2.3. The site count reference indicated within Figures 2.1-2.3 match the data collection format, and the list of junction counts can be found in Table 1.1.

2.7 The traffic count data is vehicle classified data, including 5 vehicle classes; Cars, Light Goods Vehicles (LGVs), Other Good Vehicles (OGVs) 1, OGV2 & Public Service Vehicles (PSVs), presented in 15 minute intervals for the:

- AM peak period (07:30-09:30);
- Inter-peak period (11:30-13:30); and
- PM peak period (16:30-18:30).

Figure 2.1 Traffic count location - A49 north / A438 West

Figure 2.2 Traffic count locations - south of the River Wye

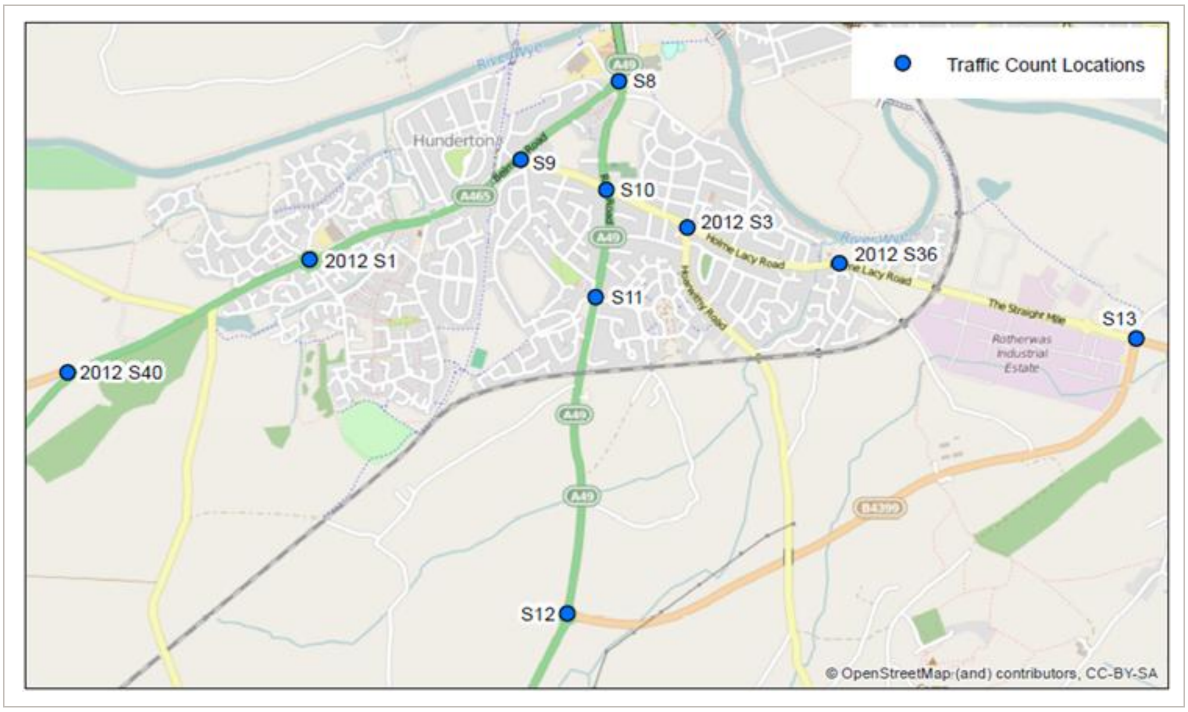
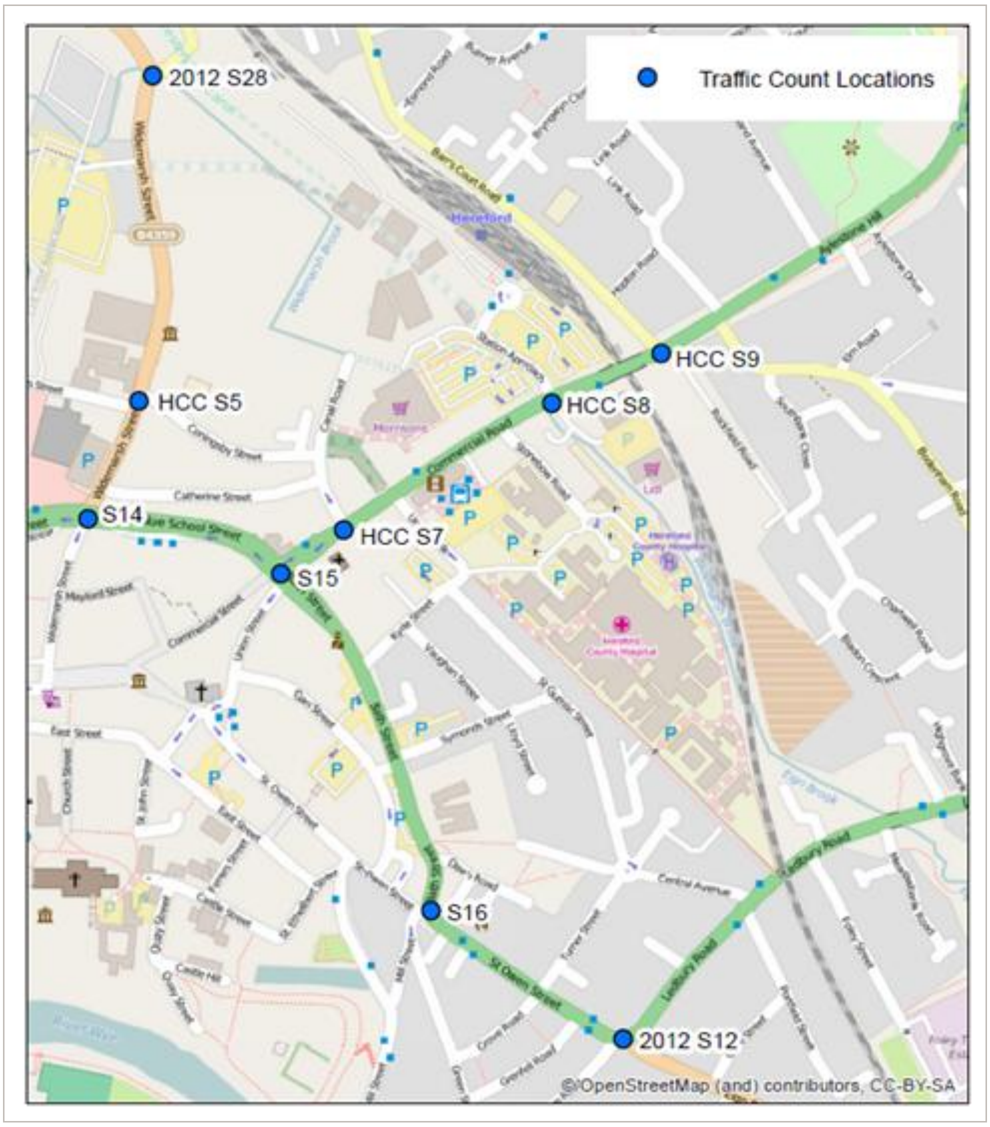


Figure 2.3 Traffic count locations - A438 east / A465 northeast



2.8 The junction count information is used to determine the junction entry and exit flow (links) and junction turning volumes, as part of the model calibration, in accordance with DfT TAG guidance. Based on the information collated the following comparisons have been identified for the model calibration;

- 189 Link counts; and
- 293 Turn counts.

2.9 This level of detail provides a comprehensive array of information for the calibration of traffic movements along the A49 corridor, including over 75 Link Counts and 100 Turn Counts, as summarised below;

- S1 - A49 / A4103 Roman Rd – 4 Arm Roundabout = 8 Link Counts and 12 Turn Counts;
- S2 - A49 / Priory Place – 3 Arm Roundabout = 6 Link Counts and 6 Turn Counts;
- S3 - A49 / Farriers Way / Newton Rd – 4 Arm Roundabout = 8 Link Counts and 12 Turn Counts;
- S4 - A49 / Blackfriars St – 3 Arm Priority Junction = 6 Link Counts and 6 Turn Counts;
- S5 - A49 / A438 Newmarket St - 3 Arm Roundabout = 6 Link Counts and 6 Turn Counts;
- S6 - A49 / A438 Eign St - 3 Arm Signalised Junction = 6 Link Counts and 5 Turn Counts;

- S7 - A49 / Barton Rd / St.Nicholas St - 4 Arm Signalised Junction = 8 Link Counts and 12 Turn Counts;
- S8 - A49 / ASDA Junction – 5 Arm Signalised Junction = 10 Link Counts and 20 Turn Counts;
- S10 - A49 / Holme Lacy Rd / Walnut Tree Ave - 4 Arm Signalised Junction = 8 Link Counts and 12 Turn Counts;
- S11 - A49 / Bullingham Ln - 3 Arm Signalised Junction = 6 Link Counts and 5 Turn Counts; and
- S12 - A49 / B4399 - 3 Arm Roundabout = 6 Link Counts and 6 Turn Counts;

Automatic Traffic Counts (ATC)

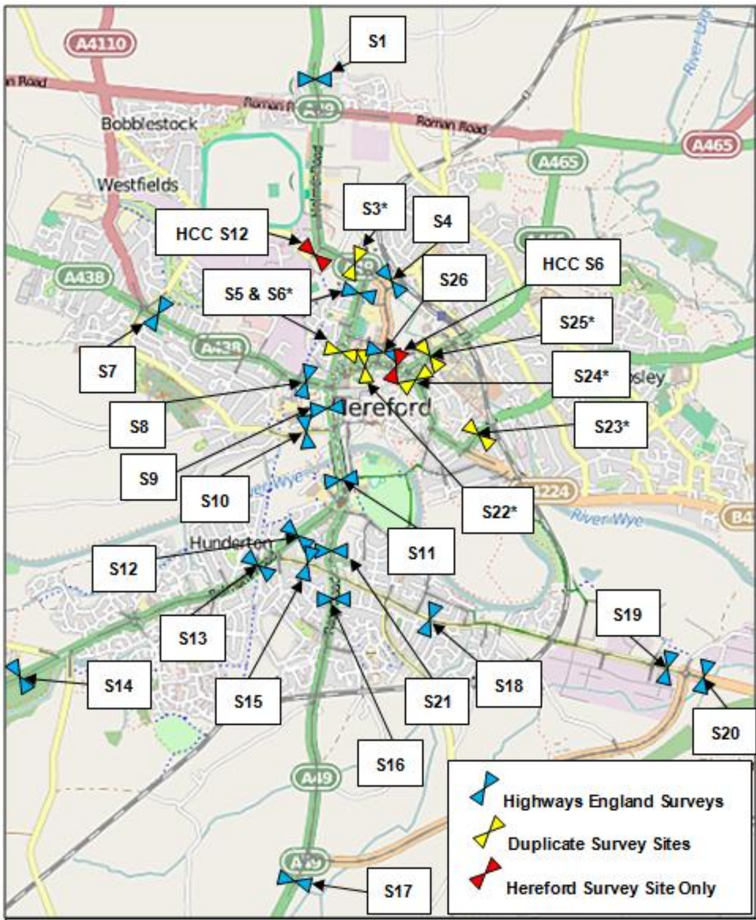
2.10 In order to ensure the model is representative of the average weekday traffic conditions (Monday-Friday) a series of independent Automatic Traffic Count (ATC) has been collected. This data represents the average weekday flows for the modelled periods by direction.

2.11 ATC's were commissioned in both the Highways England and the Herefordshire County Council (HCC) surveys in conjunction with the turning counts as previously described, as below;

- Highways England - 1 Week ATC – 26 locations (10^{th} – 16^{th} November 2014); and
- Herefordshire CC – 3 Week ATC – 8 locations (4^{th} – 24^{th} October 2014)

2.12 Figure 2.4 below presents the location of each ATC count locations, which are an available as part of the independent model validation data.

Figure 2.4 2014 automated traffic count location



S1	A49 (N)
S2	A49 Homer Rd
S3	A49 Newtown Rd
S4	Widemarsh St
S5	A49 Edgar St (N of Nolan Rd)
S6	A49 Edgar St (S of Canonmoor St)
S7	A438 Whitecross Rd
S8	A438 Eign St
S9	A49 Victoria St
S10	Barton Rd
S11	A49 (N) (N of St Martin's St)
S12	A465 Belmont Rd (N of Belmont Ave)
S13	A465 Belmont Rd (N of Hunderton Rd)
S14	A465 (N of B4349)
S15	Walnut Tree Ave
S16	A49 Ross Rd
S17	A49 (S)
S18	Holme Lacy Rd (E of Hinton Rd)
S19	The Straight Mile
S20	B4399 The Straight Mile
S21	A49 Ross Rd (N of Priors Walk)
S22	A438 Newmarket St
S23	A438 Ledbury Rd
S24	A438 Bath St
S25	A465 Commercial Rd
S26	B4359 Widemarsh St
HCC5	A49 Newtown Rd
HCC6	A438 Blueschool St
HCC7	A438 Bath St
HCC8	A438 Newmarket St
HCC9	A465 Commercial Rd
HCC10	A49 Edgar St
HCC12	Priory Place
HCC16	A438 Ledbury Rd

*Duplicate Survey Sites;
(S3* - HCC5 A49 Newton Rd), (S6* – HCC10 A49 Edgar St), (S22* – HCC8 A438 Newmarket St, (S23* - HCC16 A438 Ledbury Rd),
(S24* - HCC7 A438 Bath St) & (S25* - HCC9 A465 Commercial Rd)

QUEUE COUNTS

2.13 Queue length observations have been collected as part of the independent validation data which is used to demonstrate that the micro-simulation model is representative of the actual network conditions during the modelled periods.

2.14 Queue surveys were carried out in conjunction with the junction counts on both the 22nd October and 12th November 2014. The maximum queue lengths have been record for each lane of the approaches to the 20 analysed junctions, in 5 minute intervals for the following periods;

- AM peak period (07:00-10:00);
- Inter-peak period (11:00-14:00); and
- PM peak period (16:00-19:00).

2.15 The actual definition of a queue is subjective, as what is often considered as a queue is actually slow moving traffic. For example, at a signalised junction, the traffic could build up at an approach whilst awaiting the green signal. When the signal turns green, the traffic progresses through the junction. In this instance the queued traffic could technically be defined as the volume of vehicles that have failed to progress through the junction during the green phase and are therefore "queued" until the next green phase. It would be exceptionally difficult to monitor these conditions; therefore the model validation considers the modelled maximum observed queue within the modelled peak hour, in absence of the average queue, independent of the lane allocation.

2.16 Based on the information available, the maximum queue length has been defined for 74 observations, as summarised in Figure 2.5 below.

Figure 2.5 Queue length observations

Site	Location	Observations
S1	A49 / Roman Road	4
S2	A49 / Priory Place	3
S3	A49 / Farriers Way / Newton Road	4
S4	A49 / Blackfriars Street	3
S5	A49 / A438 Newmarket Sreet	3
S6	A49 / A438 Eign Street	4
S7	A49 / Barton Road / St Nicholas Street	4
S8	A49 / ASDA junction	6
S9	A465 / Walnut Tree Avenue	3
S10	A49 / Holme Lacy Road / Walnut Tree Avenue	4
S11	A49 / Bullingham Lane	3
S12	A49 / B4399	3
S13	B4399 / Chapel Road / The Straight Mile	4
S14	A438 / B4359 Widemarsh Street	4
S15	A438 / A465 Commercial Road	3
S16	A438 / St Owen Street	4
HCC S5	B4359 Widemarsh Street / Blackfriars Street / Coningsby Street	4
HCC S7	A465 Commercial Road / Monkmoor Street	3
HCC S8	A465 / Station Approach / Brook Retail Park	5
HCC S9	A465 / Barrs Court Road	3

JOURNEY TIME DATA

2.17 Journey time data is considered as an independent set of data which can be used to demonstrate that the modelled network conditions are representative of the observed, in accordance with DfT TAG modelling guidance.

2.18 Trafficmaster data provides an average travel time for each individual link within the Integrated Transport Network (ITN), which is a representation of the highway network in a geographical information system (GIS) format.

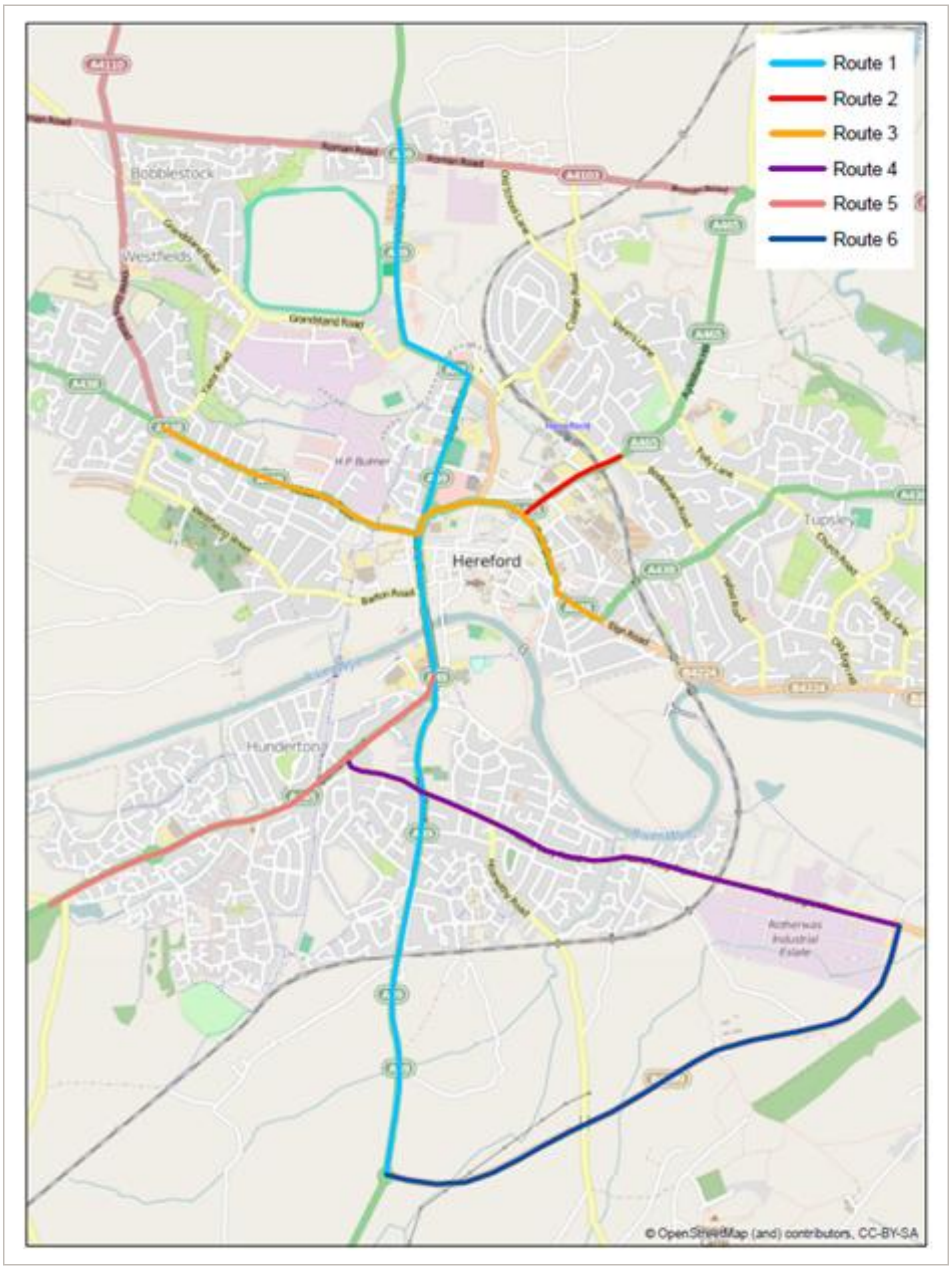
2.19 The data covers every day of 2014 based on the records collected from GPS devices, by vehicle classification in 15 minute intervals. The comparison data has been derived by the collation on ITN links into route sections, based on the car observations for the average hour in the modelled peak hour, based on the DMRB recommended neutral months in 2014 (April, May, September and October).

2.20 This approach enables the journey time analysis to be representative of the average travel time which is based on thousands of records over multiple days, rather than a set of fixed runs over limited period.

2.21 In total, 6 journey time routes have been analysed for validation purposes – 12 observation by direction, as listed below and shown Figures 2.3.

- Route 1 - A49 (A49 / B4399 to A49 / Church Way) – NB & SB;
- Route 2 - A465 (I) (A438 / Commercial Rd to A465 / Bodenham Rd) – EB & WB;
- Route 3 - A438 (A438 / Yazor Rd to A438 / St Owens St) – EB & WB;
- Route 4 - Holme Lacy Rd (A465 / Walnut Tree Av to B4399 / The Straight Mile) – EB & WB;
- Route 5 - A465 (II) (A465 / Ruckhall Ln to North of A465 / A49 Junction) – EB & WB; and
- Route 6 - B4399 (B4399 / The Straight Mile to B4399 / A49) – EB & WB.

Figure 2.6 Journey time routes – based on 2014 TrafficMaster data



DATA APPLICATION

2.22 The data collated is applied in the modelling calibration and validation process, as follows:

Calibration

- 189 Link counts; and
- 293 Turn Counts.

Validation

- 68 Link counts;
- 74 Maximum queue length observations; and
- 6 Journey time routes, 12 by direction.

2.23 This comprehensive array of information is considered as a significant advantage in the development process of the Hereford VISSIM micro-simulation model.

2.24 The data set includes a widespread set of traffic volume information for the calibration of the network demand, including an idependent validation set based on ATC data, in accordance with DfT TAG modelling guidance.

2.25 In terms of network performance information, the data set includes two independent sets of validation data, Journey Times, as specified in DfT TAG modelling guidance and Queue Length observations which a tailored data comparison set for operational assessment models.

2.26 It is considered that this array of data sources provides the required mix of information required to demonstrate that the model is representative of the observed average daily network conditions during the modelled periods.

2.27 The results of the model calibration and validation are presented in **Section 4**.

3 Model development

INTRODUCTION

3.1 The following section provides an overview of the development of the Hereford VISSIM model, including a brief description of the approach and parameters used in the model, such as;

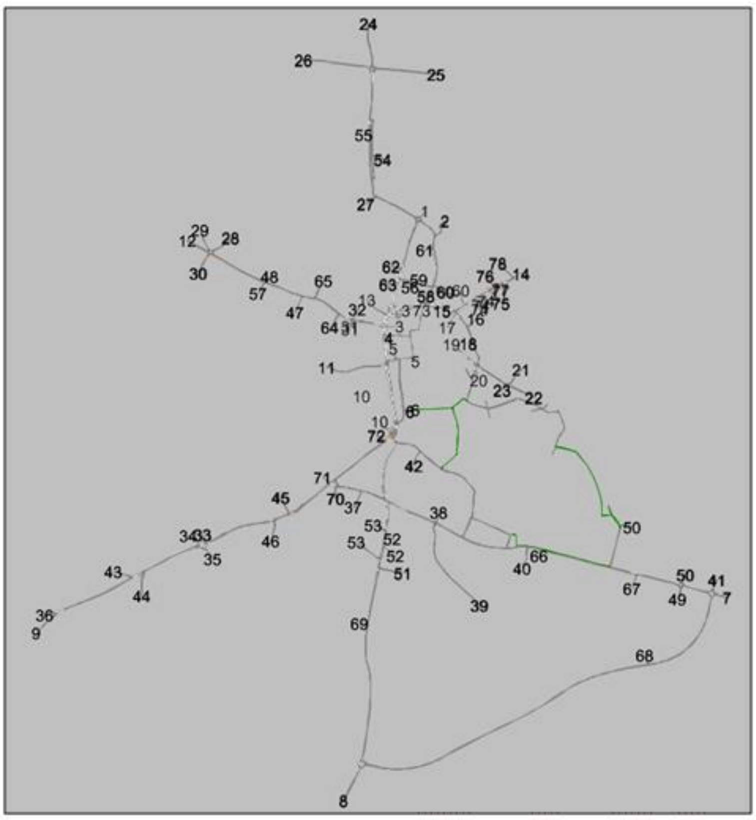
- Assignment;
- Matrix development;
- Speed limits & desired speed distributions;
- Traffic signals; and
- Driver behaviour etc....

NETWORK

3.2 Figure 3.1 below presents the 2014 Hereford VISSIM model network, which consists of 78 zones. The model has been generated by extending the 2013 Hereford VISSIM model.

3.3 The VISSIM model structure is designed to replicate the strategic movements throughout the A49 corridor, whilst retaining a representation of the local movements through Hereford and the interactions between the strategic and local road networks. As part of the creation of the 2014 Hereford VISSIM model, additional zones have been incorporated into the model to reflect the extension of the model along the A465, such as zone 76 representing Hereford Train Station.

Figure 3.1 2014 Hereford VISSIM model network



1	Farriers Way	40	St Clares Ct
2	Widemarsh St	41	Chapel Rd
3	Tesco	42	Hinton Crescent
4	West St	43	Ruckhall Lane
5	St Nicholas St	44	Unnamed Rd
6	St Martin's St	45	Beattie Ave
7	B4399 The Straight Mile	46	Goodrich Grove
8	A49 South	47	White Horse St
9	A465	48	Baggallay St (Area)
10	ASDA Access Rd	49	Netherwood Rd
11	Barton Rd	50	Thorn Business Park
12	A465 Kings Acre Rd	51	Bullingham Lane
13	Portland St	52	Bradbury Close / Garrick Ave
14	A465 A465 Aylestone Hill	53	Mayberry Ave / Pencroft Rd
15	Maylord Parking	54	Perseverance Rd
16	Kryle Street	55	Hereford Leisure Centre
17	Union Street	56	Blackfriars Development
18	Gaol St	57	Holmer St
19	St Owen St	58	Garrick House CP
20	Mill St	59	Blackfriars N
21	A438 Ledbury Rd	60	Coningsby St
22	B4224 Eign St	61	B4359 Ind Est
23	St James Rd	62	Penhaligon Way
24	A49 North	63	Cannonmoor St
25	A4103 Roman Road East	64	Ryelands St
26	A4103 Roman Road West	65	Plough Ln
27	Priory Place	66	Lower Bullingham Ln
28	Yazor Road	67	Ind Est
29	A4110 Three Elms Road	68	Waterry Ln
30	Wordsworth Road	69	Grafton Ln
31	Grimmer Road	70	Home Ln
32	Aldi	71	Hunderton Rd
33	Abbotsmead Road	72	Belmont Ave
34	Northolme Road	73	City Centre (Restricted)
35	Southolme Road	74	Bus Station Car Park, Union Walk
36	B4349	75	Stonebow Rd (County Hospital)
37	Hazel Grove	76	Station Approach
38	Chestnut Drive	77	Brook Retail Park
39	Hoarwithy Road	78	Barrs Court Rd

3.4 Based on the availability of detailed traffic count information, the model has been developed with demand matrices in 15 minute intervals for each modelled period.

3.5 A micro-simulation model requires a warm-up and cool-down period, before and at the end of the simulation, therefore each model period consists of the following Quarters, as shown in Table 3.1;

Table 3.1: Modelled Quarters

Description	Quarter	AM	Inter-peak	PM
Warm-up	Q1	07:30 – 07:45	11:30 – 11:45	16:30 – 16:45
Pre Peak	Q2	07:45 – 08:00	11:45 – 12:00	16:45 – 17:00
Peak Hour Q1	**Q3**	**08:00 – 08:15**	**12:00 – 12:15**	**17:00 – 17:15**
Peak Hour Q2	**Q4**	**08:15 – 08:30**	**12:15 – 12:30**	**17:15 – 17:30**
Peak Hour Q3	**Q5**	**08:30 – 08:45**	**12:30 – 12:45**	**17:30 – 17:45**
Peak Hour Q4	**Q6**	**08:45 – 09:00**	**12:45 – 13:00**	**17:45 – 18:00**
Post Peak	Q7	09:00 – 09:15	13:00 – 13:15	18:00 – 18:15
Cool-down	Q8	09:15 – 09:30	13:15 – 13:30	18:15 – 18:30

3.6 The focus of the model assessment, calibration and validation is the peak hour within each modelled period above. However, the additional warm-up and cool-down periods are included in the assignment to improve the realism of the model and reflect the impacts of possible congestion in the pre peak period on the peak hour.

DYNAMIC ASSIGNMENT & MATRIX DEVELOPMENT

3.7 In line with current "best practice", the Hereford VISSIM model has been set to a dynamic route choice assignment. A dynamic model is based on a matrix of origin and destination movements, which route according to the network conditions.

3.8 The initial prior matrix for the 2014 Hereford model was taken from the 2013 Hereford model. The prior matrix has then been manipulated to include all "known" movements, based on the turning count information, with the overall origin and destination zone totals constrained to the (IN/OUT) link volumes.

3.9 The model calibration process includes the minor manipulation of the matrices within a bespoke spreadsheet to match as close as possible to the observed volumes.

3.10 Based on the information available, separate matrices are produced for four vehicle classifications:

- Cars;
- Light Good Vehicles (LGVs);
- Other Good Vehicles (OGVs) 1; and
- OGVs 2.

3.11 Each of the above vehicle classification is assigned with a representative vehicle type and is assigned with individual matrices in 15 minute intervals, as per the modelled periods previously described.

SPEED LIMITS & DESIRED SPEED DISTRIBUTIONS

3.12 The speed distributions represent the desired travel speeds for vehicles related to the road classification and speed limit of the network. A range of desired speed flow distributions by road type, speed limit and vehicle type, have been defined, based on DfT statistics for Free Flow Vehicle Speeds:

- Table SPE101 – Free-flow vehicle speeds on non-built-up roads by road type and vehicle type in Great Britain, 2011; and
- Table SPE102 – Free-flow vehicle speeds on built-up roads by speed limit and vehicle type in Great Britain, 2011.

3.13 The updated desired speed distributions have been incorporated into the model structure, based on the network characteristics, such as road type and speed limit, in order to improve the realism of the model assignment, in line with DfT statistics.

TRAFFIC SIGNALS

3.14 Figure 1.4 clearly demonstrates that the Hereford highway network performance is reliant on a comprehensive set of traffic signals throughout the network, which forms a fundamental part of the traffic management toolkit.

3.15 Hereford operates an Urban Traffic Control system (UTC) for the coordination of the traffic signals throughout the principal City Centre urban corridor, A49, A438 and A465. The traffic signals operate through a series of self optimisation systems, for linked junctions and isolated junctions, such as;

- SCOOT – Split Cycle Offset Optimisation Technique; and;
- MOVA – Microprocessor Optimised Vehicle Actuation.

3.16 In essence, the traffic signal timings are optimised based on the vehicle demand, through a set of defined parameters. Therefore, the traffic signals automatically provide the maximum available capacity and subsequent network efficiency, based on the demand volumes and overall network conditions.

3.17 In order to produce a model which is representative of the available highway network, including its ability to respond to variations in the network demand, the traffic signals need to simulate this demand responsive function, in a proportional approach to requirement.

3.18 VISSIM provides the ability to model both SCOOT and MOVA based systems. However, the level of detail required and overall modelling work involved is considered as disproportionate activity to the model development. Therefore, the alternative approach is to implement the VisVAP function within VISSIM.

3.19 VisVAP is a facility which enables the traffic signals to be coded in a demand responsive format, with set available signal plans, phases, inter-greens, minimum and maximum green times.

3.20 The traffic signals are included in the model based on a set of signal heads and vehicle detectors. These detectors monitor the demand at each approach and instigate a change in the signal sequence based on the build-up of demand, within a series of set parameters.

3.21 The traffic signals represent the average available sequence and have no linkage to the changes in sequences which are generated by pedestrian demand, due the variability in the level of this demand on a day by day basis.

3.22 The Inter-green sequence is considered to be representing a scale of the impact of pedestrian demand, with individual Inter-green plans for the peak periods and the Inter-peak period.

3.23 Pedestrian crossings throughout the network are generally excluded, with the exception of those within the defined signal sequence. The exclusion of pedestrian crossings is considered to be acceptable due the limited availability in pedestrian demand and variability in this demand on a day by day basis.

3.24 The model includes the following 14 signal junctions, with defined signal controller, based on plan information collected from the Hereford UTC system for 2014;

- SC1 – A49 Edgar St / A438 Newmarket St;

- SC2 – A49 / A438 Eign St;
- SC3 – A49 / Barton Rd / St.Nicholas St;
- SC4 – A49 / A465 / ASDA Junction;
- SC5 – St.Martins River Crossing;
- SC6 – A438 Newmarket St / B4359 Widemarsh St;
- SC7 – A465 Commercial Rd / A438 Blue School St & A438 Bath St;
- SC8 – A438 St.Owen St / A438 Bath and St.Owen St;
- SC9 – A49 Ross Rd / Bullingham Ln;
- SC10 – A49 Ross Rd / Holme Lacy Rd / Walnut Tree Ave;
- SC11 – A438 Eign St / A438 Whitecross Rd / Grimmer Rd;
- SC12 – A49 Edgar St / Blackfriars St;
- SC13 – A465 Commercial Rd / Union Walk; and
- SC14 – A465 Commercial Rd / A465 Aylestone Rd / Station Approach / Brook Retail Park.

DRIVER BEHAVIOUR

3.25 In reality, driving behaviour is dependent upon road type and position; for example, drivers will exhibit different driving behaviours when travelling along a motorway compared to merging onto or leaving a motorway. Where VISSIM provides a default 'Freeway' setting for motorway driving, it is beneficial to alter or construct new behavioural parameters to reflect these expected behavioural differences. During model development, the following link behaviour has been applied to all roads:

- Urban (Motorized).

ADDITIONAL MODEL PARAMETERS

3.26 In addition to the standard model parameters as previously described, the detail in the VISSIM modelling is in the network coding which controls the way traffic operates around the key junctions, such a gap time at give-way priority junctions etc.

3.27 The following parameters below have been defined throughout the 2014 Hereford VISSIM model as part of the model development and calibration process.

- Gap acceptance;
- Conflict areas;
- Reduced speed areas;
- Lane allocations and restrictions; and
- Lane change decision distances.

3.28 In order to maintain consistency in the model structure, these parameters are consistent, as far as possible, in the AM peak hour, inter-peak hour and PM peak hour assignments.

3.29 In addition to the parameters highlighted above, in order to produce a realistic representation of the traffic conditions within Hereford, the model has been modified to include a representation of the public transport service operation, including bus stops, bus routes and bus service frequencies. It should be noted that the modelling assumes a consistent frequency across all modelled periods and excludes the influence of passenger interactions, e.g. boarding and alighting.

Model Convergence Approach

3.30 The Hereford VISSIM model is a dynamic assignment model, which is based on a matrix of origin and destination movements, which assigns to the network based on the 15 minute profile.

3.31 The objective of the assignment is to minimise the generalised cost in the network, which is a product of travel time and distance. Convergence represents a monitor of a model's stability in the assignment over multiple iterations. In VISSIM this is monitored through multiple criteria. However, in the instance of the Hereford model, this is defined as the change in the travel time in paths within each 15 minutes interval, with criteria of less than 25% change in travel time from one model iteration to the next.

3.32 As previously, described the Hereford network is characterised as a congested urban network, within is controlled through a wide range of signalised junctions, within multiple vehicle interactions, all which are hindrances to the model convergence process. Therefore an alternative approach has been applied to ensure a level of model stability.

3.33 The Method of Successive Average (MSA) has been applied to the modelling process, based on the average of the last 10 iterations, with equal weighting. In essence, this approach minimises the influence of variations between individual iterations, by considering the average over multiple iterations.

3.34 The VISSIM model is originally converged for each time period individually, using the MSA to generate a stable cost and path file. The final results are based on the assignment of the model based on these fixed parameters, in order to ensure the results are based on stabilised values.

3.35 In order to optimise the modelling process, the Hereford VISSIM model has been converged to using a fixed random seed of 42. It should be noted that the 15 minute assignment approach minimises the affect of the random seed on the final results.

SUMMARY

3.36 Based on the information presented above, the 2014 Hereford model has been developed in accordance with micro-simulation modelling "best practice". The following section presents calibration and validation results for the model, which clearly demonstrates that the model is representative of the 2014 Base Year network conditions, based on the defined model structure and parameters.

4 Model calibration and validation

INTRODUCTION

4.1 Model calibration is the process of adjusting the model key parameters so that these parameters reflect an appropriate proxy to the observed traffic conditions. These parameters include:

- Demand volume adjustments;
- Network parameter adjustments including;
  - Gap acceptance;
  - Reduced speed areas;
  - Lane allocations and restrictions;
  - Lane change decision distances; and
  - Speed distributions.

4.2 This chapter provides a summary of the outcome of the model calibration process, in accordance with the DfT TAG Unit M3.1 – Highway Assignment Modelling guidance, including both turn and link count calibration, based on the junction count data.

4.3 In addition, the model has been independently validated against a range of data types, in order to demonstrate the models "fit for purpose" status, including;

- 68 One-way link flows;
- 74 Queue lengths;
- 6 Journey times, 12 by direction.

CALIBRATION – TRAFFIC FLOW

4.4 Flow calibration is a process whereby modelled flow outputs are compared and calibrated to match observed traffic flows throughout the network. In this instance this refers to link and turning counts.

4.5 The HA's Design Manual for Roads and Bridges (DMRB), Volume 12, provides the guidance on the acceptable criteria when comparing modelled link flows against observed counts. For this assessment the link flow criteria has also been applied for the turning movement calibration, as required in TAG Unit M3.1 – Highway Assignment Modelling.

4.6 The Geoffrey E. Havers (GEH) statistic is a standard way of comparing the observed and modelled flows, as defined in DMRB, Volume 12, Chapter 4. The GEH value is similar to a chi-squared test and also incorporates both relative and absolute errors in order to give an overall measure of the accuracy of the modelled flow.

4.7 The GEH statistic has the benefit of removing bias that exists when comparing flows of different magnitudes using percentages, such that a difference of 10 in a flow of 100 vehicles per hour (vph) is less significant (GEH = 3) than a difference of 100 in a flow of 1000 vph (GEH = 11.5).

4.8 The GEH statistic is calculated by:

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

4.9 Where by: GEH = GEH statistic, M = modelled flow & C = Observed flow

4.10 The TAG & DMRB guidance indicates that the GEH statistics should be less than 5.0 for 85% of modelled hourly flows, both on link and turn volumes.

4.11 Furthermore, the percentage difference is also examined between observed and modelled flows.

4.12 The DMRB also provides a guidance for the observed vehicles per hour (vph):

- For observed flows 700-2,700 vph, modelled flow within 15% of observed flow;
- For observed flows < 700 vph, modelled flow within 100 vph of observed flow;
- For observed flows > 2,700 vph, modelled flow within 400 vph of observed flow: and
- Again, 85% of hourly flows should be within these criteria.

Key junction counts

4.13 Table 4.1 presents the key 27 junction calibration count results for the Hereford VISSIM model for the peak within the modelled period, based on link flows (entry & exit flows) and turning movement flows.

4.14 Table 4.1demonstrates that a junction link and turn count level, each modelled period exceeds the required criteria of 85% for both GEH and Flow. The PM peak hour represents the strongest correlation with the observed. However, the scale of variation with the other periods is minimal.

Table 4.1: Total Traffic Flow Calibration (Peak Hours)

Modelled Period	Link counts (189)		Turn counts (293)	
	% GEH Criteria (<5)	% Flow Criteria	GEH Criteria (<5)	% Flow Criteria
AM Peak Hr (08:00-09:00)	88%	90%	91%	97%
Inter-Peak Hr (12:00-13:00)	88%	89%	95%	98%
PM Peak Hr (17:00-18:00)	90%	90%	95%	97%

4.15 Table 4.2 below provides further details regarding the results which fall outside the GEH criteria, based on additional bandwidths of a GEH <10 and <15. Comparisons falling within these criteria represent a clear variation between the observed and the modelled traffic volumes.

4.16 The overall result demonstrates the calibration results outside the criteria are within an acceptable standard based on the scale of discrepancy in the GEH value and the overall magnitude of model calibration data.

Table 4.2: Link Count Calibration Variation

Criteria	Link counts (189)		
	AM Peak Hr (08:00-09:00)	Inter -Peak Hr (12:00-13:00)	PM Peak Hr (17:00-18:00)
% GEH <5	88%	88%	90%
% GEH <10	100%	100%	100%
% GEH <15	100%	100%	100%

4.17 Table 4.3 below provides an overview of the 27 key junction flow calibration for the peak hour in 15 minute intervals (Quarterly), based on the GEH criteria for modified peak hour flows i.e. observed and modelled flows times four.

4.18 This comparison is a step beyond the criteria specified within DfT TAG modelling guidance, which focuses on the hourly flows. Therefore, presentation of these results is primarily for reference. The overall analysis indicates the Inter-peak and PM peak hours present a stronger correlation with the observed data at the exceptionally detailed level, with the AM peak demonstrating a weaker correlation.

4.19 It should be noted that based on the aggregated hourly flows the model demonstrates a strong correlation with the observed, as shown in Table 4.3. Based on the scale of the Hereford model, achieving a 85% standard at a 15 minute interval is too onerous objective.

Table 4.3: Total Traffic Flow Calibration - Peak Hour Quarterly Comparison

Peak Hour Quarter	Links counts (189)		Peak Hour Quarter	Links counts (189)		Peak Hour Quarter	Link counts (189)
	GEH (<5)			GEH (<5)			GEH (<5)
Q1 - AM	**72%**		Q1 - IP	**79%**		Q1 - PM	**78%**
Q2 - AM	**78%**		Q2 - IP	**89%**		Q2 - PM	**85%**
Q3 - AM	**84%**		Q3 - IP	**87%**		Q3 - PM	**89%**
Q4 - AM	**69%**		Q4 - IP	**70%**		Q4 - PM	**71%**

4.20 Table 4.4 provides a comparison of the observed key 27 junction traffic volumes and model volumes, based on the two generalised vehicle types.

4.21 This analysis demonstrates that the modelled periods are generally lower than the observed volumes by an average of 5%, within identifiable variations in the HGV comparison. The HGV proportion is less than 5% and is subject to variations on a daily basis. Therefore, the imbalance between the observed and modelled HGV volumes is considered acceptable.

4.22 It should be noted, that the traffic flow calibration is based on an individual days observations, whereas the independent validation considers the average weekday flow.

Table 4.4: Traffic Calibration Junction Volume Comparison Modelled & Survey

Vehicle Class	AM Peak Hour (08:00-09:00)				Inter-Peak Hour (12:00-13:00)				PM Peak Hour (17:00-18:00)		
	Survey	Modelled	% Diff		Survey	Modelled	% Diff		Survey	Modelled	% Diff
Lights (Cars & LGVs)	53,211	50,618	-5%		47,317	44,157	-6%		56,598	53,492	-5%
HGV (OGV1 & 2)	1,938	1,487	-23%		2,291	1,586	-31%		872	1,183	36%
Total	**55,149**	**52,105**	**-6%**		**49,608**	**46,157**	**-7%**		**57,470**	**54,615**	**-5%**

4.23 Full disclosure of the individual count calibration results can be found in the following Appendices;

- Appendix A – Network Calibration Schematics – AM, Inter-peak and PM peak hours;
- Appendix B – Link Flow Calibration Results – AM, Inter-peak and PM peak hours; and
- Appendix C – Turn Flow Calibration Results – AM, Inter-peak and PM peak hours;

Correlation Analysis

4.24 In addition to the flow calibration, a correlation analysis is performed on the observed and modelled flows using link flow data. DMRB states that the acceptable values of the correlation co-efficient (R) should be greater than 0.95 and the slope of the best line-fit should be between 0.90 and 1.10, with a value of 1.00 representing a perfect fit. Figure 4.1, Figure 4.2 & Figure 4.3 present the correlation analysis for the AM, inter-peak and PM peak hours respectively. The results demonstrate that each period aligns with the required standard, in both instances.

Figure 4.1 AM peak hour – link count correlation analysis

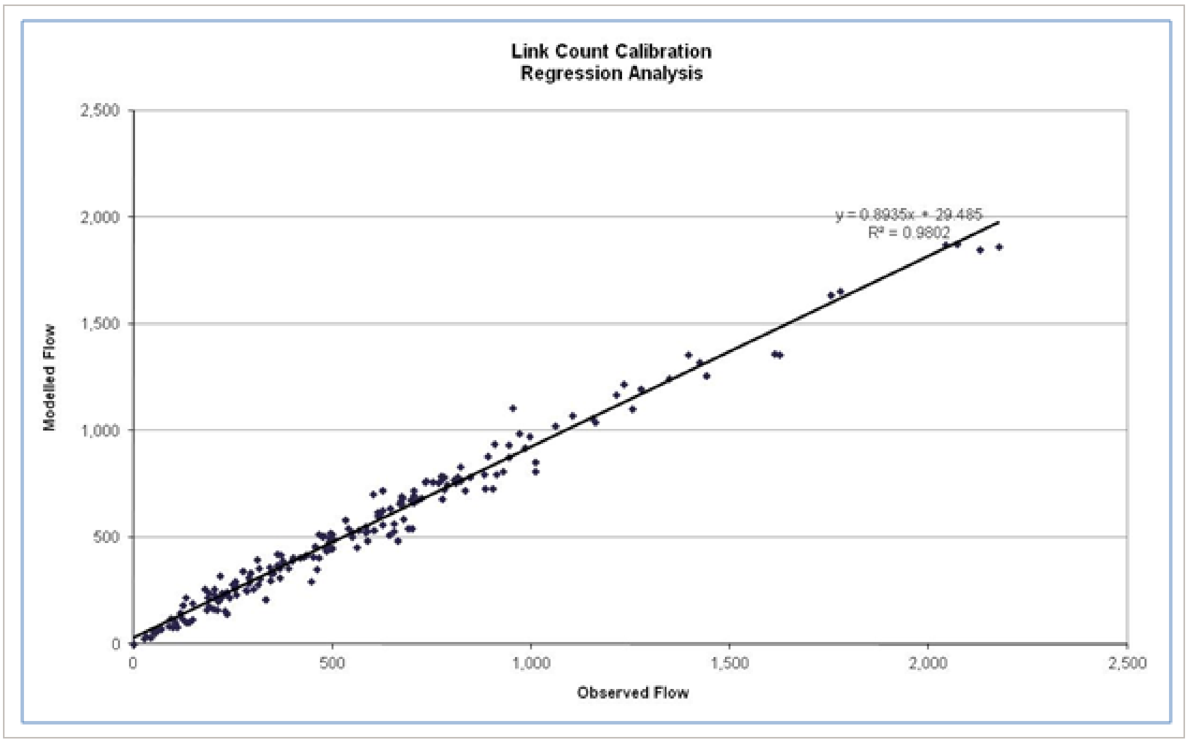


Figure 4.2 Inter-peak hour – link count correlation analysis

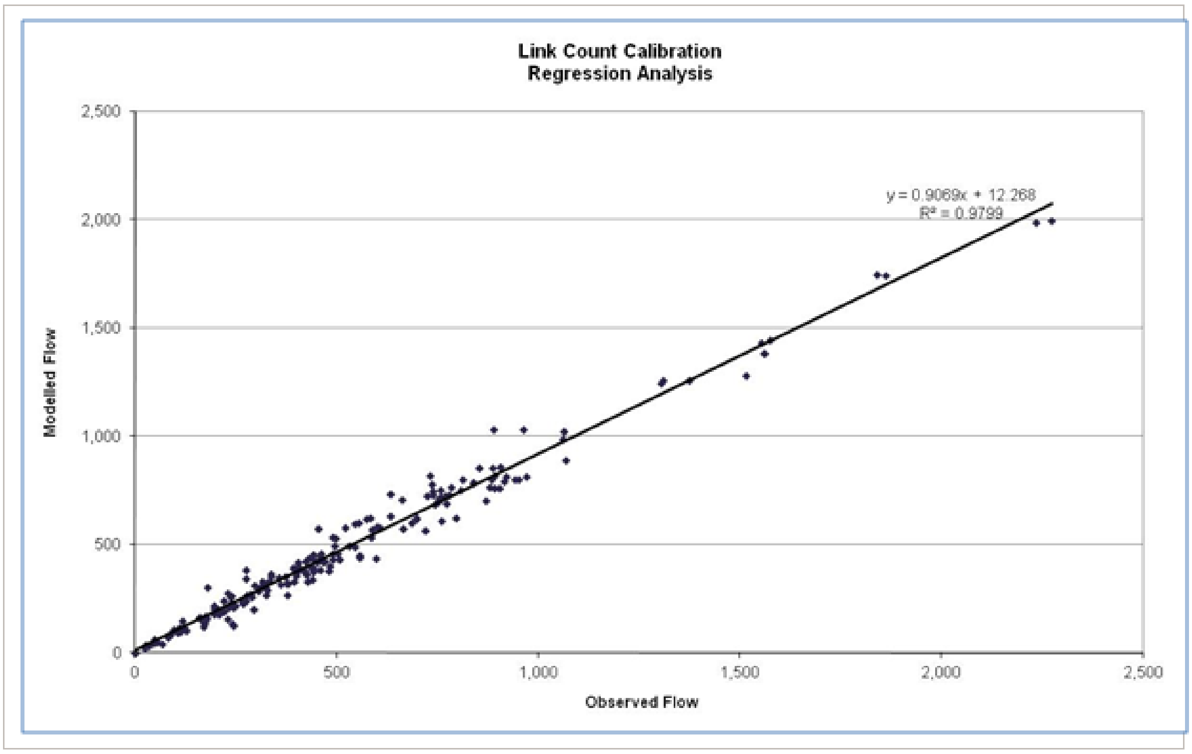
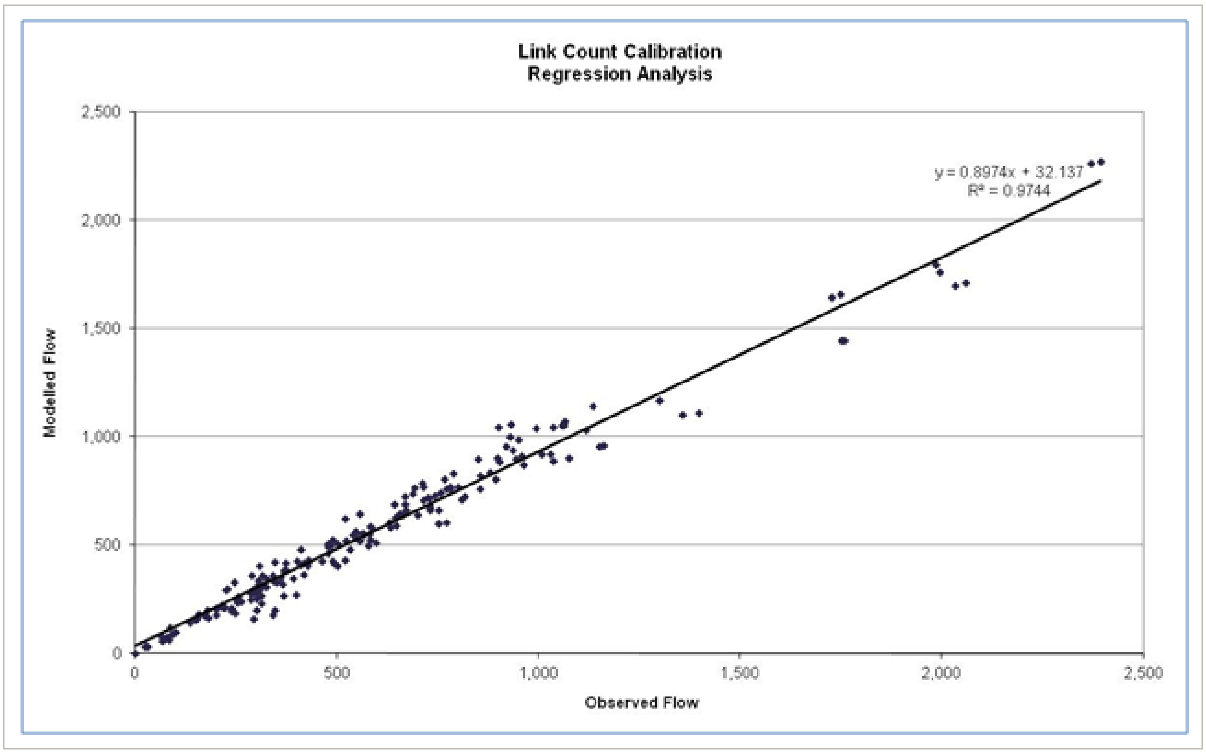


Figure 4.3 PM peak hour - link count correlation analysis



Herefordshire County Council Junction Counts

4.25 Table 4.5 & Table 4.6 present the model calibration results for the Herefordshire County Council junction counts as isolated data set, covering eight junctions, primarily along the A465 corridor, which equates to 51 links counts and 72 turn counts.

4.26 Table 4.5 indicates that based on this separate data set, the AM and PM peak hours demonstrate a strong correlation with the observed data within this area. However, the Inter-peak weaker correlation, which could be due to variation in level of activity during the day between October the November periods.

4.27 Despite this Inter-peak result, Table 4.6 indicates that overall results are within an acceptable standard, based on the broader GEH criteria.

Table 4.5: Herefordshire Junction Count Total Traffic Flow Calibration (Peak Hours)

Modelled Period	Link counts (51)		Turn counts (72)	
	% GEH Criteria (<5)	% Flow Criteria	GEH Criteria (<5)	% Flow Criteria
AM Peak Hr (08:00-09:00)	84%	86%	82%	94%
Inter-Peak Hr (12:00-13:00)	73%	78%	85%	92%
PM Peak Hr (17:00-18:00)	92%	88%	92%	96%

Table 4.6: Herefordshire Junction Link Count Calibration Variation

Criteria	Link counts (189)		
	AM Peak Hr (08:00-09:00)	Inter -Peak Hr (12:00-13:00)	PM Peak Hr (17:00-18:00)
% GEH <5	84%	73%	92%
% GEH <10	100%	100%	100%
% GEH <15	100%	100%	100%

4.28 Full disclosure of the individual count calibration results can be found in;

- Appendix G – HCC Link Flow Calibration Results – AM, Inter-peak and PM peak hours;
- Appendix H – HCC Turn Flow Calibration Results – AM, Inter-peak and PM peak hours;

VALIDATION – TRAFFIC FLOW

4.29 In addition to the calibration of the model on based on the local network junction counts, additional traffic volume information has been collected through Automatic Traffic Counts (ATC), as previously described in Section 2.

4.30 Table 4.7 presents the results for the validation of the link flows based on the ATC total traffic volumes for 50 of the 68 ATC locations, based on the availability of valid data set. The analysis is presented for the combined two-way flow and by direction.

4.31 In order to remove contradicting data, particularly the duplicated ATC sites in the Highways England and HCC surveys, as shown in Figure 2.4, the analysis is based on the Highways England surveys only for consistency with the primary junction count information.

4.32 Table 4.7 demonstrates that no individual period matches the recommended 85% criteria for both GEH and Flow at either the combined two-way flow or directional flow. However, it should be noted that the validation in accordance with the GEH criteria at the directional level across all periods.

Table 4.7: ATC Total Traffic Volume - Link Count Validation

Modelled Period	Link counts (25) two-way flows		Link counts (50) directional flows	
	% GEH Criteria (<5)	% Flow Criteria	% GEH Criteria (<5)	% Flow Criteria
AM Peak Hr (08:00-09:00)	88%	84%	86%	84%
Inter-peak Hr (12:00-13:00)	80%	84%	90%	88%
PM Peak Hr (17:00-18:00)	84%	88%	86%	82%

4.33 Table 4.8 demonstrates that the overall results in ATC based count validation are within a acceptable standard, based on the extended GEH criteria.

4.34 It should be noted that the model calibration and validation are independent processes. Therefore the validation is compared to the model independently of the demand development process, which is based on the calibration data set. It is likely that variations exist between the calibration and validation observed data at a detailed level, therefore the omission of the model validation is considered acceptable given the level of model calibration achieved.

Table 4.8: ATC Total Traffic Volume - Link Count Validation Variation

Criteria	Link counts (50) directional flows		
	AM Peak Hr (08:00-09:00)	Inter-Peak Hr (12:00-13:00)	PM Peak Hr (17:00-18:00)
% GEH <5	**86%**	**90%**	**86%**
% GEH <10	**98%**	**100%**	**98%**
% GEH <15	**100%**	**100%**	**100%**

4.35 Full disclosure of the individual count validation results can be found in the following Appendices:

- Appendix D – Link Flow Validation Results – AM, Inter-peak and PM peak hours.

VALIDATION – JOURNEY TIME

4.36 Journey time data is used as the primary indicator for the assessment and evaluation of network conditions during the modelled period.

4.37 Section 2 provided an overview of the definition of journey time data for the model validation based on 6 routes, based vehicle based TrafficMaster data. The following section provides an overview of the models performance based on this observed data set for the average of the neutral months in 2014 (April, May, September and October).

4.38 TAG Unit M3.1 & DMRB states that the difference between the observed and modelled journey time should not be more than 15% (or 1 minute, if higher) for 85% of the journey routes. Table 4.9 provides a summary of the journey time validation, followed by Figure 4.4, Figure 4.5 and Figure 4.6, which contain the individual journey time routes for the AM, Inter-peak and PM peak hours, respectively.

4.39 Table 4.9 indicates that based on the 12 directional journey time observations, the level of validation achieved is consistent across all periods, at 75% of all routes, based on the 15% criteria.

4.40 It is acknowledged that this level is below the recommended 85% criteria. However, the overarching modelling approach is to maintain a level of consistency in the model structure between the three modelled periods. Therefore, based variation in validated, slow and fast routes between modelled periods, the results presented are considered to demonstrate the model is representative of the network conditions.

Table 4.9: Journey Time Validation Summary

4.41

Modelled Period	All routes			
	% Routes within <15% criteria	Total observed travel time (secs)	Total modelled travel time (secs)	% Difference
AM Peak Hr (08:00-09:00)	**75%**	**4,651**	**4,635**	**0%**
Inter-peak Hr (12:00-13:00)	**75%**	**3,725**	**3,934**	**6%**
PM Peak Hr (17:00-18:00)	**75%**	**4,146**	**4,481**	**8%**

Figure 4.4 AM peak hour journey time validation

Route	Route Description	Criteria <15%		% PASS		75%
		AM Peak Hr (8-9)				
		Dis (m)	Obs (secs)	Mod (secs)	% Diff	PASS / FAIL
1-NB	A49 NB (A49 / B4399 to A49 / Church Way)	6,081	842	863	2%	PASS
1-SB	A49 SB (A49 / Church Way to A49 / B4399)	6,100	817	790	-3%	PASS
2-EB	A465 (I) EB (A438 / Commercial Rd to A465 / Bodenham Rd)	625	119	115	-3%	PASS
2-WB	A465 (I) WB (A465 / Bodenham Rd to A438 / Commercial Rd)	621	194	172	-11%	PASS
3-EB	A438 EB (A438 / Yazor Rd to A438 / St Owens St)	2,999	479	492	3%	PASS
3-WB	A438 WB (A438 / St Owens St to A438 / Yazor Rd)	2,943	471	515	9%	PASS
4-EB	Holme Lacy Rd EB (A465 / Walnut Tree Av to B4399 / The Straight Mile)	3,197	334	351	5%	PASS
4-WB	Holme Lacy Rd WB (B4399 / The Straight Mile to A465 / Walnut Tree	3,210	411	331	-19%	FAIL
5-EB	A465 (II) EB (A465 / Ruckhall Ln to North of A465 / A49 Junction)	2,537	430	441	3%	PASS
5-WB	A465 (II) WB (North of A465 / A49 Junction to A465 / Ruckhall Ln)	2,523	250	294	17%	FAIL
6-EB	B4399 EB (B4399 / A49 to B4399 / The Straight Mile)	3,341	166	141	-15%	FAIL
6-WB	B4399 WB (B4399 / The Straight Mile to B4399 / A49)	3,299	138	130	-6%	PASS
	Total	37,476	4,651	4,635	0%	PASS
	Average Speed (kph)		29.0	29.1	0%	PASS

Figure 4.5 Inter-peak journey time validation

Route	Route Description	Criteria <15%		% PASS		75%
		Inter-peak Hr (11-12)				
		Dis (m)	Obs (secs)	Mod (secs)	% Diff	PASS / FAIL
1-NB	A49 NB (A49 / B4399 to A49 / Church Way)	6,081	647	675	4%	PASS
1-SB	A49 SB (A49 / Church Way to A49 / B4399)	6,100	599	679	13%	PASS
2-EB	A465 (I) EB (A438 / Commerical Rd to A465 / Bodenham Rd)	625	106	111	5%	PASS
2-WB	A465 (I) WB (A465 / Bodenham Rd to A438 / Commercial Rd)	621	197	150	-24%	FAIL
3-EB	A438 EB (A438 / Yazor Rd to A438 / St Owens St)	2,999	391	438	12%	PASS
3-WB	A438 WB (A438 / St Owens St to A438 / Yazor Rd)	2,943	454	437	-4%	PASS
4-EB	Holme Lacy Rd EB (A465 / Walnut Tree Av to B4399 / The Straight Mile)	3,197	314	343	9%	PASS
4-WB	Holme Lacy Rd WB (B4399 / The Straight Mile to A465 / Walnut Tree Av)	3,210	289	303	5%	PASS
5-EB	A465 (II) EB (A465 / Ruckhall Ln to North of A465 / A49 Junction)	2,537	297	272	-8%	PASS
5-WB	A465 (II) WB (North of A465 / A49 Junction to A465 / Ruckhall Ln)	2,523	197	259	32%	FAIL
6-EB	B4399 EB (B4399 / A49 to B4399 / The Straight Mile)	3,341	119	138	16%	FAIL
6-WB	B4399 WB (B4399 / The Straight Mile to B4399 / A49)	3,299	115	129	13%	PASS
	Total	37,476	3,725	3,934	6%	PASS
	Average Speed (kph)		36.2	34.3	-5%	PASS

Figure 4.6 PM peak hour journey time validation

Route	Route Description	Criteria <15%		% PASS		75%
		PM Peak Hr (17-18)				
		Dis (m)	Obs (secs)	Mod (secs)	% Diff	PASS / FAIL
1-NB	A49 NB (A49 / B4399 to A49 / Church Way)	6,081	689	723	5%	PASS
1-SB	A49 SB (A49 / Church Way to A49 / B4399)	6,100	749	818	9%	PASS
2-EB	A465 (I) EB (A438 / Commercial Rd to A465 / Bodenham Rd)	625	103	114	11%	PASS
2-WB	A465 (I) WB (A465 / Bodenham Rd to A438 / Commercial Rd)	621	166	159	-4%	PASS
3-EB	A438 EB (A438 / Yazor Rd to A438 / St Owens St)	2,999	449	440	-2%	PASS
3-WB	A438 WB (A438 / St Owens St to A438 / Yazor Rd)	2,943	525	432	-18%	FAIL
4-EB	Holme Lacy Rd EB (A465 / Walnut Tree Av to B4399 / The Straight Mile)	3,197	298	521	75%	FAIL
4-WB	Holme Lacy Rd WB (B4399 / The Straight Mile to A465 / Walnut Tree	3,210	355	325	-9%	PASS
5-EB	A465 (II) EB (A465 / Ruckhall Ln to North of A465 / A49 Junction)	2,537	262	385	47%	FAIL
5-WB	A465 (II) WB (North of A465 / A49 Junction to A465 / Ruckhall Ln)	2,523	283	297	5%	PASS
6-EB	B4399 EB (B4399 / A49 to B4399 / The Straight Mile)	3,341	123	126	3%	PASS
6-WB	B4399 WB (B4399 / The Straight Mile to B4399 / A49)	3,299	144	141	-2%	PASS
	Total	37,476	4,146	4,481	8%	PASS
	Average Speed (kph)		32.5	30.1	-7%	PASS

4.42 With the exception of the two of the omitted routes in the PM peak period, the remaining omitted results are considered acceptable, as the vast majority of routes would validate with an adjusted criterion of 17%.

4.43 The overall travel time across all routes demonstrates a close correlation within the observed records, particularly in the AM peak hour.

4.44 The PM peak hour presents the weakest correlation, with the model demonstrating more delay in the network than the observed, despite this period showing the strongest correlation with the observed traffic volumes, as previously described. Based on the results presented the primary variation is in the south of the network in the eastbound direction, as shown for the A465 Belmont Rd corridor (4-EB) route and the Holme Lacy Rd corridor (5-EB) route.

4.45 The modelling demonstrates an inconsistency between the observed and modelled journey times. However, modelled results more closely aligns with the perceived conditions along these specific routes and the model aligns with the traffic volumes and queue conditions, therefore the omission of validation along these specific corridors is considered acceptable.

4.46 The following appendices contains further information regarding the validation of each individual journey time routes, including the cumulative travel time profile;

- Appendix E – Journey Time Validation Results – AM, Inter-peak and PM peak hours;

VALIDATION – MAXIMUM QUEUE LENGTH

4.47 A VISSIM model is an operational assessment tool which simulates every second throughout the modelled period, with the objective of reflecting the individual interactions and subsequent impact on network conditions.

4.48 The principle requirement of the queue validation is to ensure that the model does not generate excessive queued vehicles which varies from the observed or inversely underestimates the scale of congestion in the network.

4.49 The VISSIM model is set to record a queue length when the vehicle speed falls below 5kph at the junction approach and then records the queue length until the vehicle speed exceeds 10kph. Recording observed queue lengths in a consistent method in reality is impractical, therefore variations in the queue length analysis is intrinsic to the assessment.

4.50 Both the observed and modelled maximum queue length data is collected in meters. In order to assist the interpretation of these results, the queue lengths have been converted into vehicles based on an average vehicle length and space of 5.75 meters.

4.51 Based on the complexity in recording queue lengths and the absence of average queue length, the model is validated against the maximum queue length within the modelled peak hour. This technically represents the most congested phase within the peak hour and demonstrates that the model performs as consistently, as possible.

4.52 In the absence of defined DfT TAG queue length criteria, Figure 4.7 below contains a summary of the maximum queue length validation results, based on two study specific criteria, using the 85% of observation criteria;

- Total of all junction approaches maximum queue length within 30 vehicles; and
- Individual junction approaches maximum queue length with 15 vehicles.

4.53 Figure 4.7 demonstrates that the Inter-peak period presents the strongest correlation within the observed maximum queue length, within only 1% difference in the total maximum queue length in the peak hour assignment.

4.54 The PM peak hour shows a closer correlation with the observed, followed by slightly weaker result in the AM peak hour.

4.55 Figure 4.8 to Figure 4.10 presents the summary maximum queue for each individual modelled period based on the junction approach totals. Each table indicates the results which are outside the criteria and the scale of variation.

4.56 In the both the AM & PM peak hours, the primary omitted junction is the A49/A465/ASDA junction, which is the principal point of congestion in the Hereford network. This junction is primarily characterised as excessive queued vehicles on the northbound approach of the A49 Ross Road and the A465 Belmont Road.

4.57 It is considered that the models representation of queued vehicles at the A49/A465/ASDA junction in the peak hours is representative of the network conditions, despite the variation in the model validation result.

Figure 4.7 Maximum queue length validation summary

Modelled Period	Maximum queue length validation (in vehicles)				
	% Total junction (19 counts)	% Junction approaches (75 counts)	Total maximum queue - all junctions		
	Maximum queue length <30 vehicles	Maximum queue length <15 vehicles	Surveyed (vehicles)	Modelled (vehicles)	% Difference
AM Peak Hr (08:00-09:00)	74%	84%	1,011	1,340	32%
Inter-peak Hr (12:00-13:00)	95%	96%	754	763	1%
PM Peak Hr (17:00-18:00)	84%	81%	984	1,197	22%

Figure 4.8 AM peak maximum queue length results

Queue Validation	% PASS	74%
	Average Vehicle Length (m)	5.75
	Criteria <Veh	30

Junction Maximum Queue Length Validation Summary

Junction	Site	Arms	Description	Lanes	Vehicles: Survey Queue Max Q (Veh)	Vehicles: Model Queue Max Q (Veh)	Vehicles: Diff (M-S) Max Q (Veh)	PASS / FAIL <30Veh
1	Site 1	4	A49 / A4103 Roman Rd	8	63	46	-18	PASS
2	Site 2	3	A49 Holmer Rd / A49 Newton Rd / Priory Place	5	56	106	51	FAIL
3	Site 3	4	A49 Newton Rd / Edgar St / Newton Rd / Farriers Way	7	29	90	62	FAIL
4	Site 4	3	A49 Edgar St / Blackfriars St	7	19	37	18	PASS
5	Site 5	3	A49 Edgar St / A49 Victoria St / A438 Newmarket St	10	68	53	-14	PASS
6	Site 6	4	A49 Victoria St / A49 Gunners Ln / A438 Eign St	9	60	66	6	PASS
7	Site 7	4	A49 / Barton Rd / St.Nicholas St	10	83	79	-5	PASS
8	Site 8	6	A49 / A465 Belmont Rd / Hinton Rd / ASDA / St Martins	11	125	265	140	FAIL
9	Site 9	3	A465 Belmont Ave / Walnut Tree Ave	5	33	48	15	PASS
10	Site 10	4	A49 Ross Rd / Holme Lacy Rd	9	97	69	-27	PASS
11	Site 11	3	A49 Ross Rd / Bullingham Rd	4	59	59	0	PASS
12	Site 12	3	A49 Ross Rd / B4399	6	34	14	-20	PASS
13	Site 13	4	B4399 Gatehouse / The Straight Mile / Chapel Rd	7	21	10	-11	PASS
14	Site 14	3	A439 Newmarket / Blue School St / B4539 Widemarsh St	5	70	63	-8	PASS
15	Site 15	3	A438 Bath St / Blue School St / A465 Commercial Rd	9	63	61	-1	PASS
16	Site 16	4	A438 Bath St / A438 St Owen St / St.Owen St	5	70	108	37	FAIL
17	HCC Site 5	4	B4539 Widemarsh St / Blackfriars St / Coningsby St	4	7	86	79	FAIL
18	HCC Site 8	5	A465 Commercial Rd / Station Approach / Brook Retail	10	41	53	11	PASS
19	HCC Site 9	3	A465 Aylestone Hill / Barrs Court Rd	4	12	26	14	PASS
					1,011	1,340	329	

Figure 4.9 Inter-peak maximum queue length results

Queue Validation	% PASS	95%
	Average Vehicle Length (m)	5.75
	Criteria <Veh	30

Junction Maximum Queue Length Validation Summary

Junction	Site	Arms	Description	Lanes	Vehicles: Survey Queue Max Q (Veh)	Vehicles: Model Queue Max Q (Veh)	Vehicles: Diff (M-S) Max Q (Veh)	PASS / FAIL <30Veh
1	Site 1	4	A49 / A4103 Roman Rd	8	50	36	-14	PASS
2	Site 2	3	A49 Holmer Rd / A49 Newton Rd / Priory Place	5	41	21	-20	PASS
3	Site 3	4	A49 Newton Rd / Edgar St / Newton Rd / Farriers Way	7	36	31	-5	PASS
4	Site 4	3	A49 Edgar St / Blackfriars St	7	36	37	2	PASS
5	Site 5	3	A49 Edgar St / A49 Victoria St / A438 Newmarket St	10	67	50	-17	PASS
6	Site 6	4	A49 Victoria St / A49 Gunners Ln / A438 Eign St	9	55	59	4	PASS
7	Site 7	4	A49 / Barton Rd / St.Nicholas St	10	61	57	-4	PASS
8	Site 8	6	A49 / A465 Belmont Rd / Hinton Rd / ASDA / St Martins	11	88	100	12	PASS
9	Site 9	3	A465 Belmont Ave / Walnut Tree Ave	5	23	10	-12	PASS
10	Site 10	4	A49 Ross Rd / Holme Lacy Rd	9	70	52	-18	PASS
11	Site 11	3	A49 Ross Rd / Bullingham Rd	4	21	44	24	PASS
12	Site 12	3	A49 Ross Rd / B4399	6	10	11	1	PASS
13	Site 13	4	B4399 Gatehouse / The Straight Mile / Chapel Rd	7	8	3	-5	PASS
14	Site 14	3	A439 Newmarket / Blue School St / B4539 Widemarsh St	5	51	57	6	PASS
15	Site 15	3	A438 Bath St / Blue School St / A465 Commercial Rd	9	53	54	1	PASS
16	Site 16	4	A438 Bath St / A438 St Owen St / St.Owen St	5	39	46	7	PASS
17	HCC Site 5	4	B4539 Widemarsh St / Blackfriars St / Coningsby St	4	1	9	8	PASS
18	HCC Site 8	5	A465 Commercial Rd / Station Approach / Brook Retail	10	37	67	30	FAIL
19	HCC Site 9	3	A465 Aylestone Hill / Barrs Court Rd	4	9	17	8	PASS
					754	763	9	

Figure 4.10 PM peak hour maximum queue length results

					Queue Validation		% PASS	84%
					Average Vehicle Length (m)			5.75
Junction Maximum Queue Length Validation Summary					Criteria <Veh			30
					Vehicles			PASS / FAIL
Junction	Site	Arms	Description	Lanes	Survey Queue Max Q (Veh)	Model Queue Max Q (Veh)	Diff (M-S) Max Q (Veh)	<30 Veh
1	Site 1	4	A49 / A4103 Roman Rd	8	76	72	-4	PASS
2	Site 2	3	A49 Holmer Rd / A49 Newton Rd / Priory Place	5	37	23	-15	PASS
3	Site 3	4	A49 Newton Rd / Edgar St / Newton Rd / Farriers Way	7	53	36	-17	PASS
4	Site 4	3	A49 Edgar St / Blackfriars St	7	40	34	-6	PASS
5	Site 5	3	A49 Edgar St / A49 Victoria St / A438 Newmarket St	10	63	64	0	PASS
6	Site 6	4	A49 Victoria St / A49 Gunners Ln / A438 Eign St	9	68	110	42	FAIL
7	Site 7	4	A49 / Barton Rd / St.Nicholas St	10	96	123	27	PASS
8	Site 8	6	A49 / A465 Belmont Rd / Hinton Rd / ASDA / St.Martins	11	125	239	114	FAIL
9	Site 9	3	A465 Belmont Ave / Walnut Tree Ave	5	26	22	-4	PASS
10	Site 10	4	A49 Ross Rd / Holme Lacy Rd	9	85	59	-26	PASS
11	Site 11	3	A49 Ross Rd / Bullingham Rd	4	23	46	23	PASS
12	Site 12	3	A49 Ross Rd / B4399	6	23	10	-12	PASS
13	Site 13	4	B4399 Gatehouse / The Straight Mile / Chapel Rd	7	17	5	-12	PASS
14	Site 14	3	A439 Newmarket / Blue School St / B4539 Widemarsh St	5	70	73	3	PASS
15	Site 15	3	A438 Bath St / Blue School St / A465 Commercial Rd	9	43	40	-4	PASS
16	Site 16	4	A438 Bath St / A438 St.Owen St / St.Owen St	5	58	52	-6	PASS
17	HCC Site 5	4	B4539 Widemarsh St / Blackfriars St / Coningsby St	4	10	88	78	FAIL
18	HCC Site 8	5	A465 Commercial Rd / Station Approach / Brook Retail	10	57	86	29	PASS
19	HCC Site 9	3	A465 Aylestone Hill / Barrs Court Rd	4	13	16	3	PASS
					984	1,197	213	

4.58 It is considered that the overall maximum queue validation results demonstrate that the model is representative of the network conditions, principally the congestion characterised as queued vehicles.

4.59 Further detailed maximum queue length validation results are provided in the following report appendices.

- Appendix F – Maximum Queue Length Validation Results – AM, Inter-peak and PM peak hours;

MODEL CONVERGENCE

4.60 The Hereford model is a dynamic assignment model, therefore in order to produce robust results the model is assigned for multiple iterations, with the objective of minimising the generalised cost (travel time & distance) within the assignment, based on the following criteria:

- Proportion of modelled path with travel time difference less than 10% between model iterations;
- Duality Gap value, as specified in DMRB volume 12;

4.61 The duality gap expresses the convergence quality as the volume-weighted difference between the total delay calculated along the chosen routes and the hypothetical vehicle delay on the minimum cost routes, as a proportion of the minimum generalised cost.

4.62 The duality gap is comparable to the convergence 'delta' value as described in the DMRB volume 12, which states that the model iterations are considered converged once the "delta" values is equal to or below <1%.

4.63 Figure 4.11 below presents the acceptable model convergence statistics for the model assignments, based on the assigned 15 minute increments within the peak hour.

Figure 4.11 Hereford VISSIM model convergence statistics

Peak Hour Quarter	AM Peak Hr (08:00-09:00)		Inter-peak Hr (12:00-13:00)		PM Peak Hr (17:00-18:00)	
	% Path travel time <10%	Duality gap value	% Path travel time <10%	Duality gap value	% Path travel time <10%	Duality gap value
Q1	100%	0.00	100%	0.00	99.9%	0.00
Q2	100%	0.00	100%	0.00	99.5%	0.00
Q3	100%	0.00	100%	0.00	99.8%	0.01
Q4	100%	0.00	100%	0.00	99.4%	0.01

5 Model validation summary

5.1 In summary, this model calibration and validation section has provided a comparison against multiple indicators, in order to demonstrate that the model is representative of the network conditions, in accordance with DfT TAG & DMRB standards, such as;

- Traffic volumes (link & turn);
- Maximum queue length; and
- Journey time.

5.2 Table 5.1 below presents a summary of the calibration and validation results for the Hereford VISSIM model, based on the comprehensive data set, including traffic volume comparisons and indicators of the network conditions.

5.3 It is considered that the information presented throughout this document generally demonstrates that the 2014 Hereford VISSIM model has been developed in accordance with the current guidance and is representaive of the observed network conditions, based on multiple criteria, including independent validation data.

5.4 Based on this evidence, the model is considered as “fit for purpose”, in accordance with DfT TAG transport modelling guidelines and micro-simulation modelling “best practice”.

Table 5.1: Model Calibration & Validation Summary

Model Calibration & Validation	Criteria	Counts/ Records	Modelled peak hour results		
			AM Peak Hr (08:00-09:00)	Inter-Peak Hr (12:00-13:00)	PM Peak Hr (17:00-18:00)
Calibration	Junction link count GEH <5	189	88%	88%	90%
	Junction turn count GEH <5	293	91%	95%	95%
Validation	ATC total traffic two-way GEH <5	25	88%	80%	84%
	ATC total traffic one-way GEH <5	50	86%	90%	86%
	Journey time routes within 15% of observed	12	75%	75%	75%
	Junction total maximum queue length <30 vehicles of observed	19	74%	95%	84%
	Junction approach maximum queue length <15 vehicles	75	84%	96%	81%

5.5 Table 5.2 provides a summary of the vehicle demand structure in the modelled periods. The urban network of Hereford is characterised by a clear dominance of cars.

Table 5.2: Peak Hour Demand Matrices Totals (in vehicles)

Vehicle Type	AM Peak Hour (08:00-09:00)		Inter-peak Hour (12:00-13:00)		PM Peak Hour (17:00-18:00)	
	Trips (vehicles)	%	Trips (vehicles)	%	Trips (vehicles)	%
Cars	12,924	86.9%	10,814	88.5%	14,363	92.1%
LGV	1,590	10.7%	1,091	8.9%	1,045	6.7%
OGV1	212	1.4%	187	1.5%	113	0.7%
OGV2	148	1.0%	124	1.0%	104	0.4%
Total	**14,874**	**100%**	**12,216**	**100%**	**15,588**	**100%**

5.6 In conclusion, Table 5.3 below provides a summary of the modelled peak hour performance across a series of indicators, in order to demonstrate the variations in the network conditions at a more strategic level.

5.7 The network performance indicators demonstrate that the AM & PM peak hours produce similar performance statistics, despite the variation in the total demand volume and the trip distribution.

5.8 It should be noted, that despite the 20% reduction in demand in the Inter-peak scenario compared with the peak hours, the network statistics still indicate network congestion during the Inter-peak. This infers that a significant proportion of the network delay is attributable to the network structure and inefficiency in the design to accommodate the conflicting movements, rather than excessive demand.

Table 5.3: Peak Hour Model Performance Indicators

Indicator	Indicator (All Vehicles)	Unit	AM Peak Hr (08:00-09:00)	Inter-Peak Hr (12:00-13:00)	PM Peak Hr (17:00-18:00)
1	Demand total vehicles	Vehicles	14,874	12,216	15,588
2	Total travel time	hrs	1,226	847	1,192
3	Total distance travelled	km	29,802	25,522	31,238
4	Total delay in assignment	hrs	584	289	521
5	% Total travel time as delay	%	48%	34%	44%
6	Average travel time per vehicle	minutes	4.9	4.2	4.6
7	Average delay	secs	134	80	114
8	Average speed	kph	24	30	26
9	Un-assigned vehicles	Vehicles	56	0	0
10	Un-assigned vehicle delay	hrs	19	0	0

5.9 The following the completion of the 2014 Present Year Validation of the Hereford VISSIM model, it is considered that model is a robust platform, which is capable of assessing;

- Forecast traffic growth impacts;
- Development impacts;
- Infrastructure improvements impacts; and the
- Identification of infrastructure deficiencies.

5.10 The remainder of this section provides a series of model plots from the VISSIM model assignment, in order to demsontrate the modelled network conditions.

MODEL PERFORMANCE PLOTS

Figure 5.1 AM peak hour (08:30) – A49/A438/A465 "City Centre" corridors

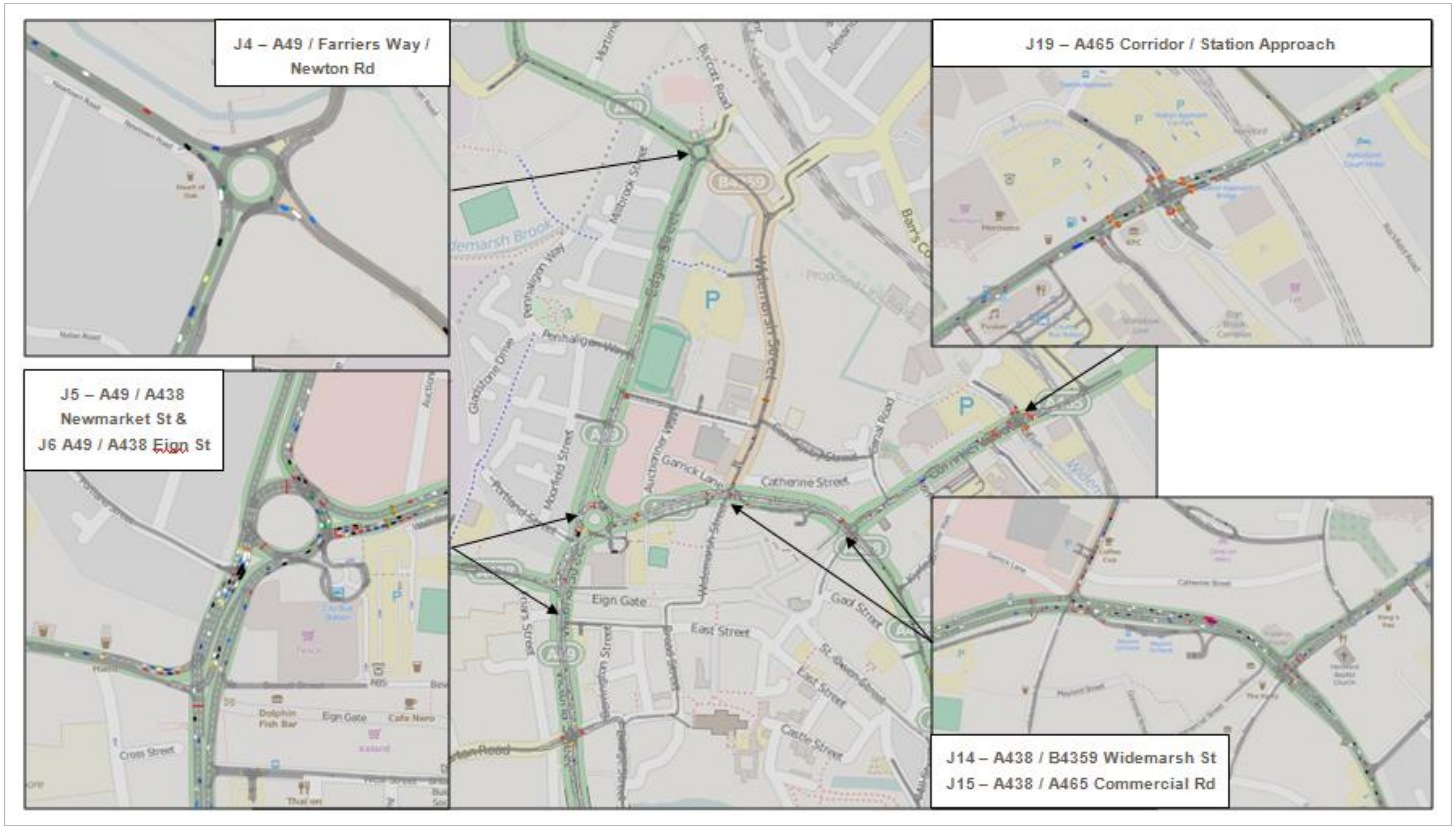


Figure 5.2 AM peak hour (08:30) – A49 corridor key junctions

Figure 5.3 Inter-peak hour (12:30) – A49/A438/A465 "City Centre" corridors

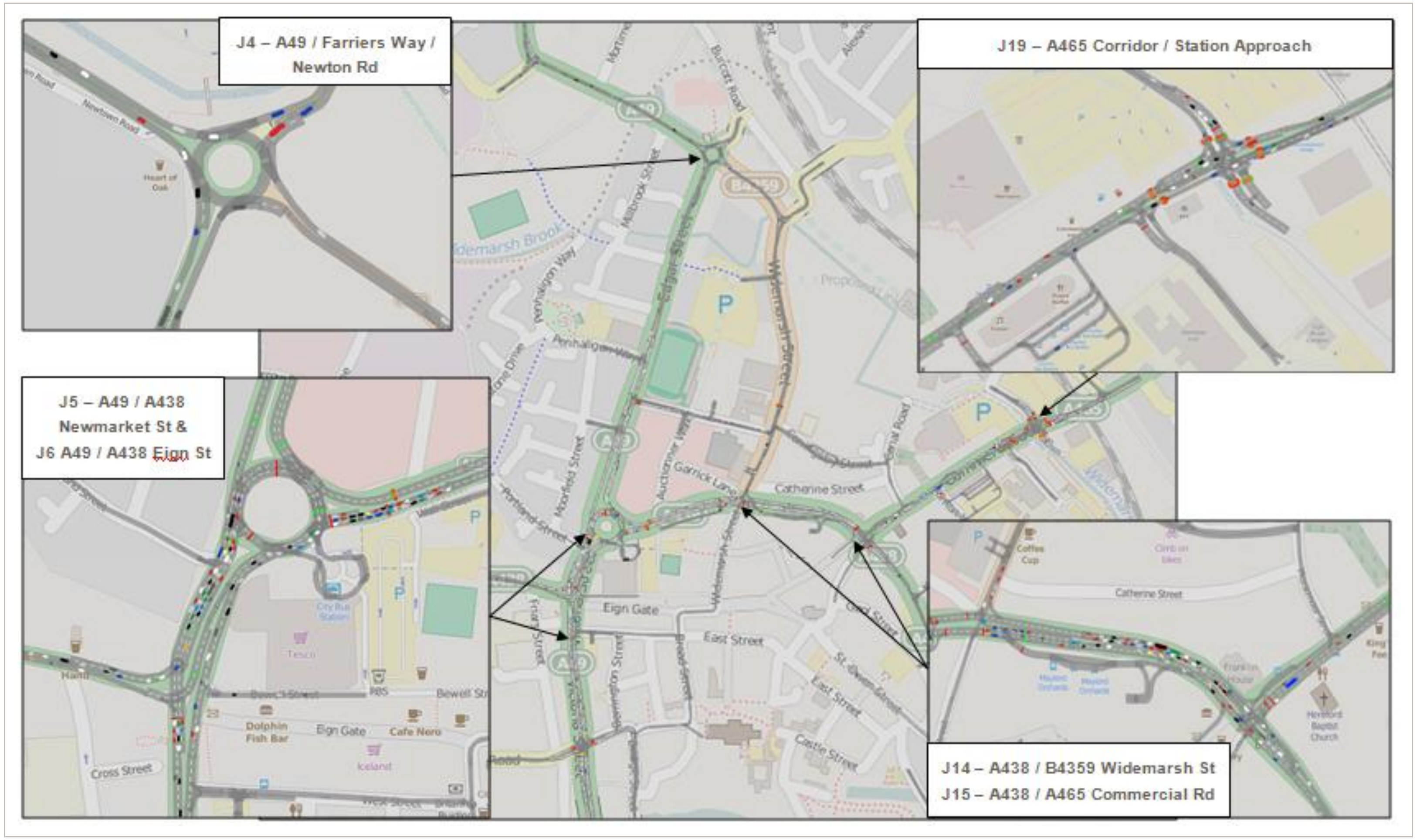


Figure 5.4 Inter-peak Hour (12:30) – A49 corridor key junctions

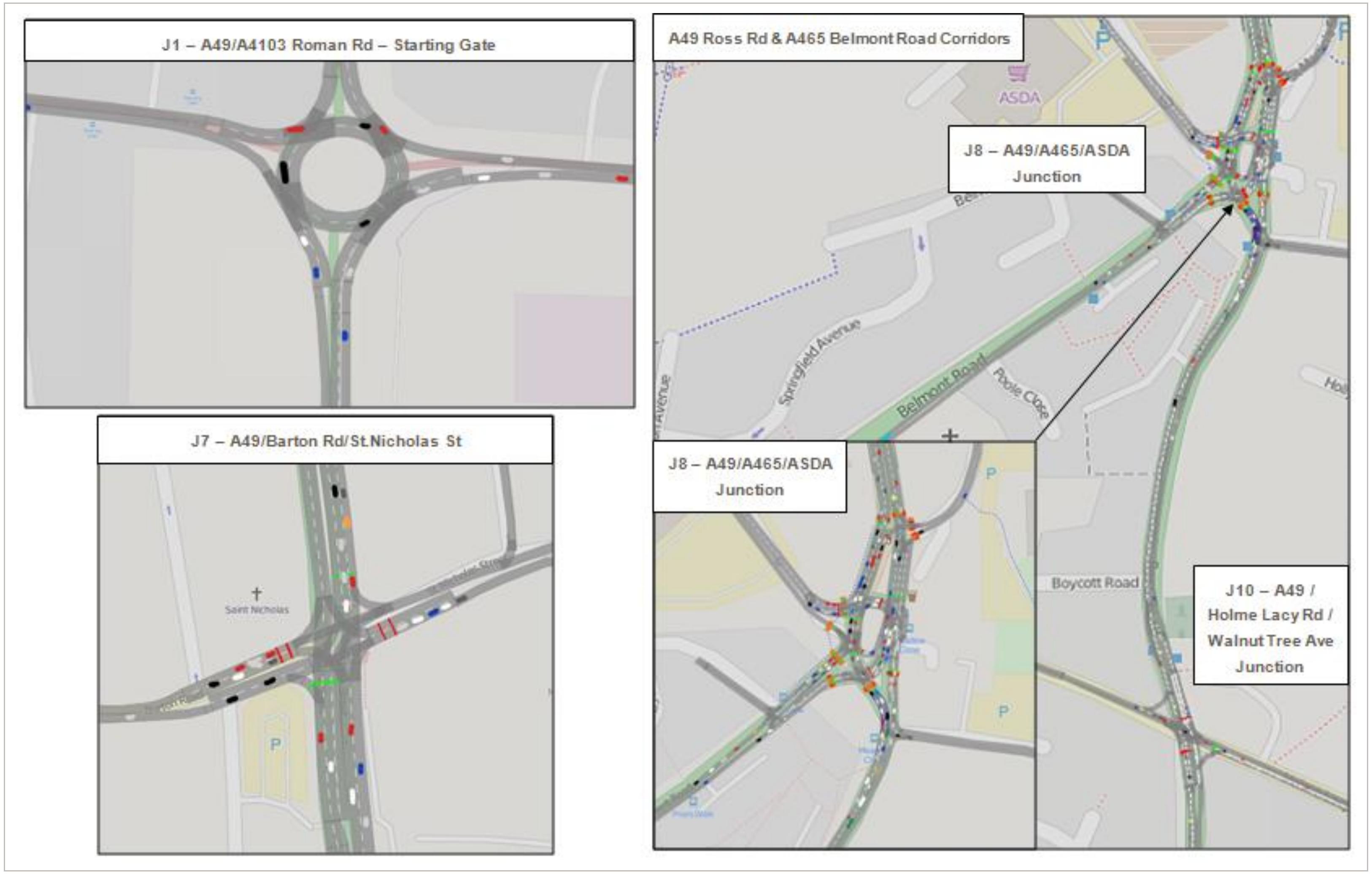


Figure 5.5 PM peak hour (17:30) – A49/A438/A465 "City Centre" corridors

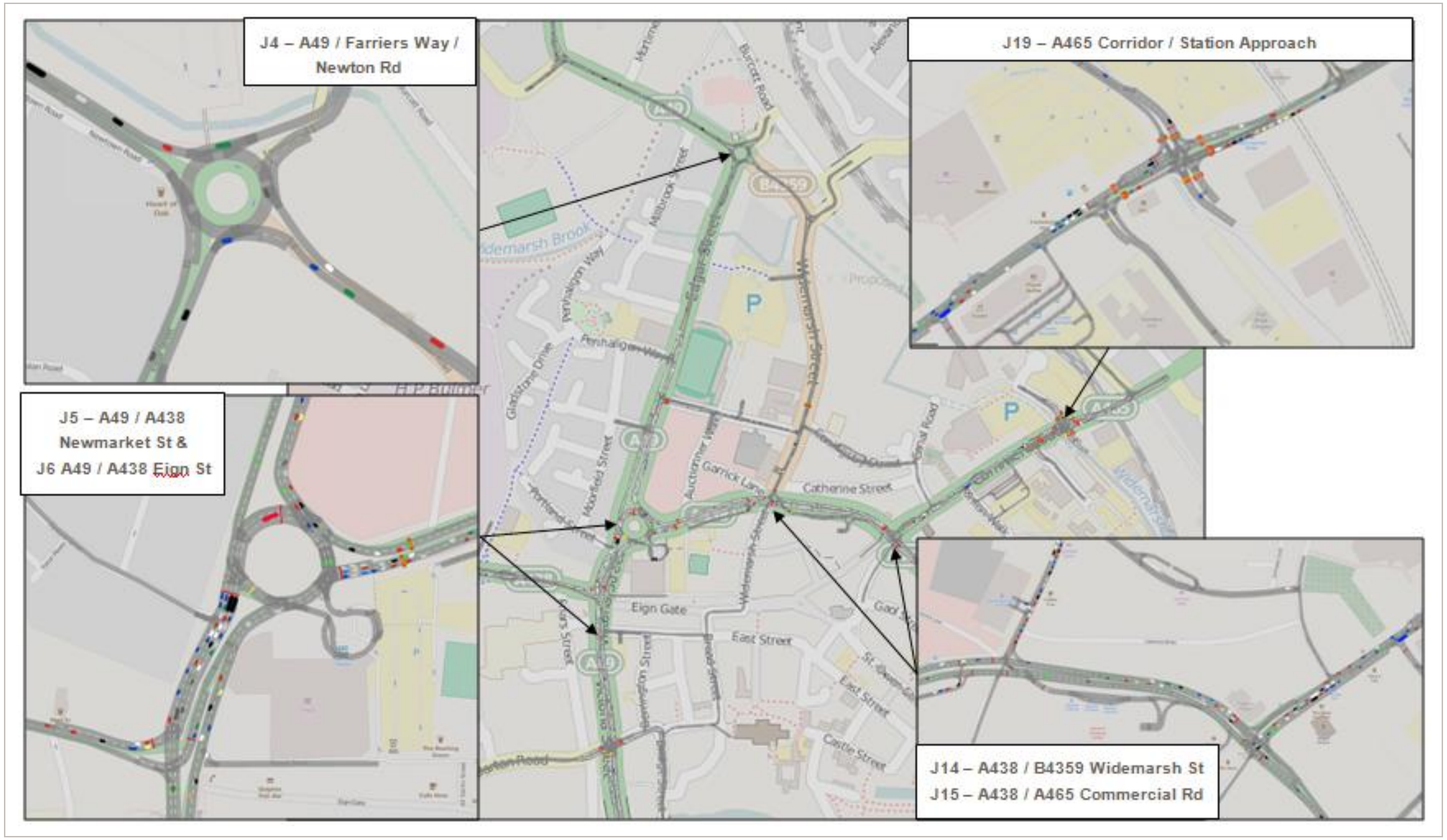


Figure 5.6 PM peak hour (17:30) – A49 corridor key junctions

Hereford VISSIM Model PYV

LOCAL MODEL VALIDATION REPORT – APPENDICIES

Hereford VISSIM Model PYV

LOCAL MODEL VALIDATION REPORT – APPENDICIES

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Report Record

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X812089	X812089-PYV	1	Adrian Hewitt	Alan Crawford	Alan Crawford	FINAL	17/06/2015

Contents Amendments Record

Issue No.	Revision description	Approved	Status	Date

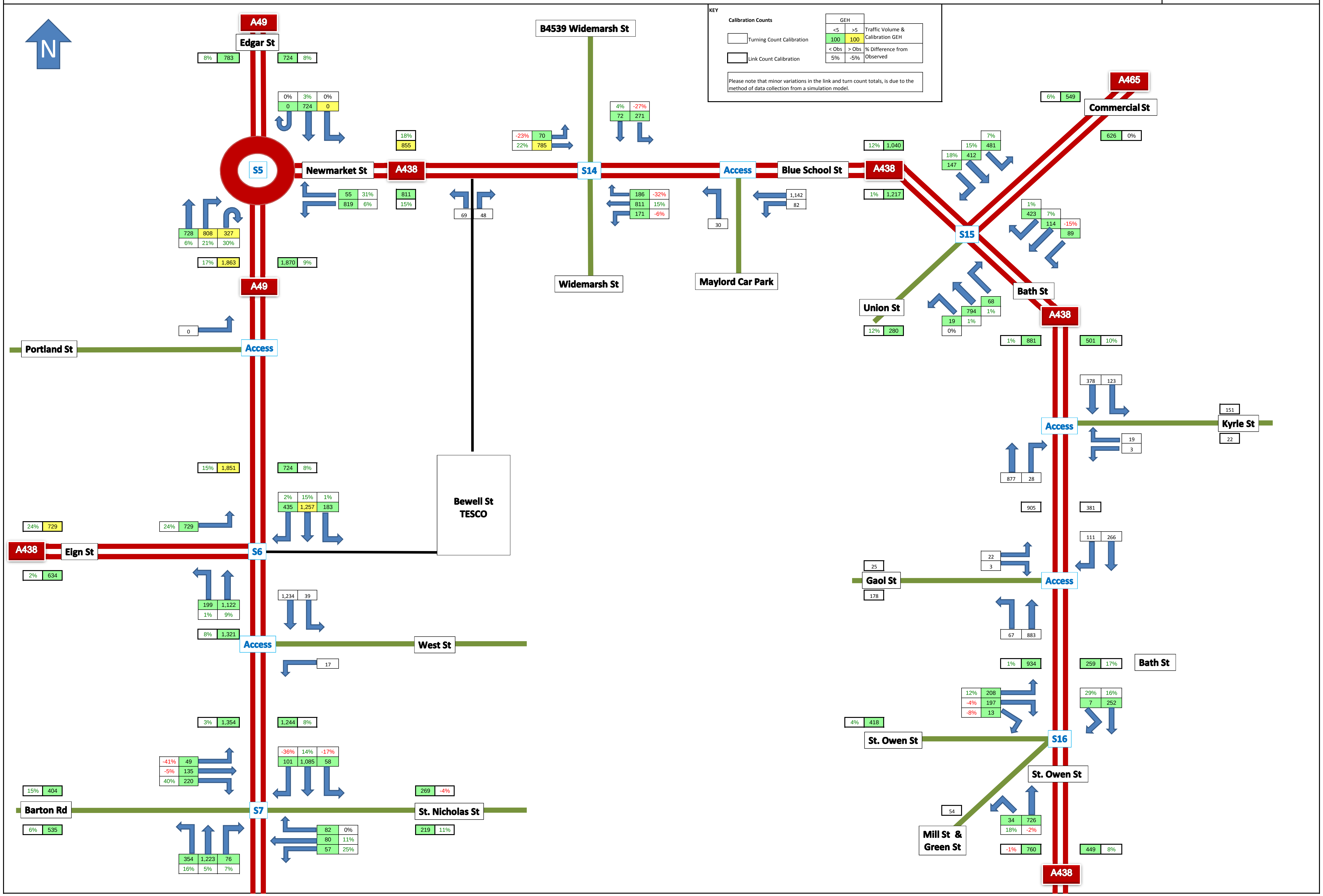
Appendices Contents

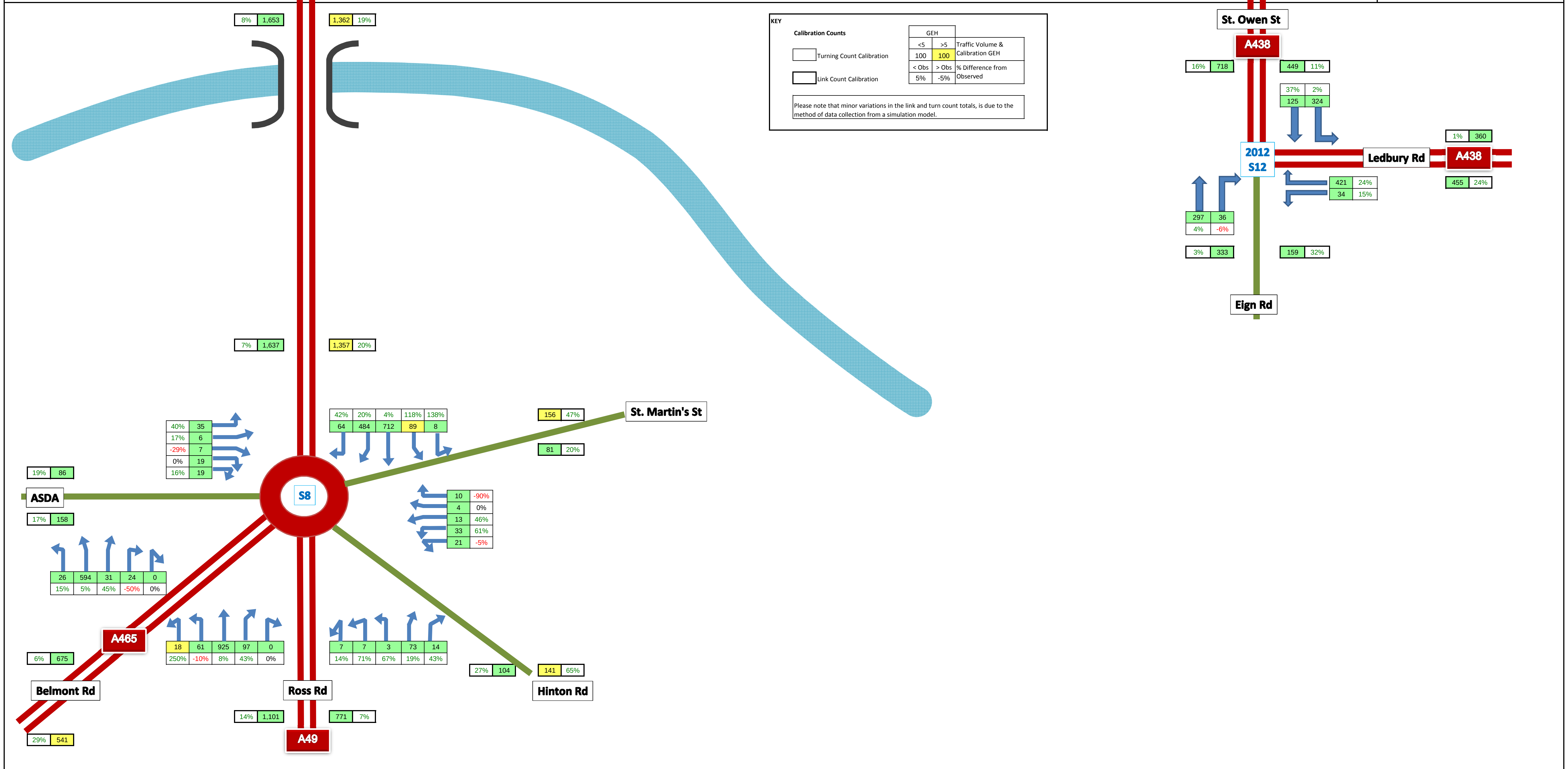
Appendix A

NETWORK CALIBRATION SCHEMATIC

AM, Inter-Peak & PM Peak Hour Total Traffic Calibration

Appendix A.1.1 - A49 Hereford VISSIM Model - 2014 BY - AM Peak Hr (8-9)-Total Traffic (Lights & Heavies) Calibration Schematics	Part 1 (City Centre North)




KEY
Calibration Counts
Turning Count Calibration
Link Count Calibration
GEH
<5
>5
100
100
Traffic Volume & Calibration GEH
< Obs
> Obs
5%
-5%
% Difference from Observed
Please note that minor variations in the link and turn count totals, is due to the method of data collection from a simulation model.
St. Owen St
A438
2012
S12
Ledbury Rd
A438
Elgn Rd
St. Martin's St
ASDA
S8
A465
Belmont Rd
Ross Rd
A49
Hinton Rd

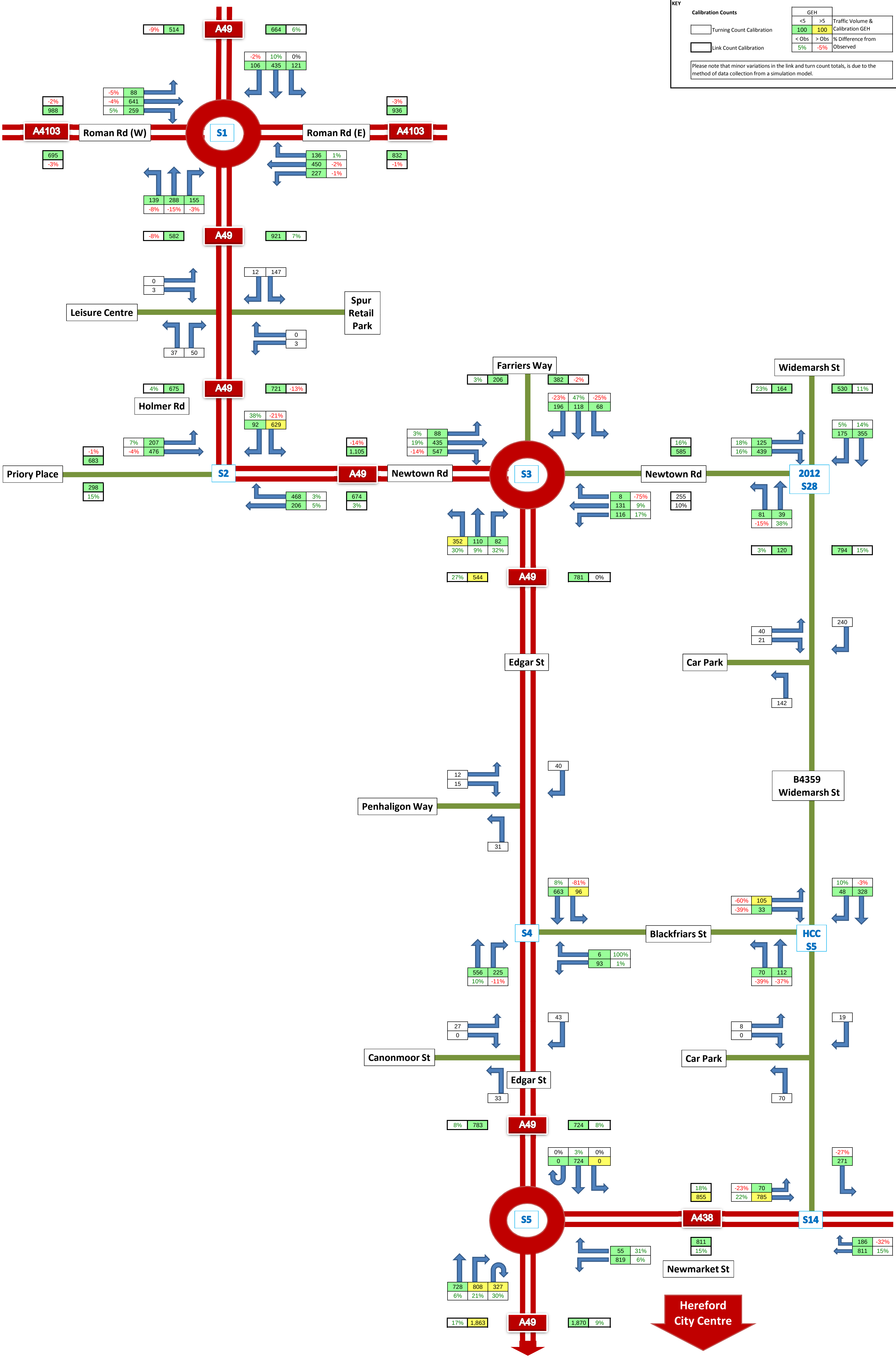
Appendix A.1.3 - A49 Hereford VISSIM Model - 2014 BY - AM Peak Hr (8-9)-Total Traffic (Lights & Heavies) Calibration Schematics	Part 3 (North)

KEY

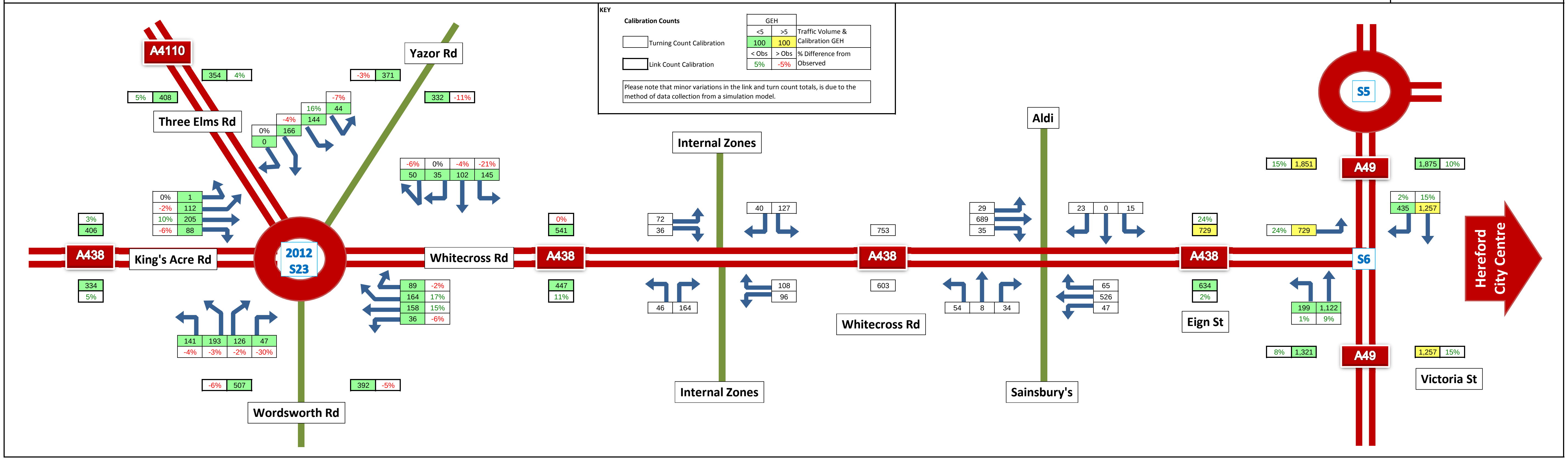
Calibration Counts

	GEH		
	<5	>5	Traffic Volume &
Turning Count Calibration	100	100	Calibration GEH
	< Obs	> Obs	% Difference from
Link Count Calibration	5%	-5%	Observed

Please note that minor variations in the link and turn count totals, is due to the method of data collection from a simulation model.

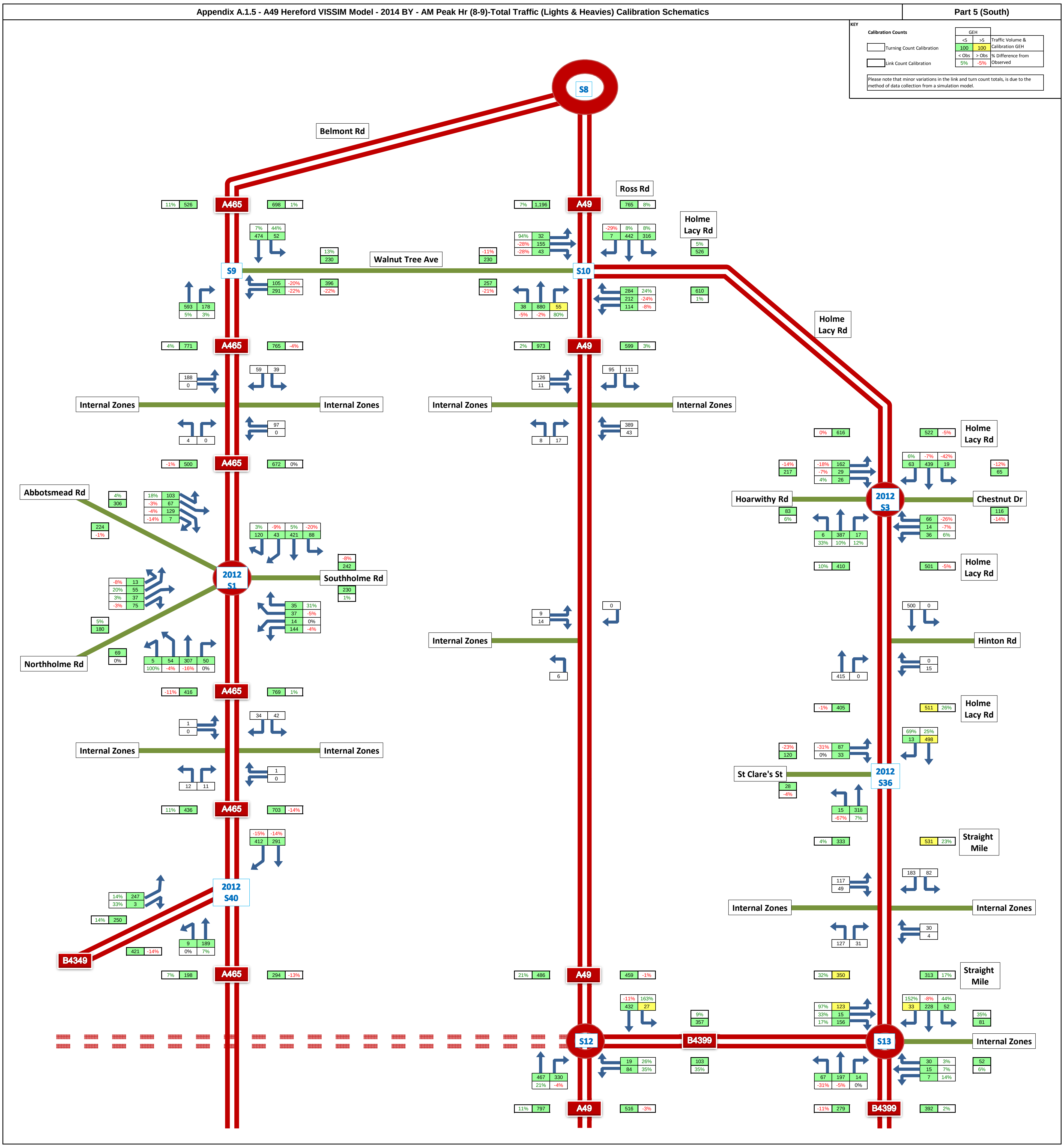


Appendix A.1.4 - A49 Hereford VISSIM Model - 2014 BY - AM Peak Hr (8-9)-Total Traffic (Lights & Heavies) Calibration Schematics	Part 4 (West)

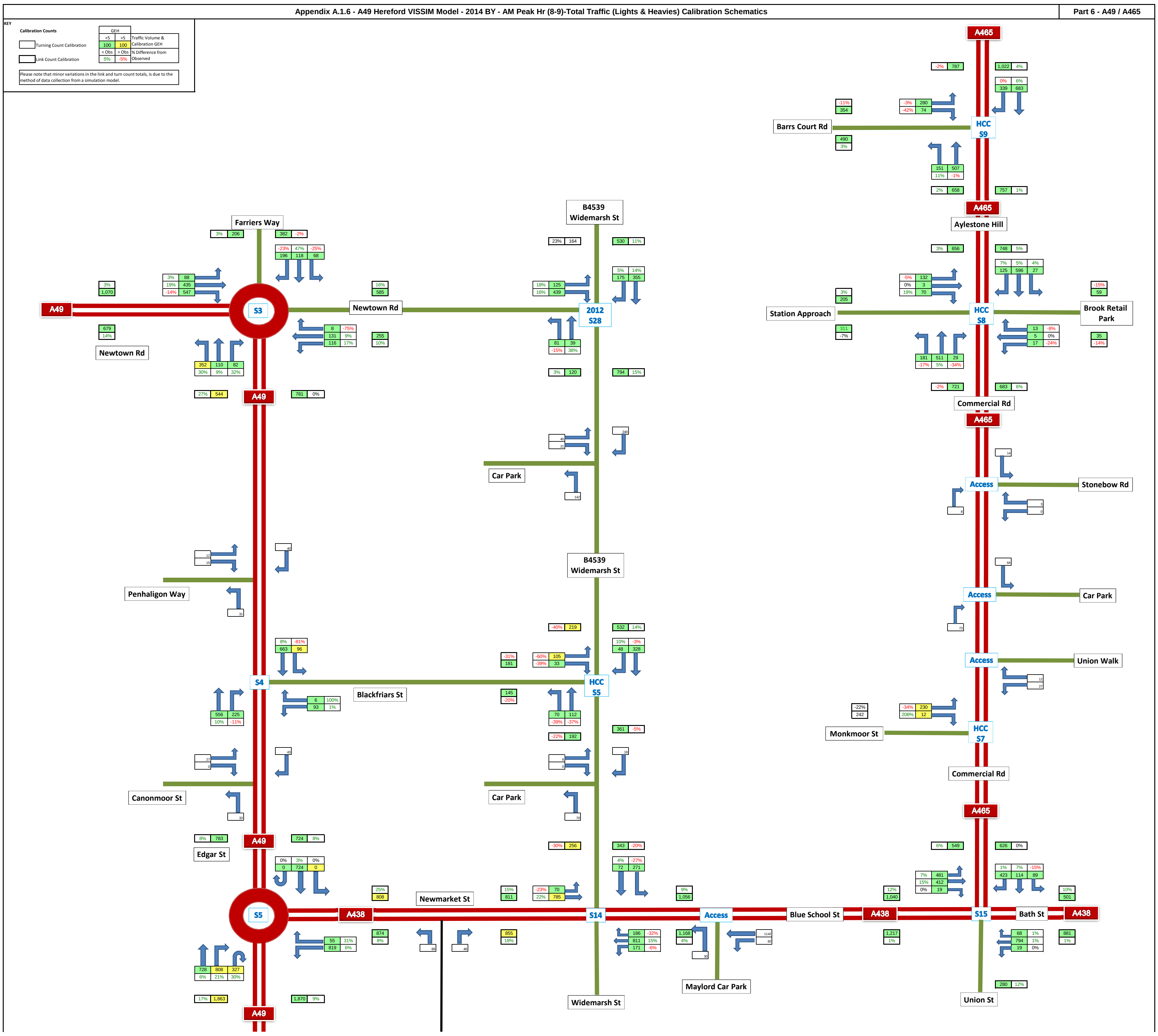


Appendix A.1.5 - A49 Hereford VISSIM Model - 2014 BY - AM Peak Hr (8-9)-Total Traffic (Lights & Heavies) Calibration Schematics

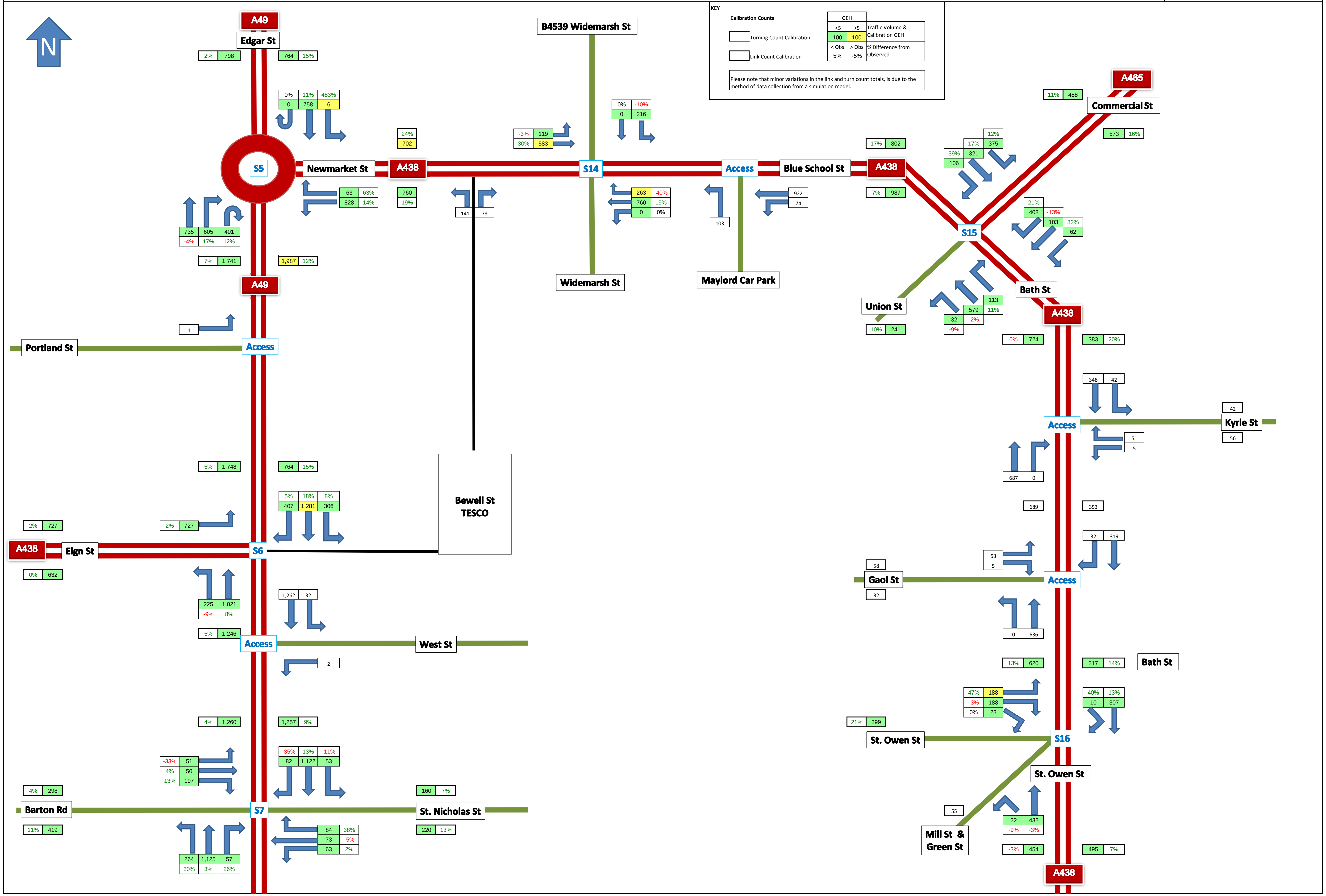
Part 5 (South)

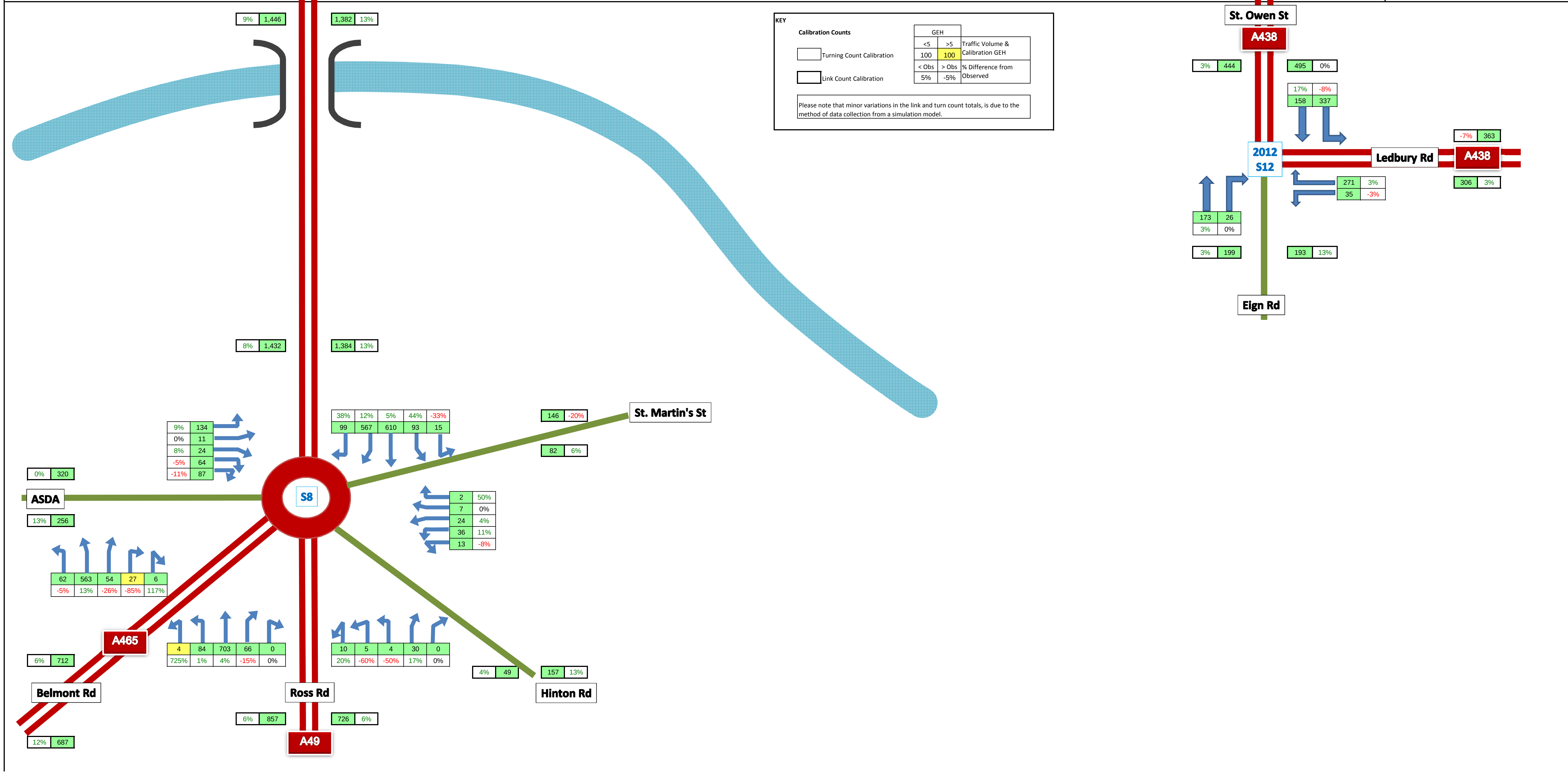


Appendix A.1.6 - A49 Hereford VISSIM Model - 2014 BY - AM Peak Hr (8-9)-Total Traffic (Lights & Heavies) Calibration Schematics | Part 6 - A49 / A465

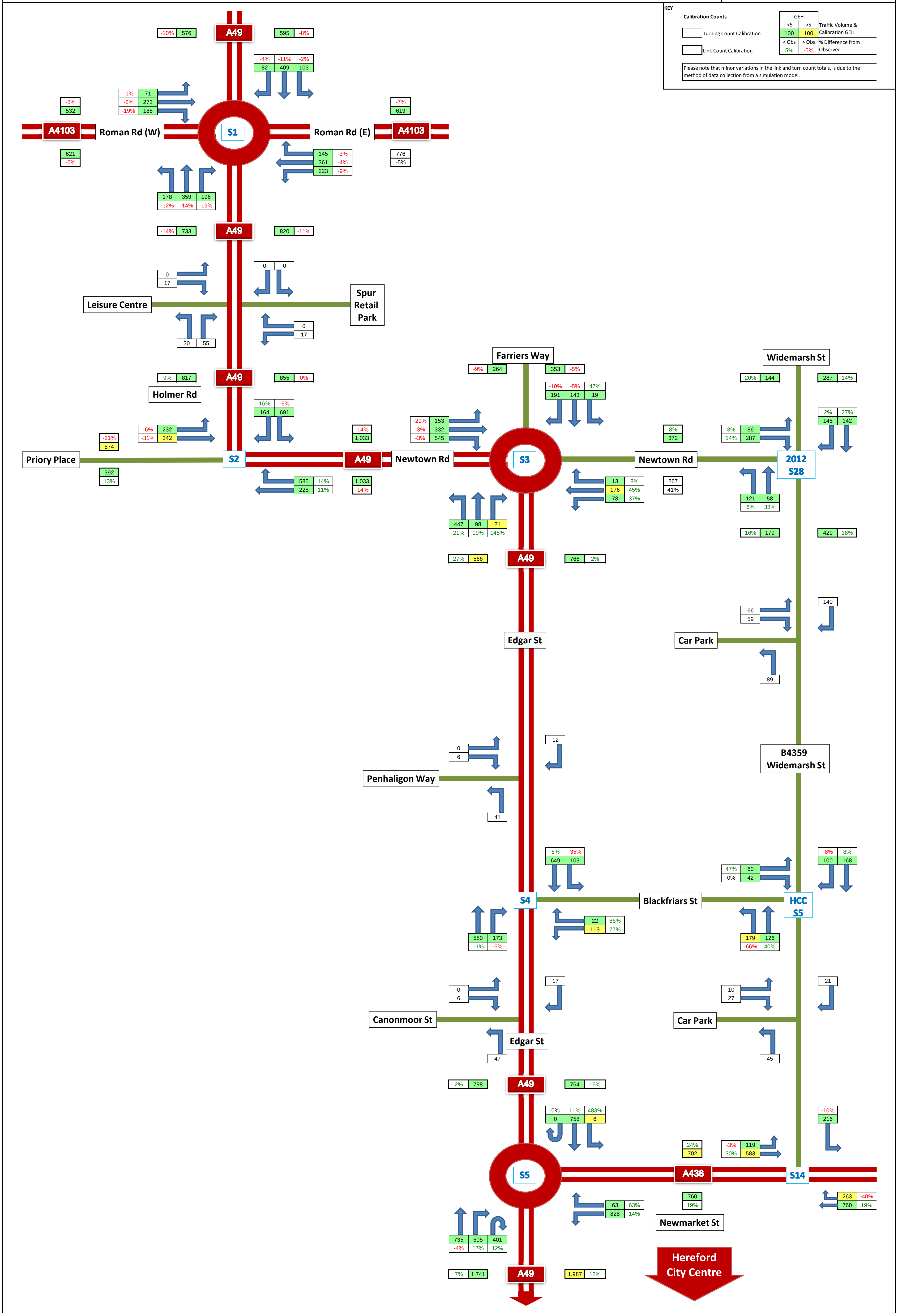


Appendix A.2.1 - A49 Hereford VISSIM Model - 2014 BY - Inter-peak Hr (11-12)-Total Traffic (Lights & Heavies) Calibration Schematics	Part 1 (City Centre North)




KEY
Calibration Counts
GEH
<5
>5
Turning Count Calibration
100
100
Traffic Volume & Calibration GEH
Link Count Calibration
< Obs
> Obs
5%
-5%
% Difference from Observed
Please note that minor variations in the link and turn count totals, is due to the method of data collection from a simulation model.
9%
1,446
1,382
13%
8%
1,432
1,384
13%
St. Martin's St
146
-20%
82
6%
ASDA
0%
320
13%
256
S8
A465
Belmont Rd
6%
712
12%
687
Ross Rd
A49
6%
857
726
6%
Hinton Rd
4%
49
157
13%
St. Owen St
A438
3%
444
495
0%
17%
-8%
158
337
2012
S12
Ledbury Rd
-7%
363
306
3%
271
3%
35
-3%
173
26
3%
0%
3%
199
193
13%
Eign Rd

Appendix A.2.3 - A49 Hereford VISSIM Model - 2014 BY - Inter-peak Hr (11-12)-Total Traffic (Lights & Heavies) Calibration Schematics	Part 3 (North)



Appendix A.2.4 - A49 Hereford VISSIM Model - 2014 BY - Inter-peak Hr (11-12)-Total Traffic (Lights & Heavies) Calibration Schematics	Part 4 (West)