Birmingham Development Plan

Transport Modelling Assessment
Initial Output Report

January 2014
Birmingham City Council

Mott MacDonald

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1 Lancaster Circus, PO Box 14439, B2 2JE

Mott MacDonald, 35 Newhall Street, Birmingham, B3 3PU, United Kingdom
t +44 (0)121 234 1500 f (0)121 200 3295, W www.mottmac.com

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Mott MacDonald, 35 Newhall Street, Birmingham, B3 3PU, United Kingdom
t +44 (0)121 234 1500 f (0)121 200 3295, W www.mottmac.com

Content

1. Introduction

1.1 Study Context

Birmingham City Council (BCC) is in the process of developing the Birmingham Development Plan; a central part of its Local Development Framework. As with any land use policy, the way the Plan is supported by transport services and associated infrastructure will be one of the elements fundamental to its successful delivery. Similarly, the way in which the transport system develops to respond to the implementation of the Plan will also be fundamental to the system's on-going effectiveness. For these reasons, and in accordance with relevant policy, BCC has commissioned Mott MacDonald to develop a Transport Evidence Base to support the emerging Birmingham Development Plan.

The Transport Evidence Base is being developed over five stages, as shown in the following table.

Table 1.1: Proposed study stages

Study Stage	Label	Description
Stage 1	Scoping	Establishing and agreeing key study parameters from the outset. This element has already been reported.
Stage 2	Establishing Context	Building up the full picture of relevant policy, plans and programmes which set the context for being able to assess the Birmingham Development Plan's future impacts
Stage 3a	Strategic Modelling	Assessing area-wide future impacts through strategic modelling
Stage 3b	Junction Modelling	Local area modelling of specific junctions and development of mitigation measures
Stage 4	Infrastructure Delivery	Considerations of design, cost, funding and delivery of required new infrastructure
Stage 5	EIP Assistance	Expert witness support to the Council at the Planning Inquiry

Stages 1 and 2 are now completed and available as separate reports. Stages 3b and 4 are being undertaken by other consultants.

The key stage of the methodology is Stage 3a (Strategic Modelling) because this is the stage where the Birmingham Development Plan's transport impacts – both positive and negative – are strategically quantified. The West Midlands Policy Responsive Integrated Strategy Model (PRISM) is being employed for this task and, in order to quantify impacts, considers the following three scenarios:

1. **Base year scenario** (2011) – which represents a present-day transport and land-use scenario.
2. **Reference Case scenario** (2021 and 2031) – which represents the future transport and land-use scenario in the hypothetical case where there is no Development Plan implemented
3. **Development Case scenario** (2021 and 2031) – which represents the future transport and land-use scenario in which the Development Plan is implemented

These scenarios allow the future transport impacts of the Development Plan to be isolated and identified by comparing the Development Case scenario with the Reference Case scenario. The three scenarios are fully defined and detailed in the Stage 2 report.

The purpose of this report is to provide initial Stage 3a modelling results in order to quantify the headline strategic level highway impact of the Development Plan proposals in 2031. This will allow mitigation options to be identified in order to manage these impacts. This work is presently ongoing, in consultation with key stakeholders, and will be reported on at the next stage (see Stages 3b and 4 above).

1.2 Report Contents and Structure

In light of the purpose of this stage of the study, this report is structured as follows:

Table 1.2: Report structure

Section	Title	Description
2	PRISM Model Overview	Introduction to and overview of the PRISM model
3	Base Year Model Improvements	Description of improvements made to PRISM base model to provide more robust representation around the proposed Sustainable Urban Extension area
4	Forecasting Scenarios	Description of forecasting scenarios used to model transport impact of Birmingham Development Plan
5	Forecasting Results	Presentation of forecasting scenario results
6	Summary	Report summary

2. PRISM Model Overview

2.1 Introduction

The purpose of this section is to provide an introduction to and overview of the PRISM model.

2.2 Model Development

PRISM (Policy Responsive Integrated Strategy Model) is a transport model of the West Midlands, comprised of a highway assignment model and a public transport (PT) assignment model, linked together with a demand model. The assignment models use the VISUM software package and the demand model is built in ALOGIT.

PRISM was originally developed between 2002 and 2004 and has undergone several updates over the last decade; the latest being the PRISM Refresh. This a comprehensive update to revalidate both assignment models and the demand model to reflect a 2011 base. During the PRISM Refresh, the demand model was also updated to create forecast models for 2021 and 2031.

The development of the highway assignment model and the level of validation achieved are described in the Local Model Validation Report (LMVR), while the forecasting process is described in the Forecasting Report. Copies of both will be available on request from Birmingham City Council once issued.

Key characteristics of the three model elements are presented below.

2.3 2011 Base Year Highway Assignment Model

The base year highway networks are modelled in two levels of detail, as outlined below:

- **Fully modelled area (FMA).** This is the area over which significant impacts of land use and transportation infrastructure interventions have influence. The fully modelled area is further subdivided into:
  - *Area of detailed modelling* (AoDM) – comprises the West Midlands Metropolitan Area. This is the area in which significant impacts of interventions are certain. Modelling in this area is characterised by representation of all trip movements, smaller zones and a detailed network representation with junction modelling (including flow metering and blocking back). In this area, the modelled traffic flow and journey times are compared and calibrated using observed data. The AoDM comprises the seven metropolitan districts
  - *Rest of the fully modelled area (RotFMA)* – consists of an intermediate area. This is the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude. It is characterised by: representation of all trip movements; somewhat larger zones and less network detail than for the AoDM; and speed/flow modelling (link-based).
- **External area** – consists of the rest of the West Midlands Region and the rest of Great Britain. The impacts of interventions can be assumed to be negligible here. This area comprises the rest of the WM region and the rest of Great Britain. In terms of network, the representation of the external area is skeletal and fixed speed modelling is used. Demand is also only partially represented, characterised by large zones and external to external trips through the FMA only.

The modelled time periods for the highway assignment models are:

- AM average hour (average hour 0700 – 0930)
- Inter-peak (average hour 0930 – 1530)
- PM (average hour 1530 – 1900)

2.4 2011 Base Year Public Transport Model

The base year PT network was developed by Centro and Mott MacDonald and combines the existing 2005/08 Centro PT and 2006 PRISM PT models. These two models were unified and updated to include all PT services that have at least one stop in the Area of Detailed Modelling.

Key characteristics of the Unified PT Model are as follows:

- The model contains the detailed link network from the Centro 2005/08 model and a simplified link network within the intermediate area for non-core services.
- The model contains a 'unified zoning system', made by updating and combining the Centro and PRISM zoning systems.
- Demand matrices have been developed using survey matrices, demand from the Centro 2005/08 model and synthetic matrices from the new PRISM 2011 demand model. Demand is split into the segments Fare and No-fare.
- Long-distance demand developed using PLANET
- Fares. These have been coded throughout the model separately for the core and non-core areas.
- Walk links. These have been updated from the Centro 2005/08 model and extended into the intermediate area.
- The model contains all services in 2011 that have at least one stop within the PRISM core or intermediate areas.

The time periods for the PT assignment model are:

- AM (0700 – 0900)
- Inter-peak (1000 – 1200)
- PM (1600 – 1800)

2.5 Variable Demand Model

The demand model forecasts future travel demand by estimating growth based on changes in synthetic trips between the base and the forecast years (see 'Pivoting' Process in Figure 2.1). This growth is then applied to a validated base year matrix. The demand model produces forecasts for 2021 and 2031.

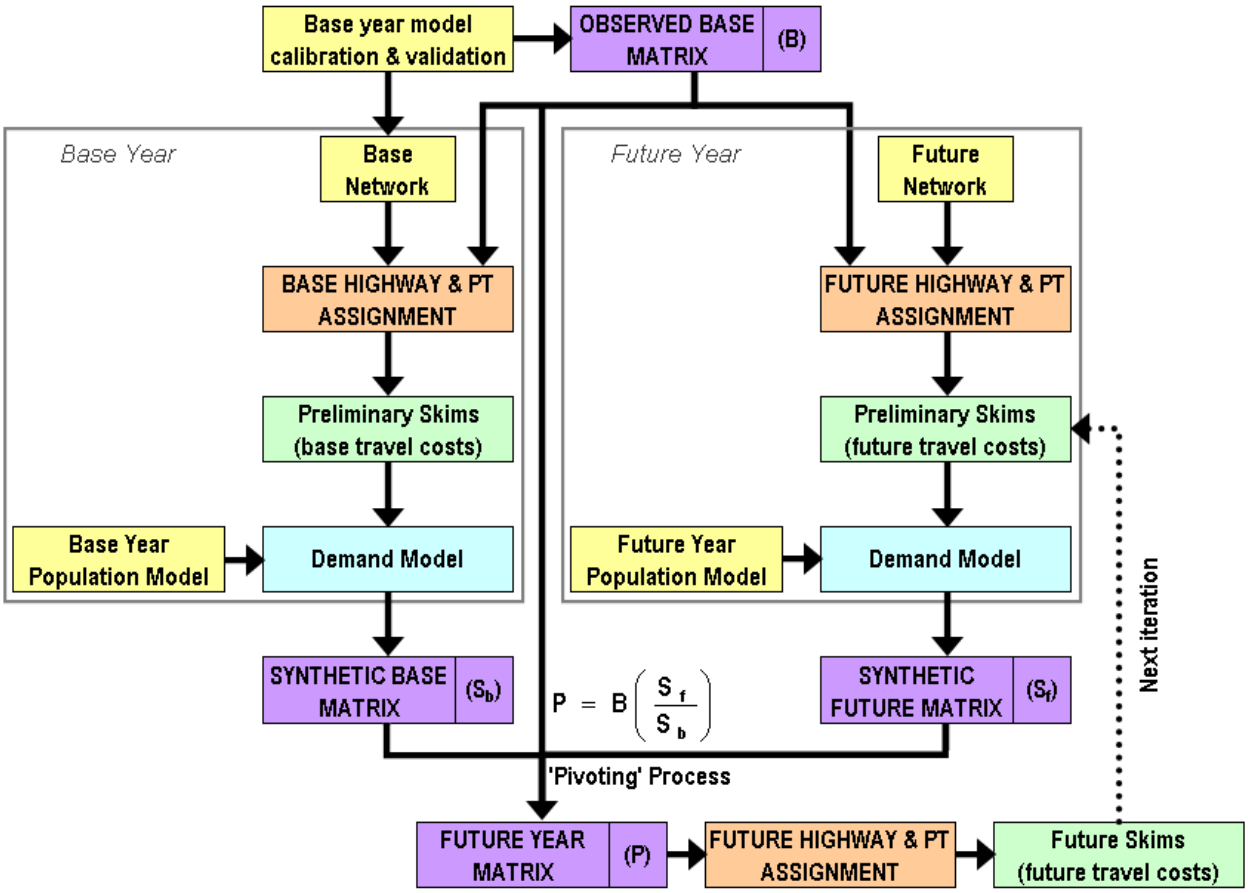
The synthetic demand is a mathematical estimation of the travel movement in the area, based on observations of the travel behaviour of the West Midlands population, spatial information and generalised travel costs for each origin-destination (OD) pair in each modelled year. The demand model contains a bespoke population forecasting module which estimates a future pseudo-household interview based on future zonal targets such as population, workers and household income. The estimation of the synthetic trips (demand) takes into account the following demand responses:

- change in trip making/trip frequency
- change in mode
- change of destination/trip distribution
- change in time of travel

The forecast matrices are assigned to the future networks to obtain an accurate representation of the generalised costs for synthetic matrix re-estimation. This process is done in an iterative process until reaching a satisfactory convergence level.

The above process is undertaken by several modules that are integrated within the demand model and controlled by a VBA program. The whole forecasting process is summarised by the flowchart in Figure 2.1.

Figure 2.1: PRISM Forecasting Process



3. Base Year Model Improvements

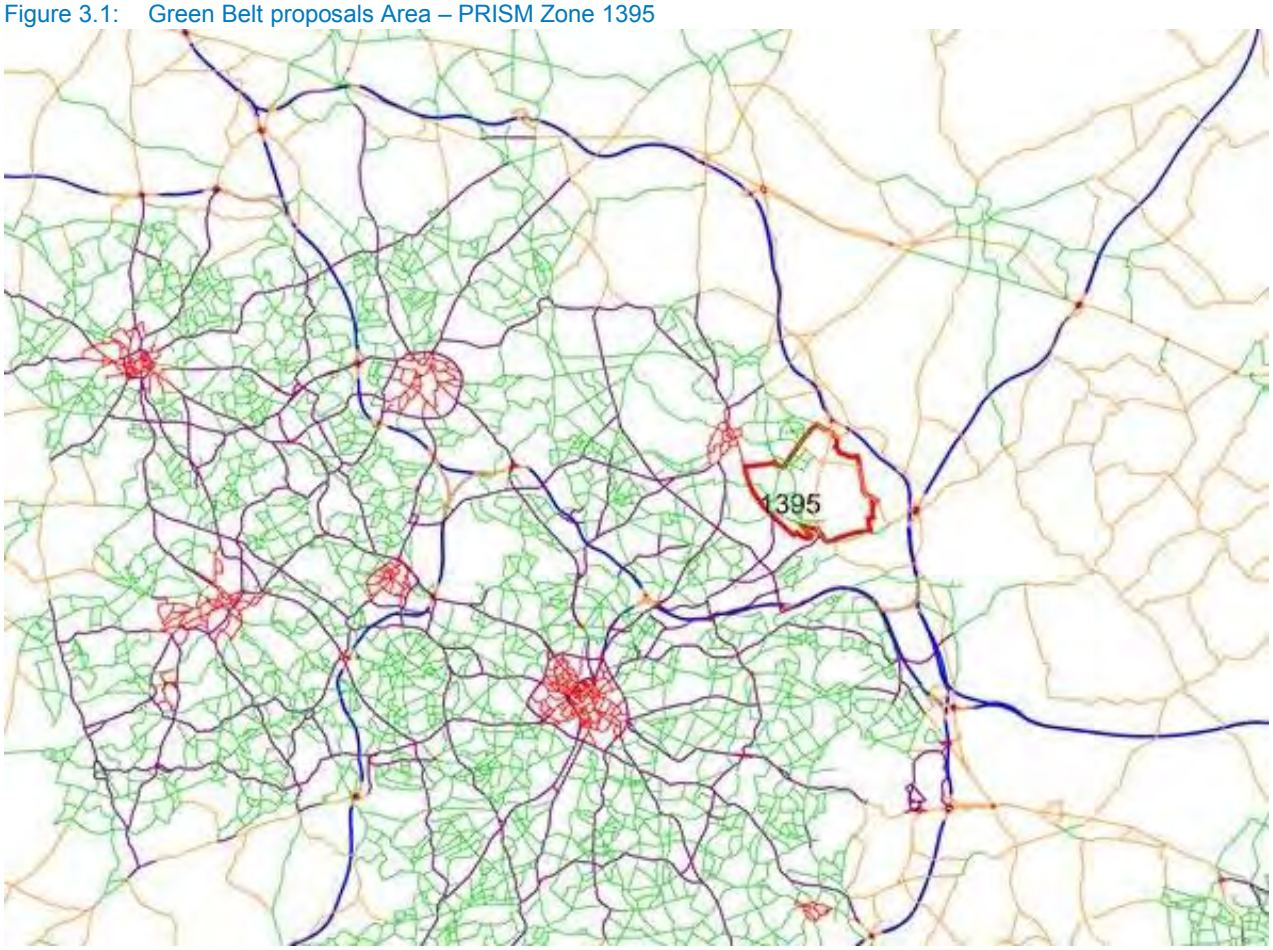
3.1 Introduction

As described in the Stage 2 report, part of the Development Plan proposals is to permit the development of housing and employment uses within an area currently designated as Green Belt (the 'Green Belt proposals'). The purpose of this section is to describe how extra traffic count data has been used to make the PRISM model more robust around this area.

3.2 Revalidation of the Base Year Model

The Green Belt proposals area is situated within PRISM zone 1395, which is on the periphery of the Area of Detailed Modelling (AoDM), as shown in Figure 3.1.

Figure 3.1: Green Belt proposals Area – PRISM Zone 1395



Due to the location of this zone on the edge of the AoDM, a revalidation exercise has been undertaken on the base year highway models. The objective of this exercise is to improve modelled traffic flow in the Green Belt proposals area in order to produce a more robust basis for forecasting.

This has led to the development of a new version of the 2011 base year highway models with improved representation of traffic flow within the Green Belt proposals area. This version of the base year highway

model is different to that reported in the PRISM LMVR and a summary of the calibration results is therefore provided below.

3.3 Validation Results

Outputs from the newly calibrated base year highway assignment models have been compared to:

- Observed traffic count data collected from ATCs
- Observed journey times extracted from TrafficMaster

3.3.1 Link Volumes

In order to analyse the performance of the highway assignment model, modelled and observed traffic flows are compared using the following criteria:

- the GEH statistic, which incorporates both relative and absolute errors
- the absolute and percentage difference between modelled flows and observed counts

The acceptability criteria are provided in Table 3.1 below.

Table 3.1: Acceptability guidelines for link flow criteria

Criteria	Description of criteria	Acceptability Guideline
1	GEH <5 for individual flows	>85% of cases
2	Individual flows less than 350 vehicles/hour for counts with flows less than 250 vehicles/hour	>85% of cases
	Individual flows within 100 vehicles/hour of counts for flows less than 700 vehicles/hour	>85% of cases
	Individual flows within 15% of counts for flows from 700 to 2700 vehicles/hour	>85% of cases
	Individual flows within 400 vehicles/hour of counts for flows more than 2,700 vehicles/hour	>85% of cases

Results are presented for two types of count:

- Calibration – these are links that have been included in the calibration of car and LGV matrices
- Validation – these are links that have been excluded from calibration of car and LGV matrices and have been retained for independent validation

Table 3.2 summarises the level of fit between modelled and observed volumes for calibration counts against WebTAG criteria.

Table 3.2: Calibration link results

Time Period	Counts	Pass	Pass (%)
AM	1846	1548	84%
PM	1848	1508	82%

Figure 3.2 and Figure 3.3 show the location of these counts for the AM and PM highway networks. In these figures counts that meet the criteria are shown in green and those that do not meet the criteria are shown in red.

Figure 3.2: Calibration counts AM

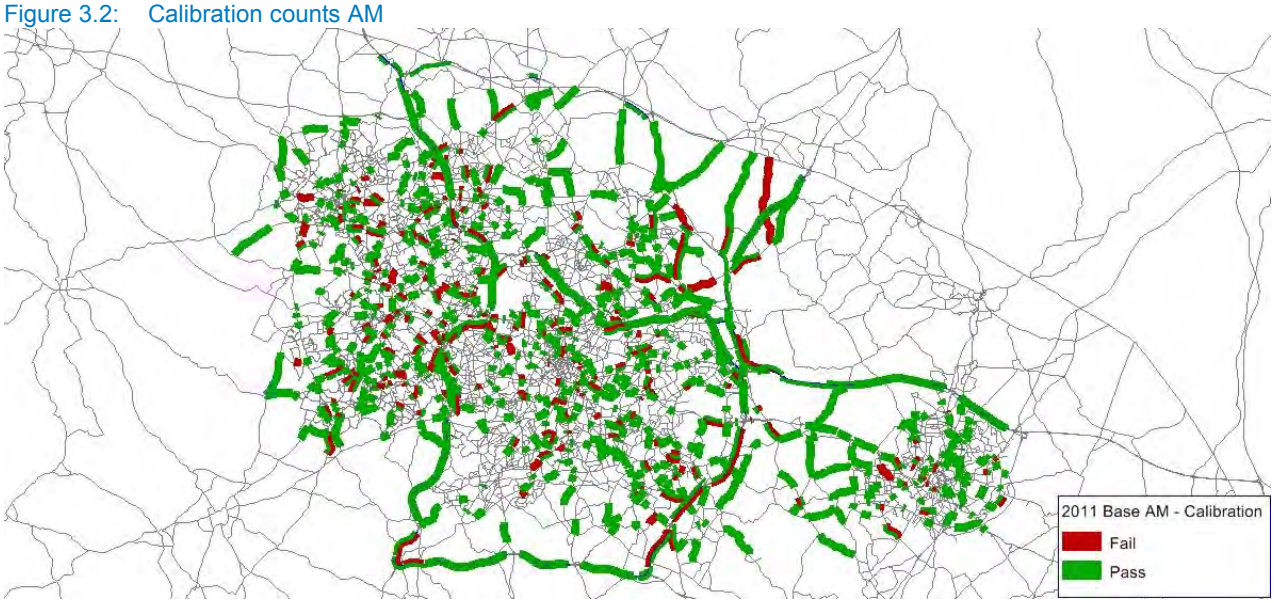


Figure 3.3: Calibration counts PM

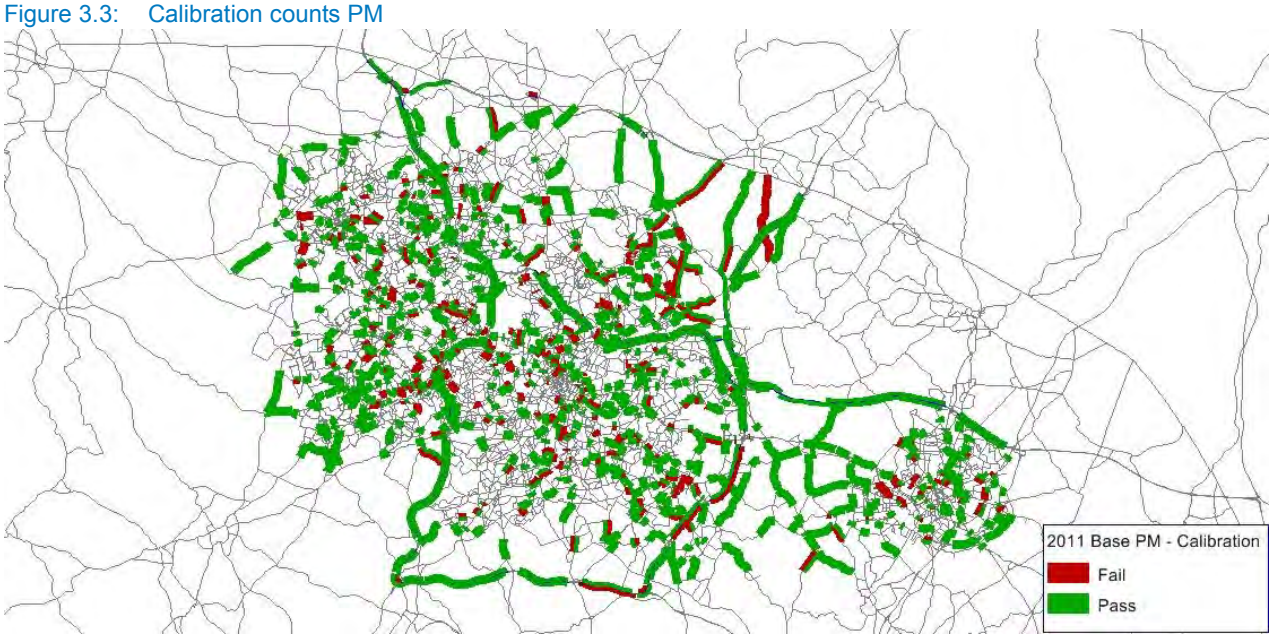


Table 3.3 summarises the level of fit between modelled and observed volumes for validation counts against WebTAG criteria.

Table 3.3: Validation link results

Time Period	Counts	Pass	Pass (%)
AM	875	707	81%
PM	875	706	81%

These count locations are shown in Figure 3.4 and Figure 3.5 below where counts that meet the criteria are shown in green and those that do not meet the criteria are shown in red.

Figure 3.4: Validation counts - AM

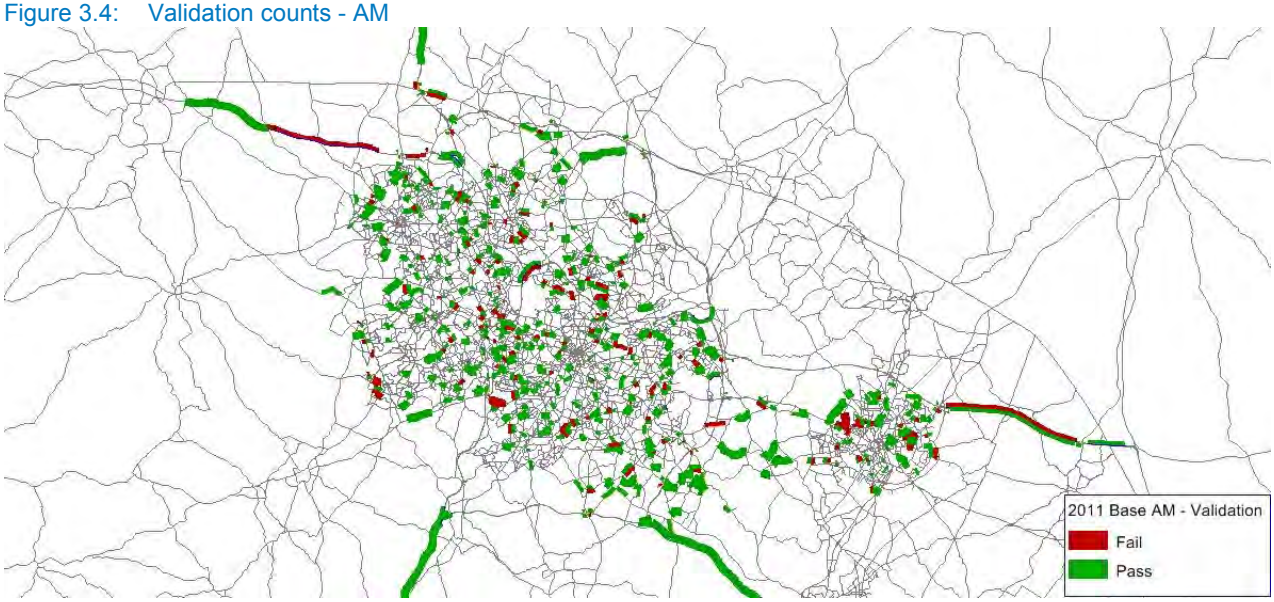
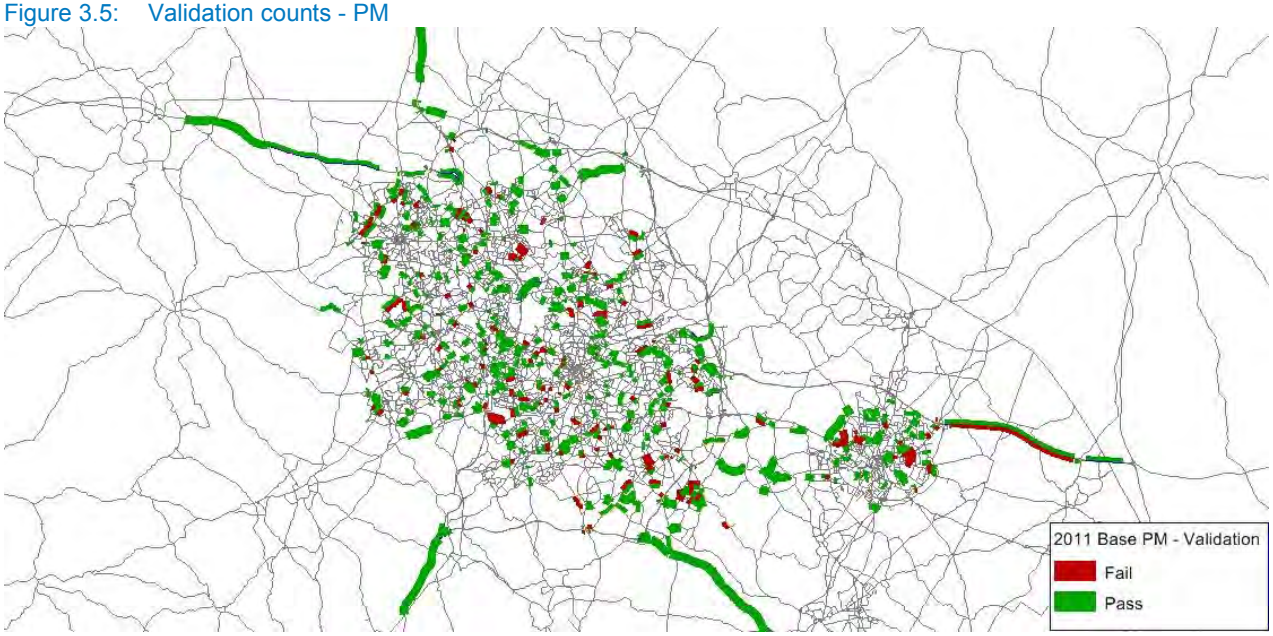


Figure 3.5: Validation counts - PM



3.3.2 Journey Times

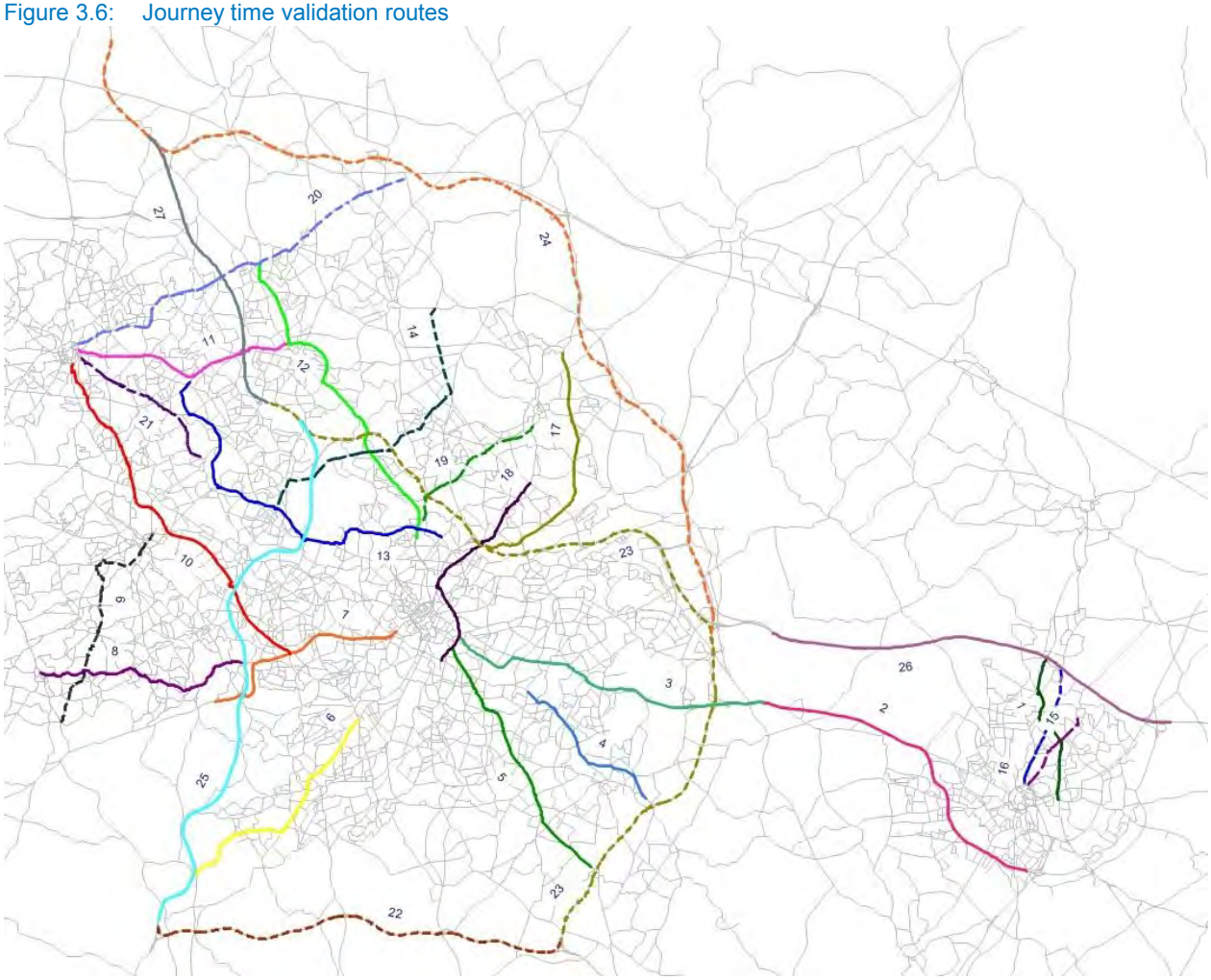
In order to analyse the performance of the highway assignment model, modelled and observed journey times are compared. The acceptability criteria are detailed in WebTAG 3.19 and summarised in Table 3.4 below.

Table 3.4: Acceptability guidelines for journey time criteria

Description of criteria	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher)	>85% of cases

Figure 3.6 below shows the 27 routes selected for journey time validation.

Figure 3.6: Journey time validation routes



Source: PRISM model

Journey time validation results for each route in each direction and for each peak hour are attached in Appendix A and summarised for all routes below in Table 3.5.

Table 3.5: Journey time validation results

Peak Hour	No of Routes	No of Passes	Pass %
AM	54	44	81%
PM	54	36	67%

The table shows that the journey time validation for the AM is good, with 81% of routes passing the WebTAG 3.19 criteria. This table also shows that journey time validation is weaker in the PM with 67% of routes passing the criteria. However, reference to the tables in Appendix A shows that validation for routes passing through or near the Green Belt proposals area (17, 23 and 24) is good.

3.4 Summary of Results

The revalidation of the Base year model to include extra traffic data around the Green Belt proposals zone has improved the robustness of the model, with the validation results showing acceptable outcomes in this area. These results are very similar to the validation results for the full model and which have been agreed with the West Midlands PRISM Management Group.

It is noted that the WebTAG guideline criteria are guideline values and not a fixed target that must be achieved. WebTAG guidance suggests that the pursuit of these guideline values should not be at the expense of adjusting the prior matrix too much (TAG Unit 3.19 states “the changes brought about by matrix estimation should be carefully monitored and should not be significant”). A compromise has therefore been sought where meeting the guideline criteria has been traded off against changes to the prior trip matrix. The quality of the trip matrix was preserved and an acceptable level of overall model validation was also achieved (particularly given the scale and complexity of the model).

4. Forecasting Scenarios

4.1 Introduction

The purpose of this section is to provide a summary of the PRISM model forecasting scenarios and details on the effectiveness of the model in simulating these scenarios.

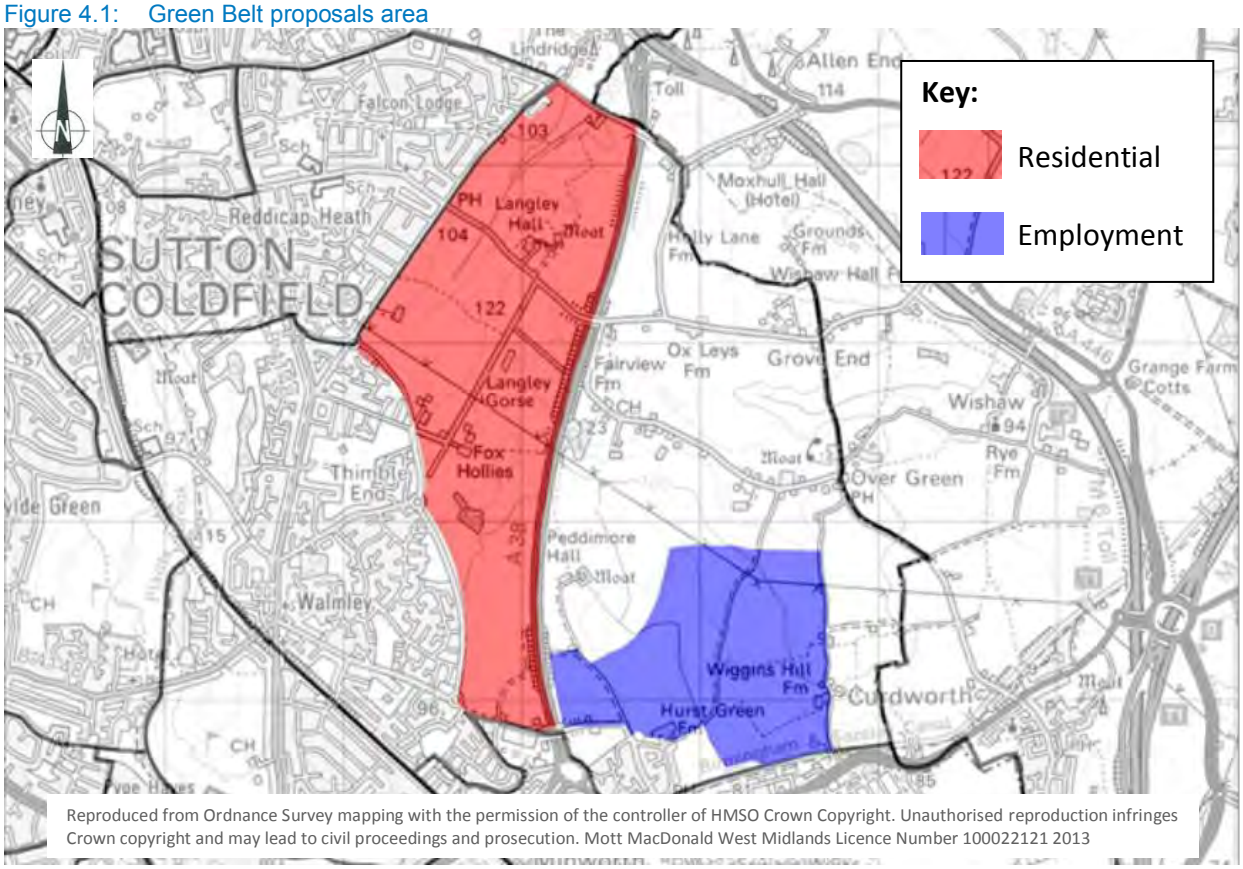
4.2 Assessment Scenarios

As described in Section 1.1 above, the transport impacts of the Birmingham Development Plan have been assessed through the modelling of the following scenarios:

- **Base year scenario** (2011) – which represents a present-day transport and land-use scenario.
- **Reference Case scenario** (2021 and 2031) – which represents the future transport and land-use scenario in the hypothetical case where there is no Development Plan implemented
- **Development Case scenario** (2021 and 2031) – which represents the future transport and land-use scenario in which the Development Plan is implemented

The impacts of the Development Plan are identified and assessed by comparing the Development Case scenario with the Reference Case scenario. The difference between the two scenarios is that, in the Development Case, a quantum of housing and employment uses is proposed to be developed in an area currently designated as Green Belt land (see Figure 4.1 below).

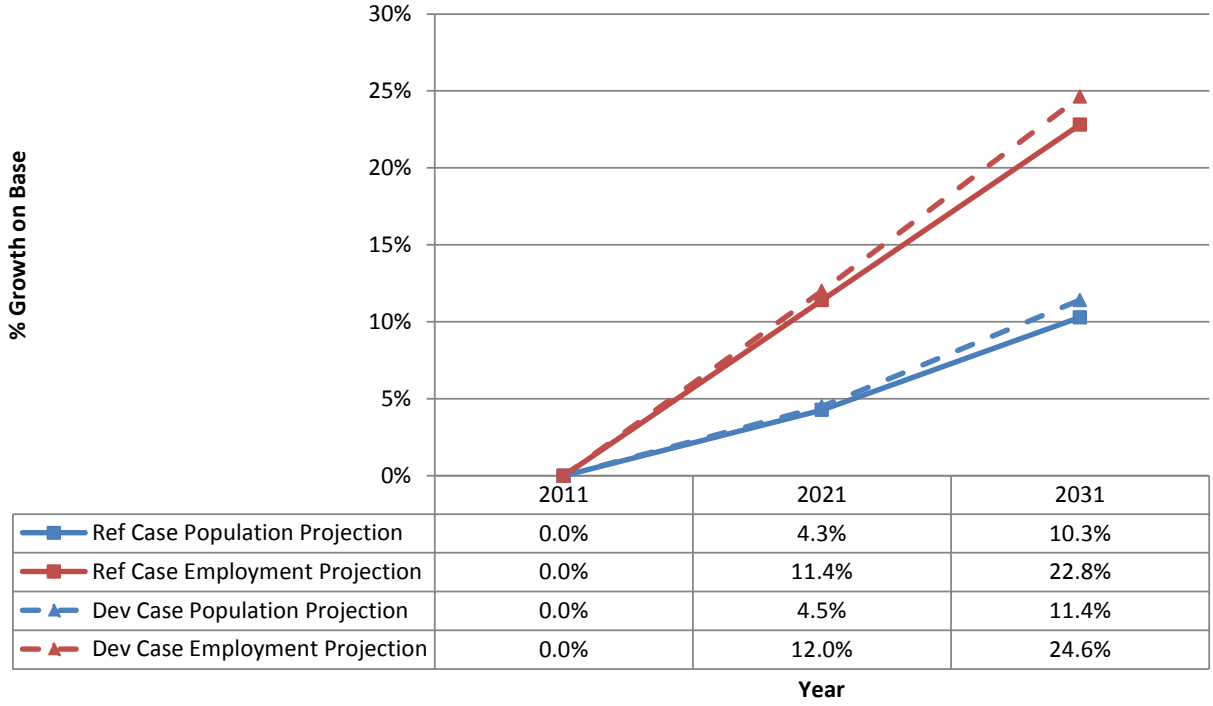
Figure 4.1: Green Belt proposals area



Source: Birmingham City Council

The release of this land will allow the population and employment within Birmingham to increase by 12,000 people and 8,129 jobs respectively, compared to the Reference Case. This difference between the two scenarios is summarised in the following figure (Figure 4.2).

Figure 4.2: Development Case vs Reference Case population and employment growth prediction



	2011	2021	2031
Ref Case Population Projection	0.0%	4.3%	10.3%
Ref Case Employment Projection	0.0%	11.4%	22.8%
Dev Case Population Projection	0.0%	4.5%	11.4%
Dev Case Employment Projection	0.0%	12.0%	24.6%

Source: Birmingham City Council

In terms of population, the Development Case increase in Birmingham results in a corresponding drop in surrounding Districts, so that the forecast population total for the UK remains the same in both scenarios. In terms of employment, however, the Development Case increase in Birmingham represents new jobs to the UK market which are assumed not to exist without the Development Plan.

Full details of the definition of these assessment scenarios are provided in the Stage 2 report.

4.3 Assessment Networks

In order to establish the transport impacts of the Plan, the Do Minimum transport network is used in both future scenarios.

For the Reference Case, this represents the transport network predicted to exist in future years and this is comprised of the existing transport network plus proposed schemes which are deemed to be 'certain' or 'more than likely' in their delivery. A full list of these highway schemes is presented in Section 5 of the Stage 2 report and is reproduced in Table 4.1 below.

Table 4.1: List of highway schemes included in 2021 and 2031 Reference Case Do Minimum network

Scheme Name	Area
Aston Hall Road/Lichfield Road	Birmingham
Chester Road	Birmingham
Churchbridge Cannock Island	Birmingham
Hard Shoulder Running M5 Junction 4a-6	Birmingham
Hard Shoulder Running M6 Junction 10a-13	Birmingham
Hard Shoulder Running M6 Junction 2-4	Birmingham
Hard Shoulder Running M6 Junction 5 to 8	Birmingham
Highgate Road/Stratford Road Junction	Birmingham
Selly Oak Phase 1B	Birmingham
Metro (extension to New Street)	Birmingham
BCCI	Birmingham
Albert Street Closure - closed between Curzon Street and Masshouse Lane	Birmingham
Paradise Circus	Birmingham
Metro to Centenary Square LTB	Birmingham
Ashted Circus - Pinch Point Scheme	Birmingham
Curzon Circle - Pinch Point Scheme	Birmingham
Holloway Circus - Pinch Point Scheme	Birmingham
Bordesley Circus - Pinch Point Scheme	Birmingham
Haden Circus - Pinch Point Scheme	Birmingham
Jennens Road/Cardigan Street New Signalised junction	Birmingham
A444 Whitley Interchange / Leaf Lane	Coventry
A45/A46 Tollbar End	Coventry
A46/A428 junction signalisation	Coventry
A4600 Congestion Reduction Scheme	Coventry
City Centre Public Realm Schemes Phase 1	Coventry
City Centre Public Realm Schemes Phase 2	Coventry
Friargate Bridge (Ring Road J6)	Coventry
Gateway Mitigation Schemes (including BRT)	Coventry
High Street, Pensnett	Dudley
A5 / A5148 - pinch points	HA
M42 J6 - pinch points	HA
M5 J2 - pinch points	HA
M5 J4 - pinch points	HA
M6 J6 Salford Circus - pinch points	HA
M42 J10 - pinch points	HA
Signal Junction - C0513 Horseley Heath/Horseley Road	Sandwell
A41 Expressway	Sandwell
A45 Bridge Maintenance scheme	Solihull
Chester Road / Dunster Road	Solihull
Signal Junction - G0142 Solihull Bypass / Hampton Lane / Marsh Lane / Yew Tree Lane - pedestrian phase introduced across Solihull Bypass and right turn filter into Yew Tree Lane added.	Solihull
A34 Stratford Rd / Haslucks Green junction	Solihull

Scheme Name	Area
A45 Diversion	Solihull
DSDA - Bentley Mill Way	Walsall
DSDA - Bentley Road South	Walsall
DSDA - Bescott Road/Wallows Road Junction	Walsall
DSDA - Brown Lion Junction	Walsall
Speed Limits – 30mph – Wolverhampton Road/Sutton Road	Walsall
Sutton Road/The Crescent	Walsall
City Centre Public Realm	Wolverhampton
Patshull Ave / Wobaston Road	Wolverhampton
Vine Island (A449 / Wobaston Road) roundabout	Wolverhampton
i54 Transport Strategy	Wolverhampton

For the Development Case, the Do Minimum network is the same as in the Reference Case but with the addition of schemes (highway and PT) deemed necessary to facilitate the Green Belt proposals. Full details of these additional schemes are provided in Section 7 of the Stage 2 report and the highway schemes are listed in Table 4.2 below. However, it is noted that this is a provisional list of schemes proposed for the purpose of this exercise and could be subject to change with further scenario testing and development.

Table 4.2: List of highway schemes added to the 2021 and 2031 Development Case Do Minimum network

Scheme Name	Description
Fox Hollies Road / Webster Way	Introduction of SPRINT infrastructure and improvements to Webster Way junction with Fox Hollies Road
Peddimore Island	Development access off A38 Sutton Coldfield bypass
Minworth Island	Capacity improvements to roundabout
Castle Vale bus link	Bus link between A38 and Manby Road
A38 Junction with Bromford Road	Introduction of SPRINT infrastructure
Bagot Arms – Chester Road	Introduction of SPRINT infrastructure
Eachelhurst Road / Walmley Ash	Introduction of SPRINT infrastructure, including improvements to Walmley Ash junction with Eachelhurst Road and new bridge across railway
Site Road Infrastructure	Internal development site distributor links

4.4 Model Convergence Results

PRISM is a transport model of the West Midlands and as such it has been developed to sufficiently represent the real world for the West Midlands Metropolitan Area, on average. It is noted that, for every study that focuses on a particular area, the model performance in terms of reproducing real world phenomena will vary.

The convergence between iterations of the Variable Demand Model for the forecasting years (measured by %GAP as defined in WebTAG Unit 3.10.4) levels off at around 0.8% for Reference Case and 0.9% for Development Case. WebTAG sets a level of 0.2% as being desirable.

Investigation into the level of change between iterations reveals that most of the changes in Origin-Destination pairs were between 0 and 1 trips, with only a few isolated cases where changes were greater.

Further investigation into Trip-End Convergence within the Green Belt proposals area of the model reveals results of 0.076% for the Reference Case and 0.036% for the Development Case. These results suggest that any future model convergence improvements would be unlikely to have a significant effect on this area.

5. Forecasting Results

5.1 Introduction

The purpose of this section is to present the PRISM modelling output for the three assessment scenarios defined in the previous section.

5.2 2011 Base Year Results

The following two figures (Figure 5.1 and Figure 5.2) show Birmingham highway network junction performance for the 2011 Base Year scenario in an average AM and PM peak hour for the Birmingham area.

Junction performance is measured in terms of whether one or more arms of the junction are operating:

- 'Under-capacity': where all traffic movements through a junction are operating below 85% capacity
- 'At-capacity': where one or more traffic movements through a junction are operating between 85% and 100% capacity (flow breakdown and cumulative queueing start to occur within this range)
- 'Over-capacity': where one or more traffic movements through a junction are operating at over 100% capacity (significant queueing and delay can occur over this value)

Only those junctions which are operating at or over capacity are shown on the figures (in yellow and red respectively), in order to allow the most congested junctions to be easily identified.

Figure 5.1 shows the following results for Birmingham in the **AM peak hour**:

- Congested centres:
  - City Centre
    - The most congested centre is the city centre. This shows congestion on the majority of junctions on the A4540 Ring Road, where junctions with the A34 (New Town Row), A456 (Five Ways) and A38 (Bristol Road) are operating over-capacity. Within the city centre core area, congestion is identified around the New Street Station and Colmore Row areas.
  - Sutton Coldfield
    - The model indicates three junctions on the east side of the Sutton Coldfield gyratory operating at-capacity. The Lichfield Road / Tamworth Road signalised junction to the north and the Birmingham Road / Jockey Road signalised junction to the south are also shown as operating at-capacity.
- Congested routes:
  - A38 (Bristol Road)
    - This radial route shows junctions operating at-capacity along its length around Longbridge, Northfield, Selly Oak, and Edgbaston, with junctions at the latter two being shown as over-capacity.
  - A456 (Hagley Road)
    - This radial route shows some junctions operating at-capacity at Ridgacre, Sandon Road and at junctions nearer to Five Ways. The junction with Wolverhampton Road is shown as over-capacity.
  - A457 (Dudley Road)

  - This radial route shows some junctions operating at-capacity near the Birmingham Hospital and at the junction with City Road.
- A34 (Walsall Road)
  - This radial route shows junctions operating at or over-capacity along its length at Great Barr, Tower Hill, Perry Barr and approaching the city centre. The latter junctions and the one at Great Barr are shown as over-capacity.
- A453 (College Road)
  - This route shows junctions at-capacity along its length at Stonehouse Road, Chester Road, Aldridge Road and Walsall Road. The junction at Aldridge Road is shown as over-capacity.
- A452 (Chester Road)
  - This route shows junctions at-capacity at Monmouth Drive, College Road, Boldmere Road and Kingsbury Road (A38)
- A4097 / A38 (Kingsbury Road / Tyburn Road)
  - This radial route shows junctions at-capacity at Water Orton Lane, Minworth Island, Tyburn House island and Norton Crossroads. M42 J9 (outside the boundary) and Salford Circus are both shown as over-capacity.
- A45 (Coventry Road)
  - This radial route shows junctions at-capacity at Sheldon, Gilbertstone and Hay Mills. Outside the boundary, the junction at Birmingham Airport is shown as over-capacity.
- A34 (Stratford Road)
  - This radial route shows junctions at-capacity at Sparkhill and Sparkbrook

Overall, the majority of over-capacity junctions are on the A38, A34 and the A4540 Ring Road.

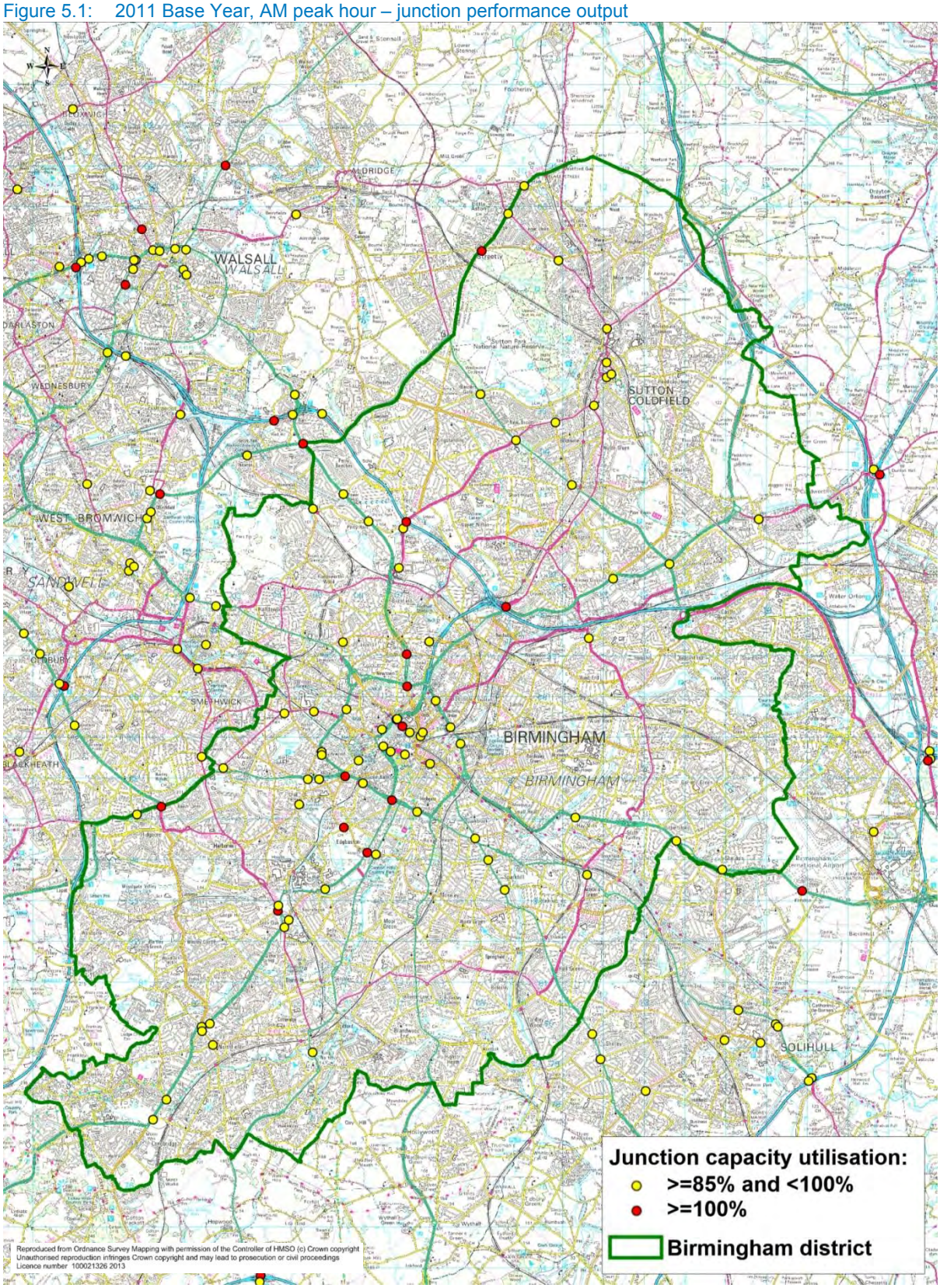
Figure 5.2 shows the following results for Birmingham in the **PM peak hour**:

- Congested centres:
  - City Centre
    - Like for the AM peak, the most congested centre is the city centre. This shows congestion on the A4540 Ring Road but at fewer junctions than in the AM. The over-capacity junctions are with the A34 (New Town Row), A456 (Five Ways) and the A38 (Bristol Road). Within the city centre core area, congestion is identified: on the A38 at Paradise Circus, near Snow Hill and approaching the Aston Expressway; around the New Street station area and on Smallbrook Queensway; and in the Colmore Row area.
  - Sutton Coldfield
    - Like for the AM peak, the model indicates three junctions on the east side of the Sutton Coldfield gyratory operating at-capacity. The Birmingham Road / Jockey Road signalised junction to the south are also shown as operating at-capacity.
- Congested routes:
  - A38 (Bristol Road)
    - This radial route shows a similar pattern to the AM peak with junctions operating at-capacity along its length around Edgbaston, Selly Oak, Northfield and Longbridge.
  - A456 (Hagley Road)
    - This radial route shows a similar pattern to the AM peak with some junctions operating at-capacity just beyond Five Ways and at Lordswood Road. The junction with Wolverhampton Road is shown as over-capacity.
  - A457 (Dudley Road)
    - This radial route shows some junctions operating at or over capacity at the cluster of junctions with Winson Green Road and City Road.

- A34 (Walsall Road)
  - This radial route shows a similar pattern to the AM peak with junctions operating at or over-capacity along its length just beyond the A4540 Ring Road, at Perry Barr Tower Hill and Great Barr. The latter two junctions are shown as over-capacity.
- A453 (College Road)
  - This route shows less congestion than in the AM peak, but junctions are at-capacity at Walsall Road and Aldridge Road.
- A452 (Chester Road)
  - Similar to the AM peak, this route shows junctions at-capacity at Monmouth Drive, Princess Alice Drive, Sutton Road and Kingsbury Road (A38)
- A4097 / A38 (Kingsbury Road / Tyburn Road)
  - This radial route shows a little less congestion than in the AM peak, but junctions are at or over capacity at Salford Circus, Norton Crossroads and Tyburn House. M42 J9 (outside the boundary) has a node shown at-capacity.
- A45 (Coventry Road)
  - This radial route shows a similar pattern to the AM peak with junctions at-capacity at Hay Mills, South Yardley and Sheldon. Outside the boundary, the junction at Birmingham Airport is shown as over-capacity.
- A34 (Stratford Road)
  - This radial route shows a similar pattern to the AM peak with junctions at-capacity at Sparkbrook and Sparkhill, but also at Hall Green.
- A441 (Pershore Road)
  - Unlike in the AM peak, this route shows junctions at or over capacity at Edgbaston and Stirchley.

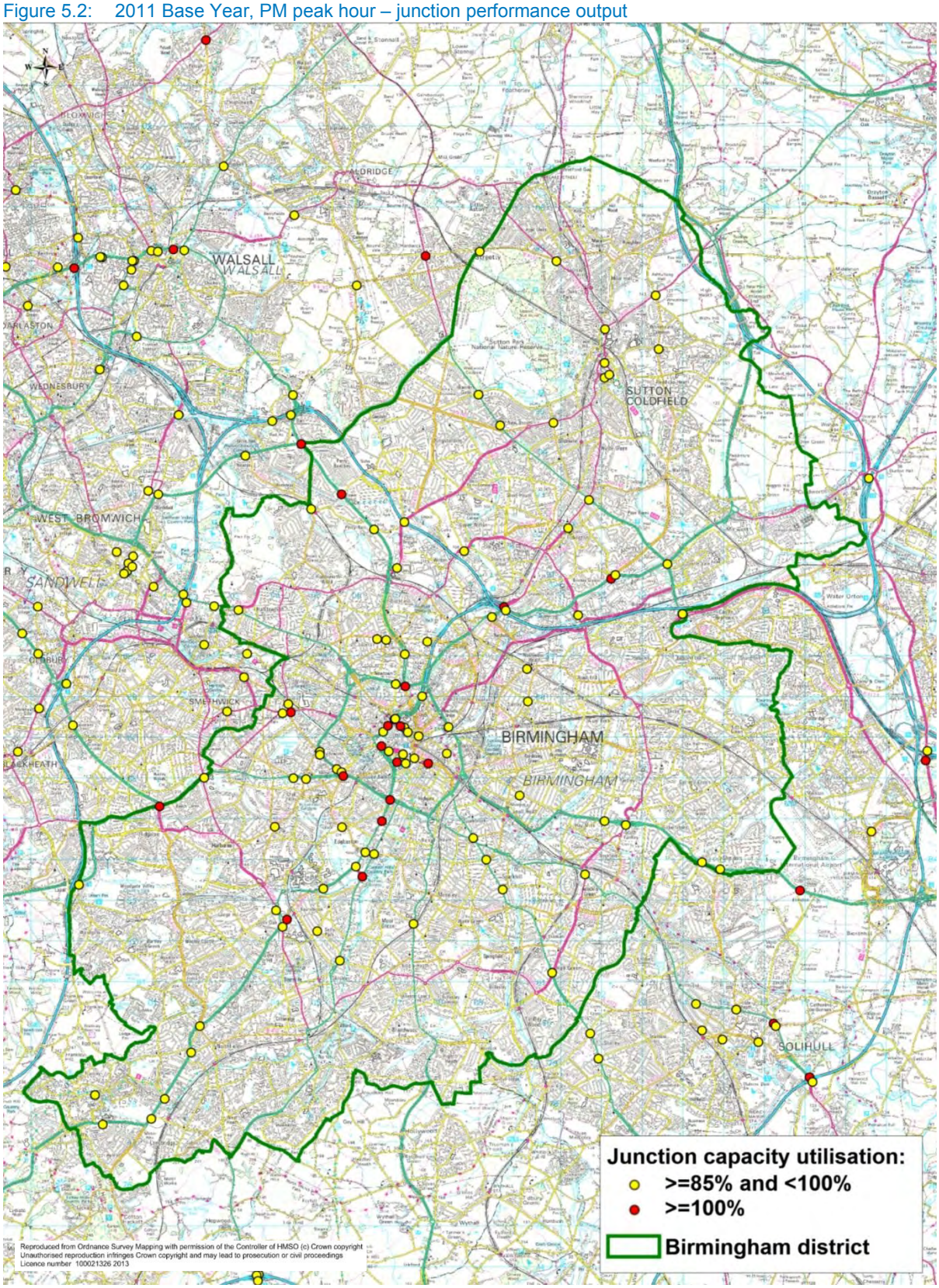
Overall, the majority of over-capacity junctions are on the A38, A34 A4540 Ring Road and city centre core area.

Figure 5.1: 2011 Base Year, AM peak hour – junction performance output



Source: PRISM model

Figure 5.2: 2011 Base Year, PM peak hour – junction performance output



Source: PRISM model

5.3 2031 Do Minimum Reference Case Results

The following two figures (Figure 5.3 and Figure 5.4) show Birmingham highway network junction performance for the 2031 Do Minimum Reference Case scenario in an average AM and PM peak hour.

As for the Base Year results, only those junctions which are operating at or over capacity are shown on the figures (in yellow and red respectively), in order to allow the most congested junctions to be easily identified.

The first result which is immediately evident from both these figures is a significant increase over the Base year of junctions which are at or over capacity. This is the modelled outcome of the 20 years of population, employment and socio-economic growth predicted in Section 4.2 above (see Figure 4.2). The steady increase in population, jobs and standard of living will place increasing pressure on the region's transport networks, leading to more travel congestion than is experienced today. This wider picture of how to accommodate the area's growing travel demand is being considered separately by the Council's 'Birmingham Mobility Action Plan' study (see Section A.4.2 of the Stage 2 report).

Figure 5.3 shows the following more detailed results for Birmingham in the **AM peak hour**:

- Congested centres:
  - City Centre
    - In 2031, the city centre highway network is predicted to be experiencing significant levels of congestion. Three of the A4540 Ring Road junctions are predicted to be at-capacity and ten over-capacity. The majority of junctions on the former Inner Ring Road alignment are shown as over-capacity. Junctions on radial routes between the two are also at or over-capacity.
  - Sutton Coldfield
    - The model shows a similar result as for the Base year AM peak hour, except that the Lichfield Road / Tamworth Road and the Birmingham Road / Jockey Road signalised junctions are now shown as operating over-capacity.
- Congested routes:
  - A38 (Bristol Road)
    - This radial route shows junctions operating at or over capacity along its length around Longbridge, Northfield, Selly Oak, the University and Edgbaston. Junctions at Selly Oak and Edgbaston are now over-capacity.
  - A456 (Hagley Road)
    - This radial route now shows most junctions operating at or over capacity. The approach to Five Ways appears particularly congested.
  - A457 (Dudley Road)
    - This radial route now shows most junctions operating at or over capacity.
  - A41 (Holyhead Road)
    - Unlike in the Base year where this route operated under-capacity, this radial route is now operating at-capacity at junctions through Handsworth.
  - A34 (Walsall Road)
    - Most of the major junctions on this route are now shown to be operating over-capacity.
  - A453 (College Road)
    - This route shows junctions at or over capacity along its length at Stonehouse Road, Kingstanding Road, Aldridge Road, Church Road and Holford Drive. The junctions at Aldridge Road and Church Road are shown as over-capacity.

- A452 (Chester Road)
  - This route shows junctions over-capacity at Monmouth Drive and College Road, which were at-capacity in the Base year. The Boldmere Road junction is still at-capacity, but the Birmingham Road junction is now also at-capacity, whereas the Kingsbury Road (A38) junction has deteriorated to over-capacity. Further south, the two roundabouts at Fort Parkway and Castle Bromwich are now over-capacity, whereas they were under-capacity in the Base year.
- A4040 (Outer Ring Road)
  - Unlike in the Base year where nearly all junctions on the A4040 Outer Ring Road are operating under-capacity, in 2031 a large number of junctions on this route are predicted to be at or over-capacity. Over-capacity sections are observed at: junction with Tyburn Road (A38); Bromford Lane roundabout; junctions at Stetchford; junction with Stratford Road (A34); junctions with Bristol Road (A38); junction with Hagley Road West (A456); and junctions with Dudley Road (A457).
- A4097 / A38 (Kingsbury Road / Tyburn Road)
  - All major junctions on this radial route are shown to operate over-capacity. M42 J9 (outside the boundary) is now over-capacity on all arms.
- A38M (Aston Expressway)
  - This link operates under-capacity in the Base year, but in 2031 its junction with the M6, Park Circus and Dartmouth Circus are all shown to be operating at or over-capacity.
- A45 (Coventry Road)
  - This radial route shows the junction at Gilbertstone to be still at-capacity, but the junctions at Sheldon and Hay Mills are now over-capacity. In addition, junctions at South Yardley are now at or over-capacity.
- A34 (Stratford Road)
  - This radial route shows that the junction at Sparkhill is still at-capacity, but those at Sparkbrook are now over-capacity, while two more junctions along this section are also now at-capacity. As noted above, the junction with the A4040 at Hall Green is now over-capacity whereas it was under-capacity in the Base year.

Overall, the majority of over-capacity junctions are on the A38, A456 (Hagley Road), A457 (Dudley Road), A34, A4040 (Outer Ring Road), A45 (Stratford Road), A4540 (Ring Road) and city centre core area.

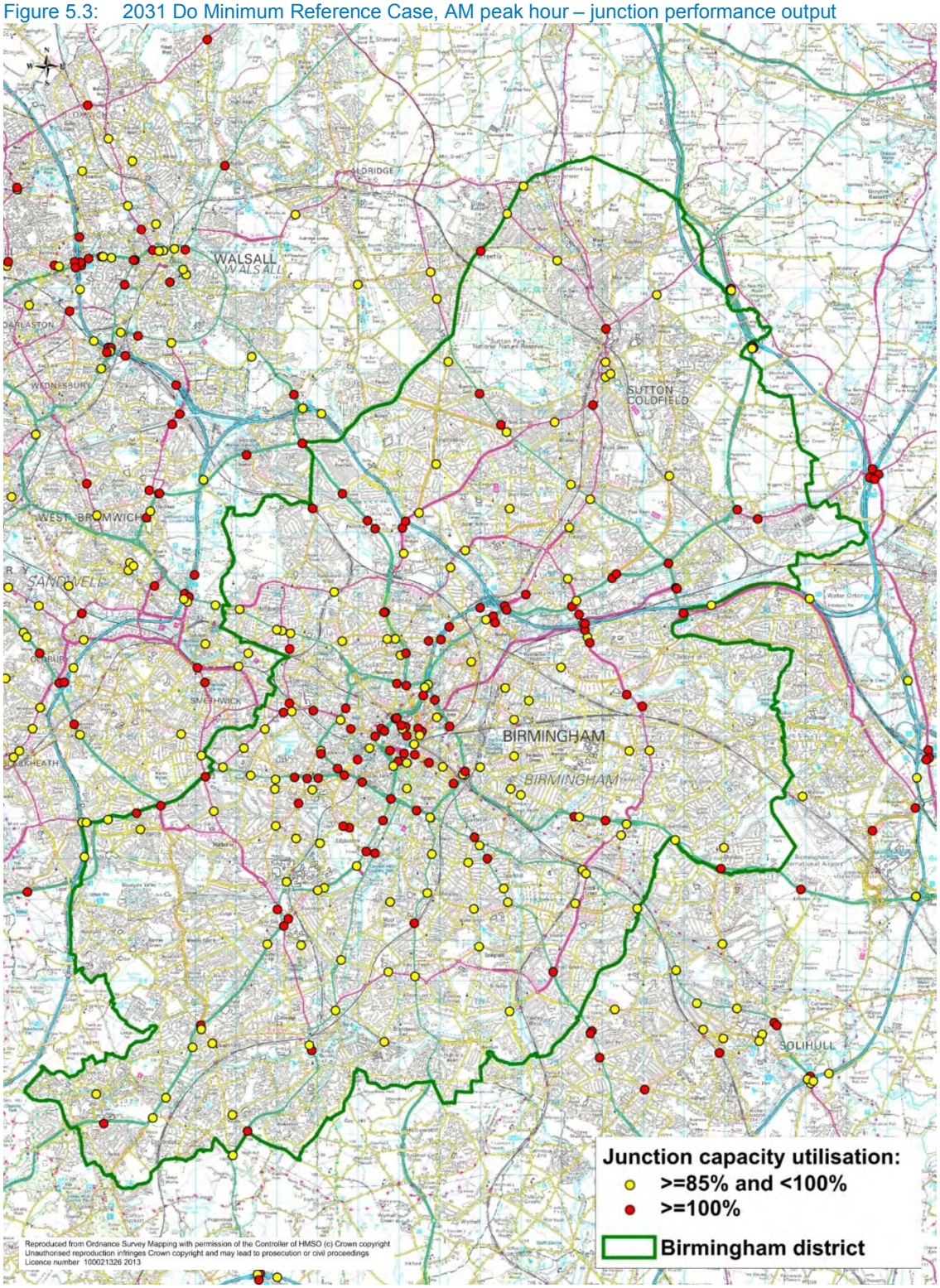
Figure 5.4 shows the following results for Birmingham in the **PM peak hour**:

- Congested centres:
  - City Centre
    - Like for the AM peak, the most congested centre is the city centre. This shows congestion on the A4540 Ring Road where most of the junctions on the south and east sides are now over-capacity. The majority of junctions on the former Inner Ring Road alignment are shown as over-capacity. Junctions on radial routes between the two are also at or over-capacity.
  - Sutton Coldfield
    - The model shows a similar result as for the 2011 PM peak hour, except that the Lichfield Road / Tamworth Road and the Birmingham Road / Jockey Road signalised junctions are now shown as operating over-capacity.
- Congested routes:
  - A38 (Bristol Road)
    - This radial route shows junctions operating over-capacity along its length around Edgbaston, the University, Selly Oak, Northfield and Longbridge.
  - A456 (Hagley Road)
    - This radial route now shows most junctions operating at or over capacity.

- A457 (Dudley Road)
  - This radial route now shows most junctions operating at or over capacity.
- A41 (Holyhead Road)
  - Unlike in the Base year where this route operated mostly under-capacity, this radial route is now operating at and over-capacity at junctions through Handsworth.
- A34 (Walsall Road)
  - This radial route shows a similar pattern of congestion to the Base year PM peak, except with extra junctions shown at-capacity at Lozells, Birchfield and Perry Barr.
- A453 (College Road)
  - This route shows junctions at or over capacity along its length at Aldridge Road, Hawthorne Road, Chester Road and Stonehouse Road. The junctions at Aldridge Road and Stonehouse Road are shown as over-capacity.
- A452 (Chester Road)
  - This route shows junctions over-capacity at Monmouth Drive and College Road, which were at-capacity in the Base year. The Sutton Road and Kingsbury Road junctions are still at-capacity, but the Boldmere Road and College Road junctions are now also at-capacity. Further south, the two roundabouts at Fort Parkway and Castle Bromwich are now at or over-capacity, whereas they were under or at-capacity in the Base year.
- A4040 (Outer Ring Road)
  - Unlike in the Base year where most junctions on the A4040 Outer Ring Road are operating under-capacity and about eight are at-capacity, in 2031 a large number of junctions on this route are predicted to be at or over-capacity. Over-capacity sections are observed at: junctions at Stockland Green; junction with Kingsbury Road; junction with Tyburn Road (A38); Bromford Lane roundabout; junctions at Stetchford; junction with Stratford Road (A34); junction with Alcester Road (A435); junctions with Bristol Road (A38); junction with Hagley Road West (A456); junctions with Dudley Road (A457); and junction in Handsworth.
- A4097 / A38 (Kingsbury Road / Tyburn Road)
  - All major junctions on this radial route are shown to operate at least at-capacity, whereas about half of them were under-capacity in the Base year. M42 J9 is now at-capacity on all arms.
- A38M (Aston Expressway)
  - This link operates under-capacity in the Base year, but in 2031 its junction with the M6, Park Circus and Dartmouth Circus are all shown to be operating at-capacity.
- A45 (Coventry Road)
  - This radial route shows the junctions at Hay Mills, South Yardley and Sheldon are now over-capacity, whereas they were under or at-capacity in the Base year.
- A34 (Stratford Road)
  - This radial route shows that the junctions at Sparkbrook, Sparkhill and Hall Green are now over-capacity, while other previously under-capacity junctions on this route are now at-capacity.
- A435 (Alcester Road)
  - This radial route now has junctions shown to be at or over capacity along its length, whereas only one of these junctions was at-capacity in the Base year.
- A441 (Pershore Road)
  - This radial route shows one at-capacity and four over-capacity junctions along its length, compared with two and one respectively in the Base year.

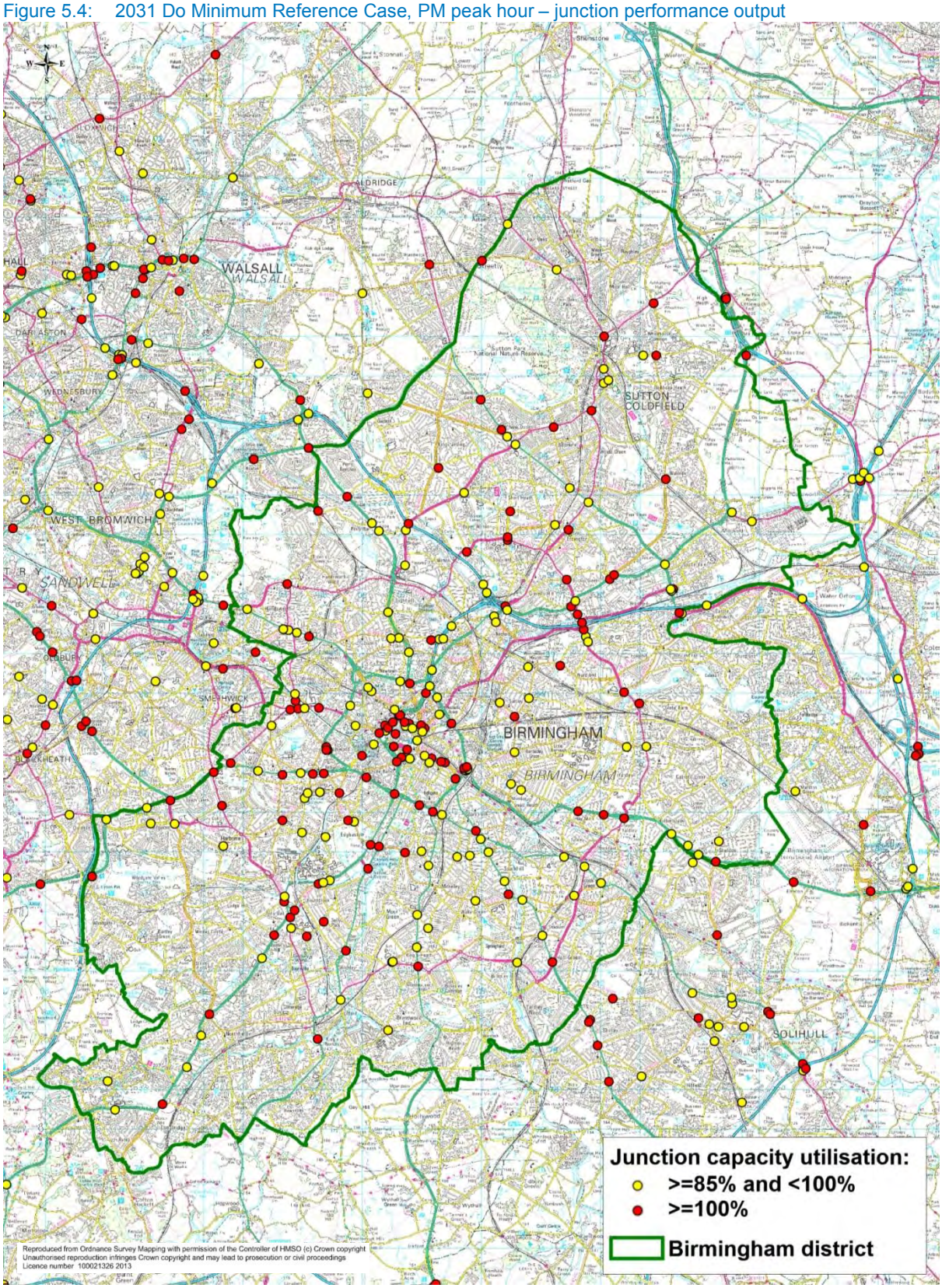
Overall, the majority of over-capacity junctions are on the A38, A456 (Hagley Road), A457 (Dudley Road), A34, A4040 (Outer Ring Road), A45 (Stratford Road), A441 (Pershore Road), A4540 Ring Road and city centre core area.

Figure 5.3: 2031 Do Minimum Reference Case, AM peak hour – junction performance output



Source: PRISM model

Figure 5.4: 2031 Do Minimum Reference Case, PM peak hour – junction performance output



Source: PRISM model

5.4 2031 Do Minimum Reference Case Impacts

The following two figures (Figure 5.5 and Figure 5.6) show junctions in the 2031 Do Minimum Reference Case scenario (see Section 5.3 above) where the performance category has changed compared to the 2011 Base Year (see Section 5.2 above). The purpose of these two figures is to isolate those junctions where performance is predicted to change as a direct result of the Reference Case scenario conditions.

The figures show the junctions as follows:

- Positive change:
  - Green: Shows junctions which are at or over-capacity (see definitions in Section 5.2 above) in the Base Year but under-capacity in the Reference Case
  - Cyan: Shows junctions which are over-capacity in the Base Year but at-capacity in the Reference Case
- Negative change:
  - Yellow: Shows junctions which are under-capacity in the Base Year but at-capacity in the Reference Case
  - Red: Shows junctions which are under or at-capacity in the Base Year but over-capacity in the Reference Case

These figures confirm the observations made in the previous section as to how conditions are predicted to change in 2031 compared to 2011. Clearly, due to the 20 years of population, employment and socio-economic growth shown in Figure 4.2 above, the net impact on Birmingham's highway network is predicted to be negative, with a deterioration in junction performance observed on most routes. However, it is also noted that this change would take place gradually over the full 20 year period.

In the AM peak period, junction performance deterioration is most clearly observable on the following routes/areas:

- A4540 (Ring Road)
- City centre core area
- A38 (Bristol Road)
- A456 (Hagley Road)
- A457 (Dudley Road)
- A41 (Holyhead Road)
- A34 (Walsall Road)
- A453 (College Road)
- A452 (Chester Road)
- A4040 (Outer Ring Road)
- A4097 / A38 (Kingsbury Road / Tyburn Road)
- A38M (Aston Expressway)
- A45 (Coventry Road)
- A34 (Stratford Road)

A small number of junctions show a performance category improvement, which could be associated with the improvements included in the 2031 Reference Case Do Minimum network. Comparison of Figure 5.5 below with the schemes listed in Table 4.1 above suggests that this could be the case on Chester Road, on the A4540 Ring Road and at Selly Oak.

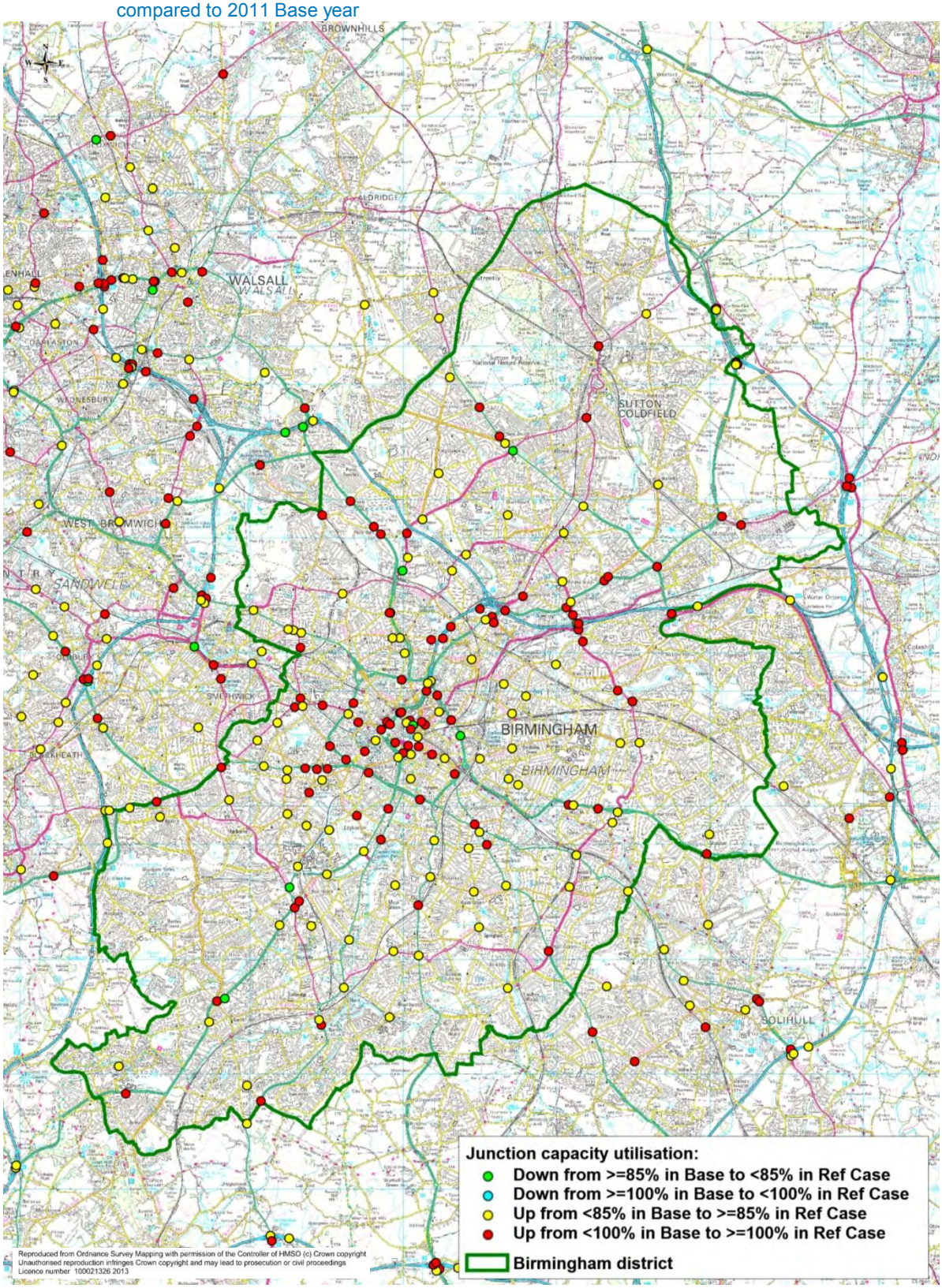
In the PM peak period, junction performance deterioration is clearly observable on the following routes:

- A4540 (Ring Road)
- City centre core area
- A38 (Bristol Road)
- A456 (Hagley Road)
- A457 (Dudley Road)
- A41 (Holyhead Road)
- A34 (Walsall Road)
- A453 (College Road)
- A452 (Chester Road)
- A4040 (Outer Ring Road)
- A4097 / A38 (Kingsbury Road / Tyburn Road)
- A38M (Aston Expressway)
- A45 (Coventry Road)
- A34 (Stratford Road)
- A435 (Alcester Road)
- A441 (Pershore Road)

As in the AM peak, a small number of junctions show a performance category improvement, which could be associated with the improvements included in the 2031 Reference Case Do Minimum network. Comparison of Figure 5.6 below with the schemes listed in Table 4.1 above suggests that this could be the case on the A4540 Ring Road and at Selly Oak.

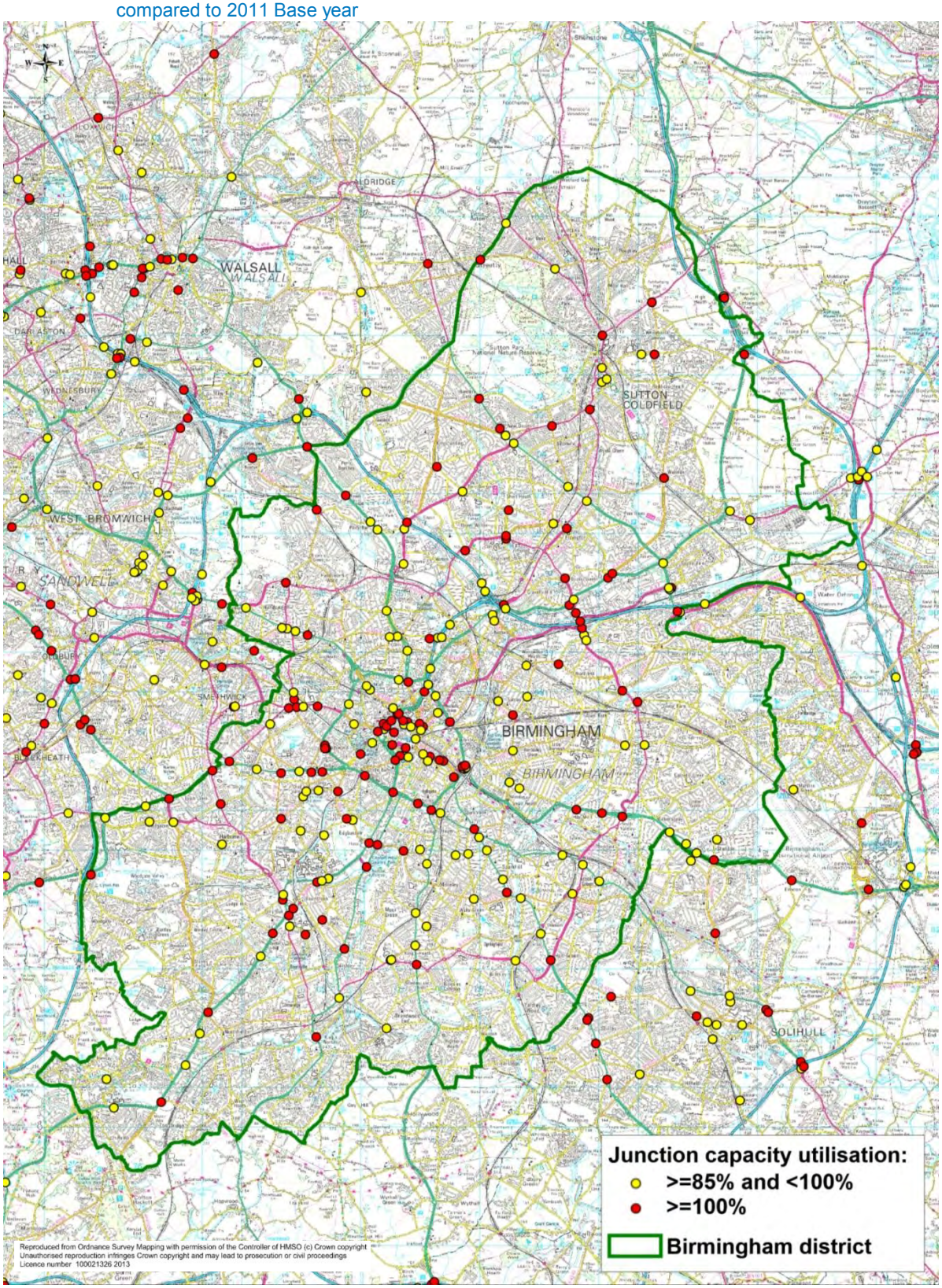
It is noted that these two figures identify impacts in terms of junctions which have changed performance category, as these will represent the most substantial impacts. For junctions where the performance category is not shown to have changed, there could still be some positive or negative change in performance between the two scenarios within that category, but this will be a lower order of change which is therefore not identified at this strategic level.

Figure 5.5: 2031 Do Minimum Reference Case, AM peak hour – junctions showing performance category change compared to 2011 Base year



Source: PRISM model

Figure 5.6: 2031 Do Minimum Reference Case, PM peak hour – junctions showing performance category change compared to 2011 Base year



Source: PRISM model

5.5 2031 Do Minimum Development Case Results and Impacts

The following two figures (Figure 5.7 and Figure 5.8) show Birmingham highway network junction performance for the 2031 Do Minimum Development Case scenario in an average AM and PM peak hour.

As for the Reference Case results, only those junctions which are operating at or over capacity are shown on the figures (in yellow and red respectively), in order to allow the most congested junctions to be easily identified.

The first result which is immediately evident is that these two figures show a very similar pattern of impact to the corresponding 2031 Reference Case figures above (see Figure 5.3 and Figure 5.4). The impact descriptions associated with those two results therefore apply equally to describe the impacts of the Development Plan shown below.

In order to isolate the actual differences between the two scenarios, and therefore the direct impact of the Development Plan proposals, the further two figures below (Figure 5.9 and Figure 5.10) show junctions in the 2031 Do Minimum Development Case scenario where the performance category has changed compared to the 2031 Reference Case scenario. As for the above change plots, these figures show the junctions as follows:

- Positive change:
  - Green: Shows junctions which are at or over-capacity (see definitions in Section 5.2 above) in the Reference Case but under-capacity in the Development Case
  - Cyan: Shows junctions which are over-capacity in the Reference Case but at-capacity in the Development Case
- Negative change:
  - Yellow: Shows junctions which are under-capacity in the Reference Case but at-capacity in the Development Case
  - Red: Shows junctions which are under or at-capacity in the Reference Case but over-capacity in the Development Case

The difference between the 2031 Development Case and Reference Case scenarios is described above in Section 4, but is summarised as follows:

- The Birmingham population is 12,000 higher in the Development Case (due to development of the Green Belt proposals), but correspondingly 12,000 lower in surrounding Districts (as less Birmingham housing shortfall is required to be redistributed)
- The Birmingham employment level is higher by 8,129 jobs in the Development Case (due to development of the Green Belt proposals)
- Infrastructure to enable the Green Belt proposals, including new link roads and local capacity and public transport improvements, is included in the Development Case

The change plot for the **AM peak hour** (Figure 5.9) shows the following:

- Overall, a low level of net impact within an already congested network scenario.
- The preliminary capacity improvements to Minworth Island included in the model are predicted to result in some performance gain at this junction.
- Some performance deterioration is observed at the Kingsbury Road approach to M42 J9.
- Changes which are shown some distance away from the Green Belt proposals area reflect the strategic reassignment capability of the model, where local changes can produce remote reactions elsewhere in

the network. Some of the remote changes shown on the figure will also be due to the drop in population in surrounding Districts, plus the effect of the Green Belt proposals generating and attracting some relatively long distance trips. However, some of these remote changes could also be a reflection of model convergence issues in a particular area (see Section 4.4 above). Ways in which to improve model convergence in these locations is under investigation.

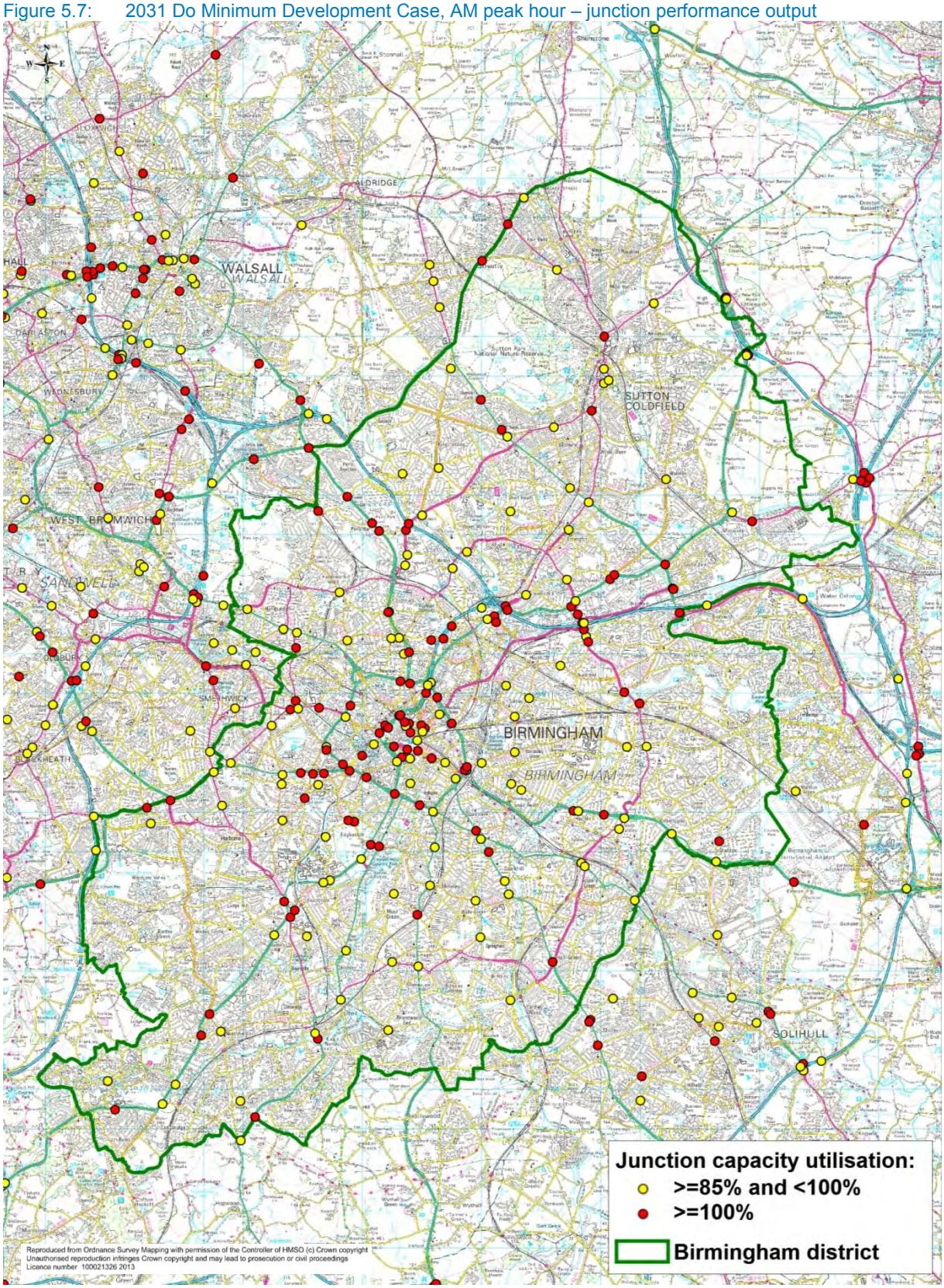
The change plot for the **PM peak hour** (Figure 5.9) shows the following:

- Overall, a higher level of impact than in the AM peak hour. This is partly because of a greater demand difference from the Reference Case scenario in the PM peak, but also because the Reference Case PM peak period is not as congested as the equivalent AM period, and so the scope for impact is greater.
- In particular, this scenario shows greater impact on the A38 Tyburn Road corridor, taking three at-capacity junctions to over-capacity. The same impact is seen on the B4531, Gravelly Lane, and its junction with Chester Road.
- As with the AM period, some of the remote changes shown will be a result of the model strategically reassigning trips due to the drop in population in surrounding Districts, plus the effect of the Green Belt proposals generating and attracting some relatively long distance trips on the network. However, some of these remote changes could also be a reflection of model convergence issues in a particular area (see Section 4.4 above). Ways in which to improve model convergence in these locations is under investigation.

It is noted that these two figures identify impacts in terms of junctions which have changed performance category, as these will represent the most substantial impacts. For junctions where the performance category is not shown to have changed, there could still be some positive or negative change in performance between the two scenarios within that category, but this will be a lower order of change which is therefore not identified at this strategic level.

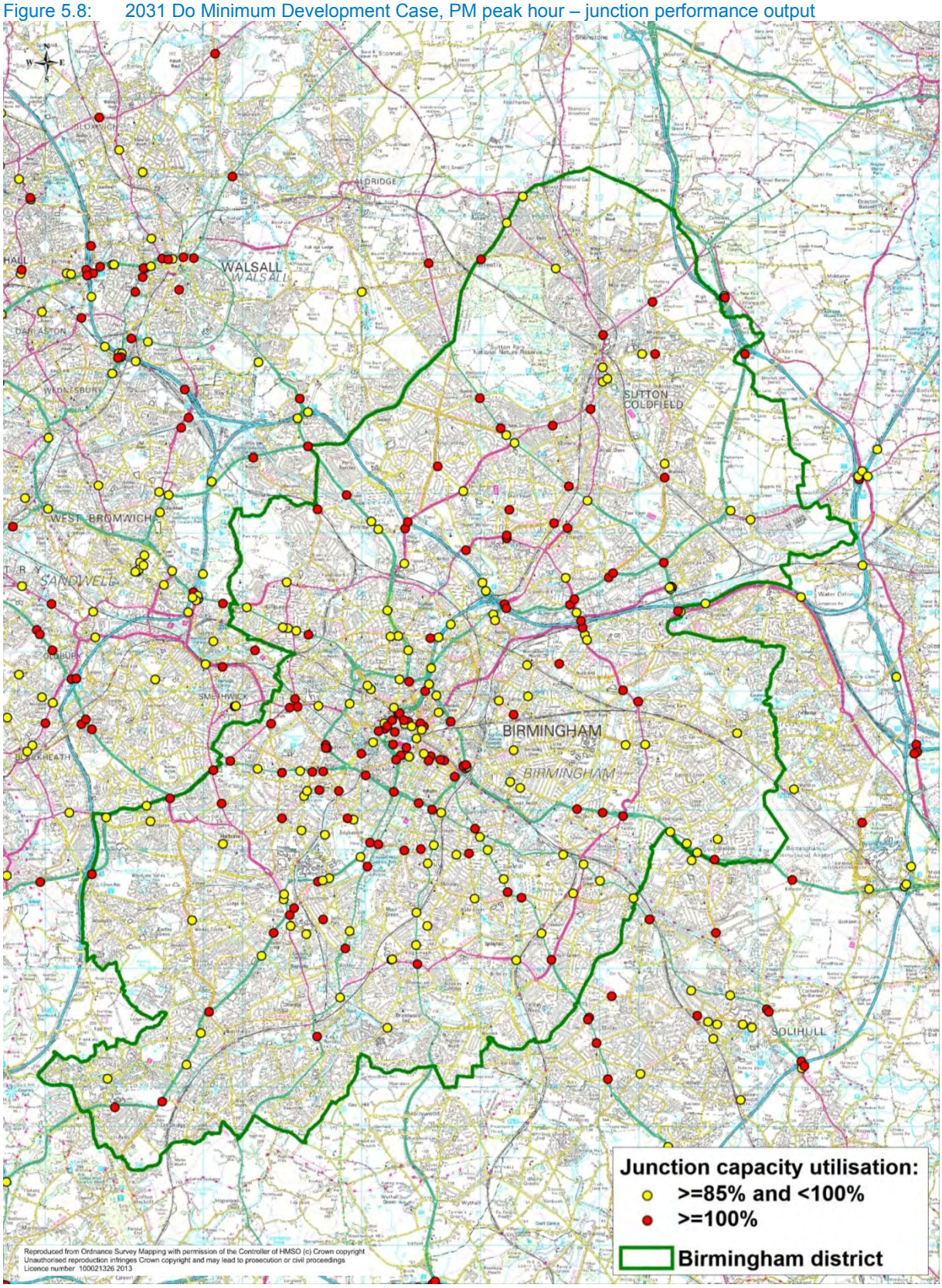
Overall, therefore, it is considered from these results that the main impacts directly arising from the changes which would result from the Development Plan, as measured against the Reference Case scenario, are centred on the A38 corridor between the Green Belt proposals area and the city centre. To a lesser extent, some impact is also noticeable on Chester Road and towards M42 J9.

Figure 5.7: 2031 Do Minimum Development Case, AM peak hour – junction performance output



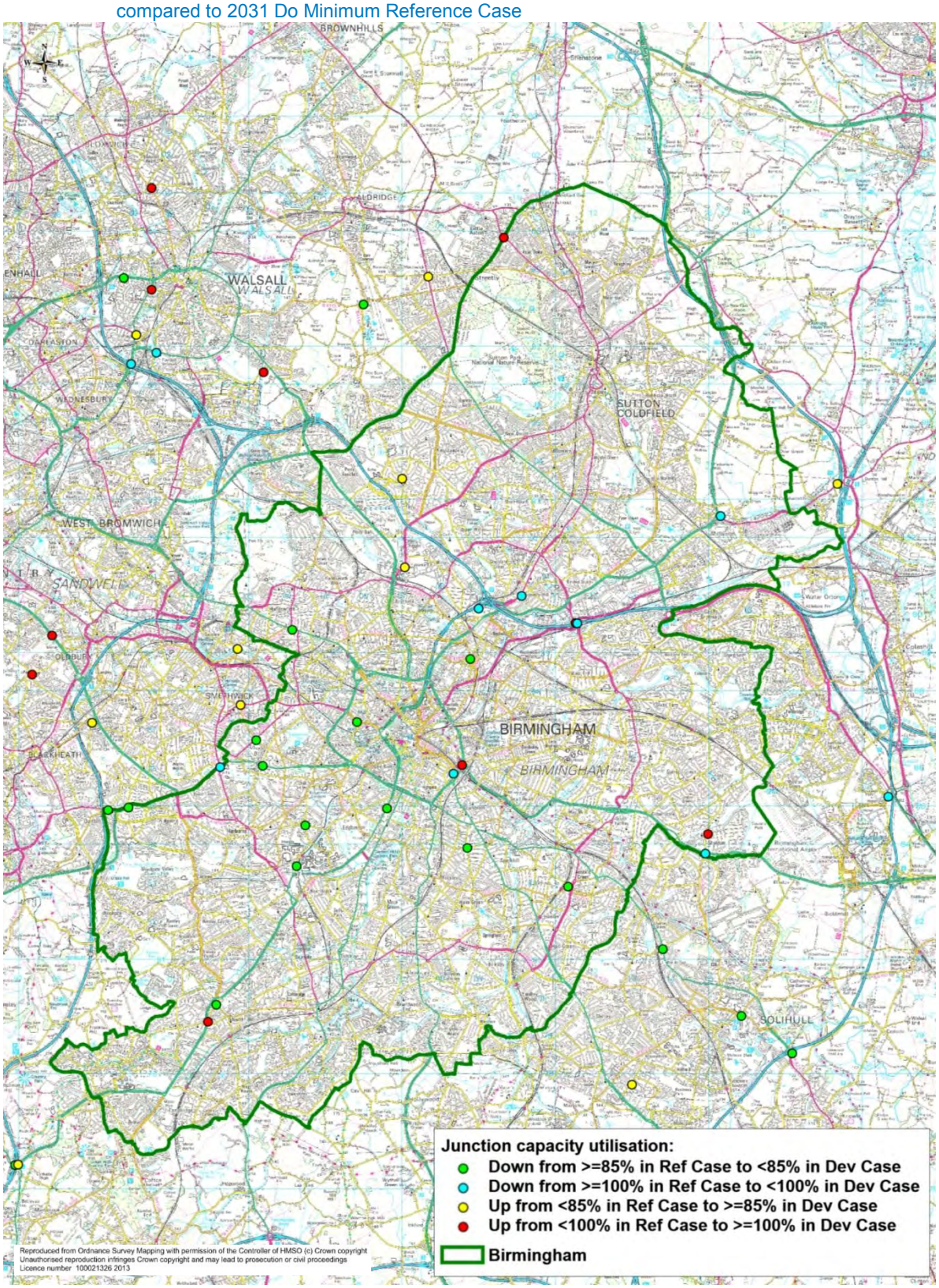
Source: PRISM model

Figure 5.8: 2031 Do Minimum Development Case, PM peak hour – junction performance output



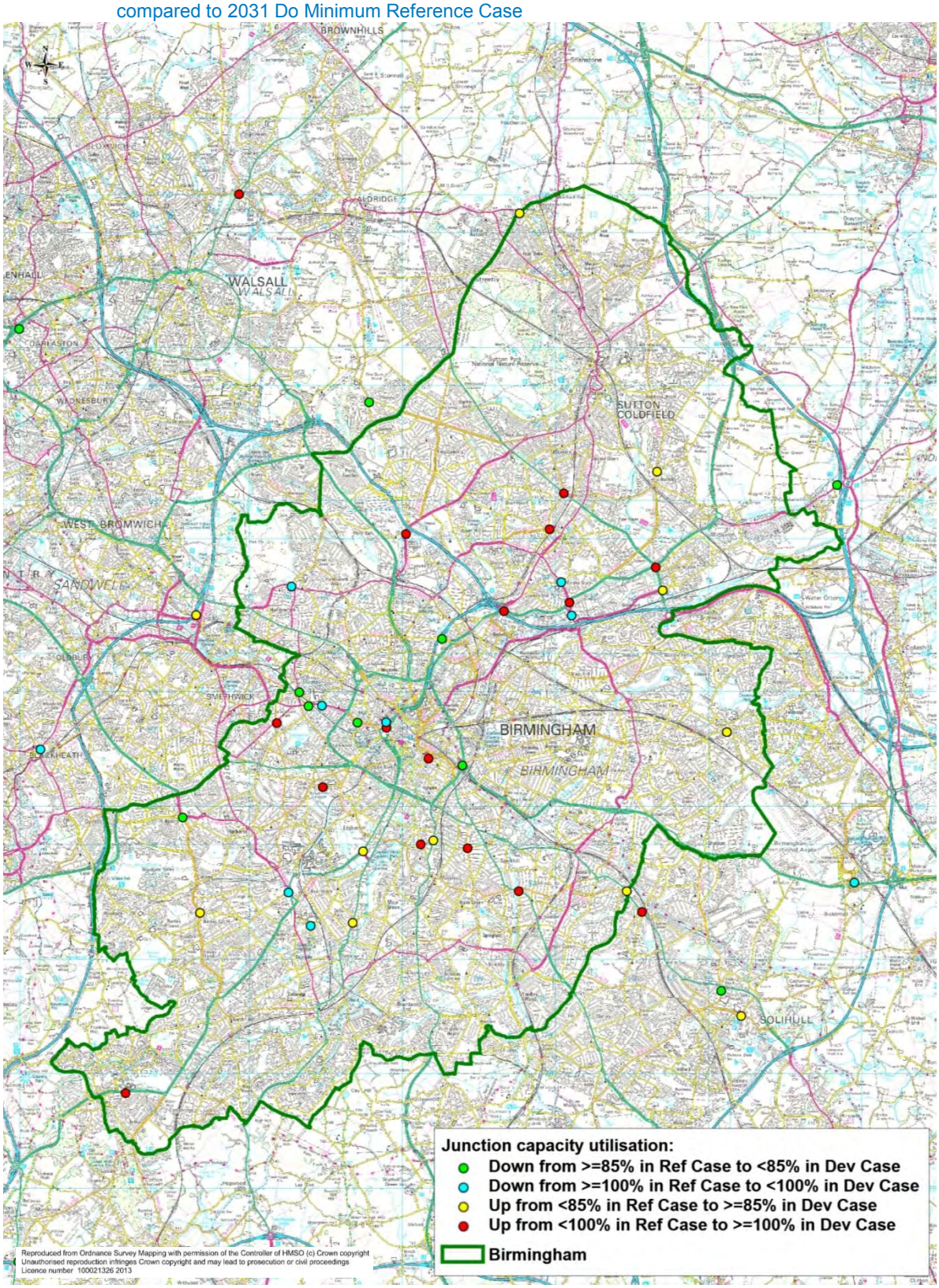
Source: PRISM model

Figure 5.9: 2031 Do Minimum Development Case, AM peak hour – junctions showing performance category change compared to 2031 Do Minimum Reference Case



Source: PRISM model

Figure 5.10: 2031 Do Minimum Development Case, PM peak hour – junctions showing performance category change compared to 2031 Do Minimum Reference Case



Source: PRISM model

6. Summary

6.1 Overview

Birmingham City Council (BCC) is in the process of developing the Birmingham Development Plan – a central part of its Local Development Framework – and has commissioned Mott MacDonald to develop a Transport Evidence Base to support it.

The key stage of the Transport Evidence Base methodology is where the Birmingham Development Plan's transport impacts – both positive and negative – are strategically quantified. The West Midlands Policy Responsive Integrated Strategy Model (PRISM) is being employed for this task and, in order to quantify impacts, considers the following three scenarios:

4. **Base year scenario** (2011) – which represents a present-day transport and land-use scenario.
5. **Reference Case scenario** (2021 and 2031) – which represents the future transport and land-use scenario in the hypothetical case where there is no Development Plan implemented
6. **Development Case scenario** (2021 and 2031) – which represents the future transport and land-use scenario in which the Development Plan is implemented

These scenarios allow the future transport impacts of the Development Plan to be isolated and identified by comparing the Development Case scenario with the Reference Case scenario. The three scenarios are fully defined and detailed in the Stage 2 report.

The purpose of this report is to provide initial Stage 3a modelling results in order to quantify the headline strategic level highway impact of the Development Plan proposals in 2031.

6.2 Assessment Results

The 2031 Reference Case scenario test shows that the 20 years of population, employment and socio-economic growth in the West Midlands will have a significant level of impact on highway network junction capacity in Birmingham, as would be expected. Junctions in the city centre core area and on the surrounding Ring Road show a predicted deterioration in performance, as do junctions on the main radial routes in and out of the centre. The Council are currently developing a range of measures to manage this level of predicted impact through the Birmingham Mobility Action Plan strategy.

The difference between the 2031 Development Case and Reference Case scenarios is described above in Section 4, but is summarised as follows:

- The Birmingham population is 12,000 higher in the Development Case (due to development of the Green Belt proposals), but correspondingly 12,000 lower in surrounding Districts (as less Birmingham housing shortfall is required to be redistributed)
- The Birmingham employment level is higher by 8,129 jobs in the Development Case (due to development of the Green Belt proposals)
- Infrastructure to enable the Green Belt proposals, including new link roads and local capacity and public transport improvements, is included in the Development Case

In comparison with the Reference Case scenario, the Development Plan scenario results in only a very marginal change in impacts on Birmingham's highway network. Overall, the results suggest that the main impacts directly arising from the Development Plan are centred on the A38 corridor between the Green Belt

proposals area and the city centre. To a lesser extent, some impact is also noticeable on Chester Road and towards M42 J9.

Based on these initial results, the next stage of this study will identify and test a suitable package of multi-modal measures to both support and mitigate the impacts of the development of the Green Belt proposals.

Appendices

Appendix A. Journey Time Validation Results

A.1. AM Peak Results

Table A.1: Journey time validation results – AM peak

Route ID	Direction	Observed Time (s)	Modelled Time (s)	Time Difference (s)	Time % Difference	Pass Criteria?
1	NB	478	461	-18	-4%	✓
1	SB	502	506	4	1%	✓
2	EB	1157	1000	-157	-14%	✓
2	WB	1104	941	-162	-15%	✓
3	EB	1080	1023	-57	-5%	✓
3	WB	1400	1319	-80	-6%	✓
4	EB	887	904	17	2%	✓
4	WB	851	863	12	1%	✓
5	NB	1652	1390	-262	-16%	✗
5	SB	1538	1346	-192	-12%	✓
6	NB	1073	1051	-22	-2%	✓
6	SB	952	836	-116	-12%	✓
7	EB	1260	1140	-120	-10%	✓
7	WB	816	875	59	7%	✓
8	EB	1221	1099	-122	-10%	✓
8	WB	1131	975	-156	-14%	✓
9	NB	1180	1140	-39	-3%	✓
9	SB	1054	1057	3	0%	✓
10	NB	2051	2283	233	11%	✓
10	SB	2230	2414	183	8%	✓
11	EB	1305	1452	146	11%	✓
11	WB	1406	1469	63	4%	✓
12	NB	1910	1936	27	1%	✓
12	SB	2168	1895	-273	-13%	✓
13	NB	1709	1729	20	1%	✓
13	SB	1815	1772	-43	-2%	✓
14	NB	1260	1681	421	33%	✗
14	SB	1619	1750	131	8%	✓
15	NB	552	563	11	2%	✓
15	SB	627	651	24	4%	✓
16	NB	694	689	-6	-1%	✓
16	SB	820	834	13	2%	✓
17	NB	1185	1097	-88	-7%	✓
17	SB	1454	1155	-299	-21%	✗
18	NB	1306	1320	14	1%	✓
18	SB	1478	1282	-196	-13%	✓
19	NB	869	971	102	12%	✓
19	SB	988	911	-77	-8%	✓
20	EB	1947	2919	972	50%	✗

Route ID	Direction	Observed Time (s)	Modelled Time (s)	Time Difference (s)	Time % Difference	Pass Criteria?
20	WB	2187	2011	-176	-8%	✔
21	NB	1076	1137	61	6%	✔
21	SB	925	1074	149	16%	✘
22	EB	823	676	-147	-18%	✘
22	WB	663	684	21	3%	✔
23	NB	2051	1624	-427	-21%	✘
23	SB	1974	1766	-208	-11%	✔
24	NB	1390	1489	99	7%	✔
24	SB	1490	1502	12	1%	✔
25	NB	1264	1040	-224	-18%	✘
25	SB	1034	1036	2	0%	✔
26	NB	1106	942	-164	-15%	✔
26	SB	1148	922	-226	-20%	✘
27	NB	666	683	17	3%	✔
27	SB	1543	683	-860	-56%	✘

A.2. AM Peak Results

Table A.2: Journey time validation results – PM peak

Route ID	Direction	Observed Time (s)	Modelled Time (s)	Time Difference (s)	Time % Difference	Pass Criteria?
1	NB	515	529	14	3%	✔
1	SB	556	476	-80	-14%	✔
2	EB	1013	941	-71	-7%	✔
2	WB	1097	1371	274	25%	✘
3	EB	1309	1046	-263	-20%	✘
3	WB	1257	1217	-40	-3%	✔
4	EB	852	986	135	16%	✘
4	WB	959	1033	74	8%	✔
5	NB	1853	1431	-422	-23%	✘
5	SB	1886	1385	-501	-27%	✘
6	NB	971	918	-53	-5%	✔
6	SB	1101	831	-270	-24%	✘
7	EB	953	905	-49	-5%	✔
7	WB	1266	1107	-159	-13%	✔
8	EB	1097	1015	-82	-7%	✔
8	WB	1341	990	-351	-26%	✘
9	NB	1100	1085	-15	-1%	✔
9	SB	1171	1135	-36	-3%	✔
10	NB	2173	2030	-143	-7%	✔
10	SB	2043	2478	435	21%	✘
11	EB	1290	1382	92	7%	✔

Route ID	Direction	Observed Time (s)	Modelled Time (s)	Time Difference (s)	Time % Difference	Pass Criteria?
11	WB	1273	1664	390	31%	✗
12	NB	2089	2463	373	18%	✗
12	SB	1849	1711	-137	-7%	✓
13	NB	2028	1722	-306	-15%	✗
13	SB	1765	1622	-143	-8%	✓
14	NB	1427	1635	209	15%	✓
14	SB	1308	1474	166	13%	✓
15	NB	623	683	61	10%	✓
15	SB	617	736	119	19%	✗
16	NB	938	831	-107	-11%	✓
16	SB	815	833	18	2%	✓
17	NB	1340	1209	-131	-10%	✓
17	SB	1214	1085	-129	-11%	✓
18	NB	1689	1206	-483	-29%	✗
18	SB	1437	1146	-291	-20%	✗
19	NB	989	858	-131	-13%	✓
19	SB	851	889	38	5%	✓
20	EB	2064	2177	113	5%	✓
20	WB	2240	1980	-260	-12%	✓
21	NB	1087	1340	253	23%	✗
21	SB	991	1082	91	9%	✓
22	EB	652	665	13	2%	✓
22	WB	703	706	3	0%	✓
23	NB	2069	1649	-420	-20%	✗
23	SB	1781	1603	-178	-10%	✓
24	NB	1478	1506	29	2%	✓
24	SB	1443	1495	52	4%	✓
25	NB	1280	997	-283	-22%	✗
25	SB	1030	1007	-23	-2%	✓
26	NB	1011	937	-74	-7%	✓
26	SB	909	885	-24	-3%	✓
27	NB	765	685	-80	-10%	✓
27	SB	1028	673	-356	-35%	✗