

## BRIEFING NOTE

### TO: MKE Local Stakeholder Group

Transport modelling 24<sup>th</sup> September 2019



#### **Purpose**

This Briefing Note is to inform the MKE Local Stakeholder Group of the work done by MKC and others on the transport impacts of the MKE development and infrastructure proposals, in advance of a meeting with the LSG on 26 September.

#### **Summary**

The note summarises the background to the traffic modelling work that MKC has undertaken to date, the tests carried out in respect of the MKE development proposals, potential mitigation measures, and the key results and implications arising from these tests. It also describes ongoing and planned work and the reasons behind this.

#### **Background Information**

This section summarises the modelling work done to date using the Milton Keynes Multi-Modal Model (MKMMM), an application of proprietary modelling software developed for Milton Keynes and its environs. The model is 'strategic': it covers the wider area of Milton Keynes and represents average weekday conditions. It provides a guide to future traffic conditions based on input assumptions about growth, infrastructure improvements and economic trends.

#### **Base Year 2016:**

Initially a 'base' model was developed using observed 2016 traffic data (principally traffic flows, vehicle type proportions and journey times for the AM, PM and 'inter-peak' (10:00-16:00) periods) and the model was calibrated and validated to replicate current conditions within standard tolerances as set out by DfT. The purpose of this is to give confidence that the model can be used as the basis for future year forecasts. The results of this work are set out in the 'Local Model Validation Report', June 2017.

#### **Future Year 2031 – Reference Case:**

The Reference Case refers to the changes expected in Milton Keynes between 2016 and 2031 in terms of committed developments (including Tick ford Fields and Olney NP sites) and infrastructure. It represents the most likely outcome of current proposals. The results of this work are set out in the 'Traffic Forecasting Report', November 2017. The Reference Case was revised later to update the assumed infrastructure schemes. The main updates included in this 'Revised Reference Case' were:

- Improvements to the Kelly's Kitchen junction, approved by HE
- Refinements to the A421 dualling scheme

The Revised Reference Case results are reported in Technical Note 20, 'Revised Reference Case', June 2018.

### Future Year 2031 – Plan:MK:

The purpose of the Plan:MK tests was to see how the further development proposals associated with Plan:MK (i.e. over and above those of the Reference Case) would affect the traffic on the network in 2031. Of the various scenarios tested, those most relevant to the MKE work were:

- Scenario 2: Full Plan:MK up to 2031 including 3,000 dwellings at MKE
- Scenario 2b: A 'worst case' for MKE, assuming a further 2,000 dwellings over Scenario 2
- Scenario 2b v2 DS: see below – MKE mitigation tests

Scenarios 2 and 2b are included in the 'Impacts of Plan:MK' report, November 2017, although they were based on the Reference Case, not the Revised Reference Case.

### MKE mitigation testing:

The MKE Scenario 2b was updated and re-run with the Revised Reference Case improvements added, as 'Scenario 2b v2'. The results of this test were then used to identify junctions that were adversely affected as a result of the MKE development, and to consider mitigation measures that would improve their performance. These improvements were coded into the Scenario 2b v2 network and re-tested as 'Scenario 2b v2 DS' (DS being a convention for 'Do Something', i.e. taking measures to reduce issues of congestion). They included improvements to M1 Junction 14. These results are reported in Technical Note 21, 'Plan:MK East of M1 Mitigation Testing', June 2018.

The planning assumptions underlying the Reference Case and Plan:MK scenarios are set out in Appendix A. Appendix A also includes the list of infrastructure improvements assumed in each scenario, plus the junctions considered for mitigation of the MKE proposals.

### Bridge Optioneering and scope of future work

As part of the current work underway, 'optioneering' is being used to look at the potential for alternative access arrangements for the new MKE site including a 'no new bridge' option that would be based on Willen Road widening and improvements to the adjacent roundabouts. The purpose of these is to help understand whether a new bridge is pre-requisite and if so, whether there are alternative locations for it. These tests are being specified now and will be undertaken over the next few weeks.

### **Transport Modelling**

This section summarises the results from the above tests as a series of incremental steps starting from the Base Year 2016:

- Base Year 2016
- Revised Reference Case 2031 (RRC) (committed development, no MKE, no bridge)
- Scenario 2 2031 (RRC+3k MKE homes, new bridge)
- Scenario 2b 2031 (RRC+5k MKE homes, new bridge)

The results concentrate on eastern Milton Keynes, and specifically on those junctions identified in TN 21, as shown at the end of Appendix A, and also on the new bridge in those scenarios that include it.

The results consist of traffic flows, junction delays and 'volume over capacity ratios' (V/C). These V/C ratios represent the degree of loading as a percentage of the junction capacity. Typically a value below 85% indicates that a junction approach works reasonably well. Between 85% and 100%, the junction approach is nearing capacity and flows may be unstable with some queuing. Above 100% indicates that the junction approach is over-capacity, leading to delays and queues. By plotting these three levels on a map and using colour-coding, areas of congestion can be seen – also changes in traffic conditions as a result of different development and infrastructure scenarios.

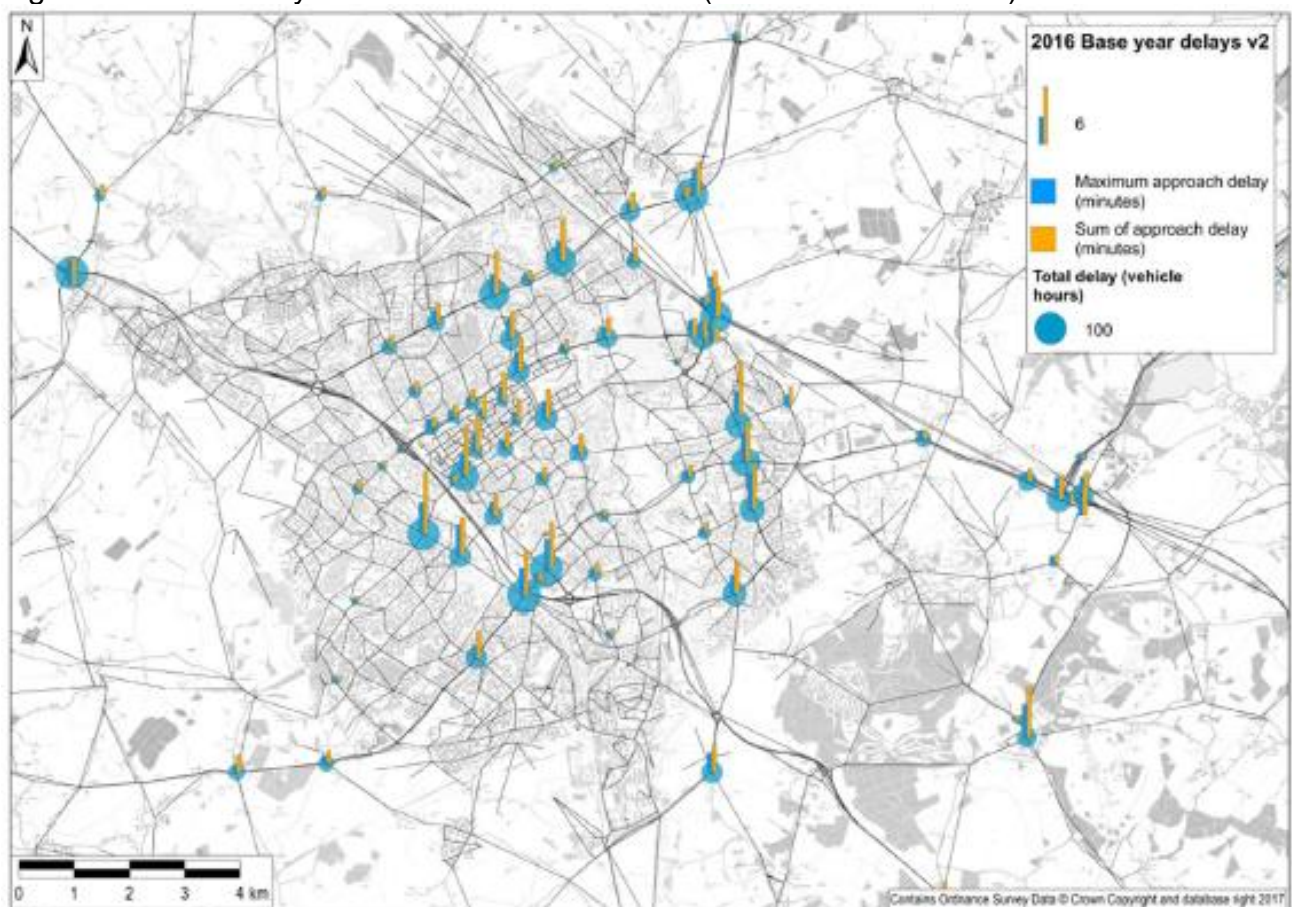
### Base Year 2016 (Appendix B1)

The base year modelling generally replicates congestion in north-eastern MK fairly well, with queues and delays on:

- A509 and A422 south-westbound AM at Renny Lodge, Tickford, Marsh End and Blakelands roundabouts
- Willen Road southbound AM
- Queuing around M1 J14 AM
- A509 and A422 north-eastbound PM at Renny Lodge, Tickford, Marsh End and Blakelands roundabouts
- A509 and Childs Way approaches to Northfield Roundabout and J14 PM

V/Cs are generally worse in the AM due to in-commuting. A summary of delays is provided in Figure 1 below:

Fig. 1: Junction Delays in 2016 Base Year Model (Worst of AM and PM)



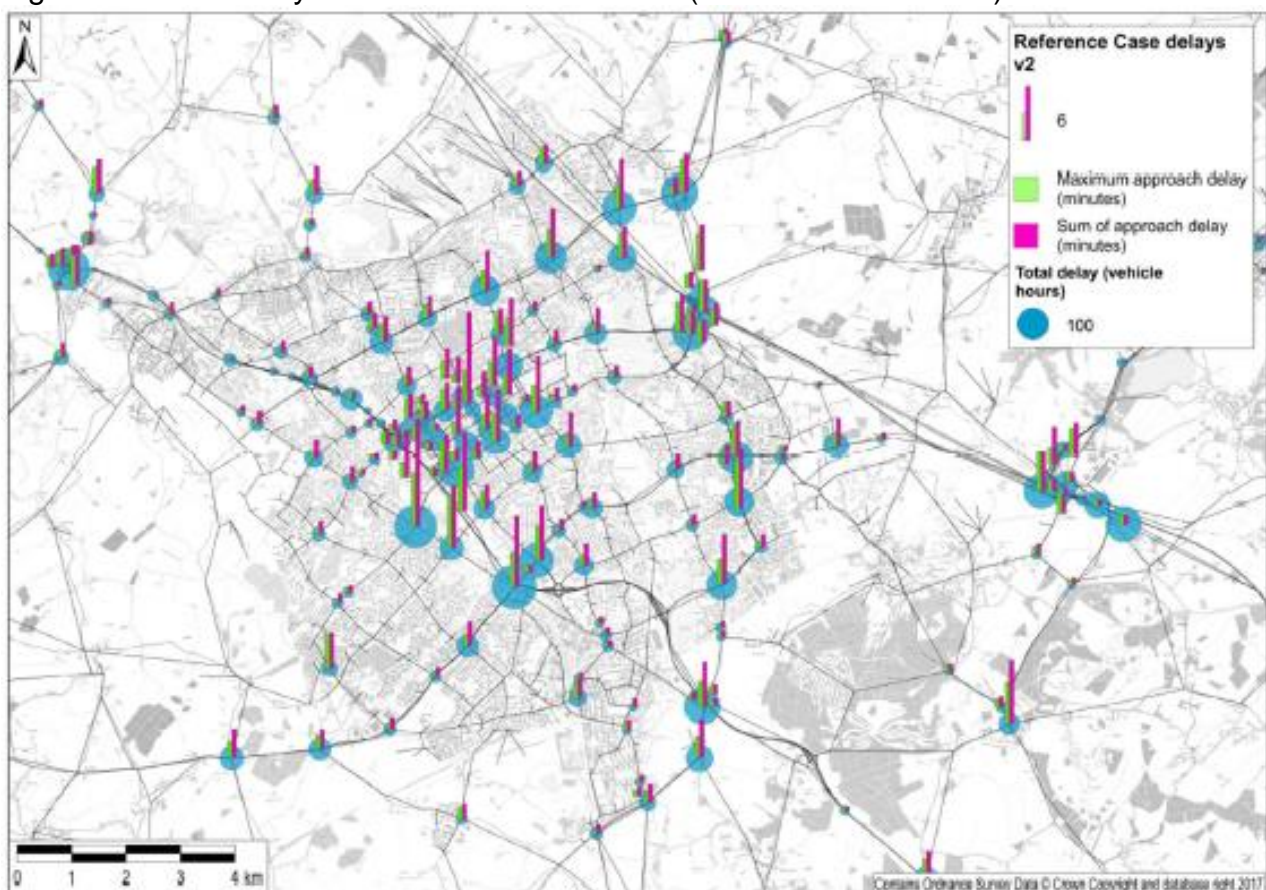
Revised Reference Case 2031 (committed development, no MKE, no bridge) (Appendix B2)

The changes due to the Reference Case growth are summarised as follows:

- The A421 junctions are more overloaded in both the AM and PM peaks, though now worse in the PM Peak.
- The A509 entry links are more overloaded and more junctions along the A422 are becoming over-capacity
- M1 J14 in particular shows a greater level of over-capacity than the Base with further stress at Northfield Roundabout, the next junction into Milton Keynes.
- Although the Reference Case schemes at Brinklow and Monkston roundabouts provide additional capacity to help accommodate growth there, there are still delays modelled in the Reference Case.

The Revised Reference Case shows a general worsening of the situation in both peaks in the north east area of MK. The links referred to above are generally more 'stressed', alongside the internal Central MK network due to the greater level of in-commuting from outside Milton Keynes, and the fact that this area does not include any local Reference Case road improvements. A summary of delays is provided in Figure 2 below:

Fig. 2: Junction Delays in 2031 Reference Case (Worst of AM and PM)



Scenario 2 2031 (RRC+3k MKE homes, new bridge) (Appendix B3)

The changes due to the Scenario 2 growth are summarised as follows:

Plan:MK Scenario 2 has a relatively small impact in relation to the 2031 Reference Case.



Although the main impacts are in the vicinity of the South East Milton Keynes Allocation (SEMK1 and SEMK2) near Bow Brickhill and the East of M1 development site, both these developments include new road infrastructure that helps mitigate some of the impacts of the additional traffic on the network, and in the case of East of M1 this new network has also helped alleviate some pressures on parallel routes. However the higher flows forecast in Scenario 2 have resulted in new or additional congestion issues modelled around Central Milton Keynes, and at junctions along the A422, V10 and V11 corridors. Figures 3 and 4 below show the changes in average junction delays between the Reference Case and Scenario 2.

Fig. 3: Change in AM Junction Delays between Reference Case and Scenario 2, 2031

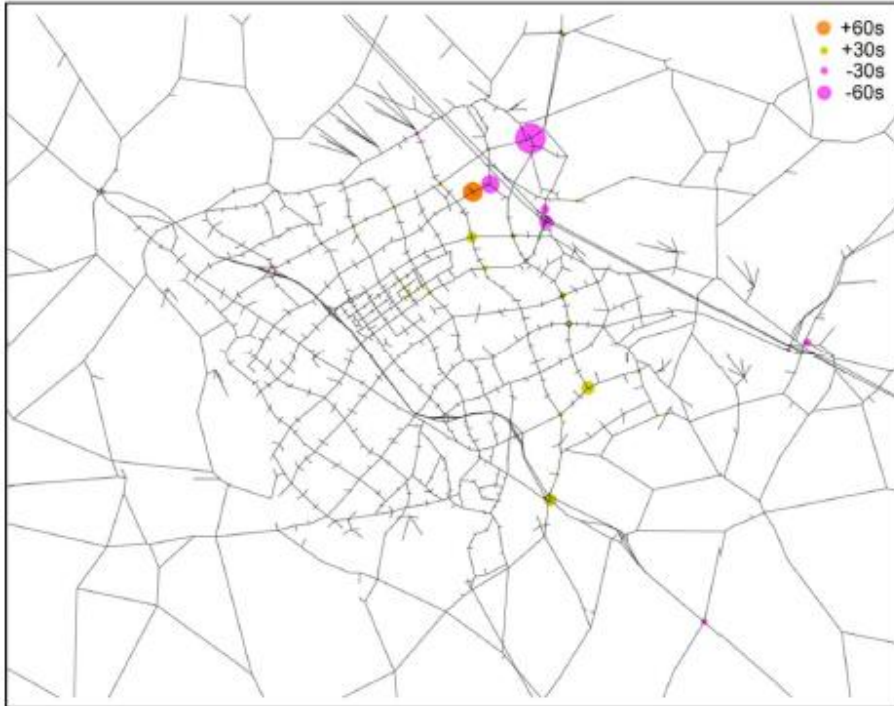
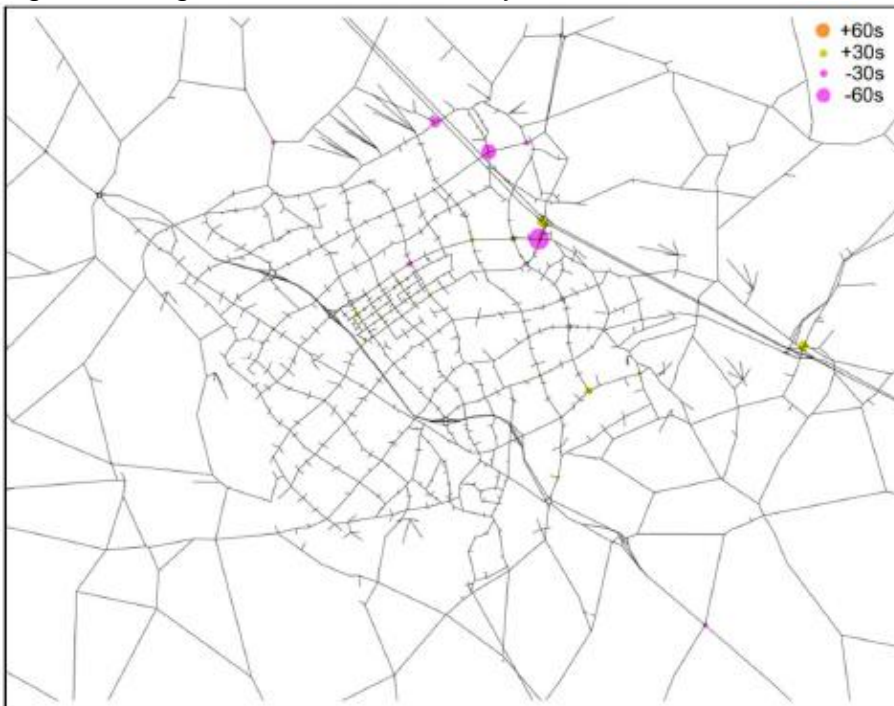


Fig. 4: Change in PM Junction Delays between Reference Case and Scenario 2, 2031



### Scenario 2b 2031 (RRC+5k MKE homes, new bridge) (Appendix B4)

The new M1 road bridge is predicted to take a significant volume of flow (1500-1700 PCU/hr [passenger car units/hour] in the direction of peak tidal flow), which helps mitigate the impact of the East of M1 development. In the AM Peak there is still an increase in flow crossing J14 towards Milton Keynes of around 250 PCU, however the model is showing little impact in delay at J14, partly due to addition of the dual carriageway link on southbound approach alleviating a current pinch point.

The traffic flows for the main M1 crossing points are shown in Tables 1 and 2, south-westbound and north-eastbound respectively (Note that these were based on the original Reference Case and will therefore those for Scenario 2b will differ marginally from those presented in the 'mitigation' section below).

Table 1: Comparison of flows from East of M1 towards MK PCU/hr)

| Time Period | Scenario       | A422 | Willen Road | New Bridge | J14 through Traffic | Total |
|-------------|----------------|------|-------------|------------|---------------------|-------|
| AM          | Reference Case | 1164 | 1651        | n/a        | 1195                | 4010  |
|             | Scenario 2b    | 1110 | 1576        | 1666       | 1445                | 5797  |
|             | Difference     | -54  | -75         | n/a        | 250                 | 1787  |
| PM          | Reference Case | 1066 | 768         | n/a        | 815                 | 2649  |
|             | Scenario 2b    | 1210 | 467         | 856        | 802                 | 3335  |
|             | Difference     | 144  | -301        | n/a        | -13                 | 686   |

Table 2: Comparison of flows from MK towards East of M1 (PCU/hr)

| Time Period | Scenario       | A422 | Willen Road | New Bridge | J14 through Traffic | Total |
|-------------|----------------|------|-------------|------------|---------------------|-------|
| AM          | Reference Case | 1037 | 559         | n/a        | 154                 | 1750  |
|             | Scenario 2b    | 977  | 343         | 593        | 323                 | 2236  |
|             | Difference     | -60  | -216        | n/a        | 169                 | 486   |
| PM          | Reference Case | 1714 | 1148        | n/a        | 307                 | 3169  |
|             | Scenario 2b    | 1790 | 985         | 1545       | 62                  | 4382  |
|             | Difference     | 76   | -163        | n/a        | -245                | 1213  |

It is also possible that amending the signal timings at the junctions on the new link would encourage a further shift in through-trips away from J14. (The increase delay shown in the PM peak is due to the extra delay experienced by traffic joining the M1). It is clear without the additional infrastructure there would be significant extra pressure on the existing roads and associated junctions across the motorway: along the A422, on Willen Road and the A509 through J14.

The modelling has indicated that there will still be significant congestion at M1 Junction 14. Although the new M1 crossing removes some through A509 traffic from J14 the majority of traffic at J14 remains (as it accessing the M1) and some of the additional highway capacity is taken up by the additional development-related traffic. It is possible that the proposed Park & Ride site on the north side of Junction 14 may reduce traffic volumes at J14 but this cannot be modelled at the current time.

Appendix B4 shows the change in flows due to Scenario 2b compared to those of the Reference Case (green indicates an increase, blue a decrease) for the AM and PM peaks. It also shows the corresponding changes in average delay.

### Effects of mitigation (Appendix C)

Various mitigation measures were proposed for some of the junctions in NE MK shown at the end of Appendix A, being based on those with congestion issues identified from the Scenario 2 and Scenario 2b v2 tests.

These measures are summarised in Table 3 below.

Table 3: Proposed Improvements to Mitigate Scenario 2b

| Junction  | Identified Impact                                   | Mitigation   | Comments  |
|---|---|--|---|
| H6 Childs Way / V10 Brickhill St. Woodstone Roundabout) | Impact on all approaches                            | Provision of extended flares and entry widths to roundabout  | Changes can be modelled   |
| Blakelands  | Impact upon southern, western and northern approach | Provision of increased flares on Brickhill St (S) and Monks Way (W) and change of road markings on Brickhill (N) | Changes too minor to model in SATURN  |
| Fox Milne   | Impact on western and northern approach             | Propose full signalisation of the existing junction  | Changes can be modelled   |
| Marsh End   | No negative impact                                  | -  | -   |
| Northfield  | Impact upon northern approach and internal queueing | Additional exit lane provided on Childs Way (S) and Portway (W) alongside change of road markings                | Changes can be modelled   |
| Pagoda  | Impact upon all approaches to the junction          | Increased flares to improve arms affected by development   | Northbound approach changes can be modelled, Changes on eastbound approach too minor to model in SATURN |
| Pineham   | Impact on northern and western approaches           | Partial signalisation (Partial signalisation provided on Tongwell Road (N).                                      | Changes can be modelled   |
| Tongwell  | No negative impact                                  | -  | -   |
| Willen  | Impact on western and eastern approaches            | Flare increased on western approach. Two lane exit provided on western exit.                                     | Changes too minor to model in SATURN  |
| Renny Lodge   | No negative impact                                  | -  | -   |
| Tickford  | No negative impact                                  | -  | -   |
| North Overgate Roundabout                               | No negative impact                                  | -  | -   |

These were tested as a variation of Scenario 2b v2, called 2b v2 DS. The results of these two tests were compared to check the effectiveness of the mitigation measures.

In Appendix C1 the AM and PM flow differences are plotted as bandwidths to the left side of each link by direction, with an increase in flow in Scenario 2b v2 DS compared to Scenario 2b v2 shown in green, and a decrease in blue. It is also important to note that where new links have been added (e.g. the new bridge) no comparison is shown.

This shows a large increase in AM flow on Childs Way between Childs Way / Tongwell St roundabout and the Childs Way / Brickhill Street roundabout. This was mirrored to a lesser extent in the PM peak in the opposite direction. In the PM peak the main flow increase was parallel on A509. There was also an increase in northbound flow on the M1 between J13 and J14 in both AM and PM, peaks, with an increase of over 200PCU/hr modelled in the PM peak north of J14 also.

In both peaks there is a reduction in flow along V11, Tongwell Street between Childs Way and A421.

A comparison of flows on the roads which cross the M1 motorway between the A422 and M1 J14 inclusive are presented in Tables 4 and 5.

Table 4: Comparison of flows from MK towards East of M1 (PCU/hr)

| Time Period | Scenario       | A422 | Willen Road | New Bridge | J14 through Traffic | Total |
|-------------|----------------|------|-------------|------------|---------------------|-------|
| AM          | Scenario 2b DM | 1102 | 1567        | 1665       | 1433                | 5767  |
|             | Scenario 2b DS | 1145 | 1551        | 1652       | 1359                | 5707  |
|             | Difference     | 43   | -16         | -13        | -74                 | -60   |
| PM          | Scenario 2b DM | 1226 | 469         | 924        | 840                 | 3459  |
|             | Scenario 2b DS | 1194 | 481         | 985        | 788                 | 3448  |
|             | Difference     | -32  | 12          | 61         | -52                 | -11   |

Note: Scenario 2b DM is the same as Scenario 2b v2

Table 5: Comparison of flows from MK towards East of M1 (PCU/hr)

| Time Period | Scenario       | A422 | Willen Road | New Bridge | J14 through Traffic | Total |
|-------------|----------------|------|-------------|------------|---------------------|-------|
| AM          | Scenario 2b DM | 978  | 345         | 602        | 320                 | 2245  |
|             | Scenario 2b DS | 1025 | 338         | 585        | 317                 | 2265  |
|             | Difference     | 47   | -7          | -17        | -3                  | 20    |
| PM          | Scenario 2b DM | 1694 | 958         | 1555       | 54                  | 4261  |
|             | Scenario 2b DS | 1785 | 967         | 1350       | 89                  | 4191  |
|             | Difference     | 91   | 9           | -205       | 35                  | -70   |

Note: Scenario 2b DM is the same as Scenario 2b v2

Despite the re-assignment of some traffic, these show that the mitigation measures have minimal impact on modelled traffic crossing the M1 motorway. Overall there was slightly less traffic crossing the M1, the largest reduction being towards the East of M1 from Milton Keynes in the PM peak, but the reduction was only 70 PCU/hr.

The differences in delays between the Scenario 2b v2 (without mitigation) and 2b v2 DS (with mitigation) in the AM and PM are also shown in Appendix C1. Key observations from here are:

In the AM,

- A significant reduction in delay on the A422
- A large reduction in delay on the M1 northbound off slip at junction 14
- A reduction in delay at the H6 / V10 roundabout going towards central Milton Keynes
- A reduction in delay at Brinklow and Monkston with traffic transferring to Childs Way
- A noticeable increase in delay at the westbound approaches to the junctions with V9 Overstreet as the traffic is no longer held back upstream
- A notable increase in delay on the northbound approach to Pagoda roundabout

In the PM,

- A reduction in delay on the northbound A509 approach to Junction 14
- An increase in delay on the northbound approach to Pagoda roundabout
- A reduction in delay on the eastbound approach to Northfield roundabout. However this delay moved downstream to the southwest part of the Junction 14 circulatory
- A slight increase in delay on the southbound off slip approach to the Junction 14, and a more notable increase in delay at the end of the southbound on-slip the latter due to additional traffic joining the motorway



The summary of the mitigation measures based on these findings is presented in Appendix C2.

## **Summary**

The mitigation measures cannot be looked at solely on a junction by junction basis. The grid structure of Milton Keynes road network widens the impact of the mitigation measures. Increased capacity at one junction attracts traffic off parallel routes, with the additional traffic reducing the benefit at that particular junction in terms of delay although the benefits are gained on the parallel routes.

In the AM peak the mitigation at the H6 Childs Way / Brickhill St. roundabout has the most notable impact in terms of re-assignment. This measure is forecast to attract traffic from parallel routes, such as the A421, which has also helped reduce congestion at Brinklow and Monkston roundabouts. In the PM peak the combination of measures has caused traffic to re-assign to the A509 from Childs Way.

There is also a relationship between increasing east-west flows causing delays on north-south routes. In both peaks there is a reduction in traffic on Tongwell Street (V11) as a result of the increase in traffic volume of the conflicting east west flows. With exception of the northbound approach to Pagoda roundabout this does not appear to cause notable additional modelled delays on alternative north-south routes.

The measures generally help reduce the delays for traffic travelling between the M1 and central Milton Keynes, particularly in the AM Peak. However the increased capacity at the mitigated junctions has, in the AM peak, caused an uplift in delay on the approaches to Over Street (V9) as traffic is no longer blocked upstream of this junction. Signal optimisation based on the MKMMM DS (with mitigation) flows in the PM Peak could help reduce delays further.

The M1 bridge does not significantly reduce traffic on the other M1 crossing points at A422, Willen Road and M1 J14 through-traffic; however, it does carry substantial traffic flows that would otherwise put increased pressure on the existing crossings in Scenarios 2, 2b and variations.

The model shows that the mitigation measures increase the traffic travelling to and from the M1 via junction 14. However this increase has little impact on the total traffic volumes crossing the motorway between the A422 and J14 inclusive.

## **Author**

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21-09-2018

## **APPENDIX A**

### **SUMMARY OF DEVELOPMENT ASSUMPTIONS 2016 – 2031:**

#### **Reference Case (RC):**

- 22,228 dwellings (Includes 1200 homes at Tickford Fields and the Olney Neighbourhood Plan allocations)
- 28,997 jobs

#### **Plan:MK Scenario 1: 2031RC plus:**

- An additional 4,620 homes within Milton Keynes urban area (post-RC commissions 1,200, Draft SHLAA 2017 3,420);
- An additional 1,000 homes at land north of the railway line within the South Eastern Milton Keynes Allocation (SEMK1 of SE SUE); and
- An additional 4,254 industrial/logistics jobs which were allocated in South Caldecotte.

No additional infrastructure is planned as part of the development sites.

#### **Plan:MK Scenario 2: Scenario 1 plus:**

- 2,000 homes at land south of the railway line within the South East Milton Keynes Allocation (SEMK2 of SE SUE);
- 2,998 homes to the East of the M1;
- 56 homes in the Milton Keynes urban area (SHLAA 2017);
- 6,330 jobs included in the East of M1; and
- 918 further/higher education jobs within central Milton Keynes (CMK Block B4).

**Scenario 2a** includes only the 2,000 additional dwellings south of the railway line as part of the South East Milton Keynes Allocation (SEMK2) which is split evenly across the two zones north of Bow Brickhill, and the 56 SHLAA dwellings; none of the other three elements of Scenario 2.

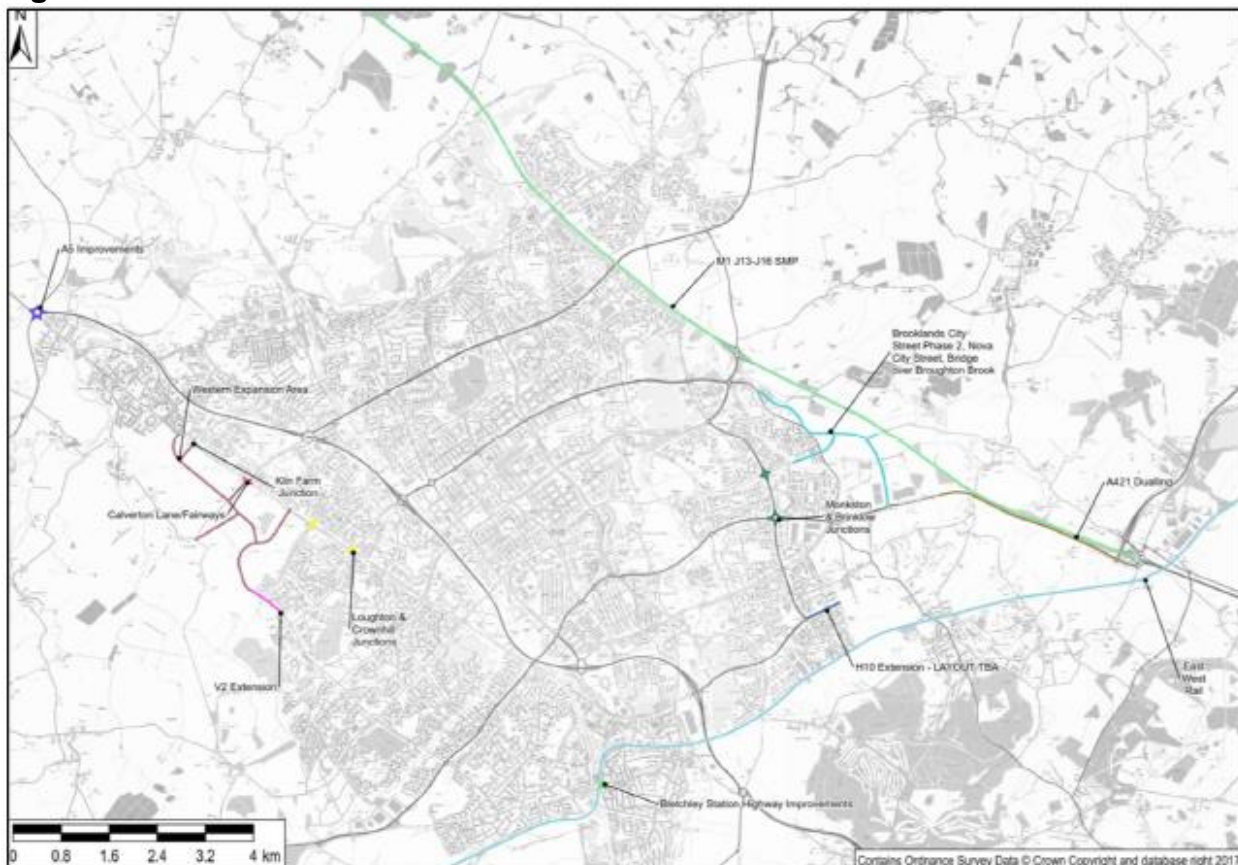
**Scenario 2b** includes all the Scenario 1 and 2 growth, which together amounts to an additional 10,674 dwellings and 11,502 jobs compared to the Reference Case. In addition a further 2,000 dwellings have been included in the East of M1 development, giving a total of 4,998 dwellings East of the M1 (and 12,674 dwellings overall). Although planned after the Plan:MK 2031 horizon year these have been included to better measure the impacts on the road network in this area. This is the highest generation scenario.

## SUMMARY OF INFRASTRUCTURE IMPROVEMENTS 2016 – 2031

Table A1: Forecast Year Schemes Included in Reference Case – List

| Scheme                                 | Delivered by |
|--|--------------|
| A421 Dualling                          | By 2031      |
| Monkston & Brinklow Junctions          | 2019         |
| Crownhill & Loughton Junctions         | 2019         |
| A5 Improvements                        | By 2031      |
| Bletchley Station Highway Improvements | 2017         |
| Brooklands City Street Phase 2         | 2017         |
| Nova City Street                       | 2018         |
| Calverton Lane/Fairways                | 2021         |
| Kiln Farm Junction                     | 2016         |
| Bridge over Broughton Brook            | 2018         |
| H10 Extension                          | 2018         |
| V2/H4 Extension                        | 2021         |
| East-West Rail                         | 2024         |
| M1 J13-J16 SMP                         | By 2031      |
| M1 J16-J19 SMP                         | 2021         |
| M1 J11a / Dunstable Northern Bypass    | 2017         |

Fig. A1: Forecast Year Schemes Included in Reference Case – Plan



NB a subsequent 'Revised Reference Case' involved improving the Kelly's Kitchen junction and refining the A421 dualling scheme to reflect latest plans

Fig. A2: Additional Forecast Schemes in Plan:MK Scenarios 2 and 2b (MKE):

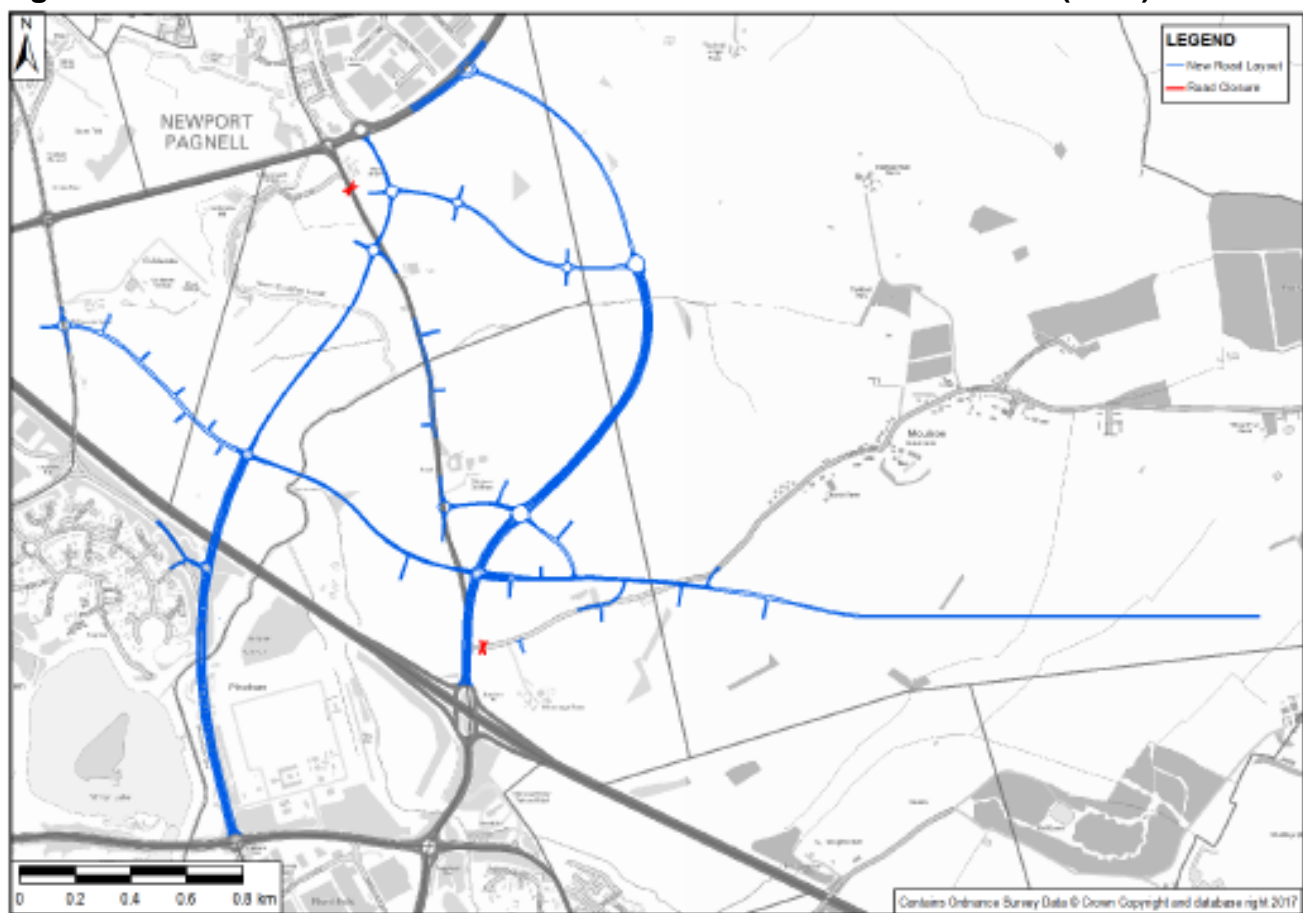
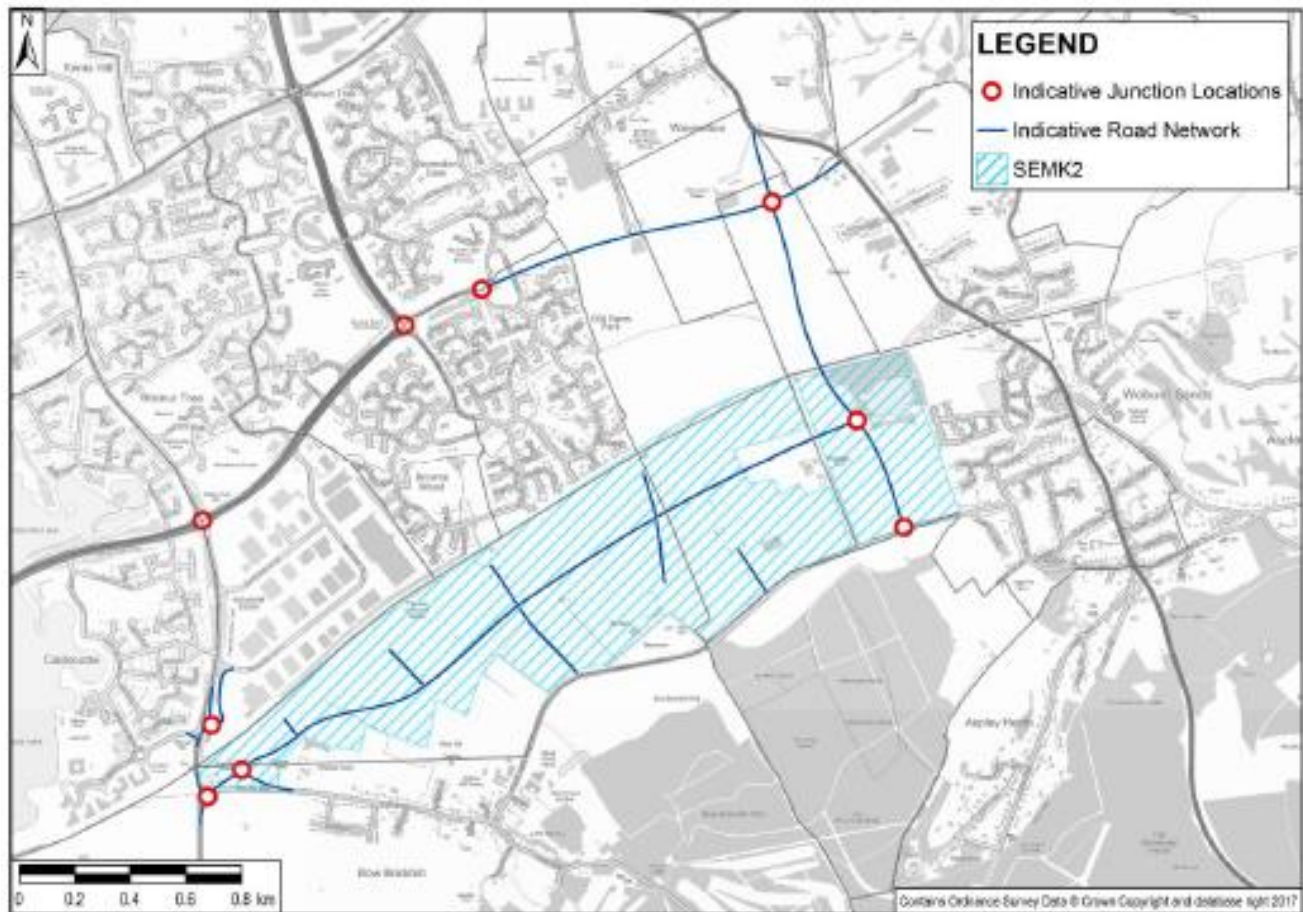


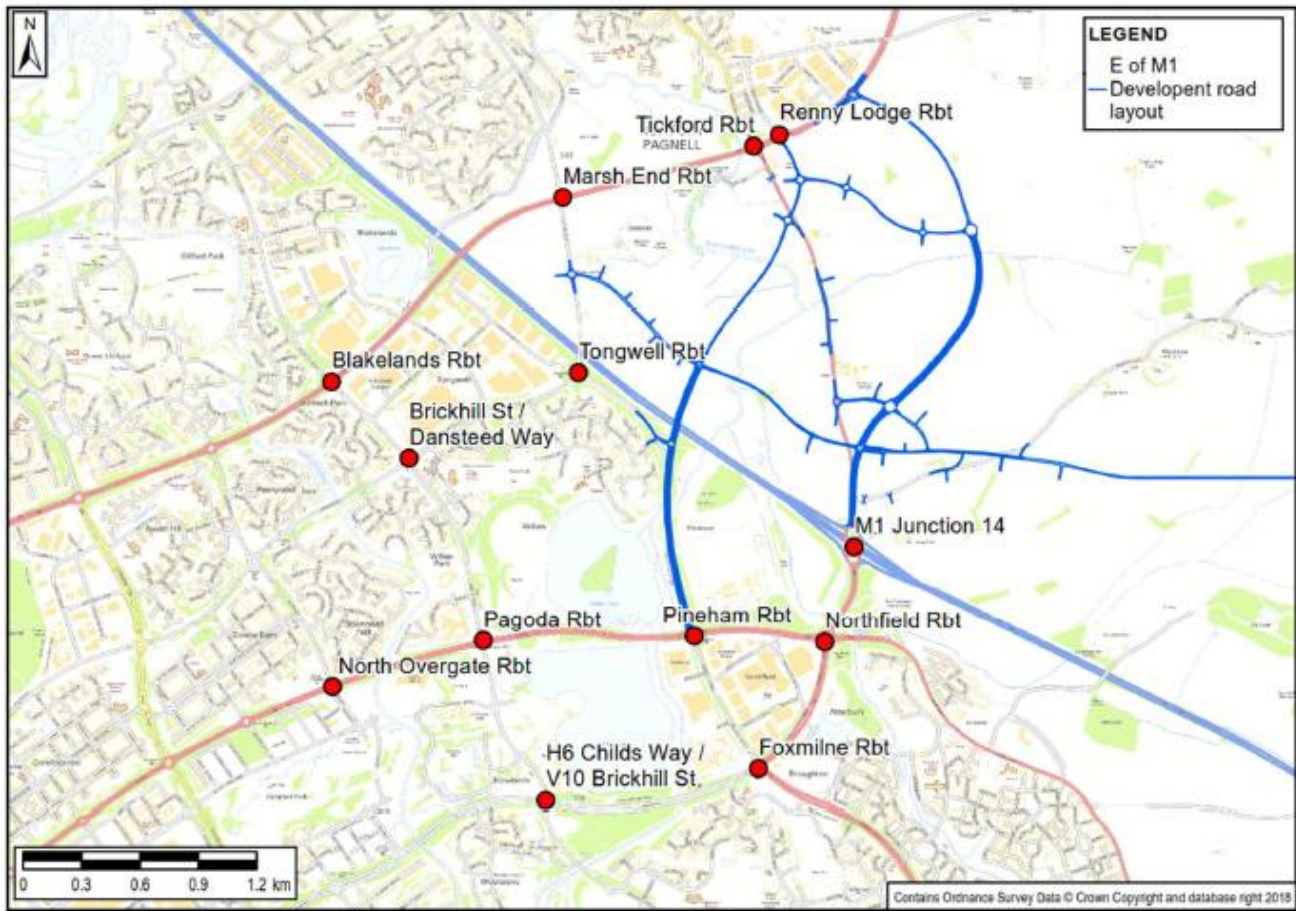
Fig. A3: Additional Forecast Schemes in Plan:MK Scenarios 2 and 2b (SMK):





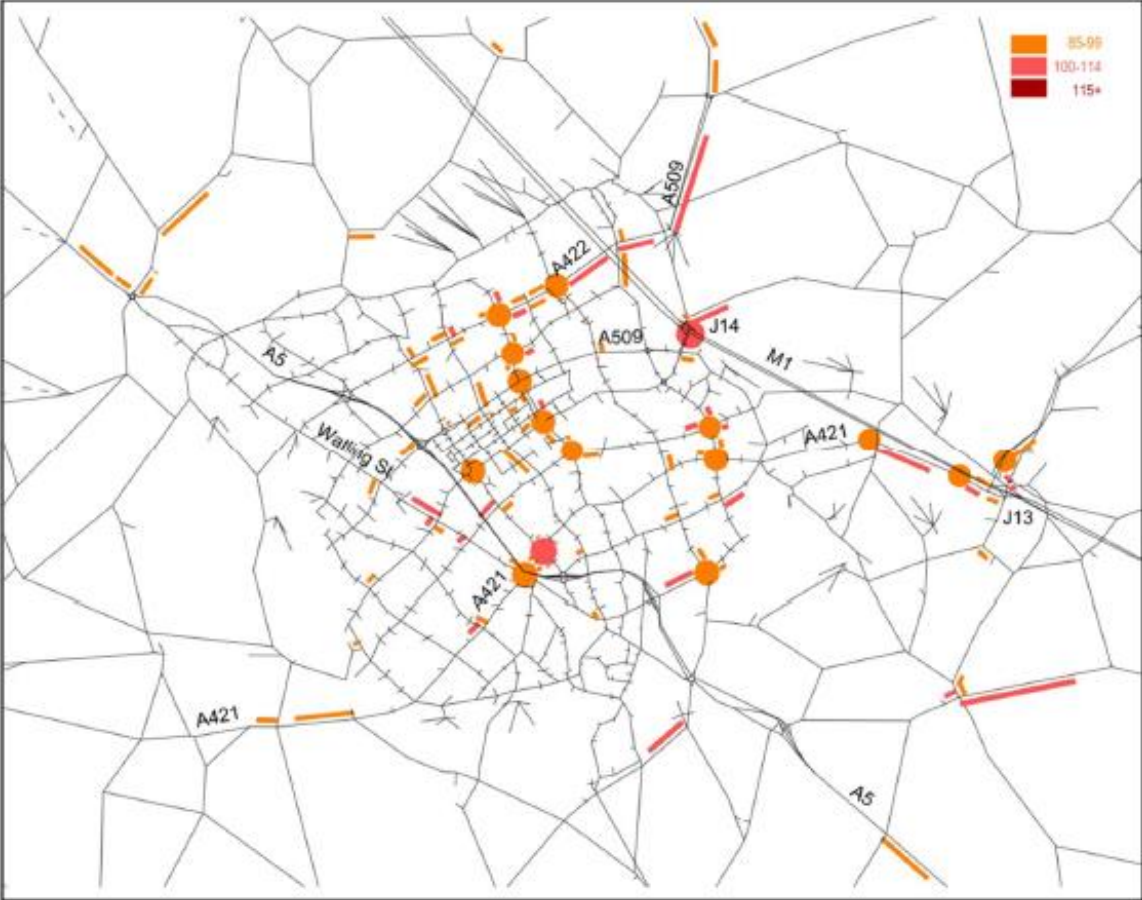
SUMMARY OF MITIGATION TESTS TO DATE

Fig. A4: Junctions Included in the Scenario 2b v2 DS Mitigation Improvements

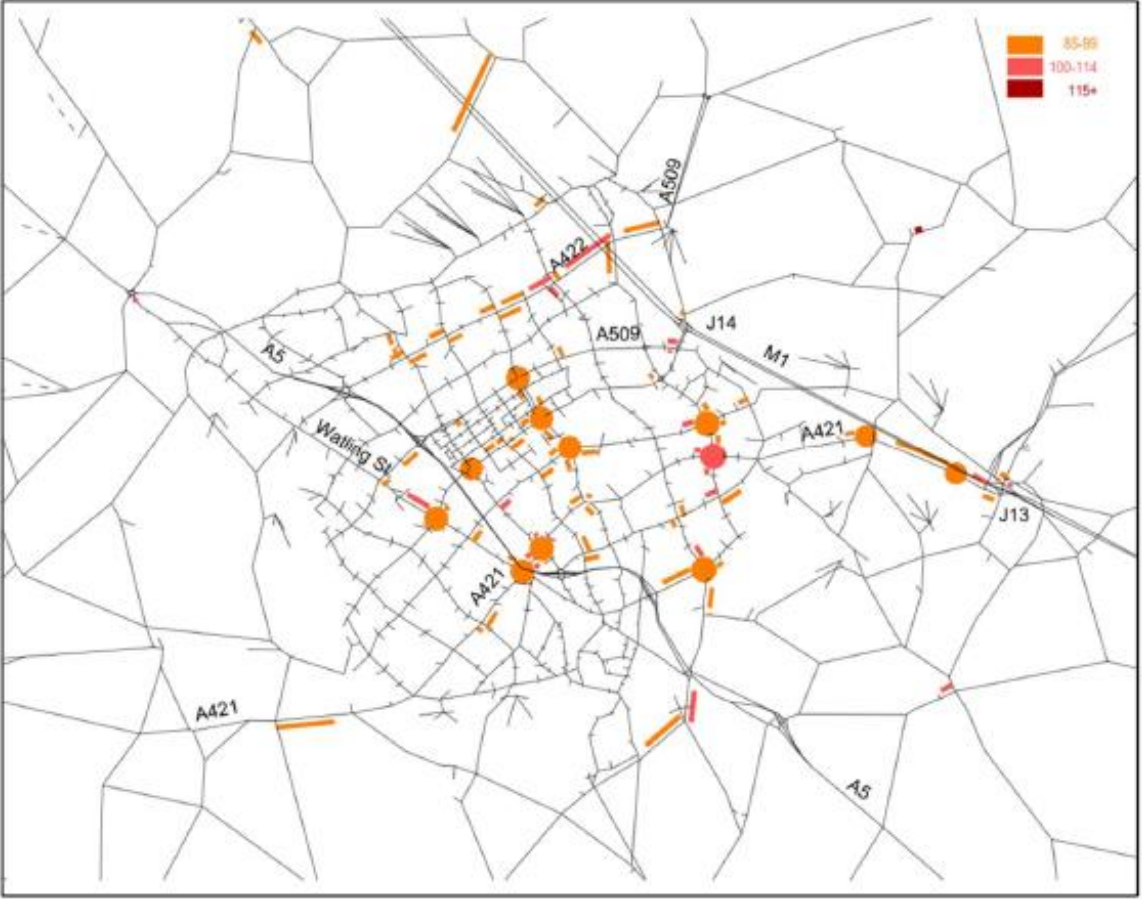


**APPENDIX B1**

**Fig B1(i): Base Year 2016: Link and Junction V/Cs Above 85%, AM**



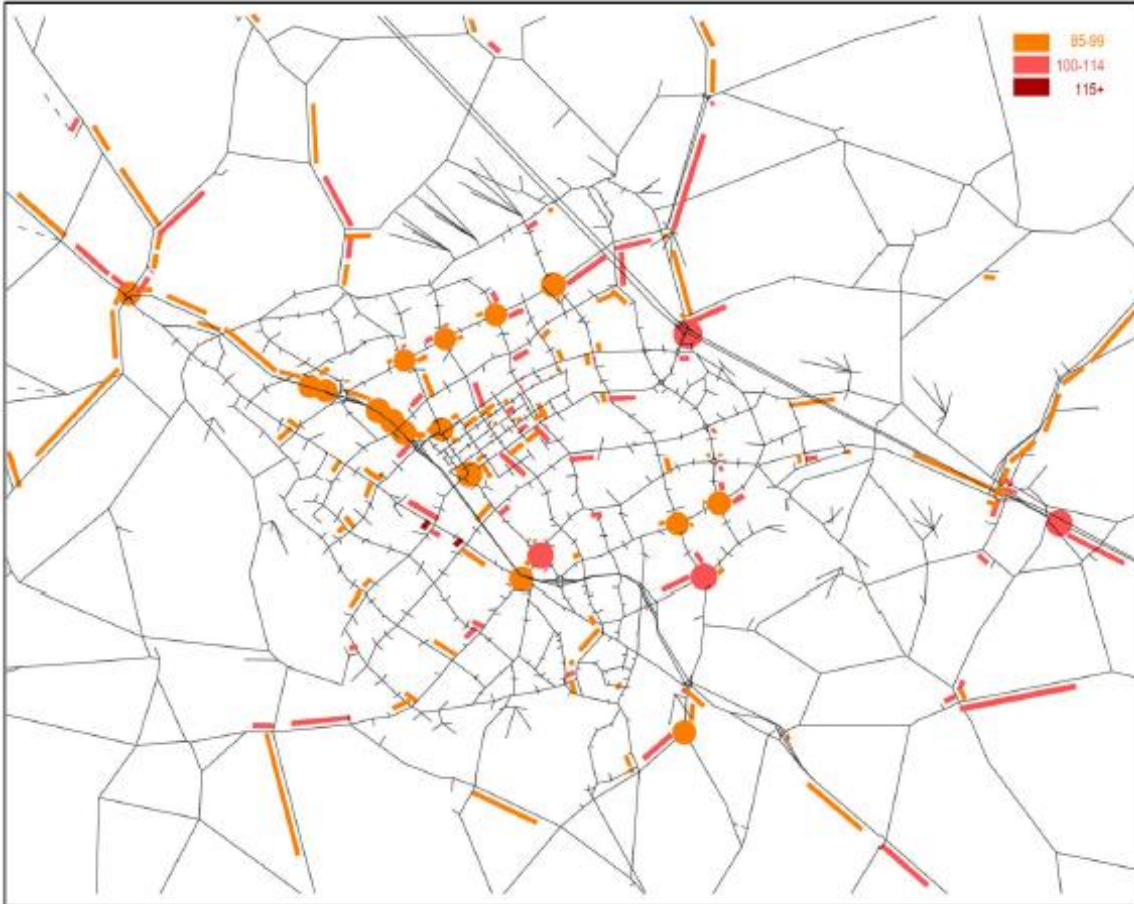
**Fig B1(ii): Base Year 2016: Link and Junction V/Cs Above 85%, PM**



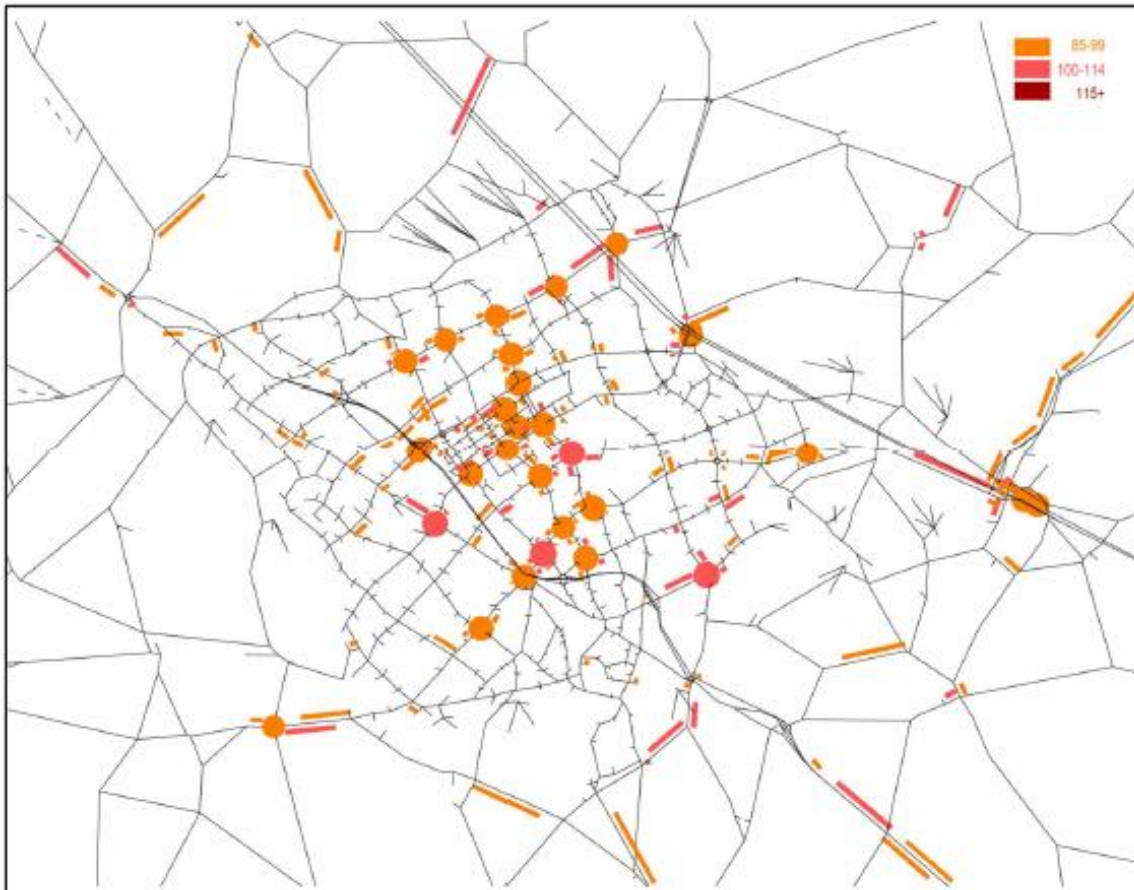


## APPENDIX B2

**Fig. B2(i): Revised Reference Case 2031: Link and Junction V/Cs Above 85%, AM**



**Fig. B2(ii): Revised Reference Case 2031: Link and Junction V/Cs Above 85%, PM**



APPENDIX B3

Fig. B3(i): Changes in V/C Ratio: Reference Case to Scenario 2, AM

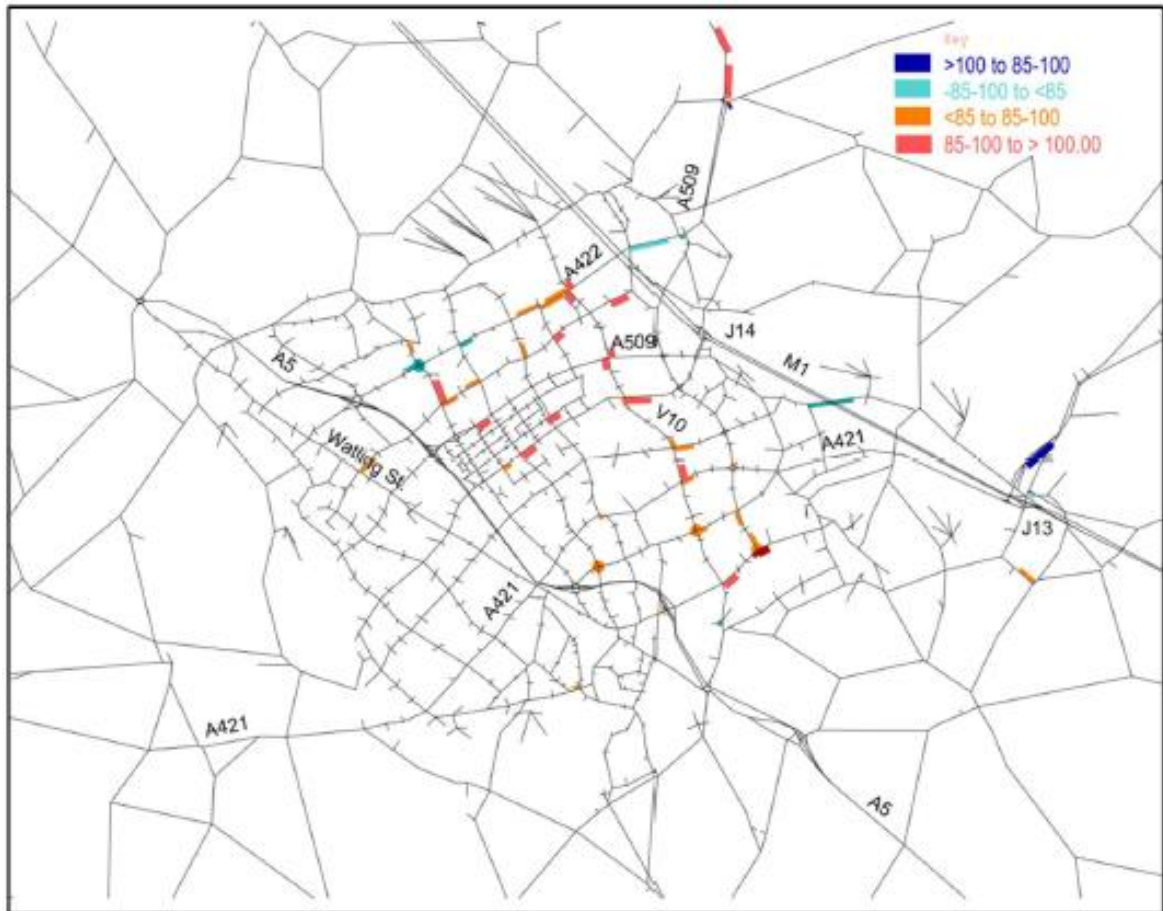
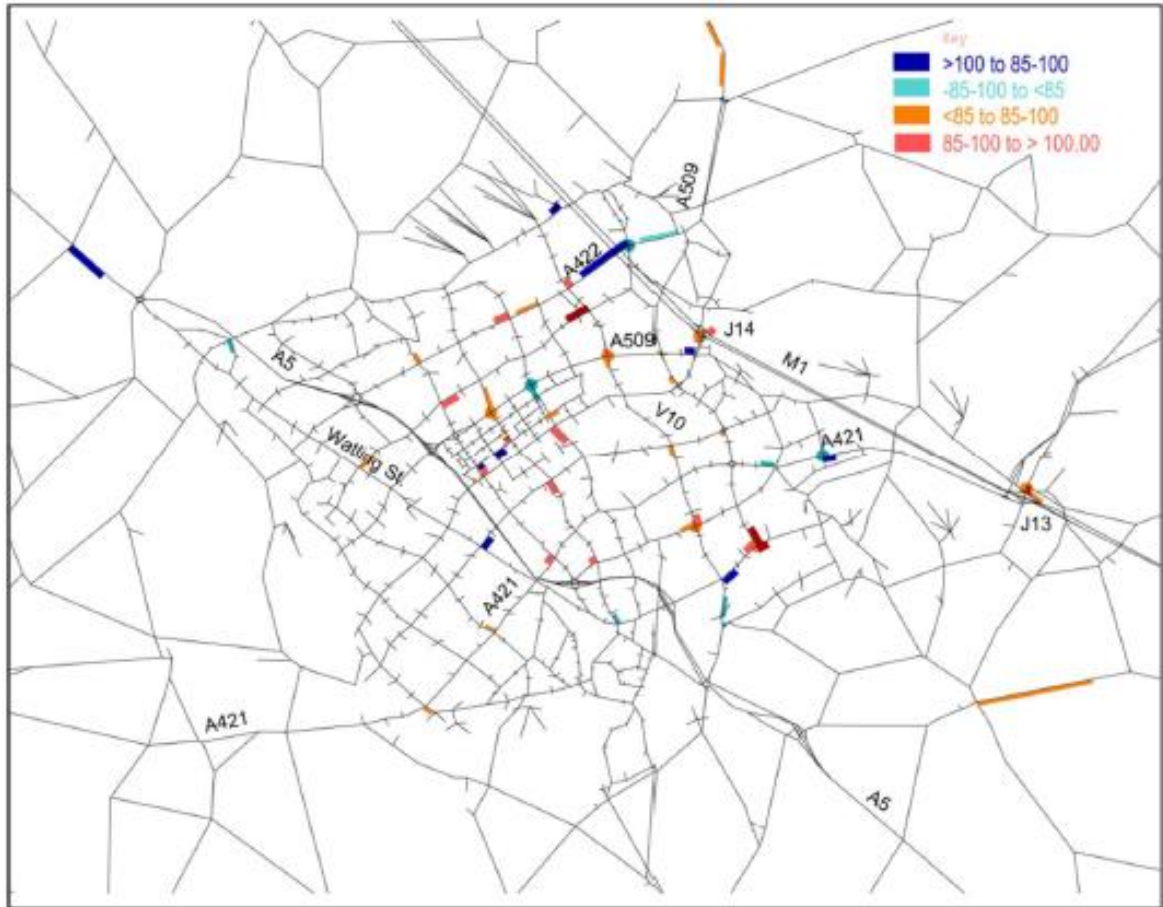
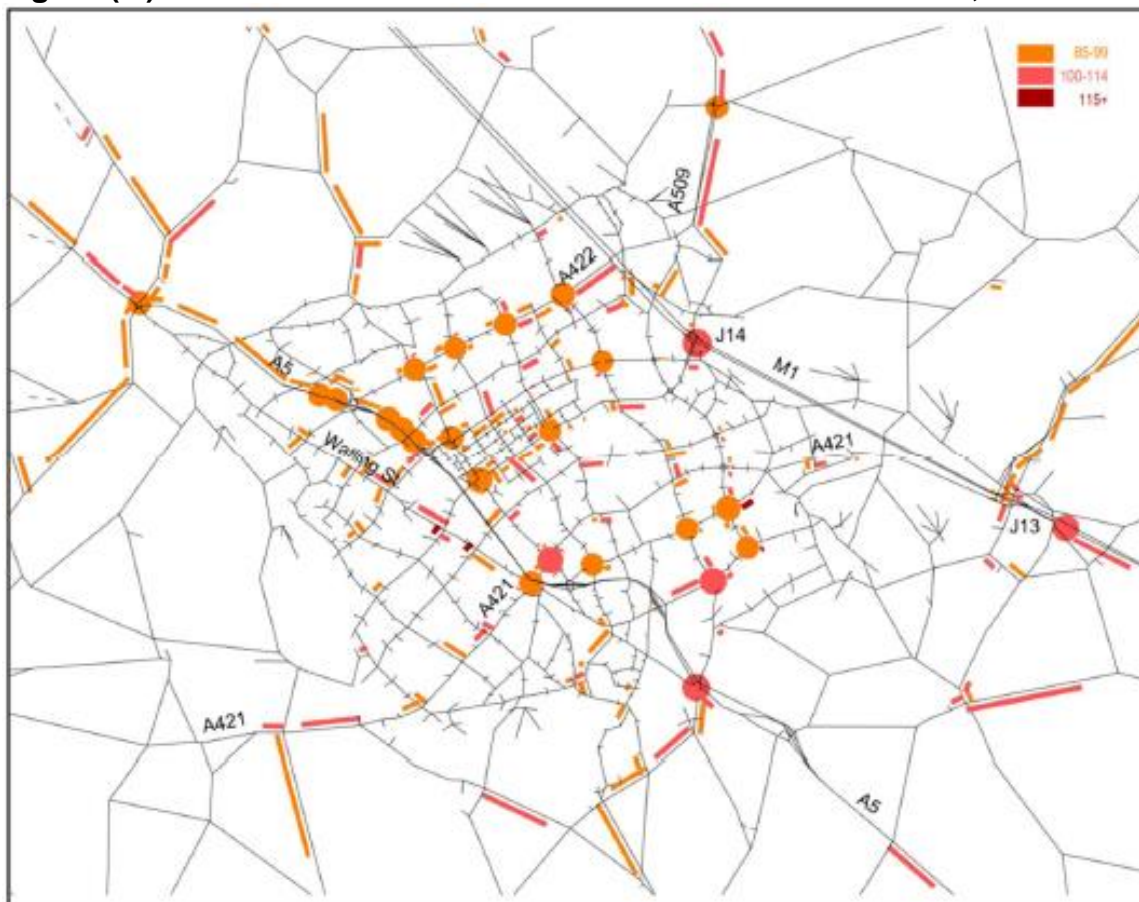


Fig. B3(ii): Changes in V/C Ratio: Reference Case to Scenario 2, PM

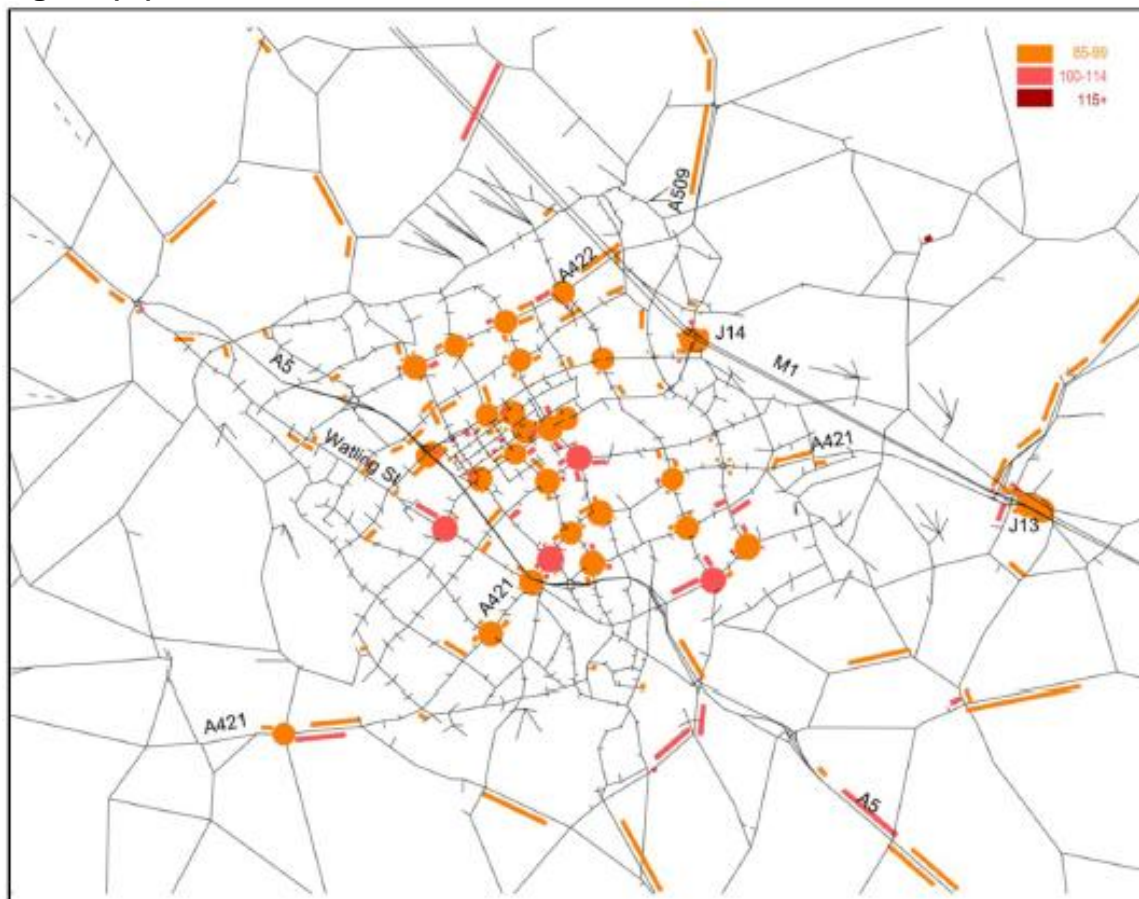




**Fig. B3(iii): Scenario 2 2031: Link and Junction V/Cs Above 85%, AM**



**Fig. B3(iv): Scenario 2 2031: Link and Junction V/Cs Above 85%, PM**



## APPENDIX B4

Fig. B4(i): Change in Modelled Flows (PCU/hr) between Scenario 2b and Reference Case, AM

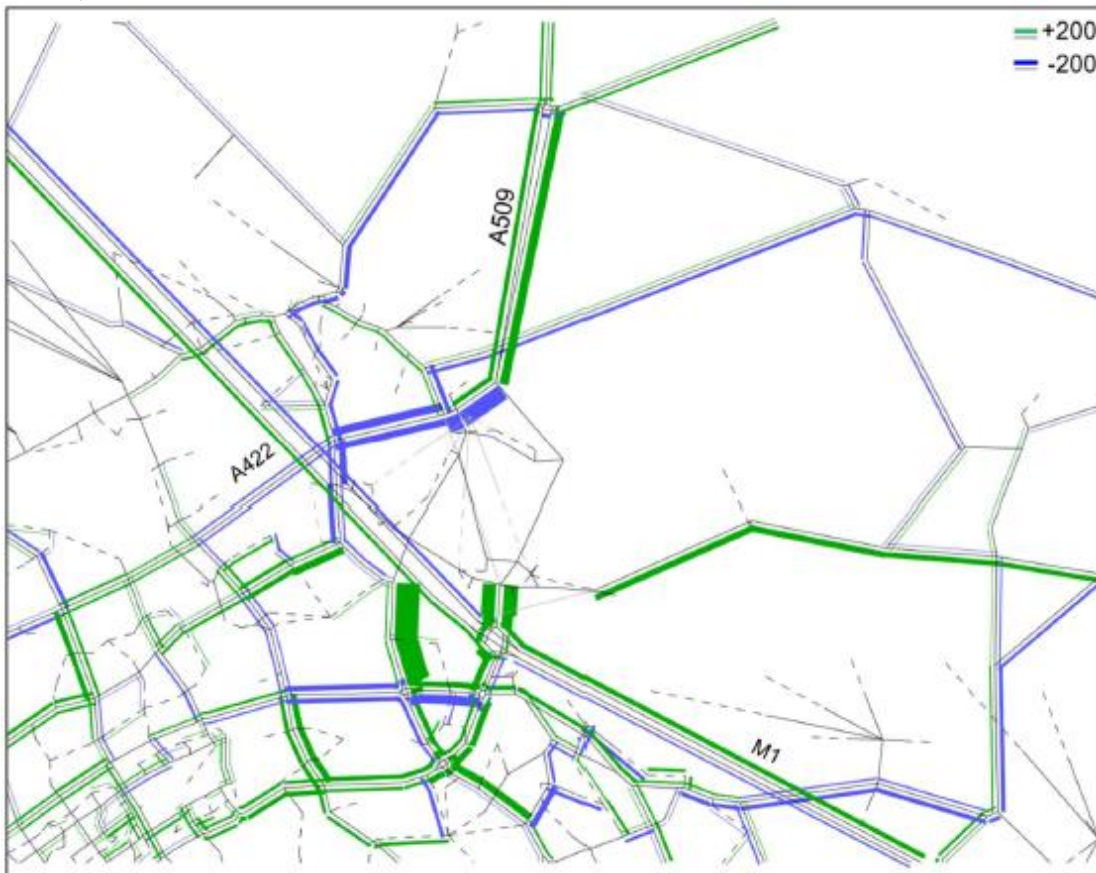
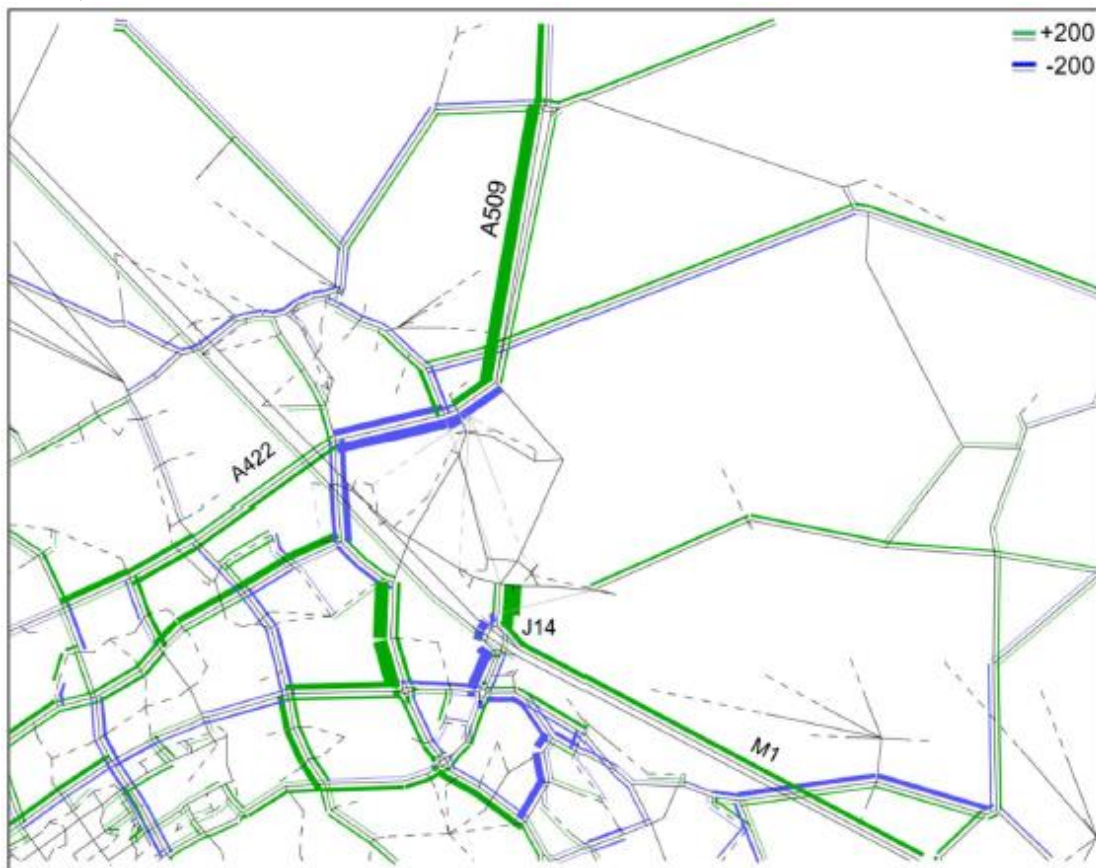
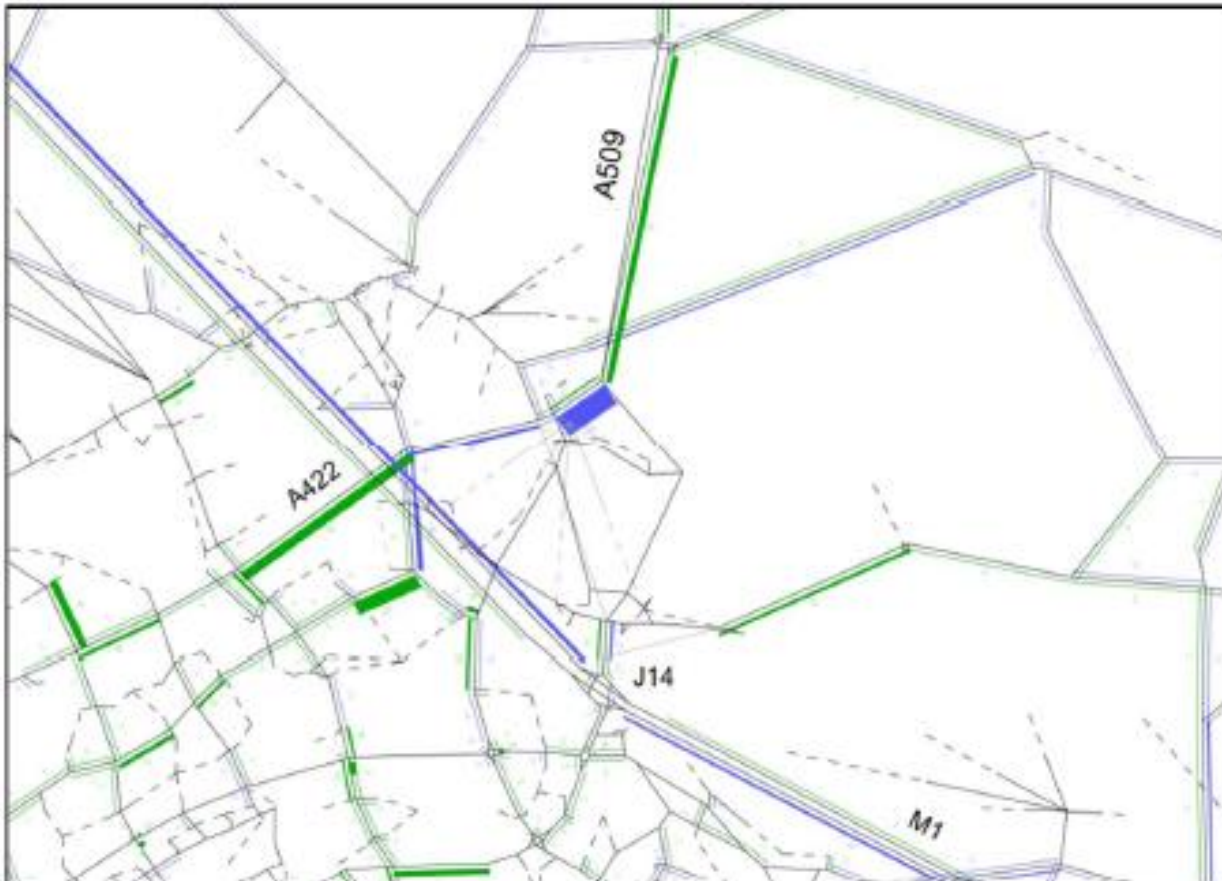


Fig. B4(ii): Change in Modelled Flows (PCU/hr) between Scenario 2b and Reference Case, PM

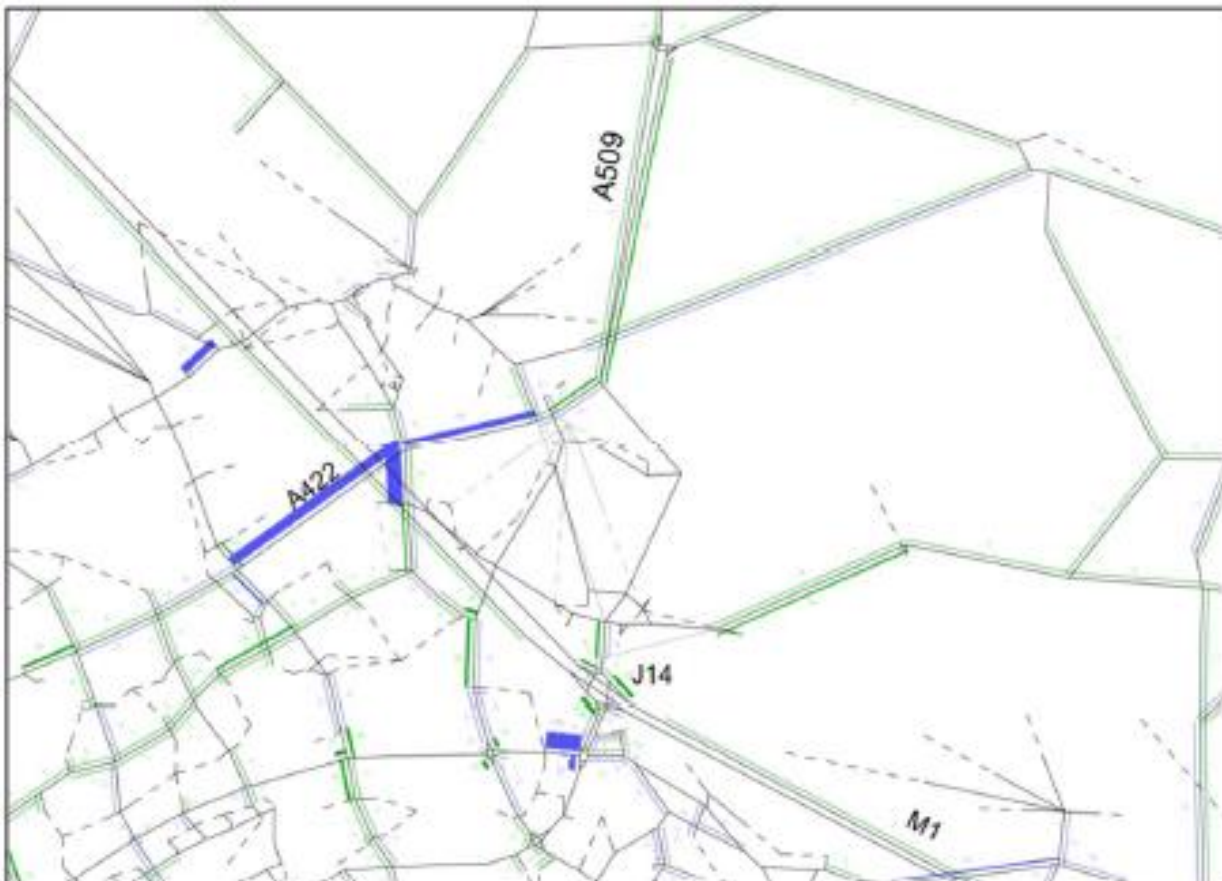




**Fig. B4(iii): Change in Modelled Delays (sec) between Scenario 2b and Reference Case, AM**

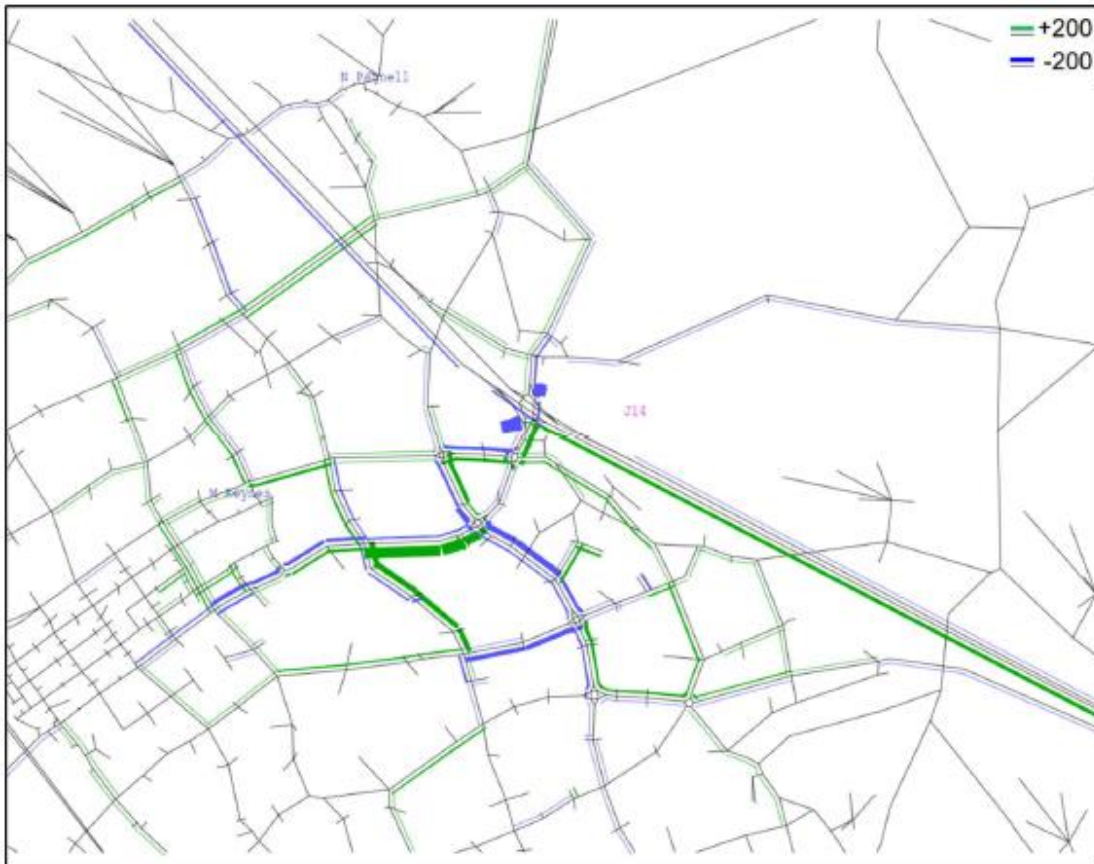


**Fig. B4(iv): Change in Modelled Delays (sec) between Scenario 2b and Reference Case, PM**

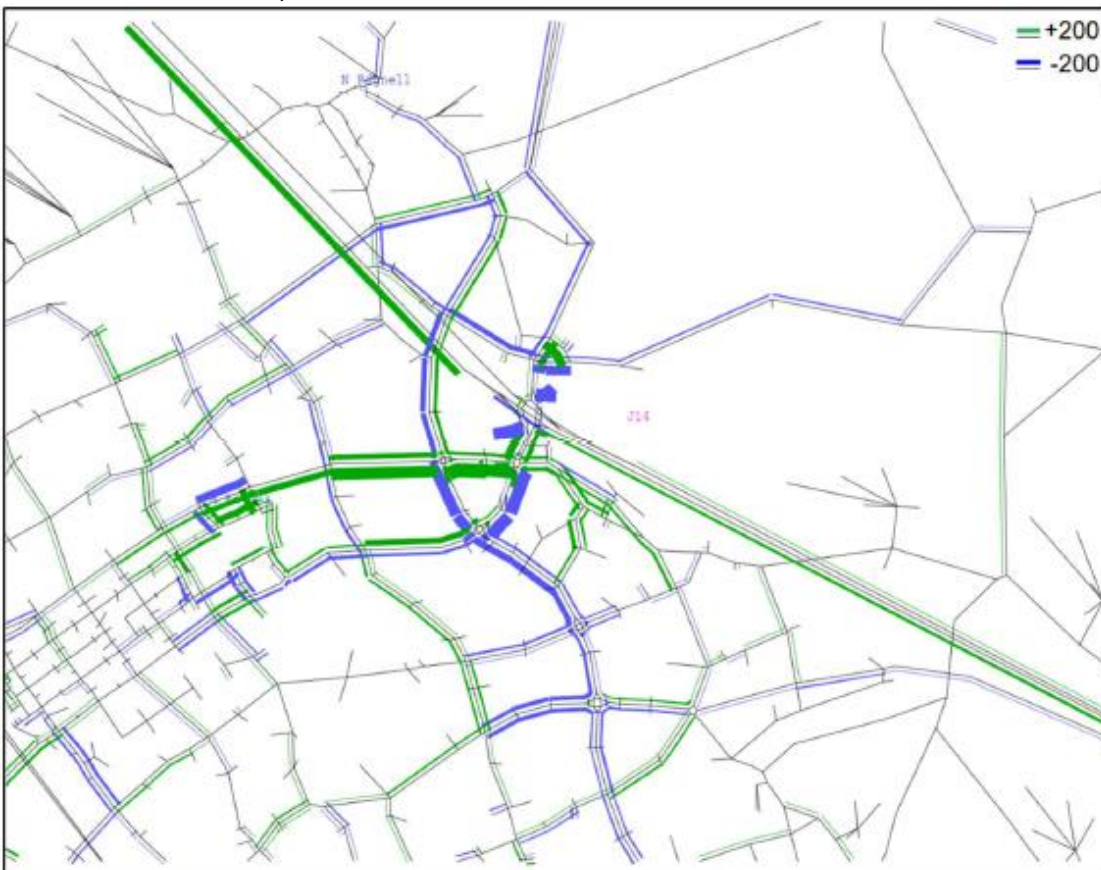


## APPENDIX C1

**Fig. C1(i): Change in Modelled Flows (PCU/hr) between Scenario 2b v2 and Scenario 2b v2 DS, AM**

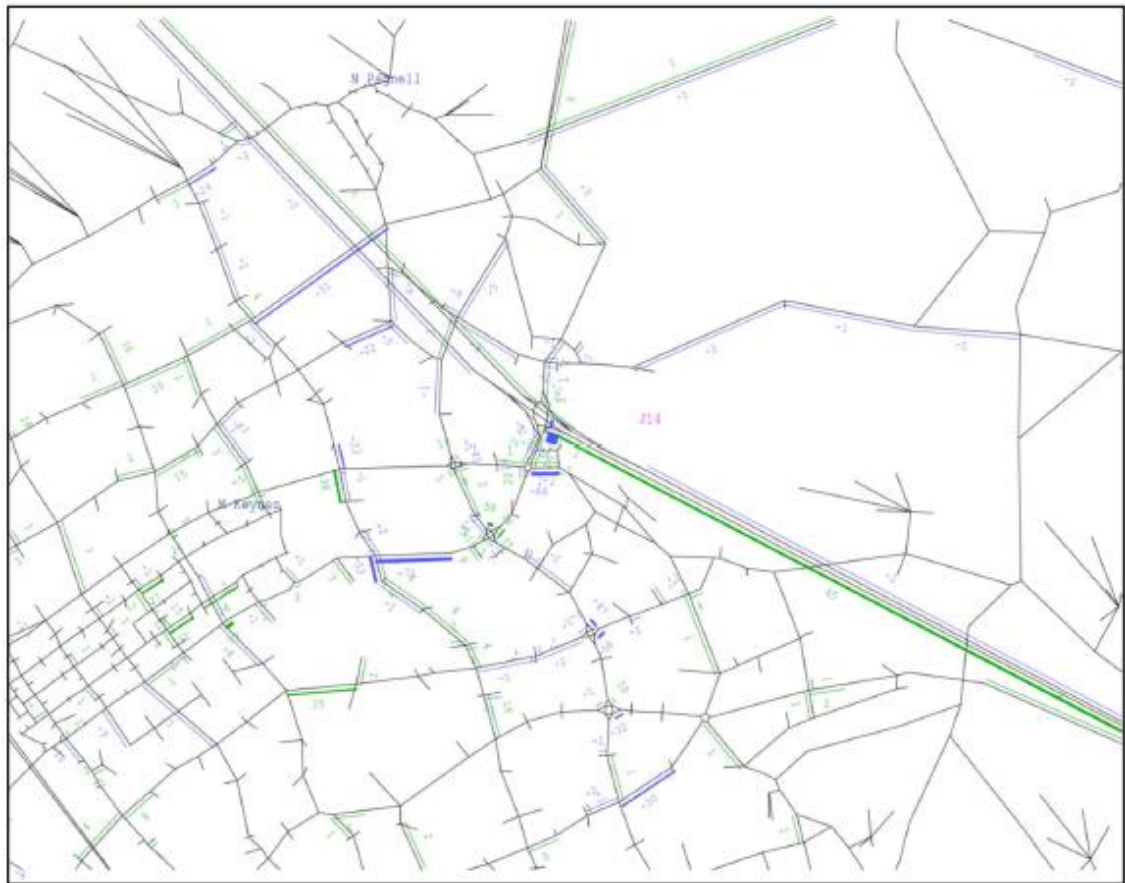


**Fig. C1(ii): Change in Modelled Flows (PCU/hr) between Scenario 2b v2 and Scenario 2b v2 DS, PM**

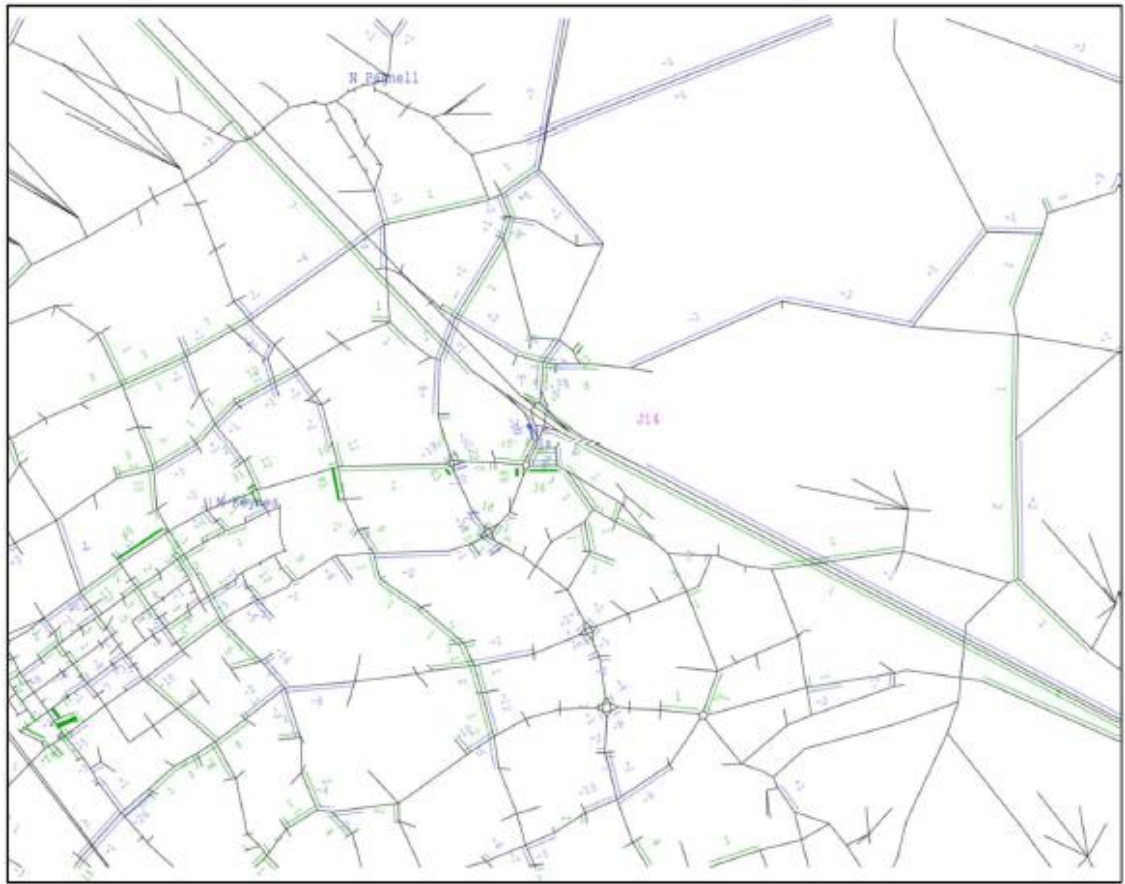




**Fig. C1(iii): Change in Modelled Delays (sec) between Scenario 2b v2 and Scenario 2b v2 DS, AM**



**Fig. C1(iv): Change in Modelled Delays (sec) between Scenario 2b v2 and Scenario 2b v2 DS, PM**



## APPENDIX C2

### Tabls C2(i): Mitigation Scheme Assessment

| Junction   | Max Ref Case Delay   | Issue in Reference Case | Max Scenario 2 delay  | Issue in Sc2 | Source of Delay  | Performance of mitigation  | Notes   |
|--|--|-------------------------|---|--------------|--|--|---|
| J14  | AM peak, 3.5 minutes both northbound and southbound off-slips<br>PM peak 1 min 47s circulatory to northbound on-slip   | High                    | AM Peak, northbound off slip 1min 42s delay,<br>1min 42s delay on circulatory<br>PM Peak 1min 21s delay circulatory to NB on slip | High         | Primarily Reference Case issue but increased delay on sb on and off slips and A509 nb approach to junction and circulatory on approach to nb on-slip | Delays for A509 sb traffic are reduced on the circulatory and the delays on the nb off slip<br>PM Peak, delays from A509 northbound to the northbound on slip are greatly reduced, whilst facilitating an increase of nearly 300PCU to join M1 northbound. | There is still a notable amount of delay at the northbound diverge on M1 which could be mitigated with a tiger tail diverge. This however may not be feasible using the land available. |
| H6 Childs Way / V10 Brickhill St. (Woodstone Roundabout) | AM Peak, Westbound approach 40s delay<br>Northbound approach 30s delay   | Moderate                | AM Peak, Westbound approach 1m 58s delay<br>Northbound approach 1min 40s delay  | High         | Delays primarily caused by Scenario 2b   | delays reduced in both AM by 1min 12s on westbound approach in AM, and 53s on northbound approach  | Delay reduction on westbound approach despite increase in traffic of 482PCU   |
| Fox Milne  | 15-25s delay on both approach and circulatory and Tongwell street approach signals<br>PM Peak, 3min 26s delay on eastbound approach, 2 minutes 42 second delay northbound approach | Low                     | PM Peak 17- 27s delay on circulatory at SB Tongwell St approach   | Low          | Primarily Reference Case Issue   | Reduced delays on north and south parts circulatory, increased on east and west circulatory  | The mitigation measures at Northfield and Pineham roundabouts has reduced the flow through this junction notably.   |
| Northfield   |  | High                    | PM Peak, 49s on eastbound approach, 1min 34s delay on northbound approach   | Moderate     | Primarily Reference Case issue   | Increased delay of 1min 29s on nb approach in PM, delay reduced on sb approach by 8s,  | The junction is handling more traffic, particularly in the PM, but further optimisation of signal timings required to reduce delay on northbound approach                               |

| Junction | Max Ref Case Delay  | issue in Reference Case | Max Scenario 2 delay   | Issue in Sc2 | Source of Delay  | Performance of mitigation   | Notes   |
|----------|---|-------------------------|--|--------------|--|---|---|
| Pagoda   | AM Peak, 1 min 16s delay eastbound approach, 58s delay northbound approach        | Moderate                | AM Peak, 3min 10s eastbound approach, 51s nb approach and 69 s sb approach | High         | Primarily East of M1 development on Eastbound approach but impact on all approaches, | negligible impact in terms of delay, though northbound approach now increase in delay of 45s  | westbound approach traffic in PM 526 PCU higher with mitigation, reassignment of traffic from Childs Way to A509  |
| Pineham  | AM Peak, 29s delay on east circulatory PM peak, 1 min 3s delay eastbound approach | Moderate                | AM Peak, 61s delay on east circulatory PM Peak 1min 9s eastbound approach  | Moderate     | Scenario 2b impact on northbound and southbound approaches and east circulatory      | AM Peak, east circulatory delay reduced by 45s but increase of 23s on north circulatory. But delays are more balanced around the junction<br>PM Peak, reduced delays on all approaches except northbound approach in PM | PM mitigation works well in prioritising east-west traffic, despite large flow increases westbound through the junction. This increase does cause more delay on the northbound approach to the junction in PM. The junction may perform better in the AM peak with adjusted signal timings, with greater green time for the eastbound traffic through the junction. |