Lincoln Eastern Bypass

LMVR Addendum

May 2015

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HIGHWAYS ALLIANCE

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1 Introduction

1.1 Background

In 2010, Mouchel was commissioned under the Lincolnshire County Council Technical Services Partnership (LCC) to undertake traffic forecasting and scheme appraisal work in support of the Best and Final Bid (BaFB) Business Case for the Lincoln Eastern Bypass (LEB). This followed earlier studies prepared by another consultancy to support the original Major Scheme Business Case (MSBC) submission for the scheme in 2009. The scheme was successful in obtaining Programme Entry status in 2011.

Following the BaFB submission to the Department for Transport (DfT) in September 2011, the opportunity was taken to enhance and update certain aspects of the traffic model in order to provide a more robust platform for the planning application and detailed highway design stages and for the subsequent updating of the business case.

Following a public inquiry in 2014, Mouchel was commissioned to undertake further refinement of the traffic forecasting and scheme appraisal work in support of the LEB, using the LEB Highway Model. The analysis is designed to support the Compulsory Purchase Order and Side Roads Order that are required for the project to proceed.

1.2 Previous Models

The history of the LEB Highway Model is as follows:

- Model commissioned in 2006;
- Improvements to the highway network model were undertaken in 2012 concerning the enhancement of the network coding;
- Model used in 2011 for LEB BAFB for DfT and subsequently to support the LEB planning application and public inquiry.

1.3 Purpose of this Report

The current report details the refinements to the model undertaken to optimise the calibration and the modelling of the Hawthorn Road area of the LEB alignment. This area has been identified as deserving special attention given the conclusions of the 2014 public inquiry. Following this it was decided to provide some additional refinement in the vicinity of the northern end of the scheme to aid in project evaluation and assessment.

The report has been issued as an addendum to the earlier Local Model Validation Report (LMVR), issued in August 2012. The document should be read in conjunction with the earlier report and as such the current document concentrates on those new elements of analysis rather than the historic information.

2 New Data Collection

2.1 Existing Data from 2006

A comprehensive database of existing data is available under the current project, including the following

- Postcard Interview Surveys were carried out at 18 locations for a 12 hour period, between 7:00 and 19:00, on one weekday between Monday 2nd October 2006 and Wednesday 29th October 2006.
- Automatic Traffic Count (ATC) surveys were undertaken in September and October 2006 at 93 locations in the Greater Lincoln area
- Manual Classified Turning Count (MCTC) surveys were undertaken at 76 junctions within the Greater Lincoln area.
- Trafficmaster journey time data for the year September 2009 to August 2010 was obtained and analysed to extract average journey times in both directions for ten routes across Lincoln.
- The detail of the data is contained in the LEB LMVR (August 2012) Recalibration

2.2 Existing Data to 2014

Some further existing data was collected as part of the best and final business case, relating to the following elements:

- Manual Classified Turning Count at A158 Wragby Road / Kennel Lane junction on 12th November 2013;
- Manual Classified Turning Count at A158 Wragby Road / Kennel Lane junction on 12th November 2013;
- Manual Classified Link Count on A158 Wragby Road throughout June 2014; and,
- Manual Classified Link Count on B1308 Greetwell Road throughout June 2014.

2.3 Additional Data Collection 2015

Based on a continued focus on traffic circulation at the northern end of the future LEB corridor supplementary data was collected in early 2015 including the following information.

- Manual Classified Turning Count data located at 17 sites as identified in Figure 2.1
- Number plate surveys using Automatic Number Plate Recognition technology (ANPR) at five locations in vicinity of Hawthorn Road

- Journey times for three localised routes to the east of Lincoln

Figure 2-1 – 2015 MCTC Survey Sites

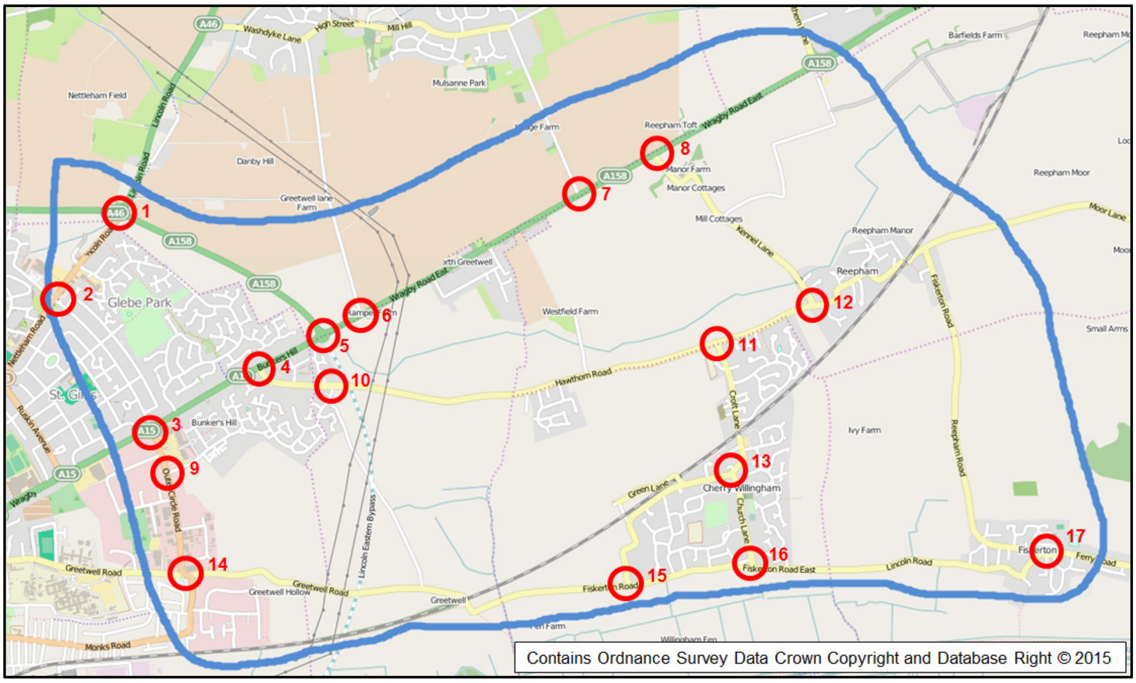


Figure 2-2 – 2015 ANPR Survey Sites

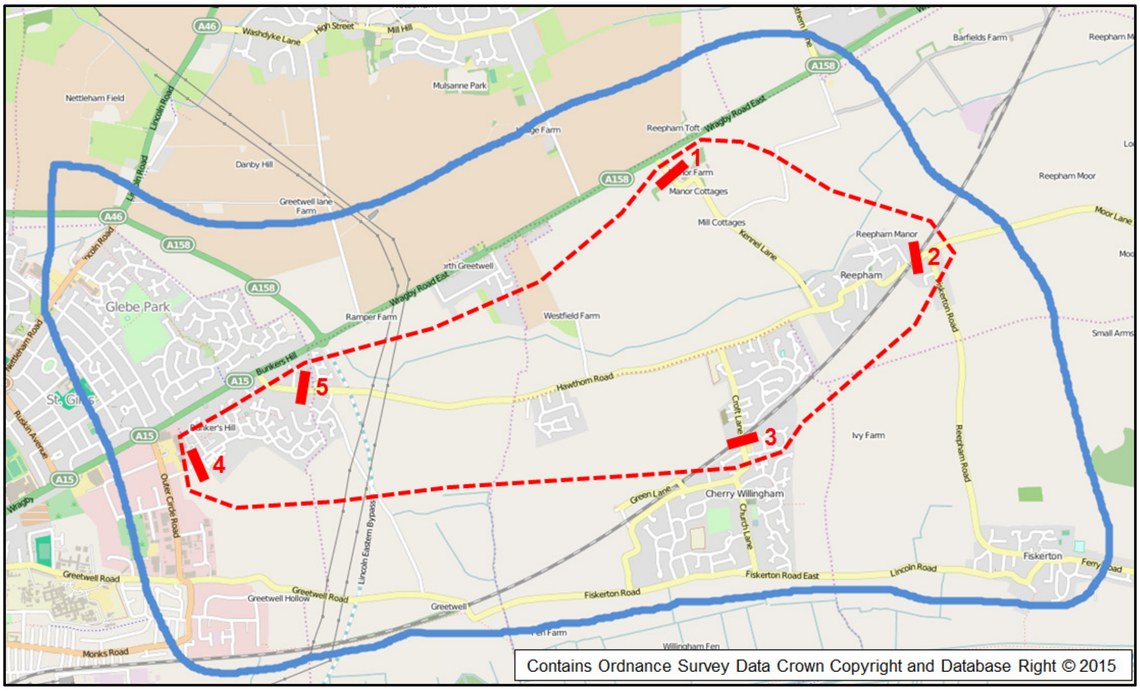
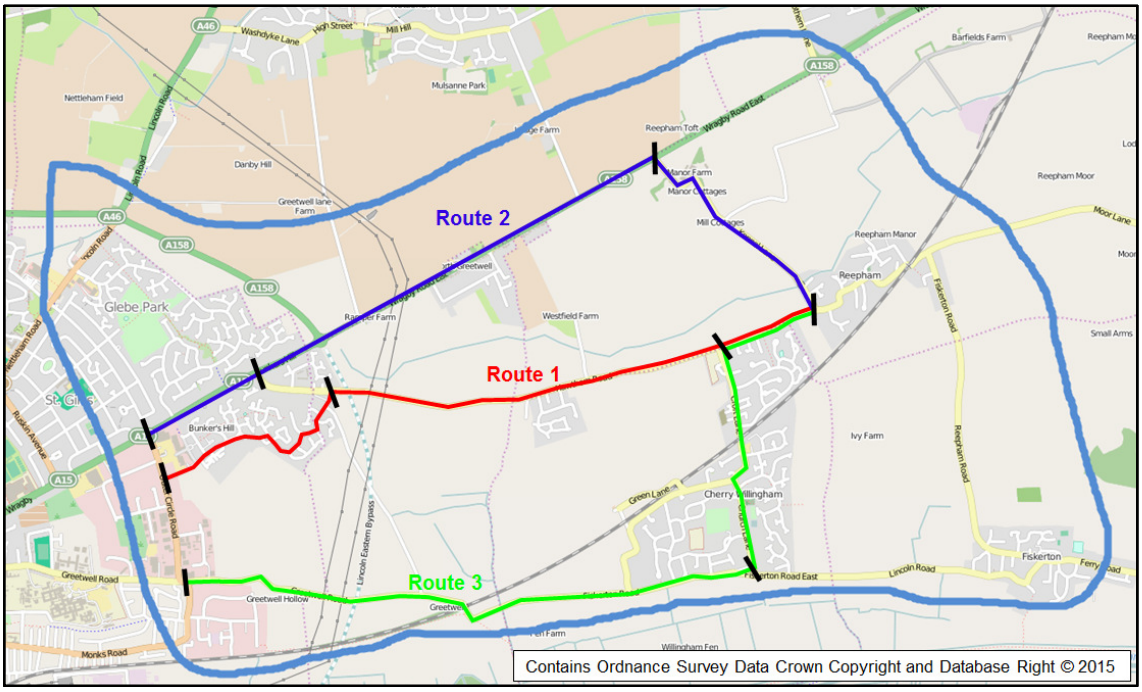


Figure 2-3 – 2015 Local Journey Time Routes



Summary of the data referenced above is reproduced in Appendix A.

2.4 Travel Data interpretation

The travel patterns implicit in the data collection exercise have been interpreted and annotated in Figures 2.4 through 2.6 for AM peak, Interpeak and PM peak periods.

The original model calibration was based on 2006 data. In general if a model is built on data from six years ago or older there is a case for updating to reflect changed travel patterns. This was considered for the current analysis based on a review of a need for change.

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Figure 2-4 – 2015 AM Peak Hour Observed Traffic Flows (pcus)

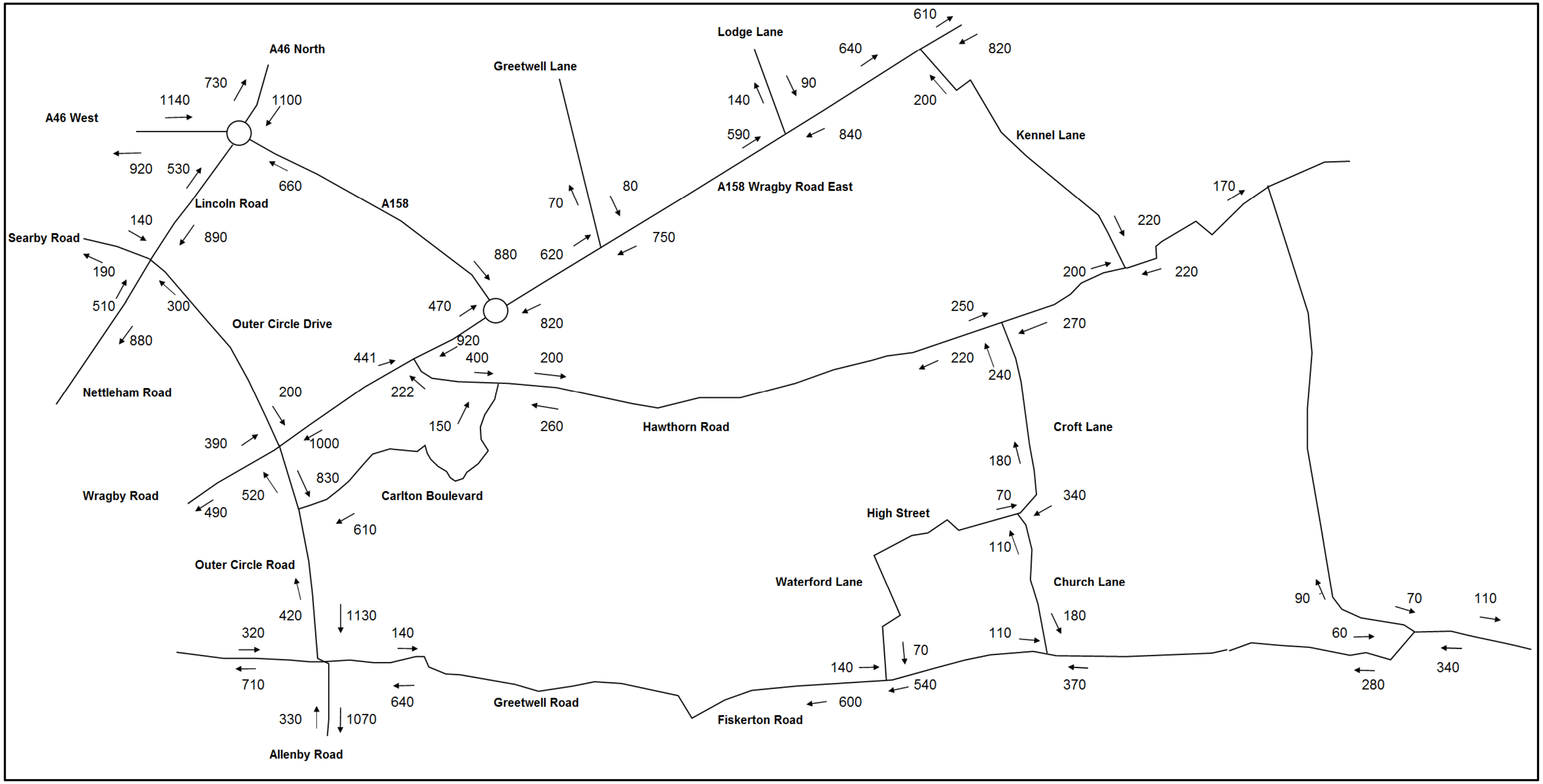


Figure 2-5 – 2015 Inter Peak Hour Observed Traffic Flows (pcus)

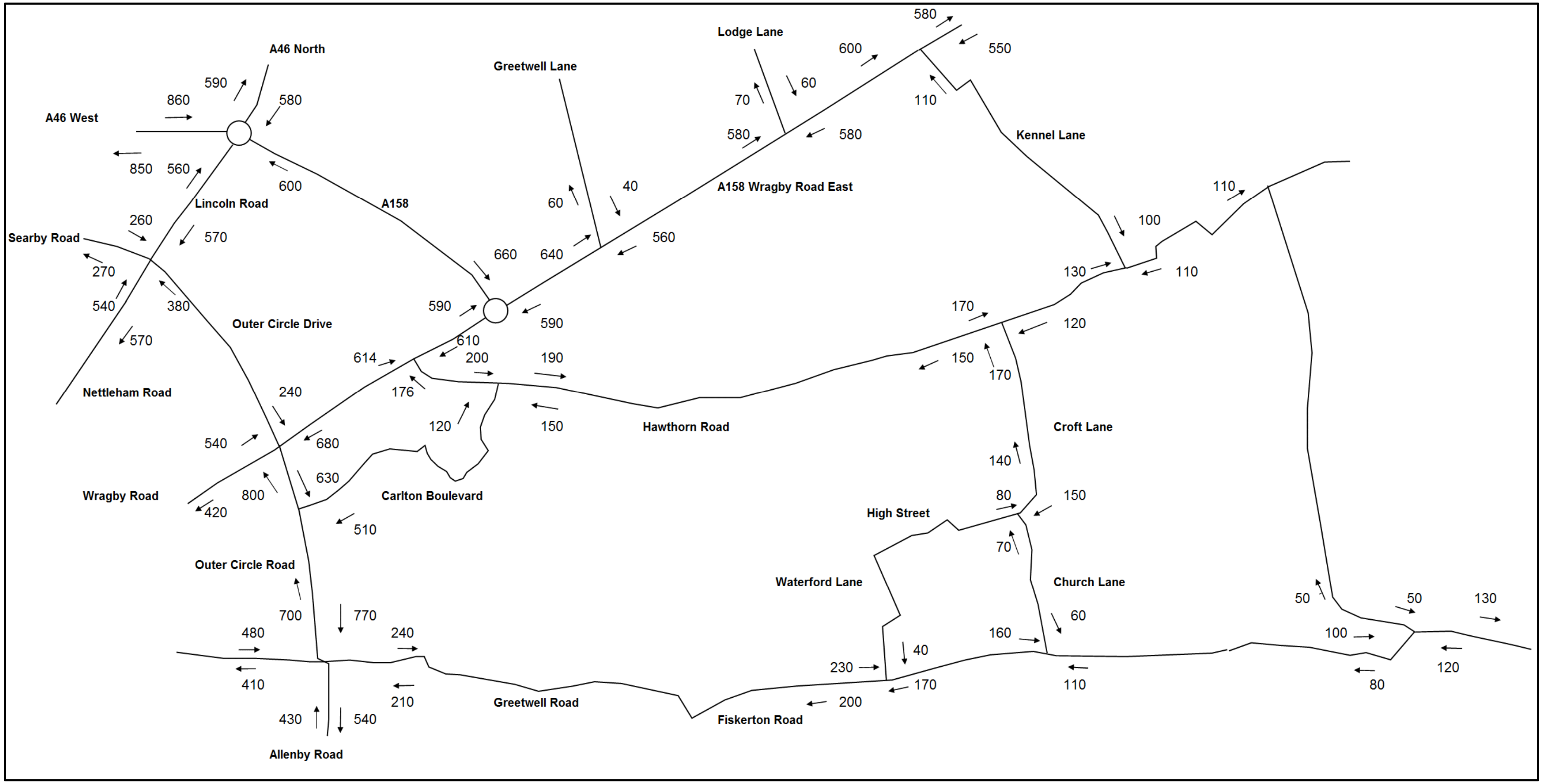
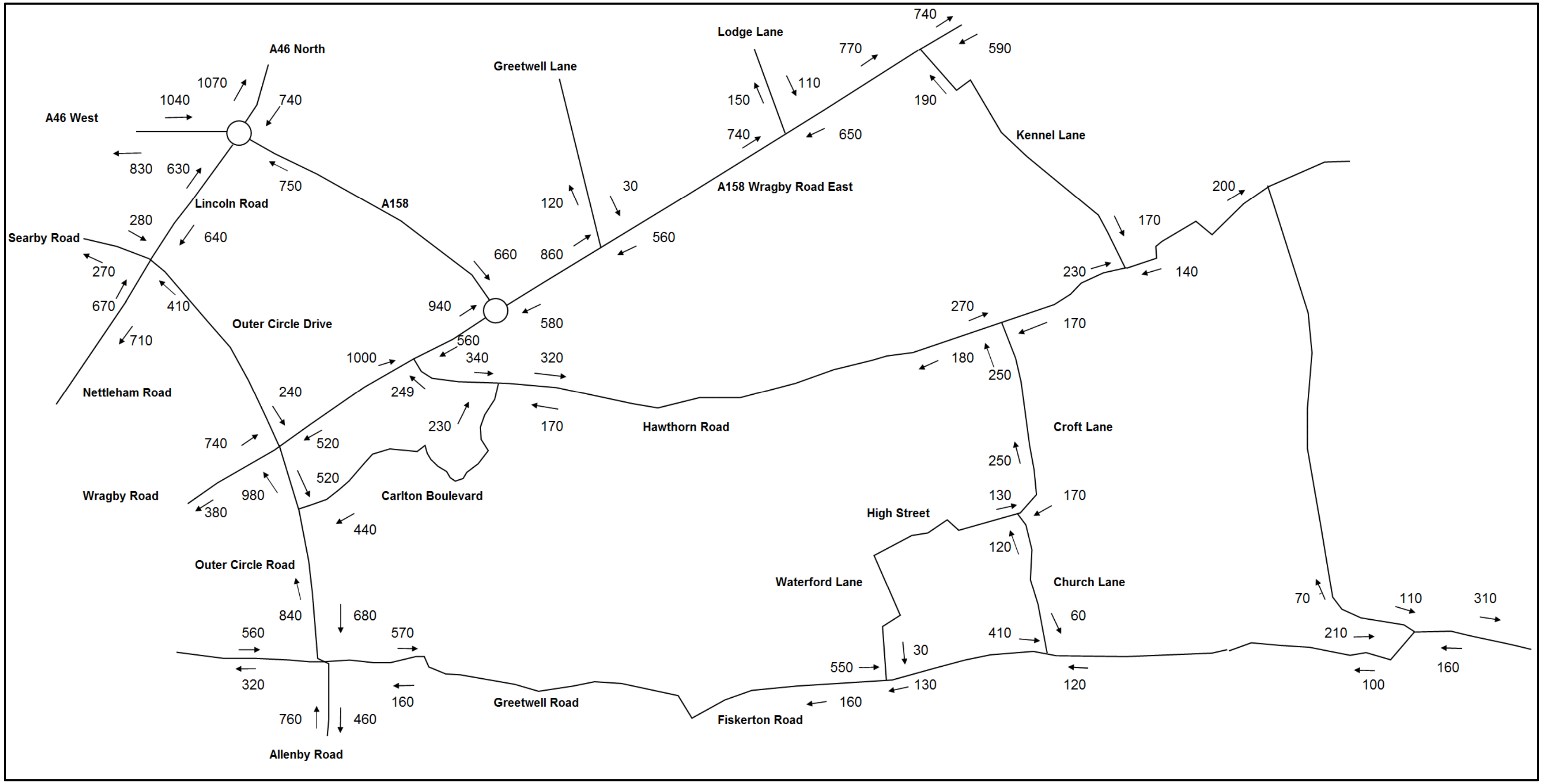
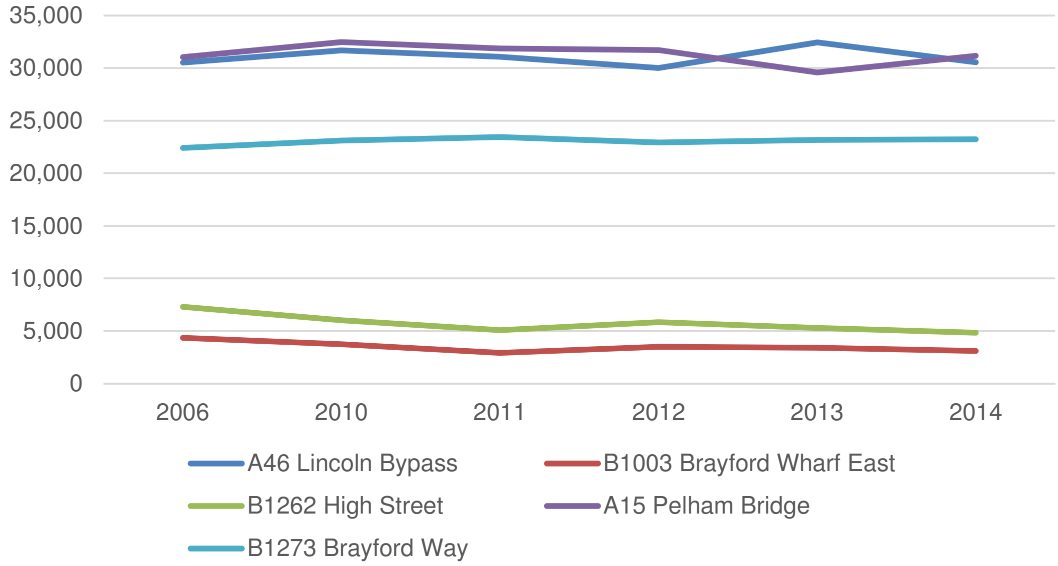


Figure 2-6 – 2015 PM Peak Hour Observed Traffic Flows (pcus)



Lincolnshire traffic statistics identified below (Figure 2.7) serve to illustrate that flow volumes (2-way AADT) are relatively static over the last eight years. Based on traffic management and new development there have been some minor flow variation, but the pattern very much reflects the national picture of static local traffic, in contrast to an increasingly congested trunk road network.

Figure 2-7 – Time Series Two-way ATC Traffic Volumes though Lincoln 2006-2014



Source: Lincolnshire County Council Monitoring Reports

Hence based on reasonably static traffic quantum the suggestion to collect new widespread travel demand data to rebuild the model was rejected on the basis that the interests of the continued assessment of the LEB would not be served by an extended exercise to update traffic patterns within the project model.

2.5 Local Traffic Review

Instead of undertaking a widespread travel demand data collection, an exercise of reviewing the local traffic movements relevant to the LEB and in the vicinity of Hawthorn Road has been undertaken. This relies on identifying traffic streams of relevance to the bypass and ensuring that these streams are modelled as accurately as possible, within the constraints of the exercise.

The review has been undertaken on local movements relevant to the current analysis in the vicinity of Hawthorn Road, but not focussed in detail in previous traffic modelling. This approach relies on a comparison of traffic patterns from recent (2015) surveys against the 2006 LEB base model. The approach is not referenced in DMRB or WebTAG guidance and therefore represents a pragmatic and proportionate method of ensuring that localised movements are fit for purpose, the purpose being to gauge the impact of local network topography and travel demand preferences following the introduction of the LEB.

These comparisons recognise a number of aspects.

- The Land Use in 2006 was lower than 2015 in a number of areas, in particular the Bunker's Hill residential development where a considerable number of dwellings have been completed since 2006

- The network configuration in 2006 has been updated to include the section of St Augustine Road which links into Hawthorn Road. The through route between Carlton Boulevard and Hawthorn Road is therefore included in the model. This link was not included in the previous Base Model. In addition the Greetwell Fields between St Augustine Road and Greetwell Road, which was not included in the previous Base Model, has been added.

In addition to a standard WebTAG modelled flow validation, a comparison of modelled flow volumes against 2015 data is included as a qualitative analysis in Chapter 6.

The survey flow pattern shows the following pattern (Table 2.1) in the AM Peak. The colours are generated from red through green to provide a gradation of importance for particular movements. The bold text denotes those movements which would be impacted (severed) by the stopping up of Hawthorn Road.

Table 2-1 – Observed Traffic Flows 2015 AM Peak

Point to Point flow values	Kennel Lane	Station Road Fiskerton	Croft Lane Cherry Willingham	Carlton Boulevard	Hawthorn Road at Wragby Road	Unmatched
Kennel Lane	19	13	76	**33**	**11**	46
Station Road Fiskerton	8	29	6	**5**	**3**	30
Croft Lane Cherry Willingham	24	9	77	**27**	**47**	26
Carlton Boulevard	**97**	**8**	**28**	42	21	18
Hawthorn Road at Wragby Road	**14**	**8**	**68**	251	68	52

Total Matched Traffic	992
Traffic impacted by Severence	349
Proportion of Severed Traffic	35%
U turning Traffic	235
Unmatched Records	172

The heaviest observations are Hawthorn Road to Carlton Boulevard, Carlton Boulevard to Kennel Lane and Kennel Lane to Croft Lane. This is representative of flow patterns from residential areas to work and education zones.

The traffic impacted by severance represents the matched data which will bisect the LEB corridor. Note that the unmatched data is excluded from this as it is not possible to ascertain whether the movement is unmatched due to observational error or due to traffic originating or destined within the cordon zone.

U turn traffic is relatively high reflecting drop-off trips at several school locations in the vicinity

Table 2-2 – Observed Traffic Flows 2015 PM Peak

Point to Point flow values	Kennel Lane	Station Road Fiskerton	Croft Lane Cherry Willingham	Carlton Boulevard	Hawthorn Road at Wragby Road	Unmatched
Kennel Lane	3	7	51	**3**	**1**	120
Station Road Fiskerton	7	4	10	**8**	**9**	30
Croft Lane Cherry Willingham	98	7	34	**14**	**107**	85
Carlton Boulevard	**69**	**7**	**58**	93	86	86
Hawthorn Road at Wragby Road	**17**	**7**	**121**	128	24	70
Total Matched Traffic	973					
Traffic impacted by Severence	421					
Proportion of Severed Traffic	43%					
U turning Traffic	158					
Unmatched Records	391					

In the PM peak there is around 30% higher flow volume with a greater mix of movements. Hawthorn Road to Carlton Boulevard, Hawthorn Road to Croft Lane, Croft Lane to Hawthorn Road and Croft Lane to Kennel Lane represent the largest individual matched movements. U turning traffic is limited and is a function of lower number of school trips in the modelled period.

The definitively severed traffic varies between 35% and 43% of matched traffic volumes in each time period.

3 LEB Model Update Process

3.1 Recap of Model Platform

The current LEB model is mounted in VISUM V12.01-09.

Three time periods are available, including:

- AM Peak Hour (08-09);
- PM Peak Hour (17-18); and
- Average Inter Peak ((10-16)

Three vehicle classes have been modelled. These include

- Cars (pcu factor 1)
- LGV (pcu factor 1)
- OGV (pcu factor 2.25)

Within the car user class the following trip purposes are retained to the OD matrix assignment level, based on differing route choice preferences.

- Commute
- Other
- Employers Business

3.2 Recap of Travel Demand Development

As a quick recap the following process has been adopted and is reported in the original LMVR.

- Observed Demand Data
    - Clean data
    - Create RIS matrices by purpose and vehicle.
    - Transpose and adjust non-interview direction
    - Remove illogical movements
    - Use selected link analysis for unobserved sites to create infill
    - Remove sample bias

  - Combine sites based on weighting by variance and adjust for multiple counting.

- Synthetic Demand Data
  - 2001 census output area household data
  - 2001 census JTW distribution
  - Employment and retail data
  - Household trip rates from NTEM 6.2
  - Census to zone lookup
  - Skim costs
  - Distribution at Production / attraction level
  - Add external movements
  - Factor to peak hours and to Origin Destination
  - Derive NHB based on NTM travel diary data.

- Demand Matrix Merge
  - Create smoothing sectors for synthetic and observed data
  - Smooth observed and disaggregate certain segments
  - Merge observed and synthetic matrices based on sector and full/partial observation

- 2011 LEB Model Enhancement
  - Adjust for route choice outside Lincoln Planning Area
  - Global adjustment of internal zones to enhance calibration.
  - Apply matrix estimation using “T” flow fuzzy logic.

The reader is referred to the LMVR, to which this document is an addendum, for the specific details of this process. In short the demand data build represents a robust best-practice approach to the development and refinement of an area wide model to create a scheme focussed model capable of analysing the LEB corridor.

These processes represent the basis for subsequent updates based on data collected in 2015.

3.3 2015 Model Refinement

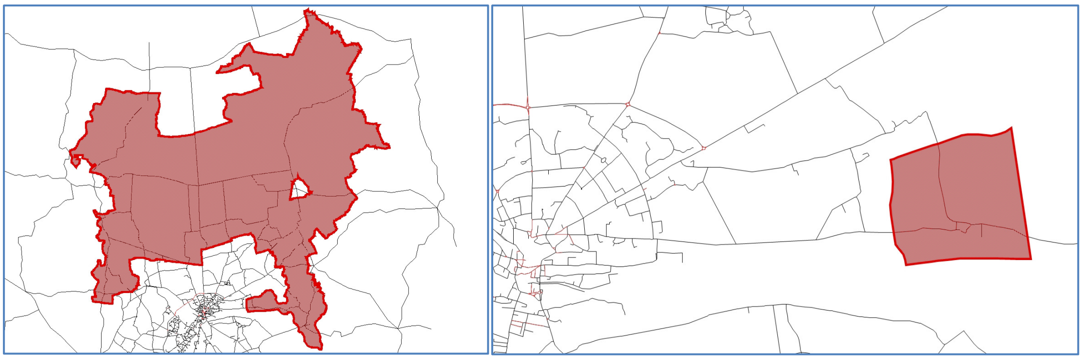
The Base Models detailed in the previous LMVR (August 2012) have been reviewed, in particular the area of interest in the vicinity of Hawthorn Road. Where considered appropriate updates to the Base Model have been applied in order to provide a more detailed traffic assignment.

3.4 2015 Zone Updates

It was considered important to review the zoning system at the northern vicinity of the model to ensure that the subtlety of traffic patterns could be captured within the model. Whilst the earlier model is considered as “fit for purpose” the additional scrutiny of traffic detail associated with the side roads necessitated several updates.

The previous Base Model did not have a separate zone for Fiskerton Village. Fiskerton was part of the West Lindsey zone 150 which loads on to the network, primarily to the north of Lincoln, but also extending to the east of the City.

Figure 3-1 – Disaggregation of Zone 150

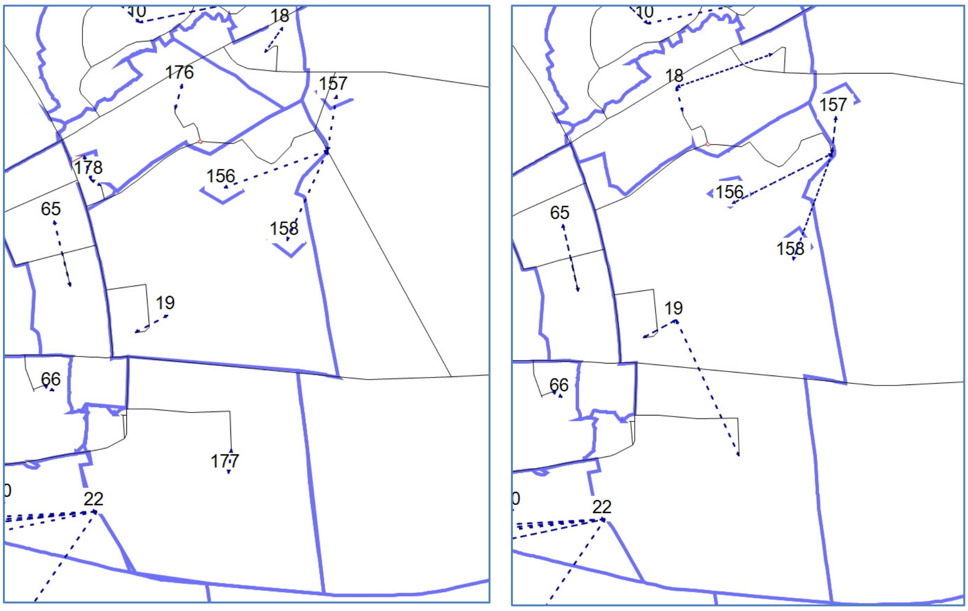


A new zone (175) has been added to represent Fiskerton, shown on the right hand diagram within Figure 3.1. The new zone loads on to Ferry Road. The trips originated from and destined to Fiskerton (including the wider bounds of the zone) have been abstracted from the 2006 travel survey demand data. Synthetic travel demand adjustments have been based on the relative weight of population according to an average of 2001 and 2011 data. In each case the travel demands have been separated by trip purpose to retain the appropriate level of detail in the conversion from 24 hour PA to peak hour assignment matrices. In this way the original travel demands has been focussed in the area of interest and trip matrix totals remain consistent.

Elsewhere in the vicinity zone 18 represents a geographical definition included in the original 2006 model, covering a wide area from Hawthorn Road to Carlton Boulevard. In 2006 the housing area was yet to be fully developed.

To separate the detail of this development, primarily for future forecasting, a new zone (176) has been added and loads on to Carlton Boulevard whilst existing Zone 18 has been amended so that is loads on to Hawthorn Road only. Again the zonal disaggregation is based on the relative number of trip ends in the original survey data, supplemented by census data, as per earlier explanations.

Figure 3-2 – Disaggregation of Zone 18 and Zone 19



Zone 19 in the previous Base Model represents a mix of commercial and industrial estate areas and has loading points on to Outer Circle Road and Allenby Road. To reflect the variation of the land use and the loading points the zone has been disaggregated.

A new Zone (177) has been added to represent the Allenby Road industrial area, whilst the existing Zone 19 has been amended so that it loads on to Outer Circle Road, in the vicinity of the commercial area. In addition a new Zone (178) has been added to represent the growing retail activity associated with the Carlton Centre. This zone loads onto the Outer Circle Road (ingress only for 2006) and Carlton Boulevard (2-way). The zonal definitions and loadings are also included in Figure 3.2.

Table 3-1 – Summary of Zonal Changes

Old Zone Number & Description	Justification for Split	Resultant New zones
150 – Lincoln East	Requirement to reflect specific traffic patterns associated with Fiskerton.	150 – Lincoln East
		175 – Fiskerton Village
18 – Bunkers Hill	Requirement to reflect specific traffic patterns associated with Carlton Boulevard versus Hawthorn Road	18 – Hawthorn Road
		176 – Carlton Boulevard
19 – Outer Circle Road	Requirement to split land uses associated with commercial, retail and industrial land uses to ensure the correct loading of trips onto the network	19 – Commercial – Outer Circle
		177 – Industrial – Allenby Road
		178 – Retail – Carlton Centre

3.5 Network Updates

In order to ensure the network has been coded correctly, a thorough audit of the model has been carried out. This section gives a brief summary of some of the checks that have been made on the network to ensure that it remains error free and robust.

- Distance checks. These were reviewed against crow fly distance calculated based on coordinate values. No links are found less than crow fly distance. Links with a value of >5% above crow fly distance validated based on impact of curvature

- Connectivity checks. These were reviewed against 2006 google earth images detailing the network at the time of base year calibration.

  - In 2006, the section of St Augustine Road linking to Hawthorn Road was constructed but not widely used. Consequently in the original modelling it was left out of the base year. To aid route choice it has been added to the network.

  - Additionally Waterford Lane, which connects High Street to Fiskerton Road in Cherry Willingham, has been added to the base model. Trips to / from Cherry Willingham via Fiskerton Road now have a route choice between Waterford Lane and Church Lane.

The network review also looked at the nodes within the study area to ensure all junctions are modelled in detail. Priority junctions were modelled using the node impedance function (ICA function). Within the VISUM software, there are several methods of modelling junction performance but the ICA method involves calculation of junction capacity to the highest level of detail (i.e. it includes consideration of opposing turns). Priority junction default saturation flows were applied as follows:

- Major Road Straight Ahead = 1,950 pcu/hr/lane;

- Major Road Left Turn = 1,950 pcu/hr/lane;

- Major Road Right Turn = 1,750 pcu/hr/lane;

- Minor Road Left Turn = 745 pcu/hr/lane;

- Minor Road Right Turn = 627 pcu/hr/lane.

Saturation flows for junctions were further adjusted during the calibration/validation process taking into account the junction geometric layout such as lane width, number of lanes and lane marking of the junction

These checks and updates serve to refine traffic route choice in the vicinity.

4 Model Calibration

4.1 Introduction

In line with best practice data has been segregated into calibration datasets, which assist in developing traffic patterns, and validation datasets which independently verify the adherence of modelled traffic characteristics to observed patterns. This section of the reporting covers the model calibration adjustments.

4.2 Generalised Cost Parameters

As part of the model recalibration, the latest WebTAG 3.5.6 (November 2014) values of time were used to update the generalised cost parameters for each user class within the VISUM models. Values of pence per kilometre (PPK) and pence per minute (PPM) for three vehicle classes (Car, LGV, HGV) by purpose type (Work, Commute, Other) were updated for all three time periods. Monetary time (PPM) and distance (PPK) costs were then converted into generalised costs. These are shown in Table 4-1.

Table 4-1 – Generalised Cost Parameters

User Class	Time Period	Monetary Values		Generalised Cost	
		Time (pence per minute)	Distance (pence per kilometre)	Time	Distance
Car Commute	AM Peak	13.34	6.68	1.00	0.50
	Inter Peak	13.34	6.68	1.00	0.50
	PM Peak	13.34	6.68	1.00	0.50
Car Other	AM Peak	18.28	6.68	1.00	0.37
	Inter Peak	18.28	6.68	1.00	0.37
	PM Peak	18.28	6.68	1.00	0.37
Car Employed Business	AM Peak	45.03	13.17	1.00	0.29
	Inter Peak	45.03	13.17	1.00	0.29
	PM Peak	45.03	13.17	1.00	0.29
LGV	AM Peak	20.52	13.70	1.00	0.67
	Inter Peak	20.52	13.70	1.00	0.67
	PM Peak	20.52	13.70	1.00	0.67
HGV	AM Peak	20.80	42.62	1.00	2.05
	Inter Peak	20.80	42.62	1.00	2.05
	PM Peak	20.80	42.62	1.00	2.05

4.3 Model Convergence

Convergence is the measure used to determine model stability during the assignment process. A suitably converged model can be expected to produce consistent outputs with minimal model noise. A total of 99 iterations were run to gain a statistically significant sample of convergence data.

The following convergence criteria were used as recommended in WebTAG:

- Duality Gap less than 1% - this expresses the difference between the current estimates of the costs associated with trips through the modelled network against the theoretical costs if all traffic were to use the minimum cost route associated with their journey. It measures how far modelled flows differ from the desired equilibrium.

- Average absolute difference less than 1 – this is the number of routes that deviate from each other based on the impedances of the assignment.

- Relative average absolute difference less than 5% - this is the percentage of routes that deviate from each other based on the impedances of the assignment.

Table 4-2 shows the Duality Gap for the last four assignment iterations in each time-period. It can be seen that all three models for each time period reached convergence within 30 assignment iterations and the models therefore converged to a stable solution.

Table 4-2 – Model Convergence Statistics

AM		IP		PM	
Iteration	%Gap	Iteration	%Gap	Iteration	%Gap
25	0.00005	19	0.00002	19	0.00004
26	0.00005	20	0.00004	20	0.00003
27	0.00004	21	0.00003	21	0.00003
28	0.00005	22	0.00002	22	0.00002

4.4 Network Calibration

Aside from the checks on the network coding, such as the consistency of link coding by direction and by time period, the observed count and journey time data provides a useful source of information against which the highway network can be compared. Using an assignment of the prior matrix the calculated capacities and journey times have been compared with this observed data. Where required junction capacities and cruise speeds were altered in the model to represent traffic flows at junctions and links. Cruise speeds were modified on sections of road which appeared to have a speed limit significantly higher than observed actual speeds, when compared to processed traffic data. No locations were found where the count was higher than capacity, but these checks were undertaken nonetheless.

4.5 Demand Data Calibration

The reporting of traffic flow volume at postcard sites is summarised in Tables 4-3, 4-4 and 4-5 below. Following the model disaggregation and reassignment these results indicate a fair correlation between observed and modelled flows with many postcard screenlines meeting DfT (validation) criteria in respect of percentage flow differences. Deviation from the original values can be expected resulting from the matrix merging procedure (removal of double counting), inclusion of synthetic data and from the traffic assignment process.

Table 4-3 – Calibration at Postcard Sites AM Peak

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
Inbound Movements								
01	B1398 Middle St	642	636	6	-38%	0.2	✓	✓
02	A15 North of Lincs	774	665	109	-14%	4.1	✓	✓
03	A57 West of Linc	1,042	1,053	12	1%	0.4	✓	✓
04	A46 North of Lincs	652	703	51	8%	2.0	✓	✓
05	B1190 Lincoln Rd	329	456	127	39%	6.4	×	×
06	A46 SW of Lincs	1,322	1,240	82	-6%	2.3	✓	✓
07	B1308 Greetwell Rd	563	546	17	-3%	0.7	✓	✓
08	B1190 Washingb. Rd	443	505	62	14%	2.8	✓	✓
09	B1188 Canwick Rd	1,122	1,119	3	0%	0.1	✓	✓
10	A15 Cross O Cliff	458	390	68	-15%	3.3	✓	✓
11	Brant Rd	418	506	88	21%	4.1	✓	✓
11a	Station Rd	329	290	38	-12%	2.2	✓	✓
12	A158 Wragby Rd East	612	672	60	10%	2.4	✓	✓
	Total	**8,705**	**8,782**	**77**	**1%**	**0.8**	**✓**	**✓**
						Total Passed Guidance	**92%**	**92%**
Outbound Movements								
01	B1398 Middle St	166	78	88	-53%	8.0	✓	×
02	A15 North of Lincs	447	458	11	3%	0.5	✓	✓
03	A57 West of Linc	661	712	51	8%	1.9	✓	✓
04	A46 North of Lincs	346	403	57	16%	2.9	✓	✓
05	B1190 Lincoln Rd	230	215	16	-7%	1.0	✓	✓
06	A46 SW of Lincs	1,267	1,169	97	-8%	2.8	✓	✓
07	B1308 Greetwell Rd	123	151	28	22%	2.4	✓	✓
08	B1190 Washingb. Rd	124	117	7	-6%	0.6	✓	✓
09	B1188 Canwick Rd	577	516	61	-11%	2.6	✓	✓
10	A15 Cross O Cliff	314	462	147	47%	7.5	×	×
11	Brant Rd	271	345	73	27%	4.2	✓	✓

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
11a	Station Rd	376	405	29	8%	1.5	✓	✓
12	A158 Wragby Rd East	481	511	30	6%	1.3	✓	✓
	Total	**5,384**	**5,541**	**157**	**3%**	**2.1**	**✓**	**✓**
						Total Passed Guidance	**92%**	**86%**

Table 4-4 – Calibration at Postcard Sites Inter Peak

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
Inbound Movements								
01	B1398 Middle St	196	124	72	-37%	5.7	✓	×
02	A15 North of Lincs	413	455	42	10%	2.0	✓	✓
03	A57 West of Linc	578	553	25	-4%	1.0	✓	✓
04	A46 North of Lincs	513	576	63	12%	2.7	✓	✓
05	B1190 Lincoln Rd	202	226	23	12%	1.6	✓	✓
06*	A46 SW of Lincs	850	850	0	0%	0.0	✓	✓
07	B1308 Greetwell Rd	199	193	6	-3%	0.5	✓	✓
08*	B1190 Washingb. Rd	202	202	0	0%	0.0	✓	✓
09	B1188 Canwick Rd	641	632	8	-1%	0.3	✓	✓
10	A15 Cross O Cliff	455	437	18	-4%	0.8	✓	✓
11	Brant Rd	322	309	13	-4%	0.7	✓	✓
11a	Station Rd	217	210	8	-3%	0.5	✓	✓
12	A158 Wragby Rd East	540	555	14	3%	0.6	✓	✓
	Total	**5,329**	**5,322**	**7**	**0.00**	**0.1**	**✓**	**✓**
						Total Passed Guidance	**100%**	**92%**
Outbound Movement								
01	B1398 Middle St	190	142	48	-25%	3.7	✓	✓
02	A15 North of Lincs	434	580	146	34%	6.5	×	×
03	A57 West of Linc	553	582	28	5%	1.2	✓	✓
04	A46 North of Lincs	526	555	30	6%	1.3	✓	✓
05	B1190 Lincoln Rd	221	226	5	2%	0.3	✓	✓
06	A46 SW of Lincs	894	877	18	-2%	0.6	✓	✓
07	B1308 Greetwell Rd	211	196	14	-7%	1.0	✓	✓
08*	B1190 Washingb. Rd	175	175	0	0%	0.0	✓	✓
09	B1188 Canwick Rd	758	791	33	4%	1.2	✓	✓
10	A15 Cross O Cliff	426	513	88	21%	4.0	✓	✓
11	Brant Rd	319	420	101	32%	5.3	×	×

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
11a	Station Rd	225	246	21	9%	1.3	✓	✓
12	A158 Wragby Rd East	558	578	20	4%	0.8	✓	✓
	Total	**5,490**	**5,882**	**391**	**0.07**	**5.2**	✓	×
						Total Passed Guidance	**92%**	**88%**

Note : * Denotes that count data was unavailable at these sites and so the observed count is set to equal the modelled count.

Table 4-5 – Calibration at Postcard Sites PM peak

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
Inbound Movements								
01	B1398 Middle St	293	399	106	36%	5.7	×	×
02	A15 North of Lincs	533	466	67	-13%	3.0	✓	✓
03	A57 West of Linc	597	765	167	28%	6.4	×	×
04	A46 North of Lincs	590	633	43	7%	1.8	✓	✓
05	B1190 Lincoln Rd	277	495	218	79%	1.1	×	×
06*	A46 SW of Lincs	1538	1538	0	0%	0.0	✓	✓
07	B1308 Greetwell Rd	127	182	54	43%	4.4	✓	✓
08*	B1190 Washingb. Rd	247	247	0	0%	0.0	✓	✓
09	B1188 Canwick Rd	614	639	24	4%	1.0	✓	✓
10	A15 Cross O Cliff	473	460	13	-3%	0.6	✓	✓
11	Brant Rd	424	410	14	-3%	0.7	✓	✓
11a	Station Rd	402	395	7	-2%	0.4	✓	✓
12	A158 Wragby Rd East	542	582	40	7%	1.7	✓	✓
	Total	**6,659**	**7,211**	**552**	**8%**	**6.6**	×	×
						Total Passed Guidance	**77%**	**77%**
Outbound Movements								
01	B1398 Middle St	608	778	170	28%	6.5	×	×
02	A15 North of Lincs	688	642	45	-7%	1.8	✓	✓
03	A57 West of Linc	1025	1029	4	0%	0.1	✓	✓
04	A46 North of Lincs	749	631	118	-16%	4.5	×	✓
05	B1190 Lincoln Rd	292	282	9	-3%	0.6	✓	✓
06	A46 SW of Lincs	1165	1050	115	-10%	3.5	✓	✓
07	B1308 Greetwell Rd	506	542	35	7%	1.5	✓	✓
08*	B1190 Washingb. Rd	323	323	28	10%	1.6	✓	✓
09	B1188 Canwick Rd	1354	1030	324	-24%	9.4	×	×
10	A15 Cross O Cliff	740	831	91	12%	3.2	✓	✓

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
11	Brant Rd	538	680	142	26%	5.8	×	×
11a	Station Rd	236	234	1	-1%	0.1	✓	✓
12	A158 Wragby Rd East	776	797	22	3%	0.8	✓	✓
	Total	**8,999**	**8,851**	**148**	**-2%**	**1.6**	**✓**	**✓**
						Total Passed Guidance	**73%**	**77%**

Note: * Denotes that count data was unavailable at these sites and so the observed count is set to equal the modelled count.

5 Model Validation

5.1 Introduction

Model Validation is undertaken to check that a transport model accurately represents the transport network that it has been based upon. The main aims of this process, as stated in TAG Unit M3.1 – Highway Assignment Modelling, are:

- To demonstrate that the model accurately reproduces an existing and independently observed situation

- To summarise the accuracy of the base from which future forecasts are to be prepared.

5.2 Network Validation

WebTAG Unit M3.1 states that: "It is not possible to validate the network in isolation, since the output traffic flows and travel times will reflect not only errors in the network, but also those inherited from the input trip matrix. This is particularly important consideration in congested urban areas, where relatively small discrepancies in a trip matrix can have a disproportionate impact on the junctions delays and hence on the routes taken by vehicles through the network."

A review of modelled flows on links demonstrates that traffic volumes are appropriate in respect to one another, with an intuitive distribution across the network according to local knowledge and with the highest flow roads having the highest level of traffic flow within the model. Whilst this is a subjective evaluation it is a useful step to verify prior to reliance on subsequent route choice and quantitative flow validation evidence.

5.3 Route Choice Validation

Route choice validation has also been undertaken to check the parts of the network where observed data was not available either in the surveyed traffic counts or as part of the journey time surveys. The ability of the model to robustly represent route choice within the network depends on:

- Correct zone sizing and definition, network structure and the realism of the zone centroid connectors to the modelled network.

- Accuracy of the network coding.

- Accuracy with which delays at junctions and cruise speeds on links are modelled.

- Accuracy of the trip matrices.

As recognised within WebTAG, it is not possible to inspect all origin-destination routeing within the model assignment. Therefore a selection of key traffic movements should be assessed focusing on key areas of population and / or employment and should be chosen so that the routes:

- relate to significant number of trips;
- are of significant length or cost;
- pass through areas of interest;
- include both directions of travel;
- link different compass directions (e.g. north to south and east to west); and
- coincide with journey time routes where appropriate.

These considerations have guided the routing checks undertaken for the LEB modelling. In addition to this, as a guide to the number of routes that should be assessed within a given model, WebTAG suggests the following rule of thumb:

Number of OD pairs = (number of zones)0.25 x the number of user classes.

This calculation suggests that around 20 route choices are analysed to ensure validation. A selection of example routes are illustrated in Appendix B.

5.4 Screenline Flow Validation

Seven screenlines (as shown in Figure 5-1) controlling major movements in the study area have been devised from observed data. Due to an overall lack of count data, some counts have been included in more than one screenline. This has resulted in screenlines containing a combination of both calibration and validation counts. Comparisons of modelled and observed flows were undertaken for these screenlines (by direction) as shown below in Tables 5-1 to 5-4.

It can be seen from the tables below that all three peak hour models validate very well against screenline flows. When comparing absolute flows, 100% of screenlines pass the screenline flow validation criteria as set out in TAG Unit M3.1. When looking at the screenline GEH flow criteria from DMRB, both the AM peak and Inter peak achieve 93% validation, with 87% achieved during the PM peak, which highlights that all three models validate well against observed flows and meet the required criteria.

The components of these screenlines, referenced at a link flow level are included in Appendix B.

Table 5-1 – Screenlines Summary

Pass/Fail	AM		Inter Peak		PM	
	Flow	GEH	Flow	GEH	Flow	GEH
Screenline 1 - NB	✓	✓	✓	✓	✓	✓
Screenline 1 - SB	✓	×	✓	✓	✓	✓
Screenline 2 - EB	✓	✓	✓	✓	✓	✓
Screenline 2 - WB	✓	✓	✓	✓	✓	✓
Screenline 3 - NB	✓	✓	✓	✓	✓	✓
Screenline 3 - SB	✓	✓	✓	✓	✓	✓
Screenline 4 - EB	✓	✓	✓	✓	✓	✓
Screenline 4 - WB	✓	✓	✓	✓	✓	✓
Screenline 5 - NB	✓	✓	✓	✓	✓	✓
Screenline 5 - SB	✓	✓	✓	×	✓	✓
Screenline 6 - EB	✓	✓	✓	✓	✓	×
Screenline 6 - WB	✓	✓	✓	✓	✓	✓
Screenline 7 - EB	✓	✓	✓	✓	✓	✓
Screenline 7 - WB	✓	✓	✓	✓	✓	×
Total Passing Criteria	**14 / 14**	**13 / 14**	**14 / 14**	**13 / 14**	**14 / 14**	**12 / 14**
% Passing Criteria	**100%**	**93%**	**100%**	**93%**	**100%**	**86%**

Figure 5-1 – Calibration & Validation Screenlines

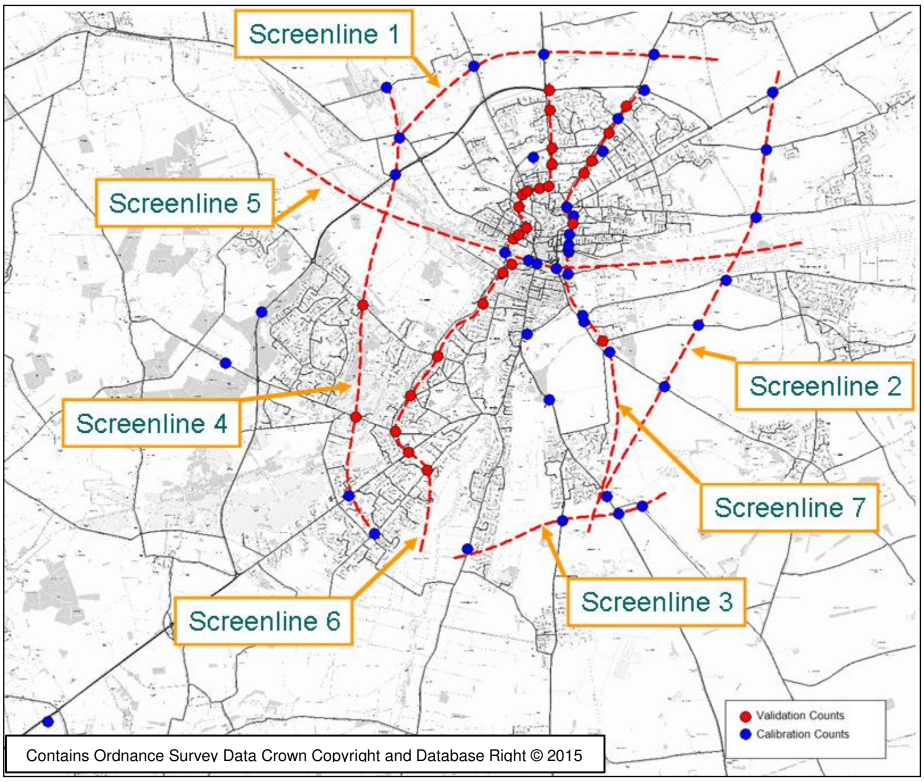


Table 5-2 – Screenline Summary – AM Peak

Screenline	Direction	Observed (pcu)	Modelled (pcu)	Abs Diff (pcu)	% Diff	Average GEH	Pass TAG Flow	Pass DMRB GEH
1	NB	1,767	1,679	-88	-5%	2.1	✓	✓
	SB	3,356	3,107	-249	-7%	4.4	✓	×
2	EB	1,895	1,833	-62	-3%	1.4	✓	✓
	WB	3,723	3,538	-185	-5%	3.1	✓	✓
3	NB	1,371	1,280	-91	-7%	2.5	✓	✓
	SB	1,538	1,444	-95	-6%	2.4	✓	✓
4	EB	5,344	5,123	-221	-4%	3.1	✓	✓
	WB	3,965	3,935	-30	-1%	0.5	✓	✓
5	NB	5,272	5,445	174	3%	2.4	✓	✓
	SB	4,212	4,348	136	3%	2.1	✓	✓
6	EB	7,206	7,283	77	1%	0.9	✓	✓
	WB	6,051	5,833	-219	-4%	2.8	✓	✓
7	EB	5,555	5,569	14	0%	0.2	✓	✓
	WB	6,128	6,165	37	1%	0.5	✓	✓
Number of Screenlines passing Criteria							**14 / 14**	**13 / 14**
Percentage of Screenlines passing Criteria							**100%**	**93%**

Table 5-3 – Screenline Summary – Inter Peak

Screenline	Direction	Observed (pcu)	Modelled (pcu)	Abs Diff (pcu)	% Diff	Average GEH	Pass TAG Flow	Pass DMRB GEH
1	NB	1,814	1,868	54	3%	1.2	✓	✓
	SB	1,840	1,735	-105	-6%	2.5	✓	✓
2	EB	1,928	2,042	114	6%	2.6	✓	✓
	WB	1,843	1,866	23	1%	0.5	✓	✓
3	NB	855	866	10	1%	0.4	✓	✓
	SB	1,021	1,081	60	6%	1.8	✓	✓
4	EB	3,512	3,737	226	6%	3.8	✓	✓
	WB	3,617	3,758	141	4%	2.3	✓	✓
5	NB	3,510	3,700	190	5%	3.2	✓	✓
	SB	3,904	4,164	260	7%	4.1	✓	×
6	EB	5,593	5,364	-229	-4%	3.1	✓	✓
	WB	5,471	5,315	-156	-3%	2.1	✓	✓
7	EB	4,804	4,700	-104	-2%	1.5	✓	✓
	WB	5,318	5,079	-240	-5%	3.3	✓	✓
Number of Screenlines passing Criteria							**14/14**	**13/14**

Percentage of Screenlines passing Criteria	**100%**	**93%**

Table 5-4 – Screenline Summary – PM Peak

Screenline	Direction	Observed (pcu)	Modelled (pcu)	Abs Diff (pcu)	% Diff	Average GEH	Pass TAG Flow	Pass DMRB GEH
1	NB	3,264	3,342	78	2%	1.4	✓	✓
	SB	2,302	2,467	166	7%	3.4	✓	✓
2	EB	3,385	3,425	41	1%	0.7	✓	✓
	WB	1,875	1,986	111	6%	2.5	✓	✓
3	NB	1,396	1,477	80	6%	2.1	✓	✓
	SB	1,492	1,365	-127	-9%	3.4	✓	✓
4	EB	4,687	4,572	-115	-2%	1.7	✓	✓
	WB	4,963	4,895	-68	-1%	1.0	✓	✓
5	NB	4,358	4,306	-52	-1%	0.8	✓	✓
	SB	5,269	5,506	237	5%	3.2	✓	✓
6	EB	6,843	6,472	-371	-5%	4.6	✓	×
	WB	6,474	6,779	306	5%	3.8	✓	✓
7	EB	6,276	6,046	-230	-4%	2.9	✓	✓
	WB	6,299	5,912	-387	-6%	5.0	✓	×
Number of Screenlines passing Criteria							**14/14**	**12/14**
Percentage of Screenlines passing Criteria							**100%**	**86%**

5.5 Journey Time Validation

It is important that journey times are properly validated to ensure that speeds on links and delays at junctions are accurately represented by the model. This will give confidence in the model's ability to correctly forecast the likely impacts of changing traffic demand and network improvements.

The journey time validation is based on comparisons of observed and modelled journey times along 10 (bi-directional) routes (shown below).

Figure 5-2 – Journey Time Routes

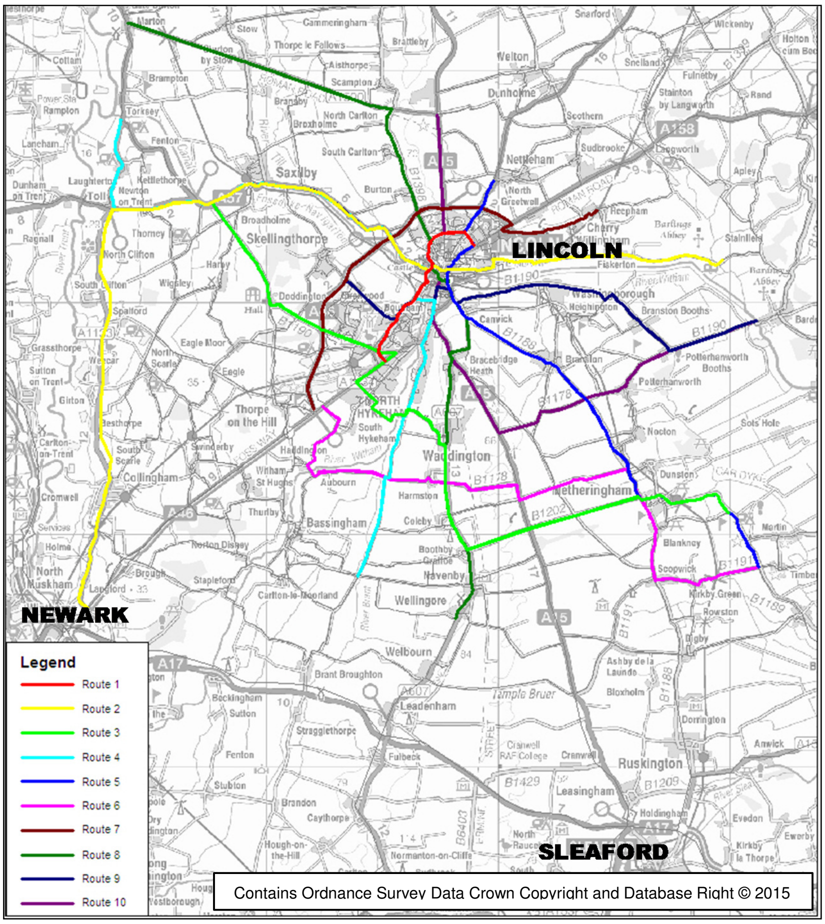


Table 5-5 provides a summary of the journey time validation results for the three modelled time periods. It shows that, for all three time periods, the difference between modelled and observed journey times is within 15% or 1 minute for 19 out of 20 routes (95%) for AM Peak, 18 out of 20 routes (90%) for the Inter-Peak and 16 out of 20 routes (80%) for the PM Peak. Therefore, both the AM Peak and Inter-Peak meet the TAG Unit M3.1 journey time validation criteria whereas the PM Peak is just slightly under. The routes / locations which are outside the criteria in the PM peak are not considered as too critical for traffic likely to divert to the LEB. Detailed journey time validation results for all routes are presented in Appendix B, which includes tables and figures showing comparisons of observed and modelled journey times over the length of each route.

Table 5-5 – Journey Time Validation Summary – All Periods

Route	Description	Pass Criteria		
		AM	IP	PM
1	B1182 Ruskin Ave/A15 Wragby Rd and A1434 Newark Rd/B1003 Tritton Rd	✓	✓	×
		✓	✓	✓
2	Ferry Rd/Short Ferry Rd and A1133/A46	✓	✓	✓
		✓	✓	✓
3	B1189 Moor Ln and A57 Gainsborough Rd/B1190 Tom Otters Ln	✓	✓	✓
		✓	✓	✓
4	Hopyard Ln/Navenby Ln and A1133 Newark Rd/A156	✓	✓	×
		✓	✓	×
5	B1189/B1191 Main St/Station Rd and A46 Lincoln Rd/Washdyke Ln	✓	✓	✓
		✓	✓	✓
6	B1191 Main St/B1189/Station Rd and A1434 Newark Rd/Boundary Ln	×	✓	✓
		✓	✓	✓
7	A46/A1434 Newark Rd and Moor Ln/Fiskerton Rd	✓	×	✓
		✓	×	×
8	A607 Cliff Rd/Skinnand Ln and A1500 Stow Park Rd/High St	✓	✓	✓
		✓	✓	✓
9	B1190 Branston Causeway at river and B1378 Skellingthorpe Rd/Lincoln Rd	✓	✓	✓
		✓	✓	✓
10	B1190 Branston Causeway at river and A1500 Horncastle Ln/A15	✓	✓	✓
		✓	✓	✓
Number of routes passing criteria		**19 / 20**	**18 / 20**	**16 / 20**
Percentage of routes passing criteria		**95%**	**90%**	**80%**

6 Model Comparisons

6.1 Traffic Patterns

The 2006 model distribution in this area has been abstracted from the LEB model and is reflected in terms of heaviest volumes as follows.

Table 6-1 – Modelled Vehicle Flows AM Peak

Point to Point flow values	**Kennel Lane**	**Station Road Fiskerton**	**Croft Lane Cherry Willingham**	**Carlton Boulevard**	**Hawthorn Road at Wragby Road**	**Unmatched**
Kennel Lane	0	39	55	**0**	**0**	99
Station Road Fiskerton	30	0	0	**0**	**0**	1
Croft Lane Cherry Willingham	72	0	0	**0**	**12**	46
Carlton Boulevard	**0**	**0**	**0**	0	5	53
Hawthorn Road at Wragby Road	**0**	**0**	**82**	14	0	110

Total Matched Traffic	309
Traffic impacted by severance	94
Proportion of Traffic	30%
U turning Traffic	0
Unmatched Records	309

Table 6-2 – Modelled Vehicle Flows PM Peak

Point to Point flow values	**Kennel Lane**	**Station Road Fiskerton**	**Croft Lane Cherry Willingham**	**Carlton Boulevard**	**Hawthorn Road at Wragby Road**	**Unmatched**
Kennel Lane	0	16	28	**0**	**0**	36
Station Road Fiskerton	8	0	0	**0**	**0**	0
Croft Lane Cherry Willingham	65	0	0	**0**	**29**	59
Carlton Boulevard	**21**	**0**	**6**	0	48	192
Hawthorn Road at Wragby Road	**0**	**0**	**16**	4	0	197

Total Matched Traffic	241
Traffic impacted by severance	72
Proportion of Traffic	30%
U turning Traffic	0
Unmatched Records	484

It is of note that the above flows are 2006 Base flows whereas the flows presented in Tables 2.1 and 2.2 are 2015 flows. As such it is considered that differences in traffic flows and patterns can be attributed to changes in land use and traffic growth that have occurred since 2006.

One of the heaviest observed movements, from Hawthorn Road to Carlton Boulevard, is not reflected in the 2006 model, with the modelled flow considerably lower. It is considered that this traffic movement can be attributed to the increase in development and congestion in the surrounding area which has occurred since 2006. It is expected that the increase in this movement will be reflected in the future year forecast models which will be more comparable with the 2015 surveyed flows.

The proportion of trips that would be affected by the closure of Hawthorn Road are similar when comparing the observed and modelled flows. In the AM peak 35% of the observed matched trips would be affected by the severance compared with 30% in the model. In the PM peak 43% of the observed matched trips would be affected compared with 30% in the model.

The observed traffic flows contain a considerable amount of trips with the same entry and exit point to the cordon. These flows are not represented in the model as modelled trips have an origin and destination only and do not include ‘via’ points.

In reality these U-turning trips are represented in the model by 2 separate trips, both into and out of the cordon.

The "unmatched flows" reported from the model are relatively high. In this case they represent trips originating from and terminating within the local zones within the cordon area (Cherry Willingham, Reepham and Bunkers Hill). Hence a significant volume of traffic is local traffic rather than through movement.

6.2 Flow Validation

To aid in a comparison with the previous model the following information is presented. It provides a metric of the changes in level of validation between previous and current models.

The model number and model percent rows relate to the proportion of elements (screenline or individual links) meeting the WebTAG guidance. An increase in numbers and percentages represents a positive outcome. The Average Model value reflects a flow weighted estimate of screenline GEH and screenline percentage differences. In this case a reduction indicates that on average modelled flows are now closer to observed flows.

Table 6-3 – Screenline and Link Validation Comparison

Model	Validation	AM Peak		Interpeak		PM Peak	
		Locations Meeting GEH Criteria	Locations meeting Flow Criteria	Locations Meeting GEH Criteria	Locations meeting Flow Criteria	Locations Meeting GEH Criteria	Locations meeting Flow Criteria
Screenlines							
Original	Model Number	9	13	11	12	8	10
	Model Percent	64	93	79	86	57	71
	Average Model Value	3.4	1.44	6.0	3.71	12.1	6.26
Updated	Model Number	13	14	13	14	12	14
	Model Percent	93	100	93	100	86	100
	Average Model Value	3.4	1.40	1.6	0.98	0.4	0.23
Links							
Original	Model Number	84	94	102	109	80	90
	Model Percent	63	71	77	82	60	68
Updated	Model Number	90	103	110	116	86	100
	Model Percent	68	77	83	87	65	75

The latest model is much improved, resulting from the more refined zone system and greater adherence to target flows within the matrix estimation process. Screenlines meeting flow validation criteria extend to 100% whereas GEH validation is improved to 86% or above.

At a link level the model also increases the number of validated locations in each modelled time period.

6.3 Journey Time Validation

Table 6.4 presents the changes in journey time validation. In both the AM and the IP periods the level of validation improves. In the PM peak there is a slight worsening as two routes now model outside the Webtag bounds, based on some modest additional delay facing traffic in the western suburbs of Lincoln. Given improvements elsewhere and the fact that this traffic is not considered important for reassignment to LEB this has been accepted as part of the model validation.

Table 6-4 – Journey Time Validation Comparison

Model	Validation	Routes Meeting Criteria		
		AM Peak	Inter Peak	PM Peak
Original	Number of Routes	18	18	18
	Percentage Pass	90%	90%	90%
	Average observed time (seconds)	2,187	2,044	2,214
	Average modelled time (seconds)	2,318	1,944	2,288
	Average difference	180	138	181
New	Number of Routes	19	18	16
	Percentage Pass	95%	90%	80%
	Average observed time (seconds)	2,187	2,044	2,214
	Average modelled time (seconds)	2,197	1,944	2,419
	Average difference	10	100	205

7 Summary and Conclusions

7.1 Summary

The focus of the current application of the Lincoln VISUM model is; to forecast the volume of traffic re-routing onto the proposed LEB alignment; to quantify the impact of this traffic on the future year network; and to evaluate the impact of the proposed side road orders in the vicinity of Hawthorn Road. The model will also be used to provide data to input into other processes, including operational assessment, economic assessment and environmental assessment.

In summary:

- the model network and matrices have been constructed using a robust and transparent methodology;
- An original extensive data collection exercise has been carried out to ensure the best understanding of traffic conditions in the study area;
- The model has achieved an acceptable level of calibration across those screenlines which are important to the LEB traffic patterns and a high level of convergence suggesting assignment stability. This will ensure that any flow changes resulting from scheme testing can be attributed to the scheme itself and not model noise.

Acceptable link flow calibration has been achieved both locally adjacent to the northern end of LEB and across the model as a whole. Peak hour and Interpeak flow validations and journey time results on key links across the network suggest that the model provides a sufficiently accurate representation of observed conditions within the core study area.

7.2 Conclusion

Based on these results it can be concluded that the LEB model is a robust model that accurately reflects the existing situation in terms of flows and journey times and is suitable for assisting scheme design, environmental assessment and economic cost benefit analysis.

Appendix A – Survey Data Summary

Manual Classified Turning Count at A158 Wragby Road / Kennel Lane junction on 12th November 2013

Manual Classified Turning Count at A15 Bunkers Hill/Hawthorn Road junction on 12th November 2013

Manual Classified Link Count on A158 Wragby Road throughout June 2014

Manual Classified Link Count on B1308 Greetwell Road throughout June 2014

Appendix B – Model Validation Detail