HEREFORDSHIRE COUNCIL

Hereford Multi-Modal Model

Forecasting

Report

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Forecasting Report

Report

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Executive Summary

Background to the study

1.2 This study, commissioned by Herefordshire Council (HC) and the Highways Agency (HA), examines the implications of potential housing development up to 2026 as proposed in the Regional Spatial Strategy (RSS) and its impact on the road network within Hereford and its surrounding area.

What growth options and transport interventions have been tested?

1.3 Five growth options have been considered. The first uses the TEMPRO forecasts to predict changes in travel demand. The forecasts were modified slightly to take account of committed developments. The remaining growth options add additional trips to the TEMPRO forecasts to take account of additional housing proposed as part of the Government's Growth Point agenda. Four different distributions of housing allocations have been tested.

1.4 The impact of these additional trips on the highway network has been considered. An Outer Distributor Road (ODR) is proposed in order to alleviate some of the problems, in terms of network stress and congestion, which these additional trips could cause. Two general alignments for the ODR are tested and compared to a situation without the road.

The study's overall objectives

1.5 The objectives of the study can be summarised as follows:

- Determine the impact of national transport demand forecasts on the operation of the Hereford highway network;
- Investigate the effects of the additional housing requirements, and their allocations, on the operation of the highway network;
- Provide details of any relief to congestion provided by an Outer Distributor Road (ODR) running either to the west or to the east of the city;
- Identify areas of capacity constraint in terms of delay;
- Evaluate and compare network conditions under each scenario; and
- Assess the level of stress on the network in terms of network operation parameters and link flows.

The methodology adopted

1.6 Each modelled scenario has been assessed in terms of;

- Flow Relief – the number of vehicles using a particular stretch of road per hour. This indicates how busy a road is or the extent to which it is a popular route.
- Stress (Volume/Capacity) – is the traffic flow using a junction divided by the nominal capacity of the junction. Junctions at 85% of capacity and above are considered to be at critical usage and are likely to cause significant delays to vehicles using them.

- Link speed – speeds on links are affected by the level of traffic using the link and the operation of the junction at the end of the link. By assessing link speeds, it is possible to determine where congestion problems are likely to occur and to see what impacts the various scenarios have on network operation.

Findings – what are the impacts on the Local Highway Network?

1.7 The results of the model runs reveal the trips associated with the additional housing have a significant detrimental effect on the operation of the Hereford highway network. Many junctions are forecast to be operating beyond their capacities, link speeds are reduced and delays are commonplace.

1.8 Adding an Outer Distributor Road, on either alignment, is forecast to provide some relief from the adverse effects. The resulting network operation would be similar to that if the additional trips had not been introduced.

1.9 Of the four possible Growth Point housing and employment options, it is found that Option 3 (North-South focused) together with the ODR on the Eastern Alignment provides the lowest overall cost of travel within the highway network model.

1 Introduction

1.10 JMP Consultants Limited has been appointed by Herefordshire Council and the Highways Agency to undertake a study to determine the impacts on the local highway network of proposed housing development, and to determine whether the impacts on future highway conditions can be alleviated by implementation of the proposed Outer Distributor Road. A further consideration is which of two possible routes for the Outer Distributor Road provides the greater alleviation of capacity problems in the future.

1.11 The various options have been tested using JMP's recalibrated and revalidated Hereford Multi-Modal Model (2008). The model contains a representation of the transport system within Herefordshire by all modes of transport. A SATURN-based highway model contains a representation of the main roads within Hereford together with the strategic road network of Herefordshire.

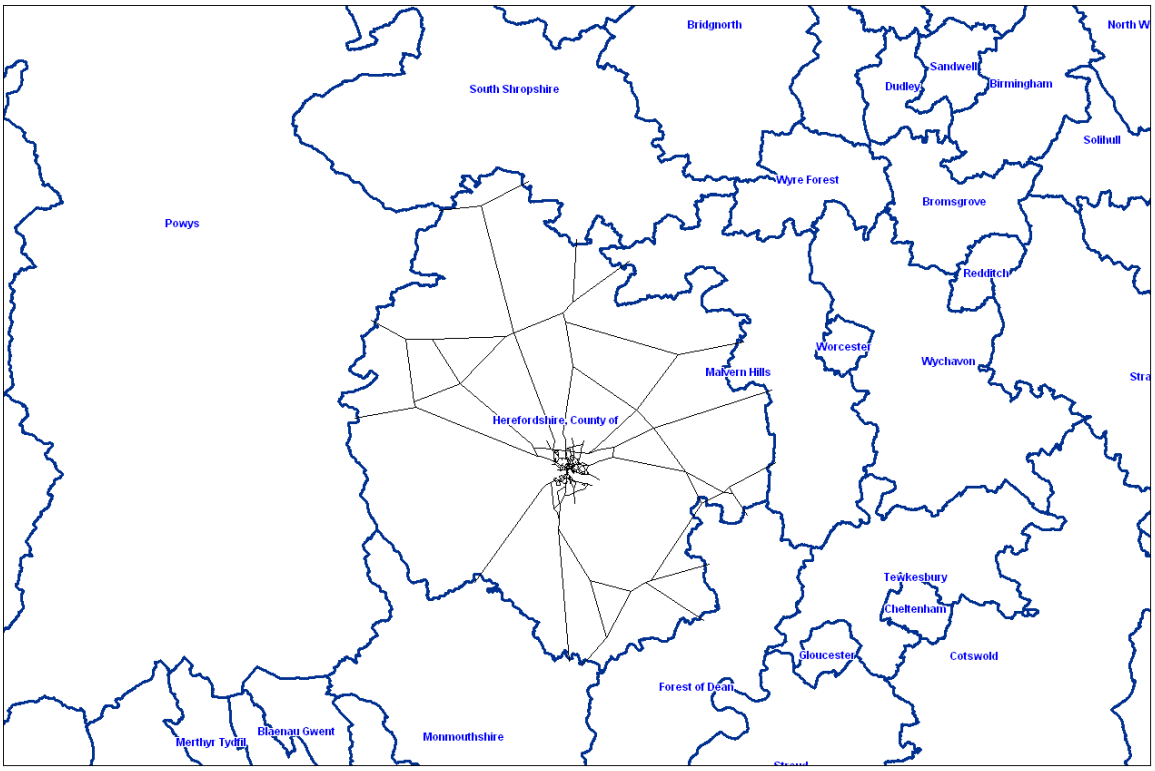
1.12 The Multi-Modal Model is based on three time periods; AM Peak (8am to 9am), an average Inter Peak hour (nominally 11am to midday) and the PM Peak (5pm to 6pm). For the current forecasting, however, only the AM and PM peak models were used.

1.13 The methodology used to test the various options uses the principles outlined in WebTAG to estimate changes in demand for travel by all modes in response to changes in the costs of travel by all modes. The methodology has been approved by Herefordshire Council's modelling advisors, Transport Planning International (TPi).

1.14 **Appendix A** is the glossary for this project, which provides a definition of the software and the terminology used throughout.

1.15 The extent of the highway model is shown in Figure 1-1 below. As can be seen, the model is focussed upon Hereford. Main roads leading to Hereford from the rest of Herefordshire are also included.

Figure 1-1 Highway Model Coverage



Summary of the objectives

1.16 The objectives of the study can be summarised as follows:

- Determine the impact of national transport demand forecasts on the operation of the Hereford highway network;
- Investigate the effects of the additional housing requirements, and their allocations, on the operation of the highway network;
- Provide details of any relief to congestion provided by an Outer Distributor Road (ODR) running either to the west or to the east of the city;
- Identify areas of capacity constraint in terms of delay;
- Evaluate and compare network conditions under each scenario; and
- Assess the level of stress on the network in terms of network operation parameters and link flows.

Report Structure

1.17 Following this introductory section, **Section 2** describes the forecasting methodology used; **Section 3** provides results of the mode-choice model; **Section 4** provides headline statistics for each modelled option, **Section 5** discusses the operation of the highway network in terms of flow relief, stress and average speed and junction delay, **Section 6** outlines how the preferred option was chosen and **Section 7** summarises the conclusions to be drawn.

2 Forecasting Methodology

Overview

2.18 Forecasts for a single future year of 2026 are required for the two time periods (AM and PM peak hours) in order to assess the likely impact of the proposed housing and employment developments upon the road network of Hereford. At the request of the client, the DIADEM program was used to forecast the changes in demand caused by the changes in highway infrastructure.

2.19 Five development scenarios have been tested:

- **2026 Do-Minimum Scenario:** Comprises of the 2008 Baseline factored to 2026 using TEMPRO growth factors.
- **2026 Do-Something 1, 2, 3 and 4 Scenarios**: Comprises of the 2026 Do Minimum Scenario with 605,000 sqm of employment / retail / office space and 8,300 additional dwellings in Hereford, and further 9,500 dwellings elsewhere in the county, with each Do Something development scenario having alternative locations for these dwellings.

2.20 For each development option, there will be three network infrastructure scenarios as follows:

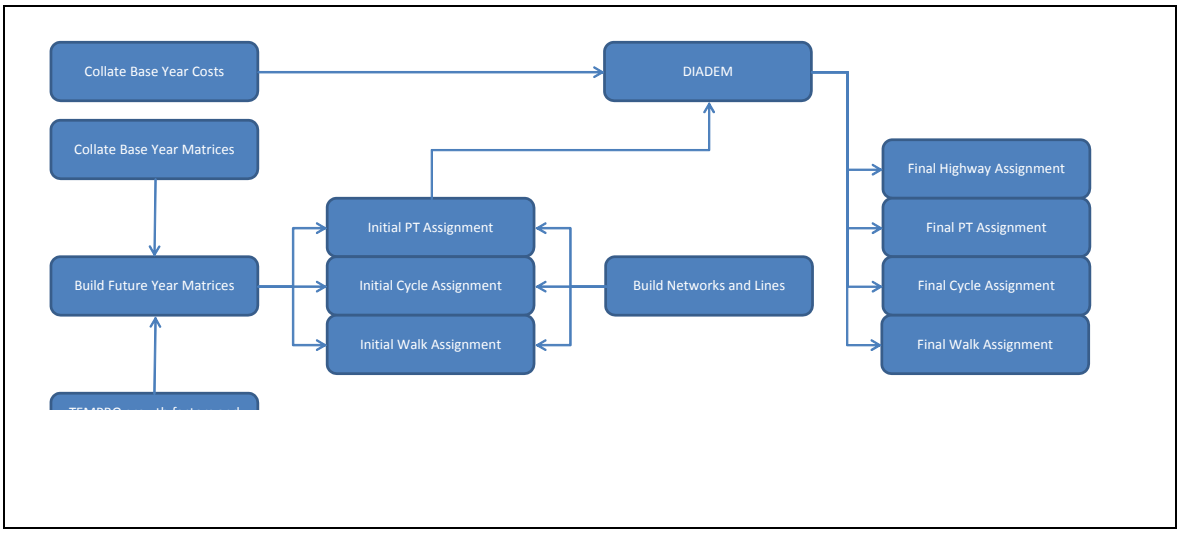
- No Outer Distributor Road (ODR)
- ODR on Western alignment
- ODR on Eastern alignment

2.21 The forecasting methodology has been developed in consultation with the Council's modelling advisors, Transport Planning International.

Outline Methodology

2.22 Figure 2-1 shows the outline methodology used in the forecasting model.

Figure 2-1 Outline Methodology



2.23 More details on the forecasting methodology are provided in the sections that follow.

Future Year Demand Matrices

Do-Minimum Scenario

2.24 The Future-Year demand matrices were built by factoring the base-year demand matrices, by time period and by mode, and then by adding trips associated with the proposed developments.

2.25 TEMPRO version 5.4 was used to provide zonal growth factors to update the base-year matrices to the forecast year of 2026. TEMPRO provides growth factors by time period and by mode (car driver, car passenger, bus, train, cycle and walk). The TEMPRO growth factors are shown in Appendix B.

2.26 In the Hereford Model, a single Public Transport model incorporates travel by bus and by train. In the Base Year model, many more trips are made by bus than train, so the growth factors for bus have been used to factor the Base Year public transport matrices.

2.27 Each of the zones of the transport model was allocated to one of the TEMPRO zones using GIS, thereby identifying the growth factors to be applied to each zone.

2.28 By applying the TEMPRO growth factors to the row and column totals from the base-year matrices, a set of future-year trip-ends were produced. These were then used by the TRIPS program MVGRAM to apply growth to the base-year matrices. The resulting matrices, therefore, contained the appropriate number of trips and the distribution of the trips was similar to that observed in the base-year matrices.

2.29 Growth factors for car passengers were used to estimate the average car-occupancy for the future-year. The average number of passengers per car trip for the Base Year was estimated from occupancy counts undertaken during the Roadside Interview Survey programme. The number of car drivers and car passengers in the Future Year was then found by applying the appropriate TEMPRO growth factors. Finally, the future year car occupancy was found from the numbers of future year drivers and future year passengers.

2.30 As TEMPRO only provides growth factors for TEMPRO zones, which are generally much larger than the model's zones, it is necessary to then adjust the TEMPRO growth factors in order to take account of committed developments. In such cases, estimates of the number trips associated with each committed development were obtained. The TRICS database was used to estimate the overall numbers of trips, by time period, entering and exiting the development. Modal splits were then found from the 2001 Census data for the ward containing the committed development. These were used to split the trips across the four modes of transport used in the model. A potential housing option for Hereford based upon Herefordshire Council's emerging Strategic Housing Land Availability Assessment (SHLAA) has been included in the TEMPRO growth scenario, as shown in Table 2-1 below.

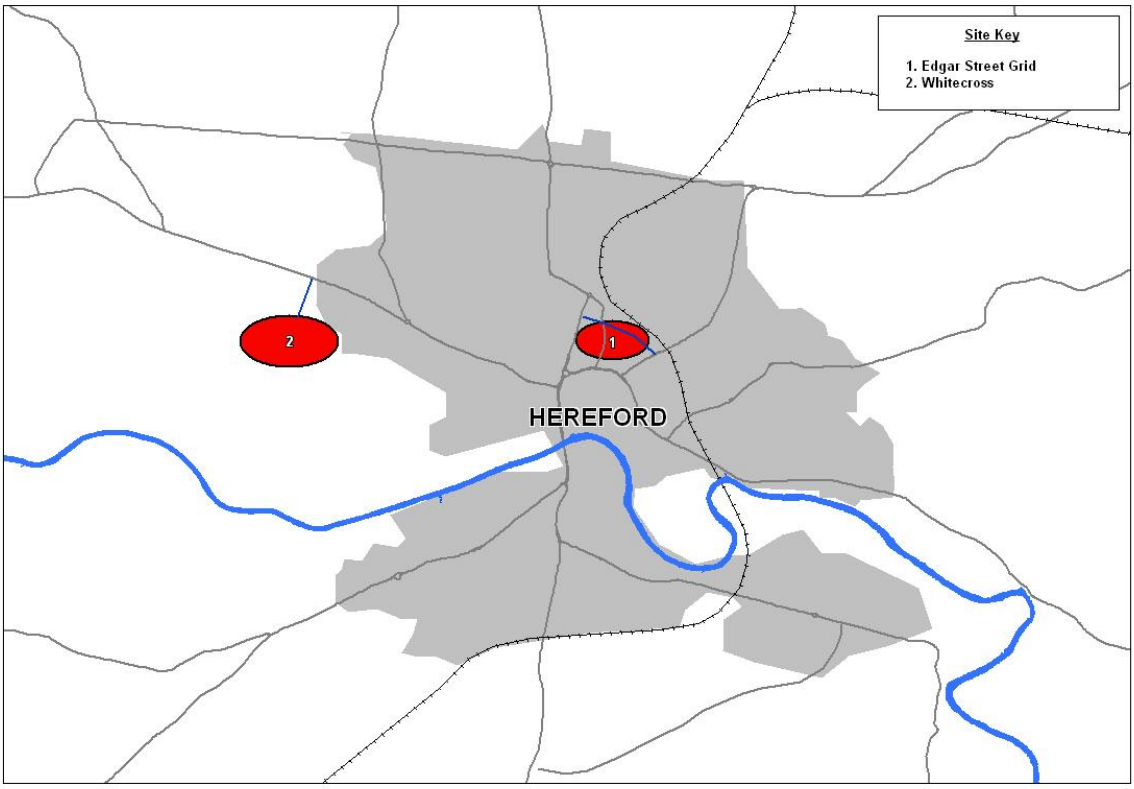
Table 2-1 Housing Assumptions in TEMPRO Scenario

Location	Number of Dwellings in TEMPRO Scenario
Whitecross	980
Edgar Street Grid	1000
Other Urban areas	500
Total	**2480**

Source: Herefordshire Council

2.31 The locations of the TEMPRO housing sites are shown in Figure 2-2 below.

Figure 2-2 - Locations of TEMPRO Housing Sites



2.32 The TEMPRO scenario assumes 500 additional houses would be distributed across the existing built-up area of Hereford. As such, the locations of these houses are not shown in the Figure above.

2.33 The trips associated with the developments were added to the relevant zones, and then the TEMPRO growth factors were adjusted so that the resulting numbers of trips matched those obtained by applying TEMPRO growth alone. This ensures that the committed development trips are not double-counted – i.e. the impacts of the developments would have been included in the TEMPRO growth factors and in the direct addition of the development-related trips.

2.34 A Park-and-Ride site, with up to 750 spaces, is proposed for the northern edge of Hereford. No current demand forecasts for the usage of the Park-and-Ride facility are available. The impact of the Park-and-Ride facility needed to be reflected in the demand forecasts, however. Therefore, it was assumed that in the AM Peak hour, 250 car users would chose to Park-and-Ride. 250 trips in the AM car matrix were identified as being likely to use a Park-and-Ride, as their origins were north of the site and their destinations were in the city centre. These trips were then moved in the demand matrix so that the car trips were between the original origin and the Park-and-Ride site. Similarly, additional trips, with their origins at the Park-and-Ride site and their destinations in the city centre, were added into the public transport matrix. For the PM peak, it was assumed that 250 car users would use the Park-and-Ride site in the outbound direction. The car and public transport matrices were altered accordingly.

2.35 This completed the building of the Do-Minimum, or TEMPRO Growth, demand matrices.

Do-Something Scenarios

2.36 For the Growth Point matrices, the trips associated with the additional housing and employment sites need to be included, as the impacts of these developments would not have been included in the TEMPRO forecasts.

2.37 Four distributions of the housing and employment sites have been developed by Herefordshire Council, based on the emerging SHLAA. These are known as the Do-Something development options and are denoted as DS1, DS2, DS3 and DS4.

2.38 Consequentially within the city of Hereford and the county of Herefordshire, the following sites, shown in **Table 2-2** below, have been identified.

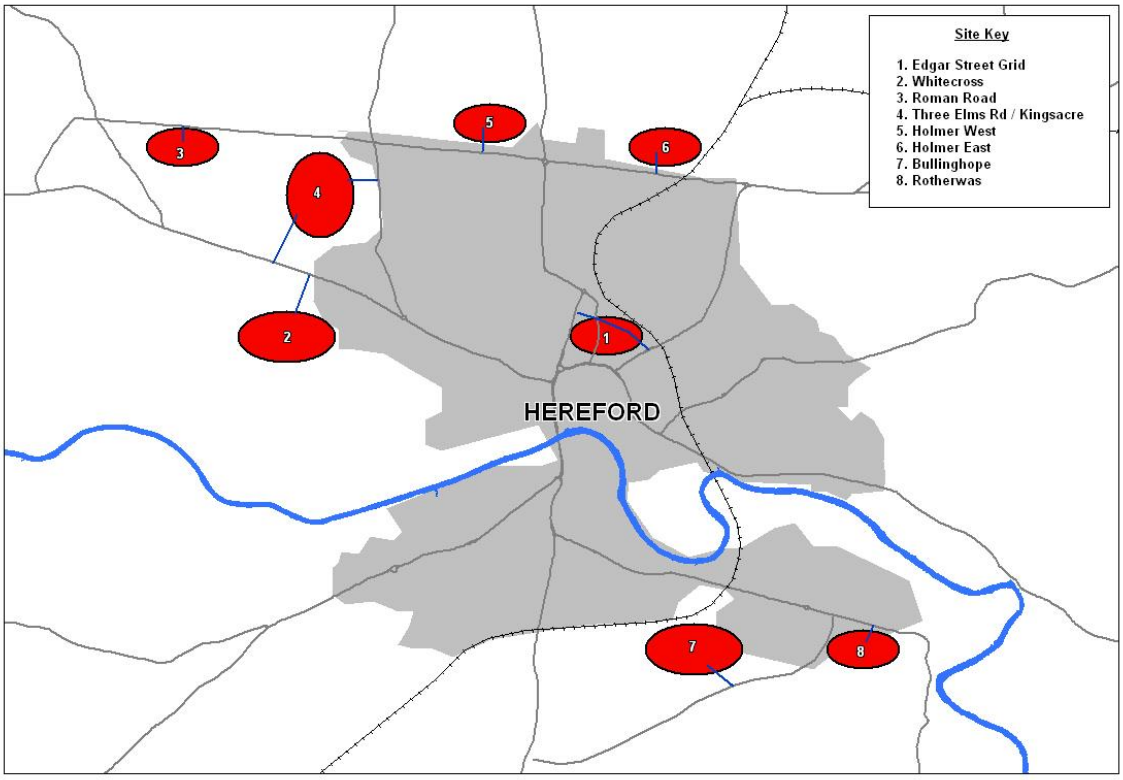
Table 2-2 Additional Dwellings Assumed for Growth Point Scenario

Housing options		DM	DS1 (North / West focus)	DS2 (South / West focus)	DS3 (North / South focus)	DS4 (Dispersed)
Hereford	Edgar St Grid	1000	1000	1000	1000	1000
	Whitecross	980	2000	2000		1500
	Three Elms Road / Kings Acre		2000	1500	2500	1500
	Bullinghope			1000	1000	1000
	Holmer West		500		500	500
	Holmer East				500	
	Other SHLAA Citywide distribution	500	1009	1009	1009	1009
	Total	**2480**	**6509**	**6509**	**6509**	**6509**
County (06 to 08)	**Built/Com Dev**	**1091**	**1091**	**1091**	**1091**	**1091**
Herefordshire	Other Urban Area Outer Hereford		1714	1714	1714	1714
	Rural Herefordshire		3070	3070	3070	3070
	Market Towns		3625	3625	3625	3625
	Total		**8409 (9,500)**	**8409 (9,500)**	**8409 (9,500)**	**8409 (9,500)**
	Grand Total	**2480**	**14,918 (17,800)**	**14,918 (17,800)**	**14,918 (17,800)**	**14,918 (17,800)**
Employment Options						
Hereford	Retail Comparison – Edgar St Grid		60,000 sqm	60,000 sqm	60,000 sqm	60,000 sqm
	Office – Edar St Grid		45,000 sqm	45,000 sqm	45,000 sqm	45,000 sqm
	Holmer East		150,000 sqm	150,000 sqm		150,000 sqm
	Rotherwas		250,000 sqm	250,000 qm	300,000 sqm	250,000 sqm
	Roman Road		100,000 sqm	100,000 sqm	150,000 sqm	100,000 sqm
	Grand Total		605,000 sqm	605,000 sqm	555,000 sqm*	605,000 sqm

*Supplied by Herefordshire Council - *assumes 5ha of additional employment land is found within city*

2.39 The development site locations are shown in Figure 2-3.

Figure 2-3 Locations of Proposed Development Sites



Herefordshire Council

2.40 These assumptions give 4,029 additional dwellings in the city in addition to those forecast by TEMPRO. The trips associated with these dwellings were forecast in the same way as in the Do-Minimum matrices.

2.41 Reflecting past trends, a further 1,714 dwellings are assumed to be built in zones just outside the existing built-up area of Hereford. Trips associated with these zones were forecast in the same way as in the Do-Minimum matrix building, and added to the Growth Point matrices.

2.42 Again based on past trends, 3,070 dwellings are assumed to be distributed across the zones covering the rural areas of Herefordshire. For these zones, the TEMPRO growth factors were adjusted in line with the additional housing to provide a set of adjusted growth factors.

2.43 Finally again based on past trends and reflecting the emerging SHLAA sites, 3,625 dwellings are assumed to be distributed across the market towns in Herefordshire (Leominster, Ross, Ledbury, Bromyard and Kington). Each of the market towns is allocated to a single zone in the transport model, so the growth factors for these zones were adjusted in line with the additional housing.

2.44 The Growth Point matrices were adjusted to take account of the Park-and-Ride site in the same way as the TEMPRO Growth matrices.

2.45 The outputs of the matrix building process were five sets of matrices; a Do-minimum set corresponding to the situation where growth forecast by TEMPRO is achieved, taking into account the locations of various specified developments; and four different Growth Point sets, where the

TEMPRO growth is supplemented by additional trips associated with the identified additional housing and employment sites.

2.46 The final step was to disaggregate the non-car matrices by car-availability. This is required by DIADEM, as only trips which have a car-available are able to switch between car and non-car modes. The public transport surveys undertaken in 2008 revealed that approximately 25% of public transport users had a car available. No corresponding information was available for the walk and cycle modes, so the same 25% proportion was assumed. TEMPRO is able to forecast changes in the proportion of households that have no cars, so these forecasts were used to estimate the proportion of non-car users with a car-available in the forecast year of 2026. The proportion used was 27.1%. The same factor was used for all non-car modes and for all time periods, in lieu of a more accurate figure.

2.47 These matrices are known as the reference matrices in the demand modelling. They represent the situation where the only changes to the matrices are caused by exogenous growth and no trips are induced or deterred by changes to the transport system.

2.48 The numbers of trips in each matrix are shown in Table 2-3 and Table 2-4 below.

Table 2-3 Morning Peak - Total Person Trips

Mode	Base	DM	DS1	DS2	DS3	DS4
Car	19,921	21,725	27,059	27,129	27,030	27,178
PT (Bus + Rail)	3,005	3,168	3,503	3,478	3,385	3,447
Cycle	850	825	1,177	1,152	1,165	1,140
Walk	6,043	5,946	6,510	6,492	6,637	6,487
Total	**29,818**	**31,664**	**38,249**	**38,251**	**38,217**	**38,252**

Table 2-4 Evening Peak - Total Person Trips

Mode	Base	DM	DS1	DS2	DS3	DS4
Car	21,053	23,357	28,077	28,140	28,068	28,183
PT (Bus + Rail)	2,025	2,271	2,569	2,548	2,468	2,520
Cycle	863	861	1,176	1,154	1,166	1,144
Walk	8,365	8,673	9,175	9,159	9,287	9,154
Total	**32,306**	**35,162**	**40,997**	**41,001**	**40,989**	**41,001**

2.49 As can be seen, there are many more trips in the Growth Point (DS) matrices than in the Do-Minimum matrices, as would be expected. The matrices for the Do-Something options all contain a similar number of trips. Do-Something option 3 contains slightly fewer trips as, for this option, 5ha of employment is assumed to be found across the city of Hereford, rather than in a specified location. This results in some trips associated with the 5ha of employment land being inter-zonal (i.e. the origin and destination of the trip is same zone), and therefore these trips are not included in the matrix totals. The difference is minor, however, with the DS3 matrices containing only about 30 fewer trips than the other options in the AM Peak, and only 13 fewer in the PM.

2.50 For LGV and HGV trips, the forecast year demand matrices were found by applying the NTM growth factors to the base-year matrices. The same LGV and HGV matrices were used in all the growth scenarios. The factors used were 1.50 for LGV trips and 1.16 for HGV trips.

Future-Year Transport Networks

2026 Do-Minimum (DM) Scenario

2.51 The Do-Minimum networks represent a future situation where only committed transport schemes are implemented. The transport schemes to be included in the Do-Minimum networks, therefore, were derived in consultation with Herefordshire Council.

Highway Model

2.52 The Do-Minimum 2026 highway network adds the following schemes to the Base Year networks;

- Edgar Street Grid (ESG) highway works
- A Park-and-Ride site located close to Hereford Racecourse, with access taken from a signalised junction on the A4103 (Roman Road).
- Access to new housing development at Whitecross, identified in the Do-Minimum housing scenario.

2.53 The ESG proposal includes a new link road running between Commercial Road and Edgar Street. A drawing of the latest proposals for this link was used to code the new route into the SATURN model. The proposals also include the modification of a section of the Inner Ring Road (Blue School Street and Newmarket Street) to make it more pedestrian friendly. This was coded by reducing the coded link speed to 20kph and reducing the capacity of the associated links to 800 pcu/hour each way. The roundabout junctions on Newtown Road were modified slightly, in order to provide slightly more capacity.

2.54 The access to a potential housing site at Whitecross was coded. It was assumed that the housing would be accessed from a new junction on Kings Acre Road, close to the existing junction with Huntington Lane. Likewise, a new signalised junction was added to Roman Road to give access to the proposed Park-and-Ride site.

2.55 As recommended in the SATURN documentation, the signal optimisation routine with the SATURN program was used to determine appropriate settings for the traffic signals in the Future Year networks. This ensures that the signal settings in the model are appropriate for the anticipated traffic flows, whilst maintaining the present day inter-green times.

Public Transport model

2.56 The public transport network was updated by adding the Edgar Street Grid highway works and the access to the Whitecross housing site. No further changes were made.

2.57 The public transport lines were assumed to be unchanged from the base-year case. It was assumed that bus fares would rise in line with forecast growth in GDP per capita. WebTAG acknowledges that forecasting changes to bus fares is difficult, so it was assumed that the fares would rise in line with GDP per capita as this acts as a proxy for rises in average incomes, including the incomes of those employed by the bus operators.

2.58 Rail and coach fares were assumed to rise at a rate of 1% per annum in real terms as growth in regulated rail fares is capped at 1% per annum by the DfT and it was assumed that coach fares would grow at a similar rate, as coach travel is usually in competition with rail for inter-urban journeys.

Cycle Model

2.59 The Edgar Street Grid works and the access to the housing site at Whitecross were incorporated into the future year cycle model. No other changes were made.

Walk Model

2.60 Likewise, the Edgar Street Grid works and the Whitecross access were incorporated into the Walk model.

Do-Something (DS) Scenarios

Highway Model

2.61 The various Do-Something networks were created by adapting the Do-Minimum networks.

2.62 The Do-Something networks included accesses to the possible housing and employment sites as follows;

- The Roman Road employment site was assumed to be accessed from a new junction on Roman Road, approximately 1km east of the Stretton Sugwas roundabout;
- The Holmer West housing site was assumed to be accessed via the proposed signalised junction on Roman Road, opposite Hereford Racecourse;
- The Holmer East housing / employment site was assumed to be accessed via a new junction on Roman Road, located between the College Road junction and the railway bridge.
- The Three Elms housing site was assumed to be accessed via a roundabout junction on Three Elms Road, replacing the existing junction with Grandstand Road; and from a new junction on Kings Acre Road. In the scenario with the Western Outer Distributor Road in place, a junction on the ODR would give access to the site in place of the junction on Three Elms Road;
- The Bullinghope housing site was assumed to be accessed from a new junction on the Rotherwas Access Road;
- The Rotherwas employment site was assumed to be accessed from a new junction on the B4399 (The Straight Mile), east of the junction with the Rotherwas Access Road.

2.63 For each development scenario, the relevant accesses were incorporated into the model networks.

2.64 Separate Do-Something networks were created to represent the situations with two possible alignments of the ODR: the ODR on a western alignment and the ODR on an eastern alignment.

2.65 The new roads were assumed to be 7.3m single carriageways with an unrestricted speed limit. Roundabout junctions were coded at the points where the new roads intersected the main roads of the existing network. It is acknowledged that the final arrangements for such junctions are not decided. Roundabouts were coded in order to provide a suitable junction, without having to determine signal settings, number of lanes, etc. Each roundabout was coded as having a two-lane circulatory carriageway and two-lane entries. Again, these are just assumptions and do not imply that the actual road should have such junctions. The final layouts of the junctions would be developed as the planning of the road progress.

2.66 The indicative alignments of the two options for the Outer Distributor Road are shown in Figures Figure 2-4 and Figure 2-5 below.

Figure 2-4 Indicative Alignment of Western ODR

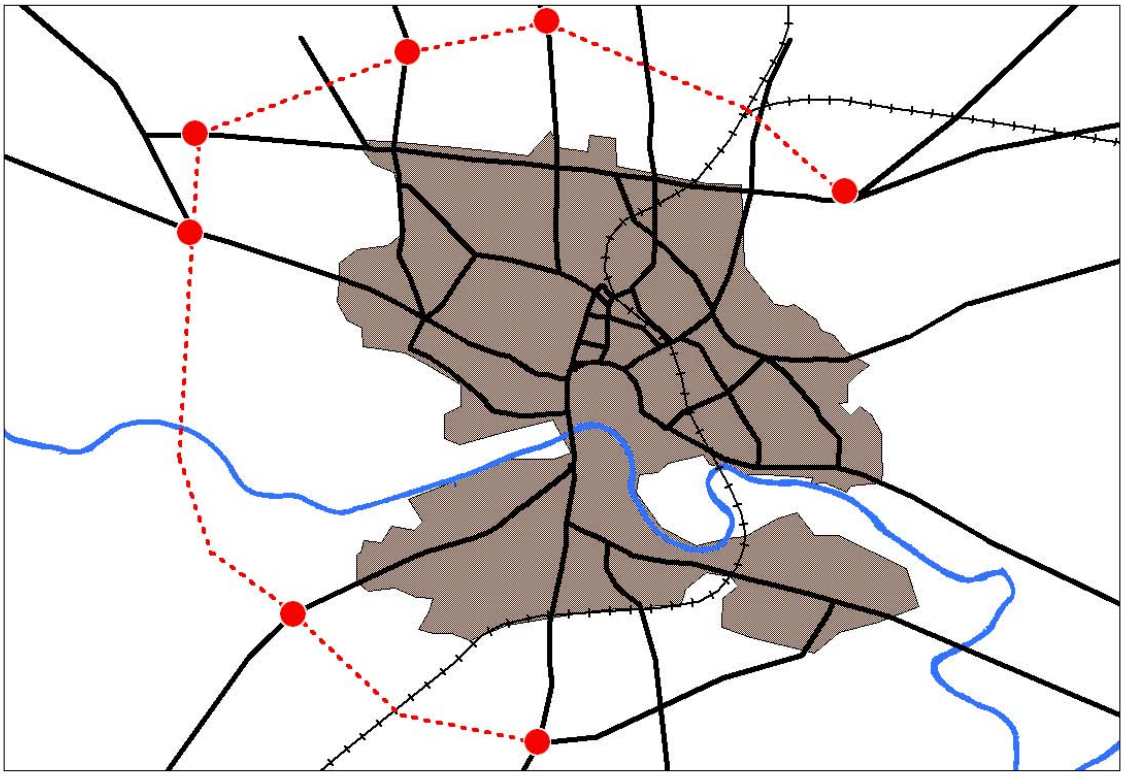
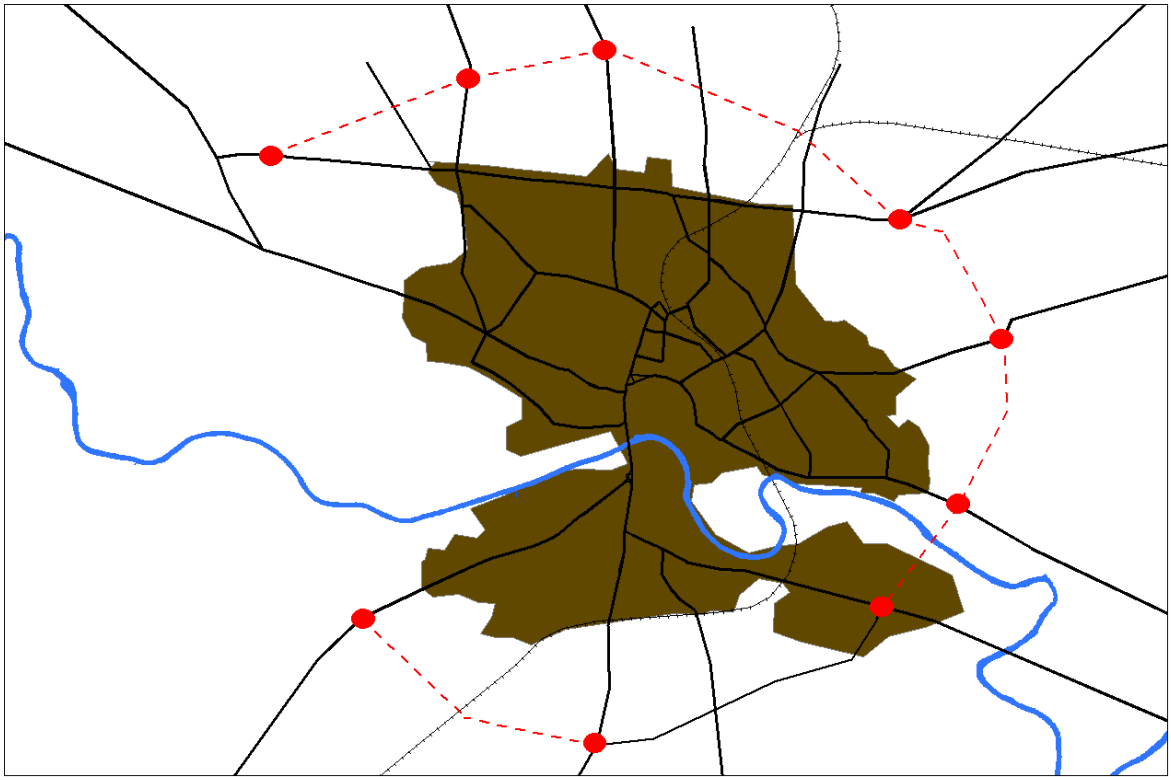


Figure 2-5 Indicative Alignment of Eastern ODR



2.67 In total, fifteen different Future Year networks were created for each modelled time period, representing all possible combinations of development options (Do-Minimum, Do-Somethings 1 to 4) and network infrastructure options (Do-Minimum (No ODR), West ODR and East ODR).

Public Transport Networks

2.68 The new roads were added to the public transport networks. No changes to public transport services were made.

Walk and Cycle Networks

2.69 The new roads were also added to both the cycle and walk networks. No other changes were made to the models for these modes.

Initial Assignments

2.70 For the public transport, cycle and walk modes, the reference case matrices were assigned to the corresponding networks and a set of future-year cost skims were produced. These are required as an input to DIADEM.

2.71 DIADEM only can estimate mode-split between car and a single alternative mode, known as “PT” in DIADEM. In the case of the Hereford model, it is necessary for DIADEM to estimate the mode split between car and the three non-car modes. Therefore, it is necessary to supply a set of non-car costs, made up of the costs of travel by the three non-car modes. The minimum of the public transport, cycle and walk costs was used. This ensures that the when the mode-choice calculations are performed, travel by car is compared to the best option of the three non-car modes. In order to prevent the mode-choice model producing unrealistically long walk and cycle trips, in cases where the walk or cycle travel time was over 60 minutes, only the public transport travel time was used.

DIADEM

2.72 The DIADEM program requires the following inputs;

- Reference Case car demand
- Reference Case non-car demand, split by car availability
- Reference Case car costs
- Reference Case non-car costs
- Forecast non-car costs

2.73 DIADEM then estimates changes to the Forecast Year demand matrices. In this case, DIADEM models the mode-choice of those with a car-available and the destination choice of all users, in response to changes in the highway network. In essence, if highway conditions worsen, users will respond by choosing to travel to closer destinations or by shifting to an alternative mode.

2.74 As no surveys had been undertaken to determine the likely responses to changed travelling conditions, the following parameters, taken from WebTAG Unit 3.10.3, were used in DIADEM

- Mode Split scaling parameter 0.85
- Highway destination choice sensitivity -0.16
- Public transport destination choice sensitivity -0.05.

2.75 A doubly-constrained distribution model was used. This ensures that, whilst individual cells in the demand matrices may change, the row and column totals remain constant.

2.76 These parameters were determined in conjunction with the council's modelling advisors. More details on this process and the resulting realism tests are provided in the Forecasting Methodology Report.

2.77 Those with no-car available can only respond by choosing to travel to different destinations.

2.78 At the end of the DIADEM run, the final SATURN highway assignment is available for inspection. The matrices of demand for the non-car modes, split by car-availability, are produced. These matrices are then split across the three non-car modes using an incremental mode-choice model. This is not strictly in line with WebTAG guidance. WebTAG proposes that destination-choice is performed after mode-choice in the model hierarchy. In the DIADEM model, the destination-choice is indeed performed after the choice of mode, but the choice of mode is only between „car' and „non-car'. The mode-choice between the non-car modes is necessarily performed after the DIADEM model has performed destination choice. This may give rise to slightly unrealistic splits between the non-car modes. As these tests are primarily concerned with the impacts on the highway network, the split between the non-car modes are of lower importance. If, however, the model is to be used to forecast the impacts of improvements to the non-car modes, the demand modelling will have to be modified. It will be necessary to dispense with the use of DIADEM and use a custom-built model that can perform the split between all four modes of transport before modelling any changes in trip-distributions.

2.79 The resulting non-car matrices were then assigned to the corresponding networks to produce the final public transport, cycle and walk assignments.

3 Modal Split

3.80 As mentioned previously, the reference forecast demand matrices for each scenario are developed using growth factors from TEMPRO and from assumptions regarding future housing and employment developments. The model includes a demand model, containing a DIADEM mode-choice component, which allows modal shift and results in a set of new demand matrices which may be different from the reference matrices. Thus, a new demand matrix for each modelled mode (i.e. car, public transport, cycle and walk) is obtained after running the demand model for each scenario. The new demand matrices are then assigned to the respective network to produce the forecasts of travelling conditions under each scenario.

3.81 Table 3-1and Table 3-2 show the final forecast person trip totals for car, public transport, cycle and walk demand matrices obtained from demand model for each modelled scenario for the AM and PM Peak models respectively. For comparison, the total trips from the validated AM and PM Base Year models are also included.

Table 3-1 Morning Peak - Total Person Trips

Scheme	Mode	Demand Scenario				
		DM	DS1	DS2	DS3	DS4
Base	Car	19,921				
	PT	3,005				
	Cycle	850				
	Walk	6,043				
	Total	**29,818**				
No ODR	Car	21,840	26,992	27,068	27,024	27,126
	PT	2,795	3,123	3,102	3,009	3,072
	Cycle	863	1,240	1,217	1,208	1,201
	Walk	6,173	6,896	6,866	6,976	6,855
	Total	**31,671**	**38,250**	**38,253**	**38,216**	**38,254**
West ODR	Car	21,914	27,185	27,235	27,160	27,293
	PT	2,764	3,050	3,039	2,954	3,008
	Cycle	858	1,222	1,200	1,203	1,185
	Walk	6,139	6,799	6,785	6,905	6,775
	Total	**31,675**	**38,256**	**38,258**	**38,221**	**38,260**
East ODR	Car	21,962	27,209	27,278	27,195	27,336
	PT	2,736	3,030	3,012	2,934	2,981
	Cycle	845	1,196	1,172	1,186	1,158
	Walk	6,135	6,817	6,792	6,901	6,781
	Total	**31,678**	**38,252**	**38,254**	**38,216**	**38,256**

Table 3-2 Evening Peak - Total Person Trips

Scheme	Mode	Demand Scenario				
		DM	DS1	DS2	DS3	DS4
Base	Car	21,053				
	PT	2,025				
	Cycle	863				
	Walk	8,365				
	Total	**32,306**				
No ODR	Car	23,440	28,026	28,083	28,042	28,126
	PT	2,014	2,307	2,289	2,208	2,263
	Cycle	895	1,236	1,217	1,191	1,204
	Walk	8,817	9,430	9,411	9,548	9,410
	Total	**35,166**	**40,998**	**41,001**	**40,989**	**41,003**
West ODR	Car	23,578	28,213	28,282	28,178	28,290
	PT	1,967	2,233	2,227	2,152	2,199
	Cycle	869	1,195	1,180	1,166	1,167
	Walk	8,758	9,364	9,373	9,497	9,353
	Total	**35,171**	**41,005**	**41,063**	**40,994**	**41,007**
East ODR	Car	23,599	28,267	28,311	28,228	28,360
	PT	1,951	2,211	2,198	2,155	2,170
	Cycle	864	1,166	1,147	1,144	1,136
	Walk	8,758	9,359	9,350	9,468	9,343
	Total	**35,172**	**41,003**	**41,006**	**40,994**	**41,008**

3.82 Comparison of the No-ODR Do-Minimum trip totals with those of the Base Year shows how demand for travel is forecast to change by application of the TEMPRO forecasts. For example, in the AM Peak, demand for travel is forecast to rise by 6.2%. This increase is not uniform across all modes, however. Demand for travel by car is forecast to rise by 9.6, whilst travel by public transport is forecast to fall by 7%. A similar pattern is seen in the PM Peak, with demand for travel forecast to rise by 8.9% - car travel is forecast to rise by 11.3%, with public transport use falling by 0.7%.

3.83 The tables show how overall demand does not change significantly in response to the provision of either alignment of the ODR. This is as expected, as the guidance in WebTAG states that overall trip-making, when all modes are considered, does not usually alter in response to altered travelling conditions. The same numbers of trips are assumed to be made, but the mode used or the destination chosen may change. The slight differences in matrix totals are due to rounding errors in the matrix calculations.

3.84 Recall that Table 2-3 and Table 2-4 show the forecast total demand by mode as forecast by TEMPRO, under the assumption that travel costs do not change from those of the Base Year.

These are known as the Reference Case demands. The figures in Table 3-1 and Table 3-2 show the forecast demands after the application of the changes in costs due to the forecast levels of congestion on the network as well as changes in public transport fares, vehicle operating costs (including the cost of fuel) and Values of Time.

3.85 In the situation without an ODR and with only the TEMPRO demand, the model predicts a slight shift away from public transport, with the trips transferring to the car and walk modes. This is not unexpected, as the forecast costs of public transport are expected to increase due to increased congestion leading to increased journey times, fares are forecast to increase and traveller's value of time is forecast to grow. All these factors lead to public transport costs increasing at a rate higher than that for the other modes. As the proportion of travellers with a car available is also forecast to increases, it is not surprising that public transport usage is forecast to fall. The fall in public transport usage is accompanied by a complementary increase in usage of the other modes.

3.86 With the additional demand associated with the Do-Something options and no ODR, a shift away from car observed as well as the shift away from public transport. These trips transfer to the walk and cycle modes.

3.87 The provision of an ODR, on either alignment, leads to a shift of demand towards car and tends to increase the fall in demand for public transport. The travel times by cycle, for some trips, are reduced by the inclusion of an ODR, as the ODR provides another crossing of the River Wye, thereby shortening the travel distance between certain areas. For example, provision of the Eastern ODR reduces the travel distance between the Hampton Park residential area and the Rotherwas employment area, cycling (and walking to a lesser extent) a realistic option for trips between these areas.

4 Model Performance Statistics

4.88 Model performance statistics were collected for all modes after assigning the demand matrices obtained from the demand model.

Non-Highway Models

4.89 The following service indicators are used to assess the PT, cycle and walk model performance:

- Total Distance (measured in person-kilometres)
- Total Time (measured in person-hours)

4.90 The comparison of total distance travelled within the modelled network (Herefordshire County) for the AM model is shown in Table 4-1.

Table 4-1 Morning Peak - Comparison of Total Distance Travelled (person-kilometres)

Scheme	Mode	Sub-Mode	Demand Scenario				
			DM	DS1	DS2	DS3	DS4
No ODR	PT	Bus	7,480	8,433	8,363	8,093	8,317
		Coach	396	417	405	420	401
		Rail	27,022	27,811	27,718	27,883	27,664
		Sub-Total	**34,899**	**36,661**	**36,486**	**36,396**	**36,382**
	Cycle		1,629	2,582	2,537	2,354	2,478
	Walk		9,953	11,666	11,591	11,803	11,579
	Total		**46,481**	**50,909**	**50,614**	**50,553**	**50,439**
Western ODR	PT	Bus	7,389	8,195	8,169	7,918	8,114
		Coach	388	399	396	408	393
		Rail	26,728	27,563	27,506	27,605	27,446
		Sub-Total	**34,505**	**36,157**	**36,071**	**35,932**	**35,953**
	Cycle		1,608	2,516	2,482	2,332	2,425
	Walk		9,868	11,440	11,412	11,662	11,397
	Total		**45,981**	**50,113**	**49,965**	**49,926**	**49,775**
Eastern ODR	PT	Bus	7,336	8,141	8,088	7,891	8,038
		Coach	412	442	439	418	435
		Rail	26,458	27,356	27,290	27,238	27,240
		Sub-Total	**34,206**	**35,939**	**35,817**	**35,547**	**35,712**
	Cycle		1,573	2,433	2,395	2,285	2,340
	Walk		9,817	11,388	11,336	11,604	11,321
	Total		**45,596**	**49,760**	**49,548**	**49,436**	**49,373**

4.91 For the non-car modes, it can be seen that the addition of an ODR, on either alignment, leads to slight fall in the distance travelled by public transport and by cycle. The changes in distance travelled by foot are insignificant.

4.92 The comparison for the PM model is shown in Table 4-2.

Table 4-2 Evening Peak - Comparison of Total Distance Travelled (person-kilometres)

Scheme	Mode	Sub-Mode	Demand Scenario				
			DM	DS1	DS2	DS3	DS4
No ODR	PT	Bus	6,080	7,252	7,186	6,867	7,165
		Coach	0	0	0	0	0
		Rail	13,714	14,852	14,740	14,643	14,686
		Sub-Total	**19,794**	**22,103**	**21,925**	**21,509**	**21,851**
	Cycle		1,728	2,626	2,585	2,386	2,546
	Walk		13,812	15,298	15,273	15,372	15,288
	Total		**35,334**	**40,027**	**39,783**	**39,267**	**39,685**
Western ODR	PT	Bus	5,656	6,656	6,644	6,384	6,605
		Coach	0	0	0	0	0
		Rail	13,721	14,793	14,728	14,635	14,662
		Sub-Total	**19,377**	**21,449**	**21,372**	**21,019**	**21,266**
	Cycle		1,660	2,507	2,470	2,318	2,435
	Walk		13,614	15,037	15,057	15,171	15,037
	Total		**34,651**	**38,993**	**38,899**	**38,508**	**38,738**
Eastern ODR	PT	Bus	5,810	6,747	6,705	6,530	6,659
		Coach	0	0	0	0	0
		Rail	13,475	14,604	14,505	14,478	14,359
		Sub-Total	**19,286**	**21,351**	**21,210**	**21,009**	**21,018**
	Cycle		1,645	2,405	2,365	2,235	2,330
	Walk		13,594	14,933	14,923	15,079	14,924
	Total		**34,525**	**38,689**	**38,498**	**38,323**	**38,272**

4.93 As in the AM Model, it can be seen that in the PM model, the addition of an ODR leads to a slight fall in passenger kilometres for the public transport and cycle modes. There is also a slight fall in the distance travelled by foot.

4.94 Table 4-3 and Table 4-4 show the comparison of total travel time by non-car modes across the scenarios and time periods.

Table 4-3 Morning Peak - Comparison of Total Travel Time (person-hours)

Scheme	Mode	Sub-Mode	Demand Scenario				
			DM	DS1	DS2	DS3	DS4
No ODR	PT	Bus	542	614	611	584	606
		Coach	6	6	6	6	6
		Rail	303	313	312	313	311
		Sub-Total	**850**	**933**	**928**	**902**	**922**
	Cycle		109	172	169	157	165
	Walk		2,488	2,917	2,898	2,951	2,895
	Total		**3,447**	**4,021**	**3,995**	**4,010**	**3,982**
Western ODR	PT	Bus	536	598	598	572	592
		Coach	6	6	6	6	6
		Rail	300	310	310	310	309
		Sub-Total	**842**	**914**	**913**	**888**	**906**
	Cycle		107	168	165	155	162
	Walk		2,467	2,860	2,853	2,916	2,849
	Total		**3,416**	**3,942**	**3,932**	**3,959**	**3,917**
Eastern ODR	PT	Bus	534	596	593	572	587
		Coach	6	6	6	6	6
		Rail	296	307	306	305	306
		Sub-Total	**836**	**909**	**905**	**883**	**899**
	Cycle		105	162	160	152	156
	Walk		2,454	2,847	2,834	2,901	2,830
	Total		**3,395**	**3,918**	**3,899**	**3,937**	**3,885**

Table 4-4 Evening Peak - Comparison of Total Travel Time (person-hours)

Scheme	Mode	Sub-Mode	Demand Scenario				
			DM	DS1	DS2	DS3	DS4
No ODR	PT	Bus	342	408	405	376	402
		Coach	0	0	0	0	0
		Rail	147	159	158	157	157
		Sub-Total	**489**	**567**	**563**	**533**	**559**
	Cycle		115	175	172	159	170
	Walk		3,453	3,825	3,818	3,843	3,822
	Total		**4,057**	**4,567**	**4,553**	**4,535**	**4,551**
Western ODR	PT	Bus	323	381	380	355	376
		Coach	0	0	0	0	0
		Rail	147	159	158	157	157
		Sub-Total	**470**	**539**	**538**	**512**	**533**
	Cycle		111	167	165	155	162
	Walk		3,404	3,759	3,764	3,793	3,759
	Total		**3,984**	**4,466**	**4,467**	**4,459**	**4,455**
Eastern ODR	PT	Bus	332	386	384	363	380
		Coach	0	0	0	0	0
		Rail	144	156	155	155	154
		Sub-Total	**477**	**543**	**539**	**518**	**534**
	Cycle		110	160	158	149	155
	Walk		3,398	3,733	3,731	3,770	3,731
	Total		**3,985**	**4,436**	**4,428**	**4,437**	**4,420**

4.95 Again, it can be seen that there is a small reduction in the total travel time for the non-car modes when an ODR is added to each demand scenario.

4.96 The 2026 highway network is capable of handling traffic predicted due to the proposed network improvements. The highway network is congested in 2026, however it is not extremely congested. On the contrary public transport services have not been improved in the future scenarios and the public transport fares have been increased. For this reason minimal modal shift was observed.

Highway Model

4.97 The highway models have been assessed based on network conditions using such measures as average speed, delays, and queues in the network. In SATURN, time spent in „Transient Queues' is defined as the time spent negotiating a junction when the junction is operating within its capacity. This time includes time spent waiting at red traffic signals, „geometric delays' at priority junctions and roundabouts (this is the time taken to slow down in order to negotiate the junction safely, and the time needed to accelerate back to a normal cruising speed), and the time spent circulating a roundabout.

4.98 Over-capacity queues are defined as those queues that develop when a junction is operating beyond its capacity. Link delays are delays caused when traffic using a link is such that the speed of that traffic is below the normal cruising speed of the link.

4.99 For comparison purposes, the network summary statistics for the Base Year models are shown in Table 4-5

Table 4-5 Highway Network Performance Statistics (Simulated Area)- Base Year Model

Indicator	AM Peak	PM Peak
Total Time / hrs	1,923	2,183
Transient Queues / hrs	673	823
Over Capacity Queues / hrs	20	82
Link Delays / hrs	31	29
Total Distance / km	61,348	63,310
Total Trips Loaded / pcu	15,802	16,414
Average Speed / kph	31.9	29.0

source: SATURN Model

4.100 The comparisons of network performance for the AM and PM Future Year models are shown in Table 4-6 and Table 4-7 below.

Table 4-6 Morning Peak - Summary of Highway Network Performance (Simulated Area)

Scheme	Indicators	Demand Scenario				
		DM	DS1	DS2	DS3	DS4
No ODR	Total Time / hrs	2,254	3,033	3,042	2,866	3,030
	Transient Queues / hrs	832	1,208	1,206	1,136	1,186
	Over-Capacity Queues/ hrs	10	155	149	83	161
	Link Delays / hrs	43	73	73	66	72
	Total Distance / km	69,134	80,802	82,082	80,480	81,965
	Total Trips Loaded / pcu	18,043	21,620	21,673	21,644	21,714
	Average Speed / kph	30.7	26.6	27.0	28.1	27.1
Western ODR	Total Time / hrs	2,050	2,672	2,657	2,574	2,657
	Transient Queues / hrs	634	898	893	875	892
	Over-Capacity Queues/ hrs	0	17	9	10	11
	Link Delays / hrs	40	93	90	74	88
	Total Distance / km	76,309	94,366	94,570	90,735	94,672
	Total Trips Loaded / pcu	18,099	21,767	21,802	21,750	21,842
	Average Speed / kph	37.2	35.3	35.6	35.3	35.6
Eastern ODR	Total Time / hrs	2,017	2,614	2,643	2,516	2,624
	Transient Queues / hrs	599	850	866	810	855
	Over-Capacity Queues/ hrs	0	17	18	4	10
	Link Delays / hrs	62	115	119	93	117
	Total Distance / km	76,208	92,010	92,947	90,622	93,026
	Total Trips Loaded / pcu	18,133	21,783	21,831	21,773	21,872
	Average Speed / kph	37.8	35.2	35.2	36.0	35.4

Table 4-7 Evening Peak - Summary of Highway Network Performance (Simulated Area)

Scheme	Indicators	Demand Scenario				
		DM	DS1	DS2	DS3	DS4
No ODR	Total Time / hrs	2,571	3,246	3,306	3,088	3,272
	Transient Queues / hrs	1,005	1,231	1,278	1,214	1,248
	Over-Capacity Queues/ hrs	100	324	324	216	324
	Link Delays / hrs	43	71	70	65	72
	Total Distance / km	71,743	82,641	83,586	81,480	83,503
	Total Trips Loaded / pcu	19,104	22,263	22,274	22,278	22,331
	Average Speed / kph	27.9	25.5	25.3	26.4	25.5
Western ODR	Total Time / hrs	2,336	2,896	3,141	2,824	2,863
	Transient Queues / hrs	796	991	1,080	991	977
	Over-Capacity Queues/ hrs	28	97	164	95	71
	Link Delays / hrs	47	96	119	76	98
	Total Distance / km	81,117	97,074	101,775	93,497	97,652
	Total Trips Loaded / pcu	19,213	22,417	22,453	22,393	22,467
	Average Speed / kph	34.7	33.5	32.4	33.1	34.1
Eastern ODR	Total Time / hrs	2,296	2,883	2,937	2,772	2,937
	Transient Queues / hrs	763	982	1,025	926	1,018
	Over-Capacity Queues/ hrs	10	87	92	87	91
	Link Delays / hrs	65	120	124	103	125
	Total Distance / km	81,315	96,085	96,290	93,518	96,730
	Total Trips Loaded / pcu	19,226	22,452	22,481	22,424	22,515
	Average Speed / kph	35.4	33.3	32.8	33.7	32.9

4.101 The default Future Year model is the situation with the Do-Minimum demand and the No ODR network. Comparison of the network statistics for this scenario with the Base Year model reveals how the model predicts conditions of the highway network will change if the Growth Point housing and employment sites are not developed and the ODR is not built.

4.102 This comparison reveals a general worsening of travelling conditions, with average speeds falling from 31.9kph to 30.7kph in the AM Peak, and from 29.0kph to 27.9 kph in the PM Peak.

4.103 The „No ODR' rows in each table show how the highway network reacts with the additional trips associated with the additional housing and employment development if the ODR were not to be built. In the AM model, transient queues, over-capacity queues and link delays are all forecast to increase, leading to a fall in average network speeds.

4.104 A similar impact is forecast for the PM Peak. In particular, time spent in over-capacity queues is forecast to increase significantly – for example, with Do-Something demand option 1, time spent in over-capacity queues is forecast to increase from 100 hours to 324 hours.

4.105 Turning to the cases with an ODR in place, it can be seen that there is general reduction in congestion across all Do-Something demand scenarios. In particular, time spent in over-capacity queues reduces when going from a „No ODR' network to either the Western ODR or Eastern ODR network for a particular demand option. This is illustrated in Figure 4-1 and Figure 4-2.

Figure 4-1- Time Spent in Over-Capacity Queues (AM Peak) / Hours

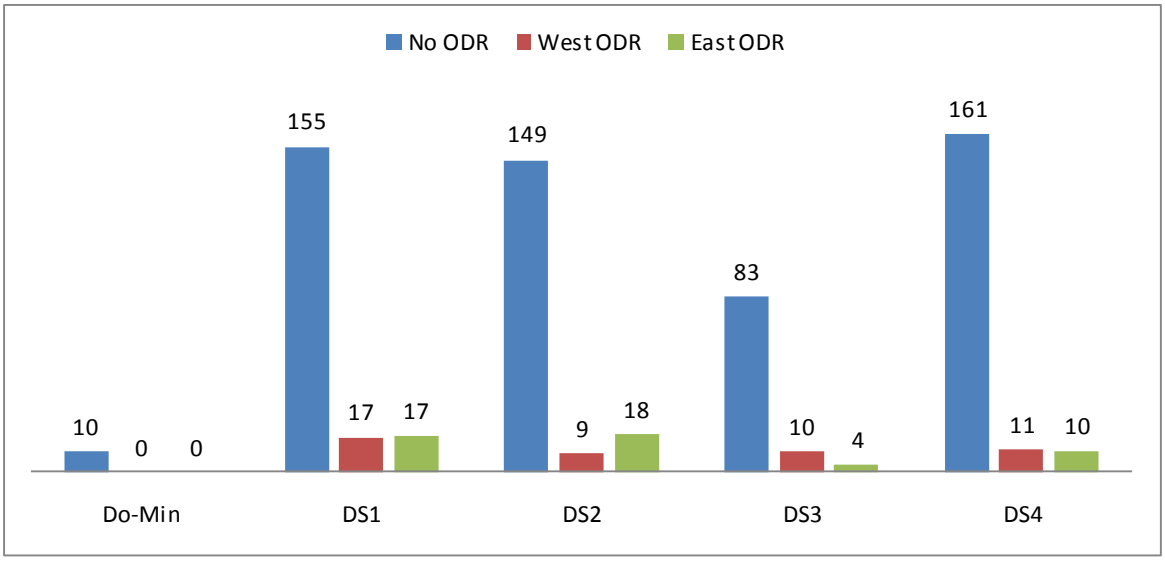
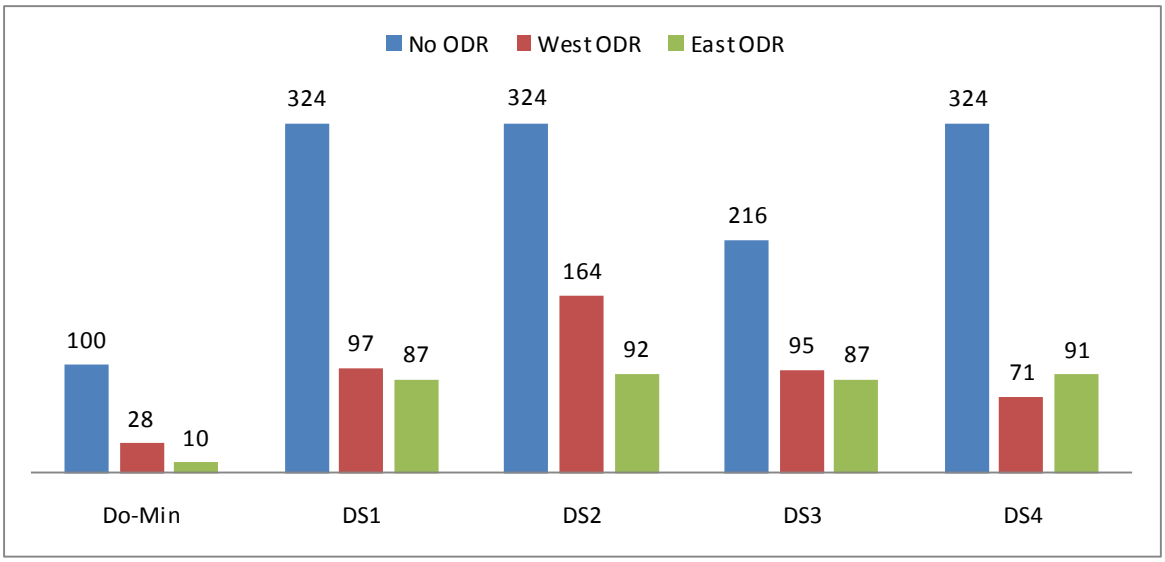


Figure 4-2 - Time Spent in Over-Capacity Queues (PM Peak) / Hours



4.106 It is notable that in each demand scenario, in the AM Peak, either alignment of the ODR is effective in reducing the time wasted in over-capacity queues. In the PM Peak, during which the network is more congested than the AM peak, it is the Eastern ODR that is more effective in reducing over-capacity queues in four of the five demand scenarios.

4.107 Examination of the highway network summary statistics reveals that demand scenario 3, with an ODR on the Eastern alignment, gives the best overall network performance, in terms of total time spent by modelled vehicles in the simulated area. It is noted that the differences between the four development options are not significant. By most measures, however, addition of the Eastern ODR leads to better overall network performance than the Western ODR within the simulated area. The average network speeds with the Western ODR are generally higher than those in the equivalent Eastern ODR network, however.

4.108 Network summary statistics have also been collected for the entire modelled area, i.e. the simulated area covering the city of Hereford and the „buffer' network consisting of the main roads within the county of Herefordshire.

4.109 Summary statistics for the entire network, for the AM Peak, are shown in Table 4-8.

Table 4-8 Morning Peak - Summary of Highway Network Performance (entire model)

Scheme	Indicators	Demand Scenario				
		DM	DS1	DS2	DS3	DS4
No ODR	Total Time / hrs	4,202	5,393	5,411	5,173	5,403
	Transient Queues / hrs	942	1,367	1,371	1,287	1,351
	Over-Capacity Queues/ hrs	10	155	149	83	161
	Link Delays / hrs *	-	-	-	-	-
	Total Distance / km	220,437	261,445	262,870	257,934	263,156
	Total Trips Loaded / pcu	18,043	21,620	21,673	21,644	21,714
	Average Speed / kph	52.5	48.5	48.6	49.9	48.7
Western ODR	Total Time / hrs	3,964	4,966	4,961	4,842	4,964
	Transient Queues / hrs	730	1,042	1,038	1,016	1,037
	Over-Capacity Queues/ hrs	0	17	9	10	11
	Link Delays / hrs *	-	-	-	-	-
	Total Distance / km	225,490	270,191	270,999	265,020	271,200
	Total Trips Loaded / pcu	18,099	21,767	21,802	21,750	21,842
	Average Speed / kph	56.9	54.4	54.6	54.7	54.6
Eastern ODR	Total Time / hrs	3,896	4,864	4,896	4,747	4,877
	Transient Queues / hrs	700	998	1,014	955	1,003
	Over-Capacity Queues/ hrs	0	17	18	4	10
	Link Delays / hrs *	0	0	0	0	0
	Total Distance / km	222,827	264,938	265,923	262,865	266,004
	Total Trips Loaded / pcu	18,133	21,783	21,831	21,773	21,872
	Average Speed / kph	57.2	54.5	54.3	55.4	54.5

* Link delays are not aggregated for the entire modelled area by SATURN

4.110 Examination of the summary statistics for the entire model network reveals that, for each demand scenario, addition of an ODR on either alignment, leads to a reduction in the total travel time, compared to the No ODR case, together with an increase in the total distance travelled. This is not unexpected for schemes such as the ODR, where the model predicts that drivers would be prepared to choose slightly longer distance routes in order to save some time.

4.111 The corresponding statistics for the PM Peak are shown in Table 4-9.

Table 4-9 Evening Peak - Summary of Highway Network Performance (entire model)

Scheme	Indicators	Demand Scenario				
		DM	DS1	DS2	DS3	DS4
No ODR	Total Time / hrs	5,482	6,702	6,754	6,516	6,747
	Transient Queues / hrs	1,119	1,411	1,456	1,391	1,432
	Over-Capacity Queues/ hrs	100	324	324	216	324
	Link Delays / hrs *	-	-	-	-	-
	Total Distance / km	233,590	272,143	272,815	268,884	273,991
	Total Trips Loaded / pcu	19,104	22,263	22,274	22,278	22,331
	Average Speed / kph	42.6	40.6	40.4	41.3	40.6
Western ODR	Total Time / hrs	5,190	6,255	6,454	6,182	6,234
	Transient Queues / hrs	899	1,157	1,243	1,159	1,144
	Over-Capacity Queues/ hrs	28	97	164	95	71
	Link Delays / hrs *	-	-	-	-	-
	Total Distance / km	239,644	281,232	282,825	277,474	282,506
	Total Trips Loaded / pcu	19,213	22,417	22,453	22,393	22,467
	Average Speed / kph	46.2	45.0	43.8	44.9	45.3
Eastern ODR	Total Time / hrs	5,095	6,185	6,247	6,069	6,250
	Transient Queues / hrs	868	1,144	1,187	1,090	1,181
	Over-Capacity Queues/ hrs	10	87	92	87	91
	Link Delays / hrs *	0	0	0	0	0
	Total Distance / km	235,831	275,973	276,753	273,093	277,341
	Total Trips Loaded / pcu	19,226	22,452	22,481	22,424	22,515
	Average Speed / kph	46.3	44.6	44.3	45.0	44.4

* Link delays are not aggregated for the entire modelled area by SATURN

4.112 Addition of an ODR has a similar impact as that observed in the AM Peak – total travel time is predicted to fall, but total travel distance rises.

4.113 The SATURN software contains the ability to estimate emissions of various pollutants for a highway network, taking into account the amount of traffic using the network and the manner in which the modelled traffic flows around the network. Estimates of emissions of Carbon Monoxide (CO), Carbon Dioxide(CO_2), Oxides of Nitrogen (NOx), Hydrocarbons (HC) and Lead (Pb) for each modelled scenario have been made and are presented in Table 4-10 and Table 4-11.

Table 4-10 Morning Peak - Emissions Summary (all values in kg)

Scheme	Indicators	Scenario				
		DM	DS1	DS2	DS3	DS4
No ODR	Carbon Monoxide	757	961	974	934	967
	Carbon Dioxide	7,148	8,846	8,988	8,692	8,934
	Nitrogen Oxides	181	215	218	213	217
	Hydrocarbons	137	173	175	168	173
	Lead	0.780	0.960	0.970	0.940	0.960
Western ODR	Carbon Monoxide	703	900	902	869	902
	Carbon Dioxide	7,242	9,180	9,209	8,858	9,221
	Nitrogen Oxides	175	219	219	211	219
	Hydrocarbons	127	163	163	157	163
	Lead	0.730	0.930	0.930	0.900	0.930
Eastern ODR	Carbon Monoxide	706	900	916	876	914
	Carbon Dioxide	7,255	9,036	9,188	8,867	9,174
	Nitrogen Oxides	175	217	219	212	219
	Hydrocarbons	128	163	165	158	165
	Lead	0.730	0.920	0.940	0.900	0.940

Table 4-11 Evening Peak - Emissions Summary (all values in kg)

Scheme	Indicators	Scenario				
		DM	DS1	DS2	DS3	DS4
No ODR	Carbon Monoxide	830	990	1,007	962	997
	Carbon Dioxide	7,724	9,119	9,275	8,925	9,208
	Nitrogen Oxides	189	216	218	213	217
	Hydrocarbons	149	177	180	173	179
	Lead	0.830	0.970	0.990	0.950	0.980
Western ODR	Carbon Monoxide	781	946	1,012	920	945
	Carbon Dioxide	7,928	9,582	10,173	9,295	9,601
	Nitrogen Oxides	189	226	237	218	227
	Hydrocarbons	141	171	182	166	171
	Lead	0.810	0.970	1.030	0.940	0.970
Eastern ODR	Carbon Dioxide	800	986	1,002	947	1,002
	Carbon Monoxide	8,055	9,771	9,880	9,433	9,896
	Nitrogen Oxides	191	227	229	220	229
	Hydrocarbons	144	177	180	171	180
	Lead	0.820	0.990	1.000	0.960	1.000

4.114 As can be seen, the addition of the extra demand associated with the housing and employment allocations leads to an increase in the modelled emissions, compared to the cases with only the

Do-Minimum demand. The addition of an ODR, on either alignment, is forecast to lead to a reduction in some emissions, such as Carbon Monoxide, but an increase in others, such as Carbon Dioxide. This is due to the mechanisms by which motor vehicle engines emit pollutants. Emissions of carbon dioxide are generally related to fuel consumption, so an increase in distance travelled would normally lead to an increase in CO_2 emissions. In all demand scenarios, provision of an ODR does lead to an increase in total distance travelled, so an increase in CO_2 emissions is not unexpected. Carbon monoxide emissions, however, are dependent upon speed of travel and so a vehicle travelling slowly tends to emit more CO than one travelling at a faster speed (up to around 50mph). So, vehicles travelling on a congested network tend to emit more CO than ones on a less congested network.

4.115 More details on the operation of the Future Year highway networks are provided in the sections that follow.

5 Analysis of Highway Model Results

Introduction

5.116 The models have been tested for the following five demand scenarios:

- Do Minimum – including traffic growth forecast by TEMPRO and ESG highway scheme;
- Do Something 1 - as Do-Minimum but with North/West focused housing and employment;
- Do Something 2 - as Do-Minimum but with South/West focused housing and employment;
- Do Something 3 – as Do-Minimum but with North/South focused housing and employment;
- Do Something 4 – as Do-Minimum but with a dispersed allocation of housing and employment.

5.117 Each demand scenario has been tested with each of three highway network options;

- No ODR – a „Do-Minimum' option, with only the ESG highway works;
- West ODR – as „No ODR', but with a Outer Distributor Road running to the West of the city; and
- East ODR – as „No ODR' but with an Outer Distributor Road running to the East of the city.

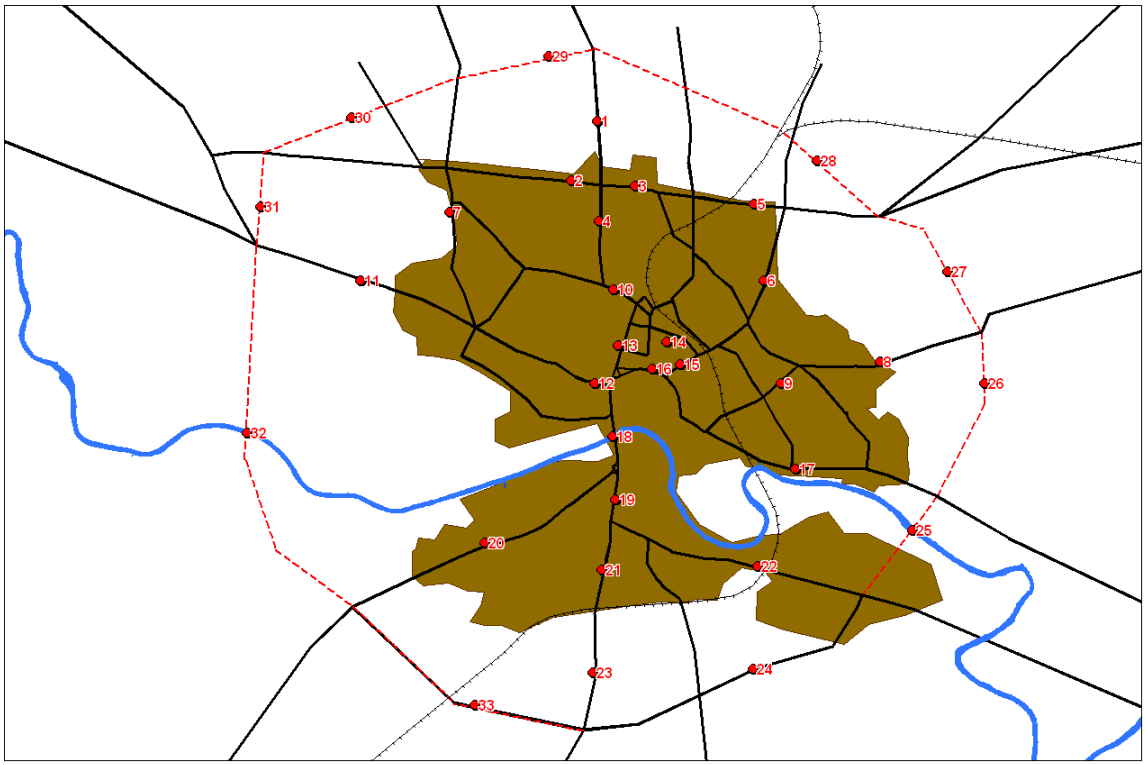
5.118 The following outputs have been assessed:

- **Link Flow Analysis**: The total flows using the network throughout the peak hours have been assessed for each scenario and comparison between the scenarios have been described in the following sections. The maps can be seen in **Appendix C**. Traffic flows are also reported in tabular format at selected locations.
- **Junction Stress (Volume/Capacity)**: A junction is considered to be operating under stress if its volume to capacity ratio exceeds 85%. If the volume to capacity ratio exceeds 100%, then large delays are to be expected, whilst if the junction operates at a volume-to-capacity ratio above 120%, the delays will be considerable. The maps can be seen in **Appendix D**.
- **Link Speed**: the link speed and the volume to capacity ratios of the junctions within Hereford town centre. Junctions above 85% capacity are located on the diagrams as well as the speed in kilometres per hour (kph). The maps can be seen in **Appendix E**.

Link Flow Analysis

5.119 Traffic flows diagrams were compared to assess the impact of the proposed developments on traffic flows and to determine the impact of the proposed Outer Distributor Road. Site locations for the link flow data comparison are shown in Figure 5-1.

Figure 5-1 Site Locations for Flow Comparison



5.120 Forecast flows at the selected locations, for the scenarios without an ODR, with a Western ODR and with an Eastern ODR are shown in Table 5-1 to Table 5-6.

5.121 Graphical representations of the forecast flows are shown in Appendix C.

Table 5-1 Selected Link Flows - No ODR - AM Peak – pcu per hour

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	517	540	538	543	555	547
1	A49 north of Holmer	A49	SB	667	700	701	716	686	696
2	Holmer Road opp Racecourse	A49	NB	598	612	651	647	713	659
2	Holmer Road opp Racecourse	A49	SB	961	917	1033	1008	1050	1018
3	Newtown Road	A49	EB	1068	1227	1317	1308	1309	1313
3	Newtown Road	A49	WB	673	654	624	632	679	641
4	Edgar Street at Football Ground	A49	NB	1015	1582	1620	1626	1571	1616
4	Edgar Street at Football Ground	A49	SB	950	1568	1697	1677	1567	1675
5	Victoria Street	A49	NB	1783	2066	2156	2265	2230	2229
5	Victoria Street	A49	SB	1563	1764	1954	1911	1806	1905
6	Ross Road nr Boycott Rd	A49	NB	1182	1327	1365	1517	1512	1523
6	Ross Road nr Boycott Rd	A49	SB	763	705	717	690	657	662
7	Ross Road nr Mayberry Ave	A49	NB	753	794	852	1037	1044	1025
7	Ross Road nr Mayberry Ave	A49	SB	467	499	564	574	584	576
9	A49 Ross Rd at Grafton	A49	NB	366	414	485	504	505	506
9	A49 Ross Rd at Grafton	A49	SB	504	548	612	810	809	799
10	Roman Road east of A49	A4103	EB	866	853	1274	1177	1217	1245
10	Roman Road east of A49	A4103	WB	555	721	822	810	847	835
11	Roman Road west of A49	A4103	EB	676	690	713	729	671	722
11	Roman Road west of A49	A4103	WB	653	764	707	734	676	724
12	Roman Road nr Staniers Way	A4103	EB	389	363	339	359	368	
12	Roman Road nr Staniers Way	A4103	WB	334	636	794	786	681	
13	Alyestone Hill	A465	NB	323	483	519	511	488	511
13	Alyestone Hill	A465	SB	446	338	522	500	564	509
14	Commercial Road at Bus Station	A465	NB	850	549	631	645	644	659
14	Commercial Road at Bus Station	A465	SB	705	191	211	199	236	212
15	Belmont Road	A465	EB	538	617	788	748	775	724
15	Belmont Road	A465	WB	529	494	575	585	614	584
16	Ledbury Road nr Quarry Rd	A438	NB	364	340	385	382	400	387
16	Ledbury Road nr Quarry Rd	A438	SB	482	482	552	549	555	550
17	Blue School Street	A438	EB	1179	675	697	703	710	700
17	Blue School Street	A438	WB	1294	388	390	389	391	391
18	Eign Street	A438	EB	786	1014	1063	1070	1036	1055
18	Eign Street	A438	WB	590	667	452	476	488	474
19	Kings Acre Road	A438	EB	532	466	515	513	607	566
19	Kings Acre Road	A438	WB	379	431	532	515	415	480
20	Three Elms Road	A4110	NB	272	406	688	670	617	650

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
20	Three Elms Road	A4110	SB	482	689	745	724	704	774
21	ESG Link Road		EB	0	578	701	694	651	690
21	ESG Link Road		WB	0	619	671	669	646	670
22	Hampton Park Road		EB	183	233	267	259	256	261
22	Hampton Park Road		WB	375	357	393	421	365	432
23	Holme Lacy Road		EB	502	758	776	732	690	726
23	Holme Lacy Road		WB	331	529	575	588	590	590
24	Rotherwas Access Road		EB	95	138	190	354	399	364
24	Rotherwas Access Road		WB	31	38	44	95	112	95
25	ODR at Eastern river crossing		NB	-	-	-	-	-	-
25	ODR at Eastern river crossing		SB	-	-	-	-	-	-
26	ODR at Lugg Meadows		NB	-	-	-	-	-	-
26	ODR at Lugg Meadows		SB	-	-	-	-	-	-
27	ODR at New Court		NB	-	-	-	-	-	-
27	ODR at New Court		SB	-	-	-	-	-	-
28	ODR at Shelwick Green		EB	-	-	-	-	-	-
28	ODR at Shelwick Green		WB	-	-	-	-	-	-
29	ODR at Lyde Arundel		EB	-	-	-	-	-	-
29	ODR at Lyde Arundel		WB	-	-	-	-	-	-
30	ODR nr Towtree Lane		EB	-	-	-	-	-	-
30	ODR nr Towtree Lane		WB	-	-	-	-	-	-
31	ODR nr Swainshill		NB	-	-	-	-	-	-
31	ODR nr Swainshill		SB	-	-	-	-	-	-
32	ODR at Western river crossing		NB	-	-	-	-	-	-
32	ODR at Western river crossing		SB	-	-	-	-	-	-
33	ODR nr Grafton		EB	-	-	-	-	-	-
33	ODR nr Grafton		WB	-	-	-	-	-	-

SATURN model

Table 5-2 Select Link Flows - ODR West - AM Peak – pcu per hour

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	517	394	440	422	431	428
1	A49 north of Holmer	A49	SB	667	741	750	815	768	757
2	Holmer Road opp Racecourse	A49	NB	598	498	475	456	508	465
2	Holmer Road opp Racecourse	A49	SB	961	974	1078	1059	1089	1076
3	Newtown Road	A49	EB	1068	1026	1239	1221	1283	1232
3	Newtown Road	A49	WB	673	484	526	507	544	487
4	Edgar Street at Football Ground	A49	NB	1015	1434	1614	1608	1540	1578
4	Edgar Street at Football Ground	A49	SB	950	1369	1461	1440	1494	1461
5	Victoria Street	A49	NB	1783	1796	2005	2114	2015	2118
5	Victoria Street	A49	SB	1563	1397	1497	1474	1435	1488
6	Ross Road nr Boycott Rd	A49	NB	1182	1144	1245	1415	1275	1404
6	Ross Road nr Boycott Rd	A49	SB	763	696	643	639	638	665
7	Ross Road nr Mayberry Ave	A49	NB	753	647	705	890	724	888
7	Ross Road nr Mayberry Ave	A49	SB	467	432	458	484	494	486
9	A49 Ross Rd at Grafton	A49	NB	366	388	416	447	445	447
9	A49 Ross Rd at Grafton	A49	SB	504	442	506	698	518	694
10	Roman Road east of A49	A4103	EB	866	537	855	687	737	817
10	Roman Road east of A49	A4103	WB	555	516	586	535	589	550
11	Roman Road west of A49	A4103	EB	676	553	587	622	538	606
11	Roman Road west of A49	A4103	WB	653	643	632	693	616	647
12	Roman Road nr Staniers Way	A4103	EB	389	118	74	86	153	
12	Roman Road nr Staniers Way	A4103	WB	334	540	619	656	540	
13	Alyestone Hill	A465	NB	323	574	671	647	626	651
13	Alyestone Hill	A465	SB	446	374	642	595	676	632
14	Commercial Road at Bus Station	A465	NB	850	528	585	576	628	591
14	Commercial Road at Bus Station	A465	SB	705	156	213	194	222	205
15	Belmont Road	A465	EB	538	492	662	624	637	617
15	Belmont Road	A465	WB	529	379	423	416	455	413
16	Ledbury Road nr Quarry Rd	A438	NB	364	318	364	362	377	364
16	Ledbury Road nr Quarry Rd	A438	SB	482	495	556	556	557	562
17	Blue School Street	A438	EB	1179	632	702	720	703	704
17	Blue School Street	A438	WB	1294	364	372	362	373	369
18	Eign Street	A438	EB	786	787	1002	963	911	956
18	Eign Street	A438	WB	590	688	571	612	688	671
19	Kings Acre Road	A438	EB	532	443	375	396	419	415
19	Kings Acre Road	A438	WB	379	473	608	633	408	567
20	Three Elms Road	A4110	NB	272	318	471	431	438	446

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
20	Three Elms Road	A4110	SB	482	421	604	592	588	582
21	ESG Link Road		EB	0	495	632	656	557	630
21	ESG Link Road		WB	0	586	650	639	633	644
22	Hampton Park Road		EB	183	210	219	213	214	217
22	Hampton Park Road		WB	375	335	341	350	351	352
23	Holme Lacy Road		EB	502	555	586	584	663	588
23	Holme Lacy Road		WB	331	481	540	545	483	547
24	Rotherwas Access Road		EB	95	407	564	598	396	592
24	Rotherwas Access Road		WB	31	129	186	216	125	219
25	ODR at Eastern river crossing		NB	-	-	-	-	-	-
25	ODR at Eastern river crossing		SB	-	-	-	-	-	-
26	ODR at Lugg Meadows		NB	-	-	-	-	-	-
26	ODR at Lugg Meadows		SB	-	-	-	-	-	-
27	ODR at New Court		NB	-	-	-	-	-	-
27	ODR at New Court		SB	-	-	-	-	-	-
28	ODR at Shelwick Green		EB	-	428	741	673	661	699
28	ODR at Shelwick Green		WB	-	361	468	448	495	448
29	ODR at Lyde Arundel		EB	-	762	1110	1115	1050	1088
29	ODR at Lyde Arundel		WB	-	424	625	599	647	610
30	ODR nr Towtree Lane		EB	-	183	359	343	279	329
30	ODR nr Towtree Lane		WB	-	147	239	235	256	239
31	ODR nr Swainshill		NB	-	478	875	853	683	813
31	ODR nr Swainshill		SB	-	447	599	552	612	567
32	ODR at Western river crossing		NB	-	418	526	573	467	589
32	ODR at Western river crossing		SB	-	580	931	883	713	867
33	ODR nr Grafton		EB	-	382	605	593	422	584
33	ODR nr Grafton		WB	-	306	407	487	342	499

Table 5-3 Select Link Flows - ODR East - AM Peak – pcu per hour

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	517	519	500	507	524	500
1	A49 north of Holmer	A49	SB	667	833	783	857	828	784
2	Holmer Road opp Racecourse	A49	NB	598	550	598	549	654	583
2	Holmer Road opp Racecourse	A49	SB	961	969	1031	1014	1080	1030
3	Newtown Road	A49	EB	1068	1156	1298	1283	1325	1291
3	Newtown Road	A49	WB	673	596	682	666	759	677
4	Edgar Street at Football Ground	A49	NB	1015	1266	1536	1539	1457	1560
4	Edgar Street at Football Ground	A49	SB	950	1147	1301	1270	1248	1297
5	Victoria Street	A49	NB	1783	1657	1860	1947	1864	1953
5	Victoria Street	A49	SB	1563	1194	1359	1345	1283	1349
6	Ross Road nr Boycott Rd	A49	NB	1182	937	1057	1218	1108	1223
6	Ross Road nr Boycott Rd	A49	SB	763	559	452	643	435	639
7	Ross Road nr Mayberry Ave	A49	NB	753	627	696	811	814	812
7	Ross Road nr Mayberry Ave	A49	SB	467	430	467	495	494	494
9	A49 Ross Rd at Grafton	A49	NB	366	390	429	445	459	442
9	A49 Ross Rd at Grafton	A49	SB	504	429	504	607	626	607
10	Roman Road east of A49	A4103	EB	866	518	919	740	767	876
10	Roman Road east of A49	A4103	WB	555	424	606	527	595	577
11	Roman Road west of A49	A4103	EB	676	581	616	663	593	603
11	Roman Road west of A49	A4103	WB	653	602	605	626	581	603
12	Roman Road nr Staniers Way	A4103	EB	389	185	201	191	204	
12	Roman Road nr Staniers Way	A4103	WB	334	497	635	643	522	
13	Alyestone Hill	A465	NB	323	396	489	489	516	502
13	Alyestone Hill	A465	SB	446	347	562	558	620	567
14	Commercial Road at Bus Station	A465	NB	850	469	532	550	553	557
14	Commercial Road at Bus Station	A465	SB	705	164	161	158	202	163
15	Belmont Road	A465	EB	538	519	626	635	629	630
15	Belmont Road	A465	WB	529	379	427	421	421	423
16	Ledbury Road nr Quarry Rd	A438	NB	364	254	288	291	298	289
16	Ledbury Road nr Quarry Rd	A438	SB	482	406	408	394	443	399
17	Blue School Street	A438	EB	1179	635	709	711	674	713
17	Blue School Street	A438	WB	1294	351	347	349	360	350
18	Eign Street	A438	EB	786	874	1041	1046	946	1034
18	Eign Street	A438	WB	590	759	557	555	597	556
19	Kings Acre Road	A438	EB	532	486	483	480	558	523
19	Kings Acre Road	A438	WB	379	380	537	518	380	471
20	Three Elms Road	A4110	NB	272	337	667	560	561	569

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
20	Three Elms Road	A4110	SB	482	379	652	589	671	634
21	ESG Link Road		EB	0	512	598	611	559	609
21	ESG Link Road		WB	0	506	603	597	572	598
22	Hampton Park Road		EB	183	505	532	533	539	535
22	Hampton Park Road		WB	375	528	569	649	601	655
23	Holme Lacy Road		EB	502	439	439	436	476	432
23	Holme Lacy Road		WB	331	494	595	588	611	589
24	Rotherwas Access Road		EB	95	402	488	715	746	718
24	Rotherwas Access Road		WB	31	300	377	434	478	436
25	ODR at Eastern river crossing		NB	-	842	1052	1228	1014	1238
25	ODR at Eastern river crossing		SB	-	1241	1498	1492	1329	1497
26	ODR at Lugg Meadows		NB	-	687	815	862	752	865
26	ODR at Lugg Meadows		SB	-	797	960	935	846	941
27	ODR at New Court		NB	-	372	441	493	380	498
27	ODR at New Court		SB	-	543	642	623	512	632
28	ODR at Shelwick Green		EB	-	628	912	867	784	874
28	ODR at Shelwick Green		WB	-	446	565	611	580	609
29	ODR at Lyde Arundel		EB	-	928	1242	1254	1110	1178
29	ODR at Lyde Arundel		WB	-	544	702	733	705	723
30	ODR nr Towtree Lane		EB	-	102	179	179	122	162
30	ODR nr Towtree Lane		WB	-	104	143	144	139	141
31	ODR nr Swainshill		NB	-	-	-	-	-	-
31	ODR nr Swainshill		SB	-	-	-	-	-	-
32	ODR at Western river crossing		NB	-	-	-	-	-	-
32	ODR at Western river crossing		SB	-	-	-	-	-	-
33	ODR nr Grafton		EB	-	145	209	180	168	181
33	ODR nr Grafton		WB	-	239	286	311	328	311

Table 5-4 Selected Link Flows - No ODR - PM Peak – pcu per hour

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	506	558	577	586	619	574
1	A49 north of Holmer	A49	SB	553	583	664	640	657	662
2	Holmer Road opp Racecourse	A49	NB	786	745	708	680	758	726
2	Holmer Road opp Racecourse	A49	SB	726	755	724	720	781	720
3	Newtown Road	A49	EB	820	822	887	867	910	886
3	Newtown Road	A49	WB	943	1164	1285	1280	1223	1283
4	Edgar Street at Football Ground	A49	NB	764	1081	1194	1175	1081	1157
4	Edgar Street at Football Ground	A49	SB	1069	1639	1625	1597	1610	1627
5	Victoria Street	A49	NB	1823	1888	1969	1985	1923	1957
5	Victoria Street	A49	SB	2085	2099	2122	2143	2109	2154
6	Ross Road nr Boycott Rd	A49	NB	1031	1279	1478	1501	1440	1490
6	Ross Road nr Boycott Rd	A49	SB	829	815	878	911	858	911
7	Ross Road nr Mayberry Ave	A49	NB	521	636	868	891	840	877
7	Ross Road nr Mayberry Ave	A49	SB	565	593	622	720	726	717
9	A49 Ross Rd at Grafton	A49	NB	386	418	451	562	565	560
9	A49 Ross Rd at Grafton	A49	SB	361	494	723	757	711	744
10	Roman Road east of A49	A4103	EB	560	735	1029	988	967	990
10	Roman Road east of A49	A4103	WB	816	929	1163	1097	1049	1171
11	Roman Road west of A49	A4103	EB	674	715	657	674	662	663
11	Roman Road west of A49	A4103	WB	737	866	803	818	790	813
12	Roman Road nr Staniers Way	A4103	EB	221	240	295	291	246	
12	Roman Road nr Staniers Way	A4103	WB	333	527	555	558	671	
13	Alyestone Hill	A465	NB	452	605	787	780	841	838
13	Alyestone Hill	A465	SB	303	257	420	405	374	416
14	Commercial Road at Bus Station	A465	NB	859	301	366	365	368	367
14	Commercial Road at Bus Station	A465	SB	691	206	232	251	237	252
15	Belmont Road	A465	EB	1010	989	1002	994	988	976
15	Belmont Road	A465	WB	1075	1054	1077	1065	1109	1073
16	Ledbury Road nr Quarry Rd	A438	NB	473	445	554	531	544	555
16	Ledbury Road nr Quarry Rd	A438	SB	232	212	214	222	240	224
17	Blue School Street	A438	EB	1053	683	762	758	766	746
17	Blue School Street	A438	WB	1228	382	385	379	343	388
18	Eign Street	A438	EB	748	874	1010	1038	928	1003
18	Eign Street	A438	WB	936	916	883	890	869	887
19	Kings Acre Road	A438	EB	417	484	636	615	583	617
19	Kings Acre Road	A438	WB	433	494	547	567	681	624
20	Three Elms Road	A4110	NB	391	486	764	708	657	625
20	Three Elms Road	A4110	SB	304	451	644	636	641	641

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
21	ESG Link Road		EB	0	623	623	620	661	627
21	ESG Link Road		WB	0	705	769	771	655	770
22	Hampton Park Road		EB	296	364	402	434	407	431
22	Hampton Park Road		WB	170	236	263	271	248	279
23	Holme Lacy Road		EB	196	268	285	301	310	303
23	Holme Lacy Road		WB	432	640	571	595	665	596
24	Rotherwas Access Road		EB	26	82	127	185	202	187
24	Rotherwas Access Road		WB	107	307	494	538	522	532
25	ODR at Eastern river crossing		NB	-	-	-	-	-	-
25	ODR at Eastern river crossing		SB	-	-	-	-	-	-
26	ODR at Lugg Meadows		NB	-	-	-	-	-	-
26	ODR at Lugg Meadows		SB	-	-	-	-	-	-
27	ODR at New Court		NB	-	-	-	-	-	-
27	ODR at New Court		SB	-	-	-	-	-	-
28	ODR at Shelwick Green		EB	-	-	-	-	-	-
28	ODR at Shelwick Green		WB	-	-	-	-	-	-
29	ODR at Lyde Arundel		EB	-	-	-	-	-	-
29	ODR at Lyde Arundel		WB	-	-	-	-	-	-
30	ODR nr Towtree Lane		EB	-	-	-	-	-	-
30	ODR nr Towtree Lane		WB	-	-	-	-	-	-
31	ODR nr Swainshill		NB	-	-	-	-	-	-
31	ODR nr Swainshill		SB	-	-	-	-	-	-
32	ODR at Western river crossing		NB	-	-	-	-	-	-
32	ODR at Western river crossing		SB	-	-	-	-	-	-
33	ODR nr Grafton		EB	-	-	-	-	-	-
33	ODR nr Grafton		WB	-	-	-	-	-	-

Table 5-5 Select Link Flows - ODR West - PM Peak – pcu per hour

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	506	610	661	633	751	658
1	A49 north of Holmer	A49	SB	553	445	445	435	533	441
2	Holmer Road opp Racecourse	A49	NB	786	718	768	772	851	799
2	Holmer Road opp Racecourse	A49	SB	726	727	689	711	840	750
3	Newtown Road	A49	EB	820	775	923	968	985	898
3	Newtown Road	A49	WB	943	1075	1232	1174	1191	1214
4	Edgar Street at Football Ground	A49	NB	764	1039	1166	1250	1092	1144
4	Edgar Street at Football Ground	A49	SB	1069	1712	1719	1761	1684	1706
5	Victoria Street	A49	NB	1823	1622	1696	1813	1655	1722
5	Victoria Street	A49	SB	2085	1952	2014	2053	1991	2028
6	Ross Road nr Boycott Rd	A49	NB	1031	851	951	1052	940	982
6	Ross Road nr Boycott Rd	A49	SB	829	789	825	864	835	870
7	Ross Road nr Mayberry Ave	A49	NB	521	356	443	543	465	503
7	Ross Road nr Mayberry Ave	A49	SB	565	565	639	711	666	711
9	A49 Ross Rd at Grafton	A49	NB	386	467	550	623	576	629
9	A49 Ross Rd at Grafton	A49	SB	361	299	392	493	416	456
10	Roman Road east of A49	A4103	EB	560	490	661	619	588	643
10	Roman Road east of A49	A4103	WB	816	522	836	816	692	781
11	Roman Road west of A49	A4103	EB	674	608	635	664	641	646
11	Roman Road west of A49	A4103	WB	737	766	837	874	832	844
12	Roman Road nr Staniers Way	A4103	EB	221	227	163	163	125	
12	Roman Road nr Staniers Way	A4103	WB	333	308	330	319	395	
13	Alyestone Hill	A465	NB	452	496	795	845	842	751
13	Alyestone Hill	A465	SB	303	374	473	434	509	469
14	Commercial Road at Bus Station	A465	NB	859	322	392	415	378	353
14	Commercial Road at Bus Station	A465	SB	691	200	226	221	219	223
15	Belmont Road	A465	EB	1010	757	735	732	757	727
15	Belmont Road	A465	WB	1075	814	805	800	839	799
16	Ledbury Road nr Quarry Rd	A438	NB	473	468	554	528	560	554
16	Ledbury Road nr Quarry Rd	A438	SB	232	199	222	209	245	223
17	Blue School Street	A438	EB	1053	695	779	774	766	776
17	Blue School Street	A438	WB	1228	316	295	302	315	321
18	Eign Street	A438	EB	748	598	702	783	746	709
18	Eign Street	A438	WB	936	739	723	722	704	730
19	Kings Acre Road	A438	EB	417	447	527	539	403	511
19	Kings Acre Road	A438	WB	433	460	480	454	420	498
20	Three Elms Road	A4110	NB	391	355	444	435	429	437

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
20	Three Elms Road	A4110	SB	304	524	746	810	653	701
21	ESG Link Road		EB	0	609	659	602	606	619
21	ESG Link Road		WB	0	717	767	773	656	752
22	Hampton Park Road		EB	296	347	380	400	373	390
22	Hampton Park Road		WB	170	169	173	170	188	177
23	Holme Lacy Road		EB	196	212	232	256	217	251
23	Holme Lacy Road		WB	432	665	727	762	737	725
24	Rotherwas Access Road		EB	26	224	310	350	253	330
24	Rotherwas Access Road		WB	107	473	618	688	524	676
25	ODR at Eastern river crossing		NB	-	-	-	-	-	-
25	ODR at Eastern river crossing		SB	-	-	-	-	-	-
26	ODR at Lugg Meadows		NB	-	-	-	-	-	-
26	ODR at Lugg Meadows		SB	-	-	-	-	-	-
27	ODR at New Court		NB	-	-	-	-	-	-
27	ODR at New Court		SB	-	-	-	-	-	-
28	ODR at Shelwick Green		EB	-	326	425	433	417	419
28	ODR at Shelwick Green		WB	-	308	498	645	460	488
29	ODR at Lyde Arundel		EB	-	609	719	749	717	710
29	ODR at Lyde Arundel		WB	-	663	921	1093	894	909
30	ODR nr Towtree Lane		EB	-	352	510	547	461	506
30	ODR nr Towtree Lane		WB	-	284	441	584	382	425
31	ODR nr Swainshill		NB	-	638	921	951	820	906
31	ODR nr Swainshill		SB	-	661	985	1151	915	968
32	ODR at Western river crossing		NB	-	666	891	947	725	880
32	ODR at Western river crossing		SB	-	513	661	820	544	702
33	ODR nr Grafton		EB	-	368	509	652	418	590
33	ODR nr Grafton		WB	-	716	955	980	815	969

Table 5-6 Select Link Flows - ODR East - PM Peak – pcu per hour

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	506	713	741	771	841	749
1	A49 north of Holmer	A49	SB	553	617	595	625	711	599
2	Holmer Road opp Racecourse	A49	NB	786	724	802	803	888	823
2	Holmer Road opp Racecourse	A49	SB	726	727	745	739	877	775
3	Newtown Road	A49	EB	820	883	996	951	1037	974
3	Newtown Road	A49	WB	943	1156	1297	1278	1198	1262
4	Edgar Street at Football Ground	A49	NB	764	1009	1118	1113	947	1101
4	Edgar Street at Football Ground	A49	SB	1069	1659	1642	1650	1629	1645
5	Victoria Street	A49	NB	1823	1567	1698	1710	1616	1721
5	Victoria Street	A49	SB	2085	1862	1935	1963	1872	1965
6	Ross Road nr Boycott Rd	A49	NB	1031	794	933	950	921	954
6	Ross Road nr Boycott Rd	A49	SB	829	629	641	673	655	680
7	Ross Road nr Mayberry Ave	A49	NB	521	397	463	494	512	494
7	Ross Road nr Mayberry Ave	A49	SB	565	583	626	658	674	658
9	A49 Ross Rd at Grafton	A49	NB	386	510	568	602	622	606
9	A49 Ross Rd at Grafton	A49	SB	361	371	447	479	505	481
10	Roman Road east of A49	A4103	EB	560	450	666	580	560	650
10	Roman Road east of A49	A4103	WB	816	498	851	729	682	802
11	Roman Road west of A49	A4103	EB	674	576	619	629	607	629
11	Roman Road west of A49	A4103	WB	737	669	803	792	749	802
12	Roman Road nr Staniers Way	A4103	EB	221	263	245	250	163	
12	Roman Road nr Staniers Way	A4103	WB	333	355	376	342	381	
13	Alyestone Hill	A465	NB	452	443	681	609	667	652
13	Alyestone Hill	A465	SB	303	246	370	333	378	352
14	Commercial Road at Bus Station	A465	NB	859	322	368	361	383	363
14	Commercial Road at Bus Station	A465	SB	691	198	226	236	218	233
15	Belmont Road	A465	EB	1010	842	885	881	871	880
15	Belmont Road	A465	WB	1075	928	977	971	963	967
16	Ledbury Road nr Quarry Rd	A438	NB	473	378	446	446	458	446
16	Ledbury Road nr Quarry Rd	A438	SB	232	139	158	160	175	158
17	Blue School Street	A438	EB	1053	656	747	736	738	741
17	Blue School Street	A438	WB	1228	324	314	325	322	324
18	Eign Street	A438	EB	748	725	854	851	794	841
18	Eign Street	A438	WB	936	879	899	892	927	898
19	Kings Acre Road	A438	EB	417	389	536	528	429	523
19	Kings Acre Road	A438	WB	433	475	527	523	570	542
20	Three Elms Road	A4110	NB	391	322	469	412	366	447

No	Location	Name	Dir	Base	Do Min	DS1	DS2	DS3	DS4
20	Three Elms Road	A4110	SB	304	465	767	697	709	709
21	ESG Link Road		EB	0	589	590	599	592	596
21	ESG Link Road		WB	0	681	725	723	625	730
22	Hampton Park Road		EB	296	569	666	689	689	668
22	Hampton Park Road		WB	170	360	384	411	414	411
23	Holme Lacy Road		EB	196	244	269	284	321	283
23	Holme Lacy Road		WB	432	635	681	633	679	628
24	Rotherwas Access Road		EB	26	443	539	630	659	637
24	Rotherwas Access Road		WB	107	614	683	824	849	826
25	ODR at Eastern river crossing		NB	-	1157	1333	1380	1272	1387
25	ODR at Eastern river crossing		SB	-	1170	1558	1612	1454	1602
26	ODR at Lugg Meadows		NB	-	822	926	946	866	952
26	ODR at Lugg Meadows		SB	-	744	867	903	788	905
27	ODR at New Court		NB	-	657	760	764	689	769
27	ODR at New Court		SB	-	555	619	638	546	636
28	ODR at Shelwick Green		EB	-	371	523	518	451	531
28	ODR at Shelwick Green		WB	-	471	738	696	560	725
29	ODR at Lyde Arundel		EB	-	673	796	813	778	804
29	ODR at Lyde Arundel		WB	-	778	1074	1057	939	1060
30	ODR nr Towtree Lane		EB	-	86	102	116	117	99
30	ODR nr Towtree Lane		WB	-	39	95	94	54	84
31	ODR nr Swainshill		NB	-	-	-	-	-	-
31	ODR nr Swainshill		SB	-	-	-	-	-	-
32	ODR at Western river crossing		NB	-	-	-	-	-	-
32	ODR at Western river crossing		SB	-	-	-	-	-	-
33	ODR nr Grafton		EB	-	290	370	388	391	394
33	ODR nr Grafton		WB	-	477	568	548	533	551

Impact of ODR

5.122 Further analysis was undertaken to assess the impact an Outer Distributor Road (ODR) has on the main roads in and around Hereford. The link flows with a NO ODR scenario were compared to that of West and East ODR scenario. The total flow comparison for each type of roads is shown in Table 5.7 to Table 5.10**.** The full comparison tables have been provided in **Appendix – F.**

Table 5.7 AM Comparison: West ODR - NO ODR

Road Type	Road Name	Direction	(West ODR minus NO ODR)				
			Do Min	DS1	DS2	DS3	DS4
Trunk Road	A49	NB	-1204	-865	-912	-1327	-931
		SB	-851	-963	-864	-749	-785
Primary Road	A4103	EB	-698	-810	-870	-828	-544
		WB	-422	-486	-446	-459	-362
	A465	NB/EB	-55	-20	-57	-16	-35
		SB/WB	-114	-30	-79	-61	-55
	A438	NB/EB	-315	-217	-227	-343	-269
		SB/WB	52	181	234	177	274
	A4110	NB	-88	-217	-239	-179	-204
		SB	-268	-141	-132	-116	-192
Non-Primary Roads	Only Major Roads	EB	-40	67	12	-166	-14
		WB	-12	34	-23	-121	-25

Table 5.8 AM Comparison: East ODR - NO ODR

Road Type	Road Name	Direction	(East ODR minus NO ODR)				
			Do Min	DS1	DS2	DS3	DS4
Trunk Road	A49	NB	-1447	-933	-1089	-1170	-996
		SB	-1211	-1400	-1180	-1149	-1153
Primary Road	A4103	EB	-622	-590	-671	-692	-488
		WB	-598	-477	-534	-506	-379
	A465	NB/EB	-265	-291	-230	-209	-205
		SB/WB	-133	-158	-147	-171	-152
	A438	NB/EB	-246	-139	-140	-277	-149
		SB/WB	-72	-77	-113	-69	-119
	A4110	NB	-69	-21	-110	-56	-81
		SB	-310	-93	-135	-33	-140
Non-Primary Roads	Only Major Roads	EB	151	123	256	324	253
		WB	285	461	495	549	491

Table 5.9 PM Comparison: West ODR - NO ODR

Road Type	Road Name	Direction	(West ODR minus NO ODR)

			Do Min	DS1	DS2	DS3	DS4
Trunk Road	A49	NB	-1031	-1063	-800	-928	-973
		SB	-536	-599	-359	-412	-561
Primary Road	A4103	EB	-365	-522	-507	-521	-364
		WB	-726	-518	-464	-591	-359
	A465	NB/EB	-320	-233	-147	-220	-350
		SB/WB	-129	-225	-266	-153	-250
	A438	NB/EB	-278	-400	-318	-346	-371
		SB/WB	-290	-309	-371	-449	-351
	A4110	NB	-131	-320	-273	-228	-188
		SB	73	102	174	12	60
Non-Primary Roads	Only Major	EB	55	144	68	-131	42
	Roads	WB	136	188	218	15	153

Table 5.10 PM Comparison: East ODR - NO ODR

Road Type	Road Name	Direction	(East ODR minus NO ODR)				
			Do Min	DS1	DS2	DS3	DS4
Trunk Road	A49	NB	-899	-910	-939	-904	-914
		SB	-469	-618	-617	-402	-644
Primary Road	A4103	EB	-401	-451	-494	-545	-374
		WB	-800	-491	-610	-698	-380
	A465	NB/EB	-288	-221	-288	-276	-286
		SB/WB	-145	-156	-181	-161	-189
	A438	NB/EB	-338	-379	-381	-402	-370
		SB/WB	-187	-131	-158	-139	-201
	A4110	NB	-164	-295	-296	-291	-178
		SB	14	123	61	68	68
Non-Primary Roads	Only Major	EB	508	627	662	681	636
	Roads	WB	402	376	416	477	418

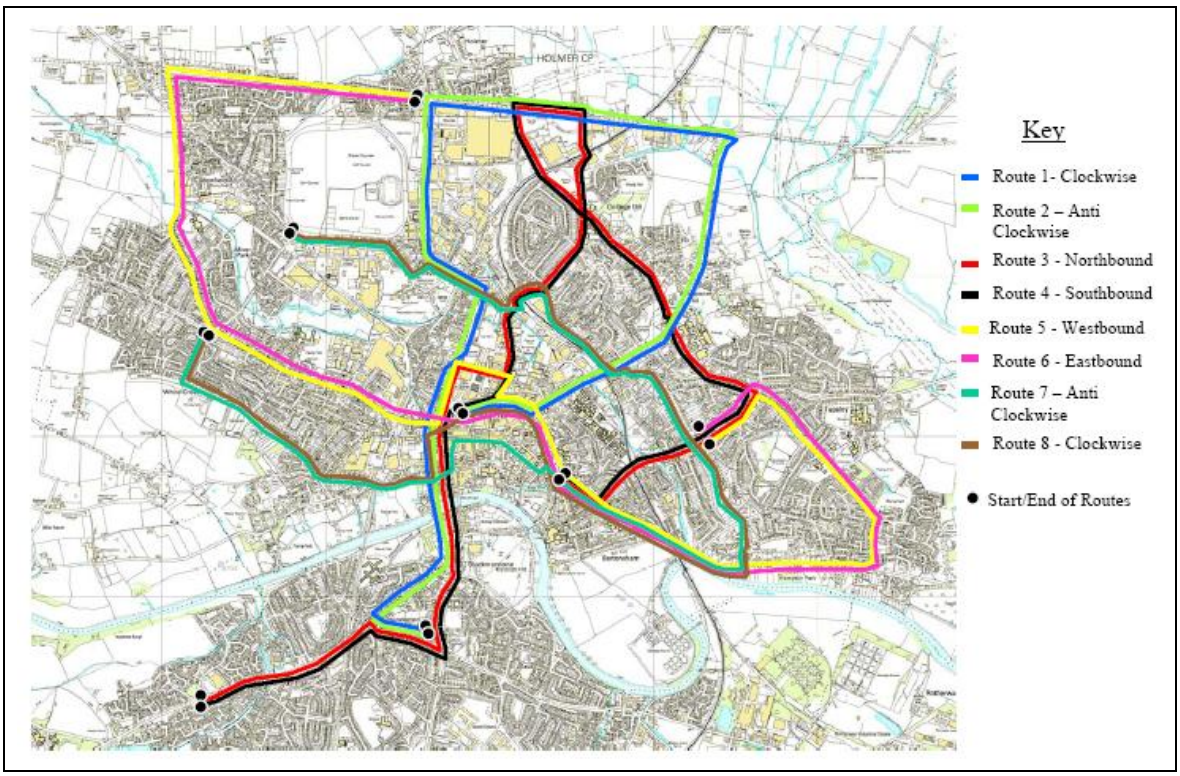
5.123 The negative values show a decrease in link flows due to the ODR. The table clearly indicates that the ODR is providing relief to the A49 and other primary roads in both peaks. However, in case of non primary roads there is an increase in traffic flow. This is mainly due to Rotherwas Access road and Home lacy road. Both roads are at the edge of Hereford centre. Traffic flows on Hampton Park Road increase due to the Eastern ODR. This is because of traffic coming in to the city centre now using the Hampton road via the Eastern ODR instead of using the A465 / A438.

Journey Time Analysis

5.124 During the construction of the Base Year models, a total of eight routes through the city were surveyed and average journey times for each route were obtained. In order to provide an assessment of the impacts on typical journey times in Hereford in each of the future year scenarios, average journey times for the same eight routes were extracted from the future year highway models.

5.125 Figure 5-2 shows the eight journey-time routes that were surveyed. Due to the changes associated with the Edgar Street Grid works, it is not possible to follow Route 5 in any of the Future Year networks.

Figure 5-2 Journey Time Route Locations



5.126 The forecast journey times for the seven available routes are shown in Table 5-11 and Table 5-12 below.

Table 5-11 AM Peak - Comparison of Journey Times

Scheme	Average Modelled Journey Time / mm:ss					
	Route	DoMin	Option 1	Option 2	Option 3	Option 4
No ODR	1	26:02	30:38	30:59	29:11	31:19
	2	21:40	25:18	24:49	25:06	25:11
	3	23:51	29:03	27:54	26:56	28:18
	4	21:22	23:56	23:45	24:06	23:49
	5	-	-	-	-	-
	6	30:20	37:21	36:44	35:17	36:08
	7	22:36	26:27	26:26	26:34	26:27
	8	24:09	28:50	28:24	27:49	28:19
	Total	**170:00**	**201:34**	**199:01**	**194:58**	**199:31**
Western ODR	1	23:01	25:59	25:37	25:37	25:59
	2	19:43	22:09	21:37	22:09	21:49
	3	22:28	24:10	24:35	24:13	24:31
	4	19:53	21:36	21:12	21:18	21:21
	5	-	-	-	-	-
	6	27:52	30:51	30:26	30:33	30:16
	7	19:17	22:43	22:39	22:39	22:44
	8	21:56	24:31	24:07	24:22	24:18
	Total	**154:10**	**171:58**	**170:13**	**170:50**	**170:59**
Eastern ODR	1	21:56	23:29	23:39	23:13	23:32
	2	19:18	21:25	21:01	21:33	21:17
	3	21:51	23:05	23:02	22:52	23:08
	4	19:15	20:17	20:06	20:04	21:51
	5	-	-	-	-	-
	6	27:11	30:00	30:33	29:19	30:09
	7	18:46	21:54	23:46	21:57	23:49
	8	20:58	23:05	22:54	23:10	22:57
	Total	**149:15**	**163:15**	**165:01**	**162:08**	**166:43**

source: SATURN models

5.127 It can be seen that in the case without an ODR, the additional demand associated with the housing and employment options leads to an increase in the sample journey times. The increases are of the order of 15% to 18%, depending on the demand option, in the AM Peak.

5.128 Provision of a Western ODR leads to the sample journey times falling back to the levels seen in the Do-Minimum situation (i.e. without an ODR and without the additional demand). The addition of the Eastern ODR gives journey times slightly lower than those seen in the Do-Minimum scenario.

Table 5-12 PM Peak – Comparison of Journey Times

Scheme	Average Modelled Journey Time / mm:ss					
	Route	DoMin	Option 1	Option 2	Option 3	Option 4
No ODR	1	30:41	37:21	36:52	34:43	37:18
	2	24:48	28:26	29:01	27:19	28:33
	3	25:10	29:22	29:22	29:09	31:11
	4	25:16	28:32	29:23	26:40	28:45
	5	-	-	-	-	-
	6	36:54	44:38	45:39	41:39	44:32
	7	25:13	27:55	27:51	28:43	29:36
	8	26:44	30:03	30:12	29:26	30:02
	Total	**194:46**	**226:18**	**228:20**	**217:40**	**229:56**
Western ODR	1	26:15	28:43	31:14	29:23	28:49
	2	21:34	23:03	25:24	24:00	22:59
	3	23:44	25:35	26:45	25:47	25:12
	4	22:00	23:41	25:36	24:26	23:15
	5	-	-	-	-	-
	6	33:07	36:55	41:43	37:43	36:14
	7	22:01	24:59	25:16	25:30	24:23
	8	24:45	26:42	28:59	26:53	26:45
	Total	**173:25**	**189:37**	**204:57**	**193:42**	**187:36**
Eastern ODR	1	24:37	28:23	28:28	27:22	28:46
	2	20:33	22:06	23:27	21:50	23:44
	3	22:07	24:20	24:35	23:43	24:47
	4	21:38	22:45	24:06	22:31	23:42
	5	00:00	00:00	00:00	00:00	00:00
	6	30:15	34:42	36:26	33:07	36:30
	7	21:59	25:04	25:37	24:43	24:33
	8	23:00	25:33	25:54	24:39	26:01
	Total	**164:09**	**182:53**	**188:33**	**177:55**	**188:03**

source: SATURN models

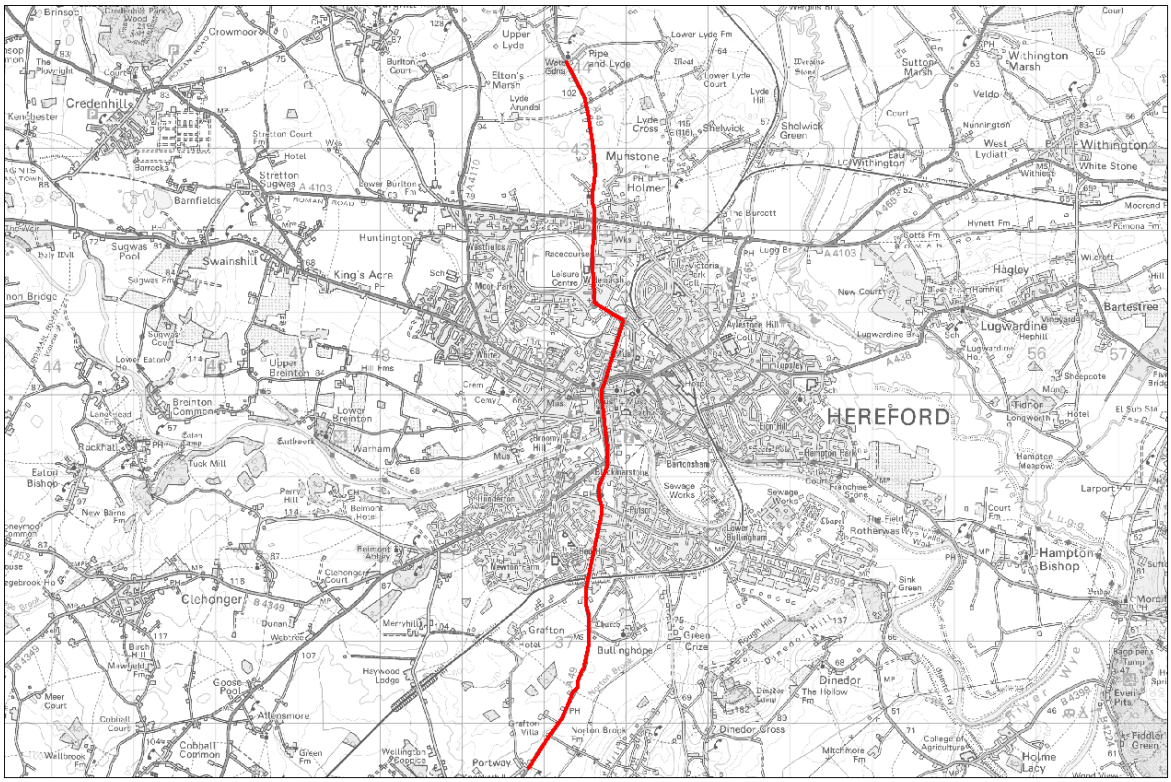
5.129 A similar effect is seen in the PM Peak, but in this case the impact of the ODR is more pronounced, with the sample journey times falling to levels well below those of the Do-Minimum in most cases. In the Do-Something Demand Option 2, however, the sample journey times are generally higher than in the Do-Minimum Demand and No ODR case/

5.130 In both the AM and PM models, the Eastern ODR with Demand Option 3 gives the lowest total time for the seven sampled routes.

Impact on A49 Trunk Road

5.131 In order to assess the impact of the various development and infrastructure options on the operation of the A49 Trunk Road, journey times for a route running along the A49 between the priority junction at Portway and the priority junction near Pipe and Lyde, in both directions, were extracted from each SATURN highway model. The route is shown in Figure 5-3 below.

Figure 5-3 - A49 journey time route



5.132 Modelled journey times from the AM models are shown in Table 5-13.

Table 5-13 Comparison of Modelled Journey Times on A49 – AM Peak

Network Scenario	Direction	Modelled Journey Time / mm:ss				
		Do-Minimum	DS1	DS2	DS3	DS4
No ODR	NB	15:32	16:43	18:01	16:46	17:59
	SB	13:52	17:33	17:13	17:02	17:16
West ODR	NB	14:28	15:08	15:33	15:05	15:35
	SB	12:53	14:27	13:50	14:22	14:07
East ODR	NB	14:27	14:59	14:59	15:01	15:03
	SB	12:54	14:38	14:07	14:36	14:10

SATURN model

5.133 It can be seen that, in the No ODR scenarios, addition of the extra demand cause journey times on the A49 to increase, with the increases being more pronounced in the southbound direction. The addition of the ODR on the western alignment leads to journey times reducing back to a level seen

in the No ODR – Do-Minimum scenario. Provision of the Eastern ODR also sees the journey times on the A49 falling to around the levels seen in the No ODR – Do-Minimum scenario.

5.134 The corresponding results from the PM Peak models are shown in Table 5-14.

Table 5-14 Comparison of Modelled Journey Times on A49 - PM Peak

Network Scenario	Direction	Modelled Journey Time / mm:ss				
		Do-Minimum	DS1	DS2	DS3	DS4
No ODR	NB	16:44	19:00	19:17	18:15	19:52
	SB	15:42	16:37	17:53	15:47	17:01
West ODR	NB	15:23	16:06	16:24	16:03	16:09
	SB	13:46	14:20	16:23	15:03	14:26
East ODR	NB	15:33	16:37	16:25	16:18	16:37
	SB	13:12	13:53	15:00	13:49	15:05

5.135 As in the AM Peak, the additional demand associated with the Do-Something development scenarios leads to journey times increasing in the No ODR scenarios. The increases are pronounced in the northbound direction, however, where increases of two to three minutes are seen. Provision of the Western ODR leads to the journey times falling to below those seen in the No ODR – Do-Minimum scenario in most development scenarios. In Do-Something Option 2, however, provision of the Western ODR does reduce southbound journey times, but not to the level of those seen in the No ODR – Do-Minimum. Provision of the Eastern ODR actually reduces journey times on the A49 to levels seen in the No ODR – Do-Minimum regardless of the development scenario.

Over-Capacity Junctions

5.136 In the highway model, delays and queues at junctions are modelled explicitly. Junction which is operating at, or close to, its nominal capacity is likely to impose delays on vehicles using it.

5.137 The volume-to-capacity ratio is often used to denote how close to capacity a particular junction is. Because the techniques used to estimate a junction's capacity were derived using statistical modelling techniques, there is always a degree of uncertainty regarding a calculation of a junction's capacity. For this reason, a junction operating at 85% of its calculated capacity is generally considered to be „congested', as although it might appear to be operating within its calculated capacity, its actual capacity could be somewhat lower.

5.138 The SATURN models were interrogated in order to obtain the volume-to-capacity ratio at each modelled junction. Junctions operating at 85% of capacity and above are divided into three bands

- 85% to 100% - operating at or close to capacity, delays are to be expected;
- 100% to 120% - operating over-capacity, delays are likely to be considerable; and
- 120% and over – operating significantly over-capacity, delays will be considerable and could lead to widespread queuing.

5.139 The numbers of modelled junctions within each volume-to-capacity band are shown in Table 5-15 for the AM Peak models and in Table 5-16 for the PM peak models. Figures showing the locations of the over-capacity junctions are shown in Appendix D.

Table 5-15 Over Capacity Junctions - AM Peak

Volume to Capacity Ratio	Do Minimum			Option 1			Option 2			Option 3			Option 4		
	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR
85% to 100%	19	16	13	36	24	23	37	20	25	35	22	20	36	19	25
100% to 120%	7	1	0	21	11	5	19	9	7	15	8	4	17	10	5
120% and over	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**26**	**17**	**13**	**57**	**35**	**28**	**56**	**29**	**32**	**50**	**30**	**24**	**53**	**29**	**30**

source: SATURN model

Table 5-16 Over Capacity Junctions - PM Peak

Volume to Capacity Ratio	Do Minimum			Option 1			Option 2			Option 3			Option 4		
	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR
85% to 100%	21	16	19	25	23	21	26	23	17	22	21	19	26	25	16
100% to 120%	15	8	5	25	12	15	24	15	17	27	13	11	24	8	16
120% and over	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0
Total	**36**	**24**	**24**	**51**	**35**	**36**	**51**	**38**	**34**	**49**	**34**	**30**	**51**	**33**	**32**

source: SATURN model

Table 5-17 Over Capacity Junctions - Both Peaks

Volume to Capacity Ratio	Do Minimum			Option 1			Option 2			Option 3			Option 4		
	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR	No ODR	West ODR	East ODR
85% to 100%	40	32	32	61	47	44	63	43	42	57	43	39	62	44	41
100% to 120%	22	9	5	46	23	20	43	24	24	42	21	15	41	18	21
120% and over	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0
Total	**62**	**41**	**37**	**108**	**70**	**64**	**107**	**67**	**66**	**99**	**64**	**54**	**104**	**62**	**62**

source: SATURN model

5.140 Examination of these results shows that provision of an ODR on either alignment leads to a reduction in the number of over-capacity junctions. There is little to choose between the two alignments in terms of reducing the number of over-capacity junctions, however.

6 Determination of Preferred Option

Do-Minimum Case

6.141 The Do-Minimum Case represents a situation where the changes in demand for travel are in line with the TEMPRO forecasts and the only changes to the highway network are those associated with the Edgar Street Grid proposals.

6.142 In this case, demand for travel by car in the modelled area in the forecast year of 2026 is estimated to be around 10% higher than at present. This will lead to a worsening of congestion and a reduction in network speeds.

6.143 In the AM Peak, particular problems are expected to occur on Blue School Street, Edgar Street, Newtown Road and Commercial Street. The signalised junction at the southern end of the Victoria Street Bridge is also forecast to experience congestion problems.

6.144 In the PM Peak, congestion is forecast at the same locations, and on Belmont Road and Roman Road.

6.145 The SATURN models show that in the Do-Minimum scenario average network speeds, in the simulated area, are forecast to be 31 kph in the AM peak and 28 kph in the PM.

Growth Point Demand with No Highway Improvements

6.146 If the additional demand associated housing and employment allocations is added to the model, the highway conditions are forecast to become much worse, with widespread congestion and low network speeds. This is not unexpected, as the allocations are forecast to increase demand for travel by car by around 20% in each peak period.

6.147 In the AM peak, particular problems of congestion are forecast on Roman Road, Holmer Road, Newtown Road, Blue School Street, Victoria Street and Belmont Road. The locations of particular congestion hot-spots are dependent on the actual distribution of the housing and employment sites. Reference should be made to the plots shown in Appendix E.

6.148 The PM peak shows more widespread congestion and lower network speeds.

6.149 Network speeds, within the simulated area, are forecast to fall to by around 10%, compared to the case without the additional demand.

Growth Point Demand with Outer Distributor Road on Western Alignment

6.150 The addition of an Outer Distributor Road on the Western alignment is an effective measure for reducing the congestion problems caused by the additional demand for travel.

6.151 In the AM, the addition of the road leads to a fall in total travel time in the simulated area of around 10% to 13% (depending on which Do-Something Demand Scenario is selected). Average network speeds rise from around 27kph to 35kph. The total distance travelled within the simulated area is forecast to rise by around 15% with the addition of the road.

6.152 A similar impact is seen in the PM Peak, with total travel time also falling by around 10%, and average network speeds rising from around 26kph to 33kph (depending on which development scenario is chosen), and total distance rising by 17%.

6.153 These figures suggest that the ODR is successful in alleviating some of the congestion, as some trips change routes to achieve a reduction in journey time. This is at the expense of having a slightly longer (in terms of distance) journey.

6.154 In the Do-Something Demand Option 2, the addition of the road only has a minor impact on the total travel time.

Growth Point Housing with Outer Distributor Road on Eastern Alignment

6.155 The addition of an Outer Distributor Road on the eastern alignment is also forecast to alleviate the congestion problems caused by the additional demand for travel.

6.156 In the AM models, the reduction in total travel time compared to the situation without the road is around 13%, whilst in the PM it is around 10%.

Preferred Development Option

6.157 The determination of the preferred development option was undertaken by calculating the total generalised cost of travel in each highway network. The total cost of travel is calculated by taking into account the time spent travelling (summed over all modelled vehicles) and the distance travelled (again summed over all vehicles). In effect, the travel cost is a combination of time and distance. This means that the option which produces the lowest overall travel time is not necessarily the option that produces the lowest overall cost of travel.

6.158 The costs for the AM peak model were then added to those of the PM peak model.

6.159 For the situation without an ODR, the total generalised costs of travel are shown in Table 6-1 below.

Table 6-1 Total Costs of Travel - No ODR

Period	Total Generalised Cost of Travel / Hours of Generalised Time			
	Option 1	Option 2	Option 3	Option 4
AM	18,017	18,008	17,743	18,019
PM	19,345	19,445	19,010	19,435
Total	**37,362**	**37,453**	**36,753**	**37,454**

SATURN models

6.160 As can be seen, in the situation without an ODR, the Demand Option that provides the lowest overall cost of travel is Option 3 (North-South focus).

6.161 With an ODR on the Western Alignment, the total costs of travel are shown in Table 6-2 below.

Table 6-2 Total Costs of Travel – ODR West

Period	Total Generalised Cost of Travel / Hours of Generalised Time			
	Option 1	Option 2	Option 3	Option 4
AM	16,915	16,902	16,849	16,919
PM	17,904	18,291	17,974	17,896
Total	**34,819**	**35,193**	**34,823**	**34,815**

SATURN models

6.162 It can be seen the Demand Option 4 (dispersed development) provides the lowest overall travel cost with the Western ODR in place, although there is very little difference between Options 1, 3 and 4.

6.163 Finally, with an ODR on the Eastern Alignment, the total costs of travel are as shown in Table 6-3 below.

Table 6-3 Total Costs of Travel – ODR East

Period	Total Generalised Cost of Travel / Hours of Generalised Time			
	Option 1	Option 2	Option 3	Option 4
AM	16,549	16,571	16,430	16,559
PM	17,549	17,687	17,412	17,673
Total	**34,098**	**34,258**	**33,842**	**34,232**

6.164 Demand Option 3 provides the lowest overall travel cost in an Eastern ODR in place.

6.165 Of all the modelled scenarios, the situation with Demand Option 3 and an ODR on the Eastern Alignment provides the lowest overall travel cost. This, therefore, is the preferred option by this measure.

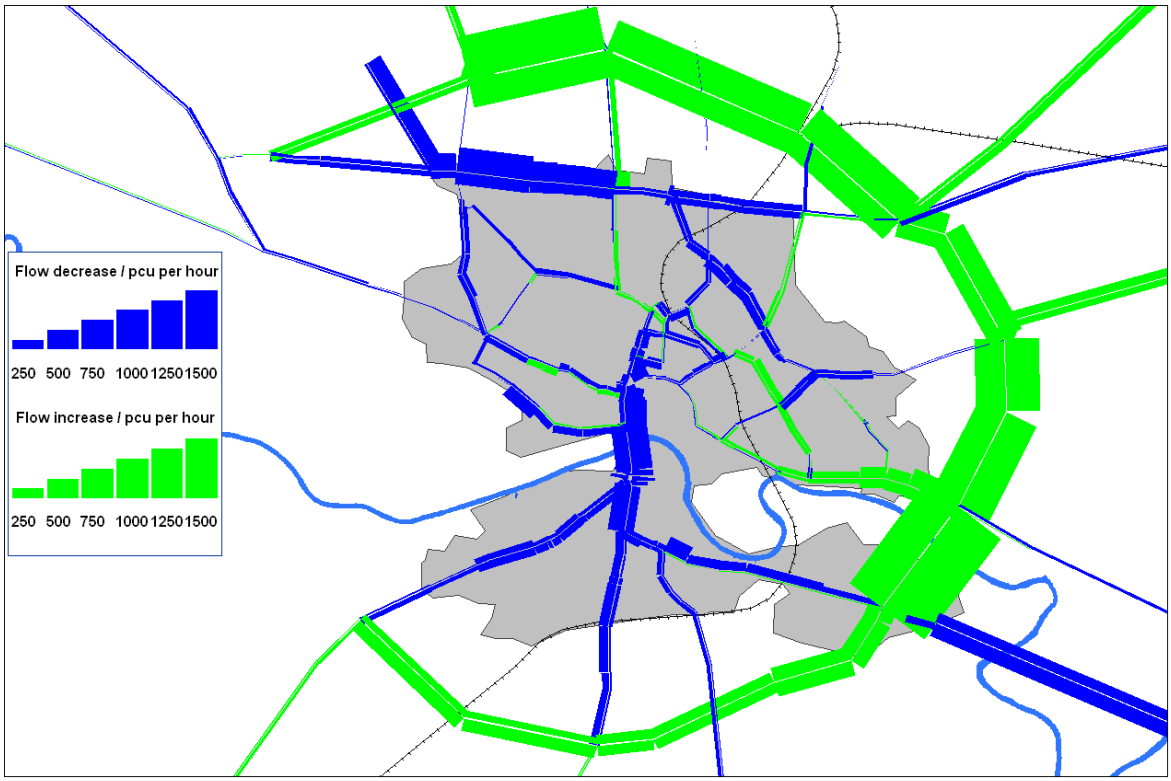
Overall Preferred Option

6.166 As mentioned above, the Option that provides the lowest overall travel cost is Demand Option 3 with an ODR on the Eastern Alignment.

Flow Differences

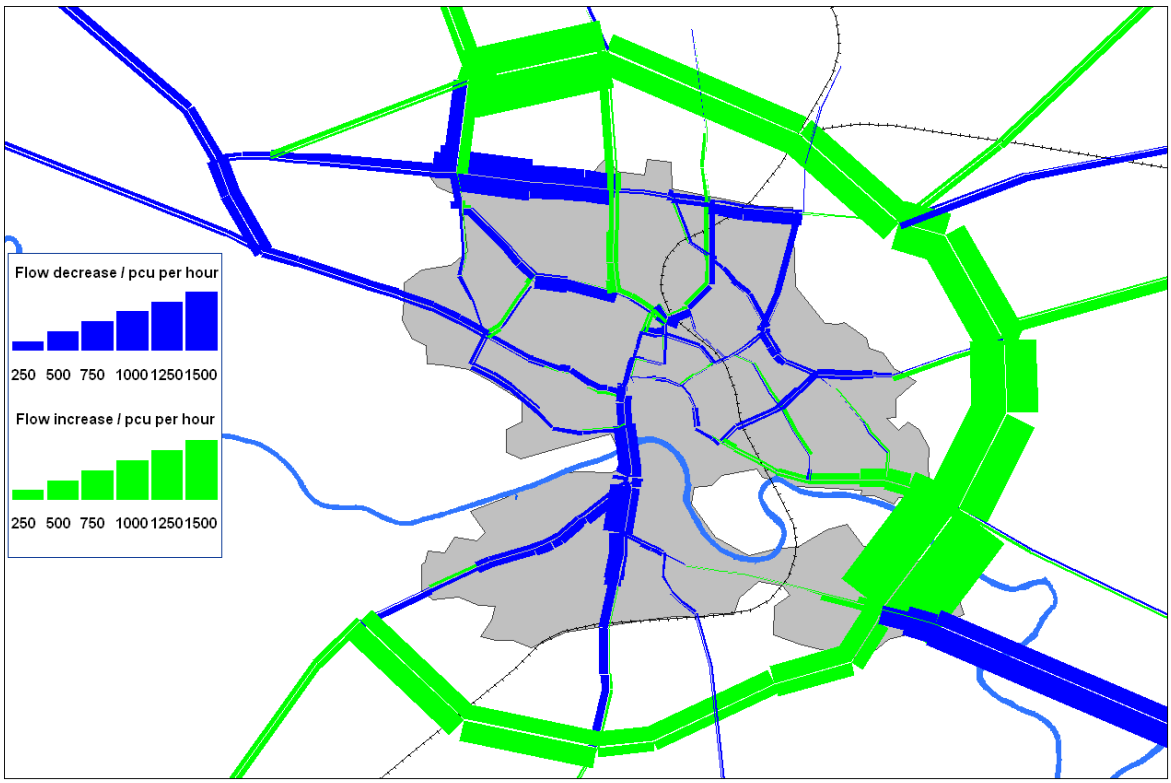
6.167 Compared to the situation with Demand Option 3, but without an ODR, the addition of the Eastern ODR leads to significant changes in traffic flows. In the AM Peak, reductions in flows are forecast on Belmont Road, Ross Road, Holme Lacy Road, Victoria Street, Edgar Street and College Road. Slight increases in flow are forecast for Aylestone Hill and Hampton Park Road. A visual indication of the changes in flow is shown in Figure 6-1 below. Green links experience an increase in usage with the addition of the ODR, whilst blue links experience a reduction in usage.

Figure 6-1- Changes in Flow (ODR East vs No ODR, Demand Option 3) - AM Peak



6.168 A similar impact is seen in the PM Peak model, as shown in Figure 6-2 below.

Figure 6-2 - Changes in Flow (ODR East vs No ODR, Demand Option 3) - PM Peak



Stress (Junction Volume to Capacity Ratios)

6.169 Addition of the ODR on the eastern alignment is forecast to lead to a fall in the numbers of junctions that are operating beyond their nominal capacity, compared to the situation without the road, as shown in Table 6-4 below.

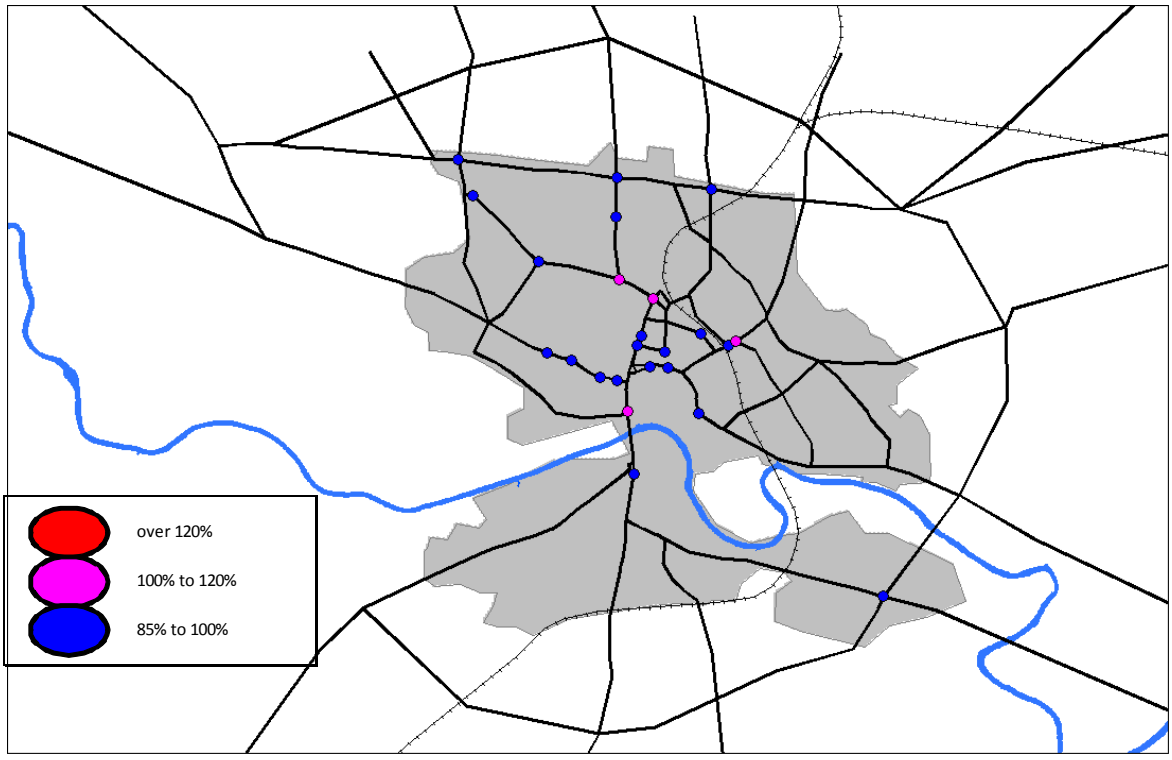
Table 6-4 Over-Capacity Junctions - East ODR vs No ODR - Option 3

Time Period	Volume to Capacity Ratios								
	85% to 100%			100% to 120%			120% and over		
	No ODR	ODR East	Change	No ODR	ODR East	Change	No ODR	ODR East	Change
AM Peak	35	20	-15	15	4	-11	0	0	0
PM Peak	22	19	-3	27	11	-16	0	0	0
Total	**57**	**39**	**-18**	**42**	**15**	**-27**	**0**	**0**	**0**

source: SATURN models

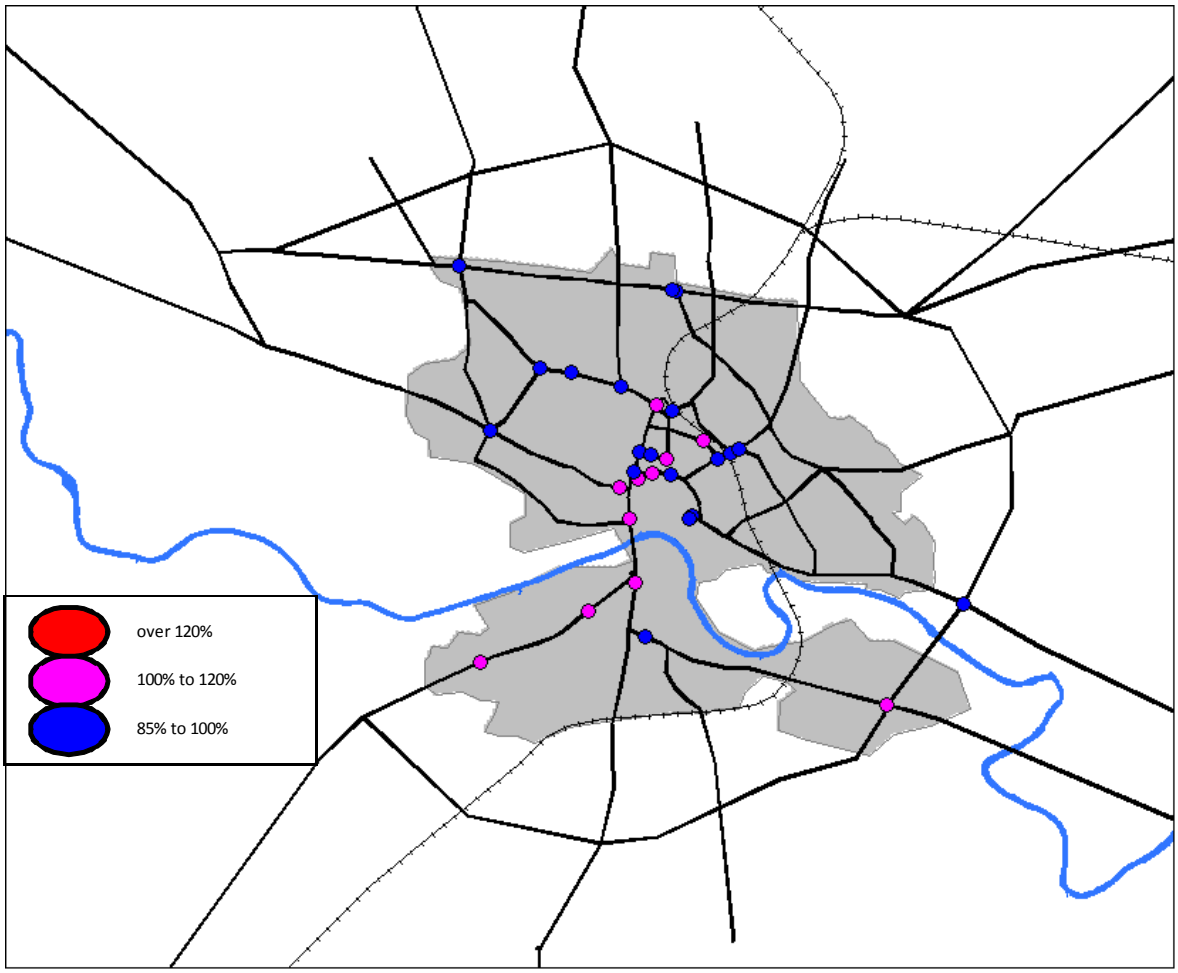
6.170 As can be seen in Figure 6-3 below, in the AM Peak, the junctions that are forecast to operating at over 85% of capacity are on key routes in and around the city centre. This suggests that some remedial work may be required at these junctions in the future even if the ODR is built.

Figure 6-3 : Junctions operating at >85% of capacity - AM Peak



6.171 In the PM Peak model, there are more junctions that are forecast to be operating at greater than 85% capacity than in the AM, again suggesting that some remedial work may be required in order to reduce congestion.

Figure 6-4 - Junctions operating at >85% of capacity - PM Peak



Overall Ranking

6.172 All of the twelve options were ranked against a number of performance indicators i.e. average speed, link delays, queues, journey time, junction stress, travel cost etc to identify the best in both AM and PM peak. The values of these indicators have been taken from the results tables that were reported in earlier sections. An average of both rankings was then calculated to show combined ranking as shown in Table 6.5. Details of ranking procedure have been provided in **Appendix G**.

Table 6.5 Recommended Options

Criteria		AM Rank	PM Rank	Average Rank
No ODR	DS1	10	10	**10**
	DS2	9	12	**11**
	DS3	8	8	**8**
	DS4	9	11	**10**
Western ODR	DS1	7	4	**6**
	DS2	4	9	**7**
	DS3	5	5	**5**
	DS4	6	2	**4**
Eastern ODR	DS1	3	3	**3**
	DS2	5	7	**6**
	DS3	1	1	**1**
	DS4	2	6	**4**

7 Conclusions

7.173 This report has described the forecasting methodology for the Hereford Multi-Modal Model. The methodology is designed to produce forecasts of for a single future year of 2026, both with and without additional trips associated with the Growth Point housing.

7.174 Five Future Year demand scenarios have been modelled;

- Do-Minimum – with growth in travel demand forecast by TEMPRO
- Do-Something 1 to Do-Something 4 – with growth in travel demand forecast by TEMPRO, plus additional trips associated with the Growth Point housing and employment allocations – four different distributions of housing and employment have been tested.

7.175 The five demand scenarios have each been tested with three network scenarios ;

- No ODR – a future-year network without an Outer Distributor Road;
- ODR West – a future-year network with an Outer Distributor Road on a Western alignment; and
- ODR East – a future year network with an Outer Distributor Road on an Eastern alignment.

7.176 The increase in travel demand, as forecast by TEMPRO, is forecast to worsen the congestion within the city of Hereford. Adding the additional trips associated with the Growth Point housing allocations will exacerbate these congestion problems, leading to longer journey times and extensive queuing.

7.177 Provision of an Outer Distributor Road, on either alignment, is forecast to provide relief from these congestion problems. By most measures, conditions on the highway network with the additional trips and an Outer Distributor Road are no worse than conditions under the Do-Minimum scenario.

7.178 Of the options tested, it is the option with an Outer Distributor Road on the Eastern Alignment and with the Do-Something Demand Option 3 (North-South focus) that produces the best overall highway network performance in terms of overall total cost of travel.

Appendix A

Glossary

Glossary

SATURN (Simulation and Assignment of Traffic to Urban Road Networks): is a suite of network analysis programs in use in the UK since 1981. It has 6 basic functions: a combined traffic simulation and assignment model; a "conventional" traffic assignment model for the analysis large networks; a simulation and assignment model of individual junctions; a network editor, database and analysis system; a matrix manipulation package for the production of, e.g. trip matrices; a trip matrix demand model covering the basic elements of trip distribution, modal split etc.

TEMPRO (Trip End Model Presentation Program): A computer program developed for DfT to present trip end, car ownership and population/workforce planning data output from a series of models developed for the Department for Transport (DfT)'s National Transport Model.

TRICS (Trip Rate Information Computer System): A powerful database to enable effective searching and filtering of the information collated from over 4,000 surveys, including detailed site information and an unprecedented amount of multi-modal survey data. The database is capable of complex trip rate calculations and graphical representation of rates and patterns. The annual survey programme is carefully targeted to reflect the development types of the future.

DIADEM (Dynamic Integrated Assignment and Demand Modelling): A variable demand model. It links highway assignment models to a variable demand model and provides a means of achieving convergence between assignment (supply) and demand models.

GIS (Geographic Information Systems): Captures, stores, analyzes, manages, and presents data that refers to or is linked to location.

TRIPS (Transport Improvement Planning System): the comprehensive transport modelling package, is specially designed for professional transport planners. As a widely applied planning system in the world, TRIPS has been continuously developed during past several decades. Same as other known transport planning packages, it is based on the classical four-step transport planning theory: (Trip) Production, Distribution, Modal choice and Assignment.

MVGRAM: Is a trip distribution model which offers the following principal functions: Calibration; Forecasting; Growth Factoring (Furness); Partial Matrix Technique.

Appendix B

Growth Factors

TEMPRO Growth Factors

AM (0700 to 0959)	Walk		Cycle		Car Driver		Car Passenger		Bus/Coach	
	Origin	Destinatio	Origin	Destinatic	Origin	Destinatic	Origin	Destinatic	Origin	Destinatio
Rural Herefordshire	1.123	1.102	1.103	1.054	1.150	1.122	1.129	1.109	1.083	1.053
Great Malvern (part of)	1.061	1.054	1.035	1.034	1.141	1.116	1.068	1.077	0.990	1.014
Leominster	1.023	1.040	1.000	1.032	1.107	1.111	1.060	1.077	0.982	1.010
Ross-on-Wye	1.034	1.042	1.007	1.040	1.098	1.110	1.055	1.076	0.990	1.017
Ledbury	1.032	1.041	1.010	1.028	1.103	1.110	1.057	1.077	0.990	1.022
Bromyard	1.026	1.040	0.996	1.056	1.107	1.108	1.052	1.075	0.980	1.020
Hereford	0.983	1.021	0.967	1.006	1.065	1.097	1.024	1.057	0.951	0.985
GB	1.057	1.057	1.050	1.050	1.173	1.173	1.146	1.146	1.029	1.029

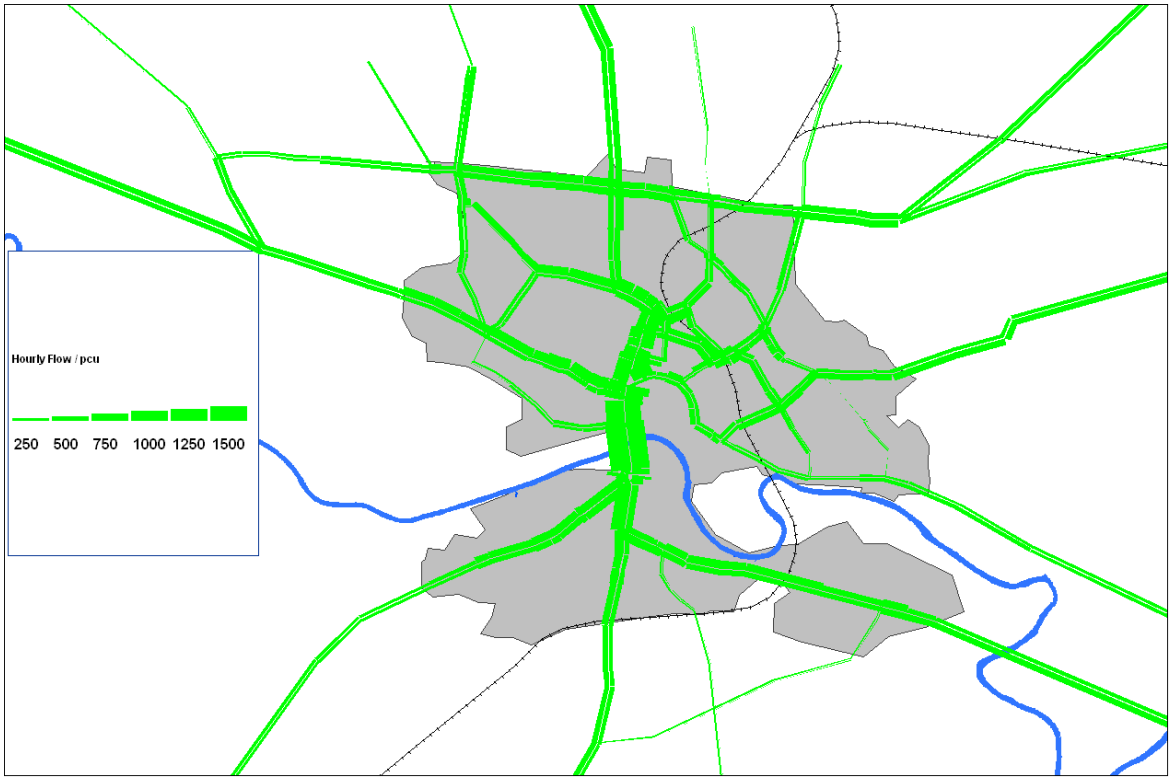
PM (1600 to 1859)	Walk		Cycle		Car Driver		Car Passenger		Bus/Coach	
	Origin	Destinatio	Origin	Destinatic	Origin	Destinatic	Origin	Destinatic	Origin	Destinatio
Rural	1.170	1.131	1.126	1.092	1.174	1.157	1.147	1.130	1.119	1.076
Great Malvern (part of)	1.126	1.104	1.049	1.072	1.170	1.139	1.096	1.108	1.041	1.057
Leominster	1.079	1.105	1.032	1.064	1.132	1.138	1.082	1.100	1.024	1.042
Ross-on-Wye	1.091	1.103	1.042	1.064	1.129	1.136	1.080	1.098	1.044	1.041
Ledbury	1.091	1.103	1.042	1.064	1.129	1.136	1.080	1.098	1.044	1.041
Bromyard	1.089	1.099	1.035	1.062	1.135	1.132	1.078	1.095	1.035	1.037
Hereford	1.035	1.091	0.991	1.045	1.090	1.123	1.044	1.084	0.990	1.030
GB	1.120	1.120	1.083	1.083	1.278	1.278	1.173	1.173	1.002	1.002

Appendix C

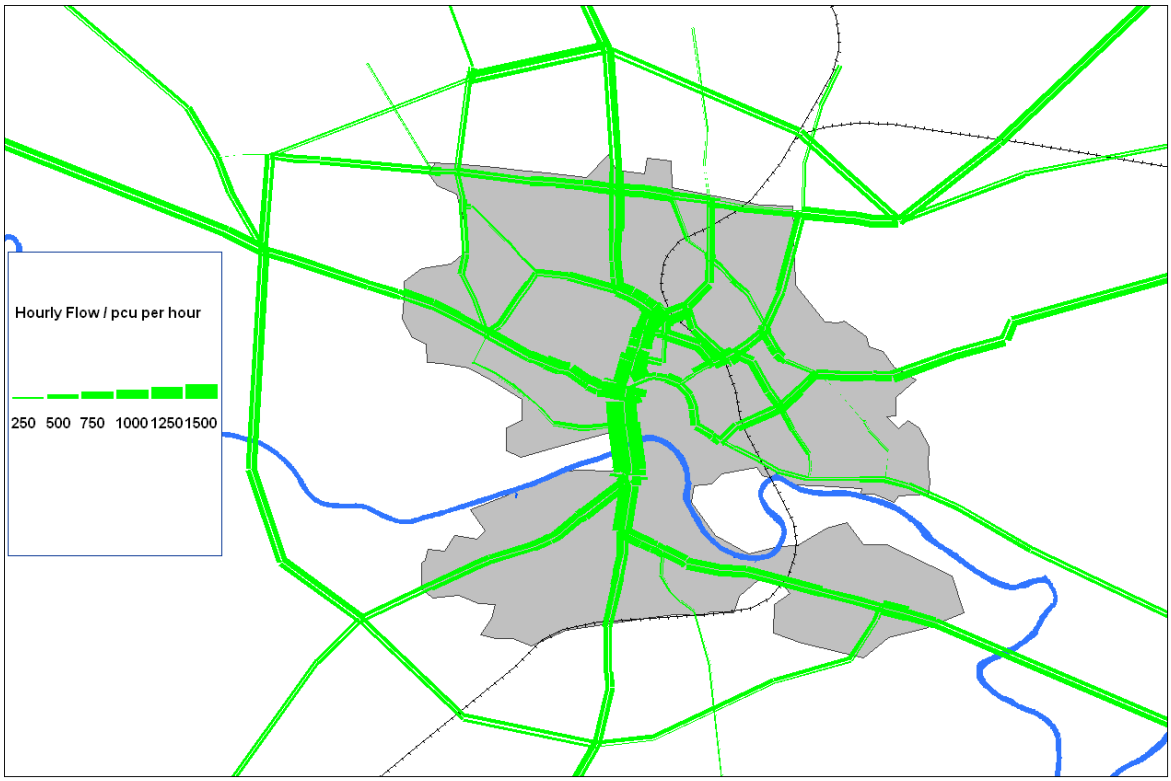
Link Flows

Do-Minimum Demand Option

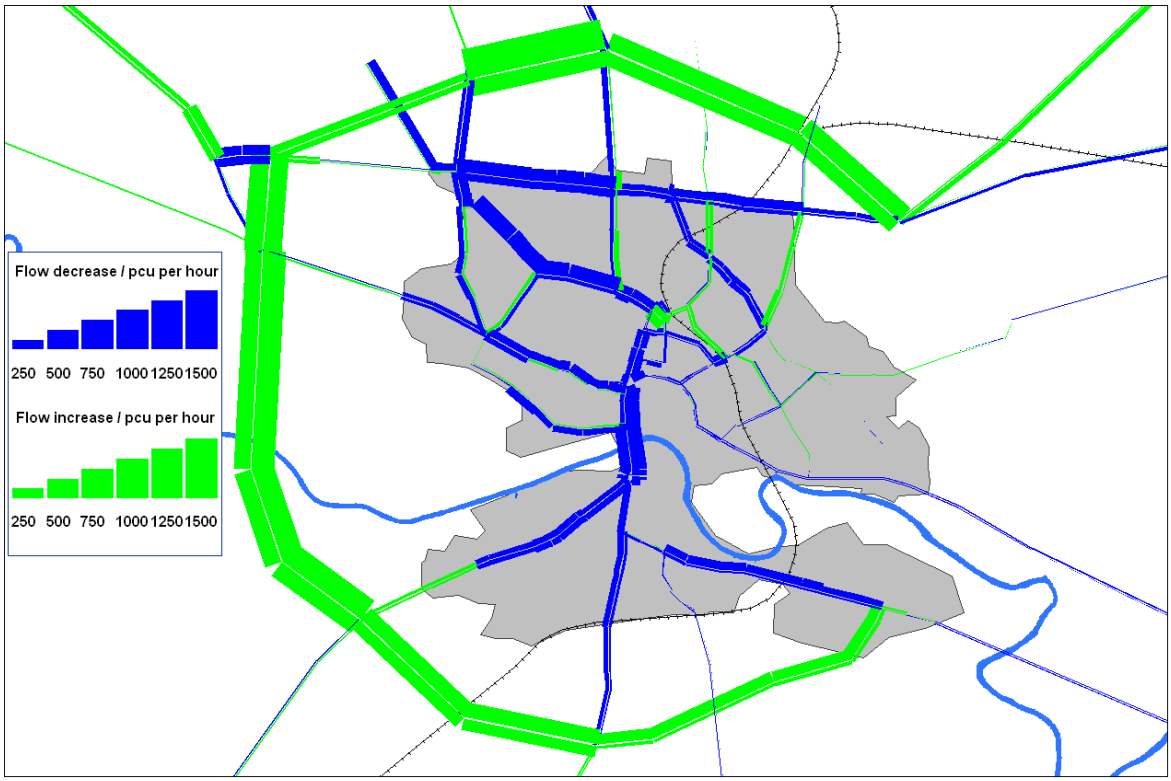
Link Flows: No ODR – Do-Minimum Demand: AM Peak



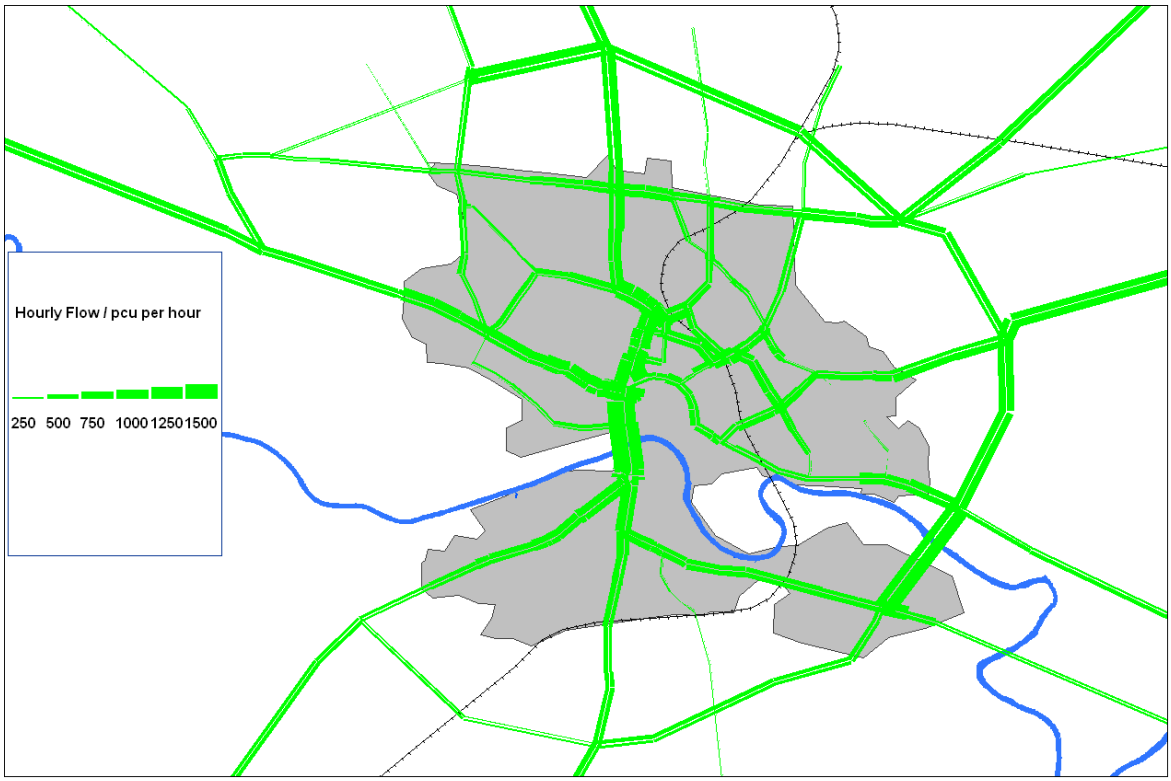
Link Flows: ODR West – Do-Minimum Demand: AM Peak



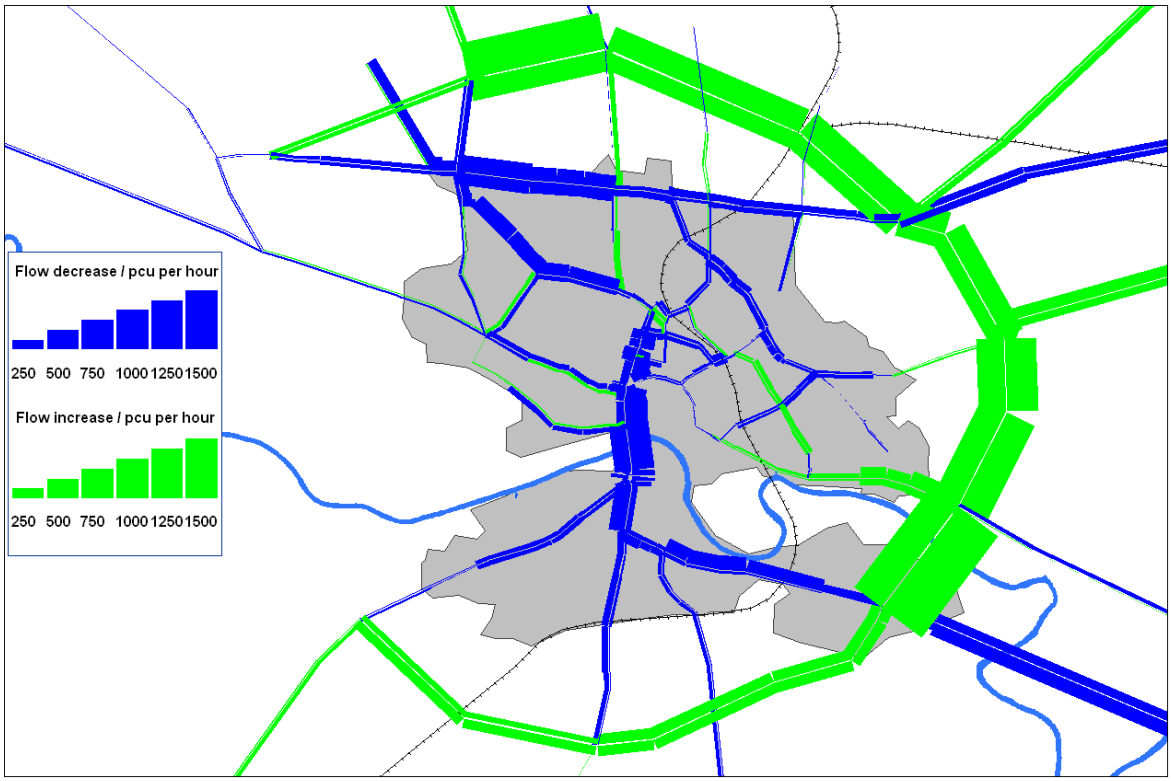
Link Flow Comparison: ODR West vs No ODR – Do-Minimum Demand: AM Peak



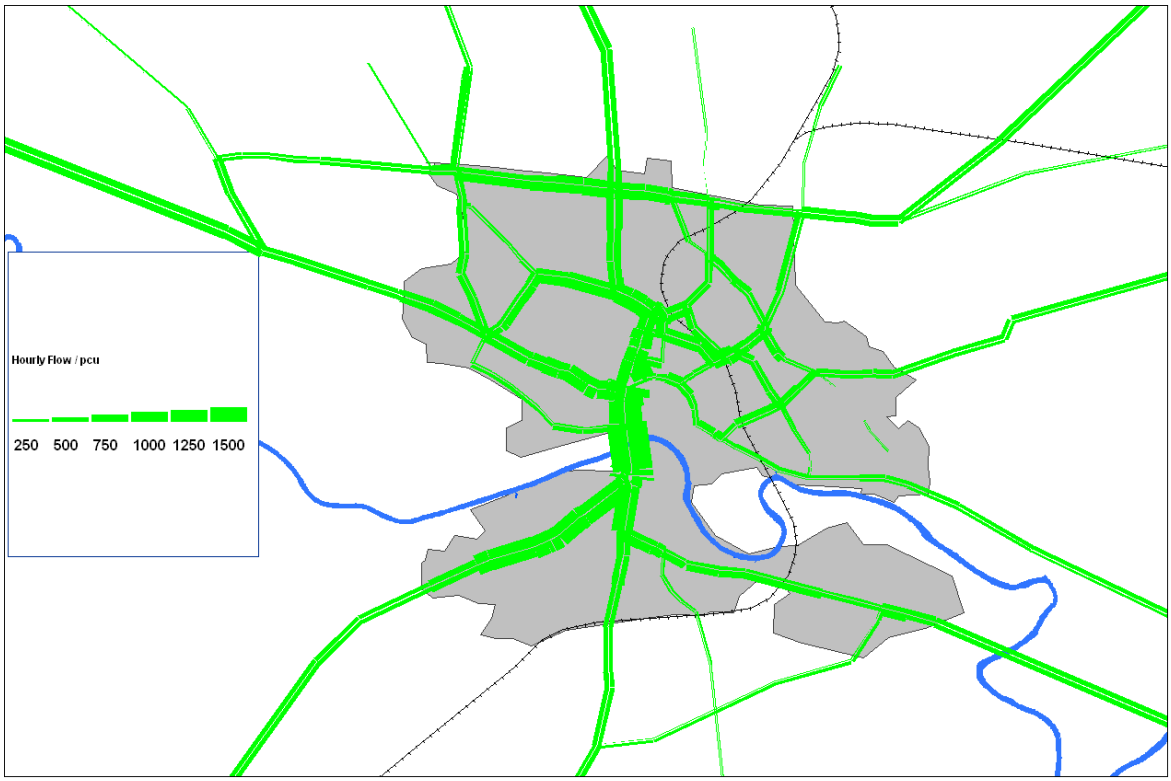
Link Flows: ODR East – Do-Minimum Demand: AM Peak



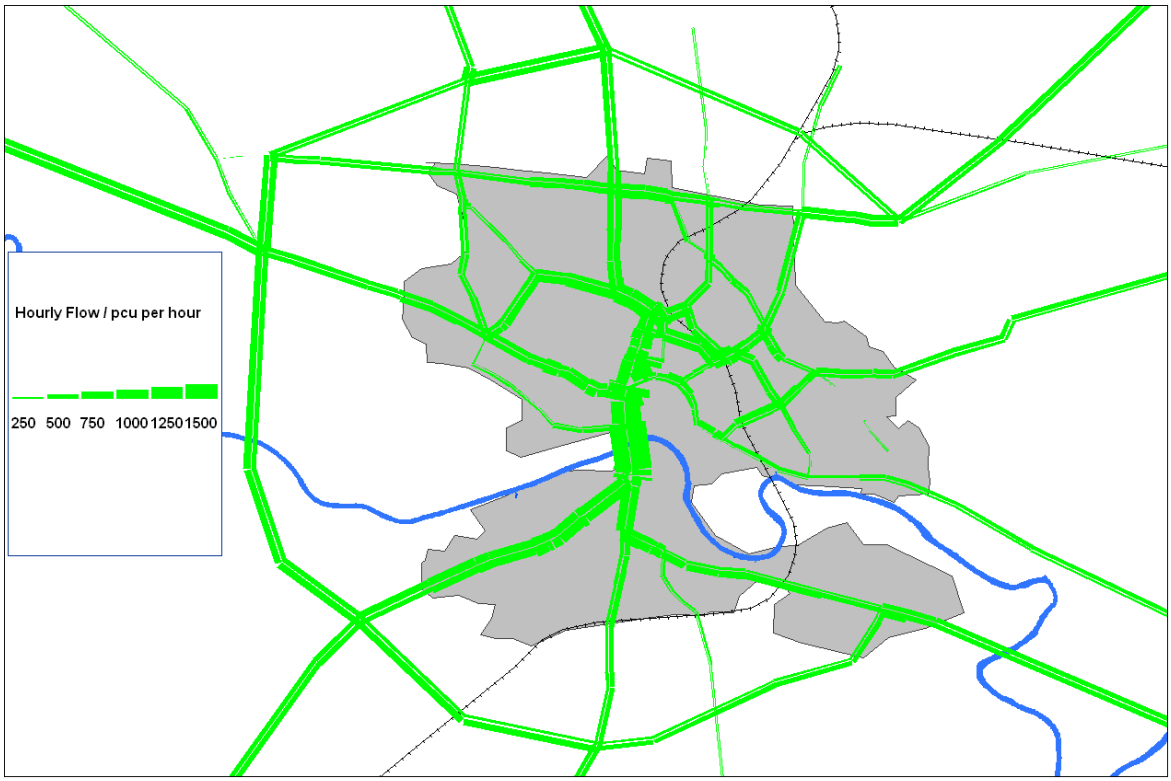
Link Flow Comparison – ODR East vs No ODR – Do-Minimum Demand: AM Peak



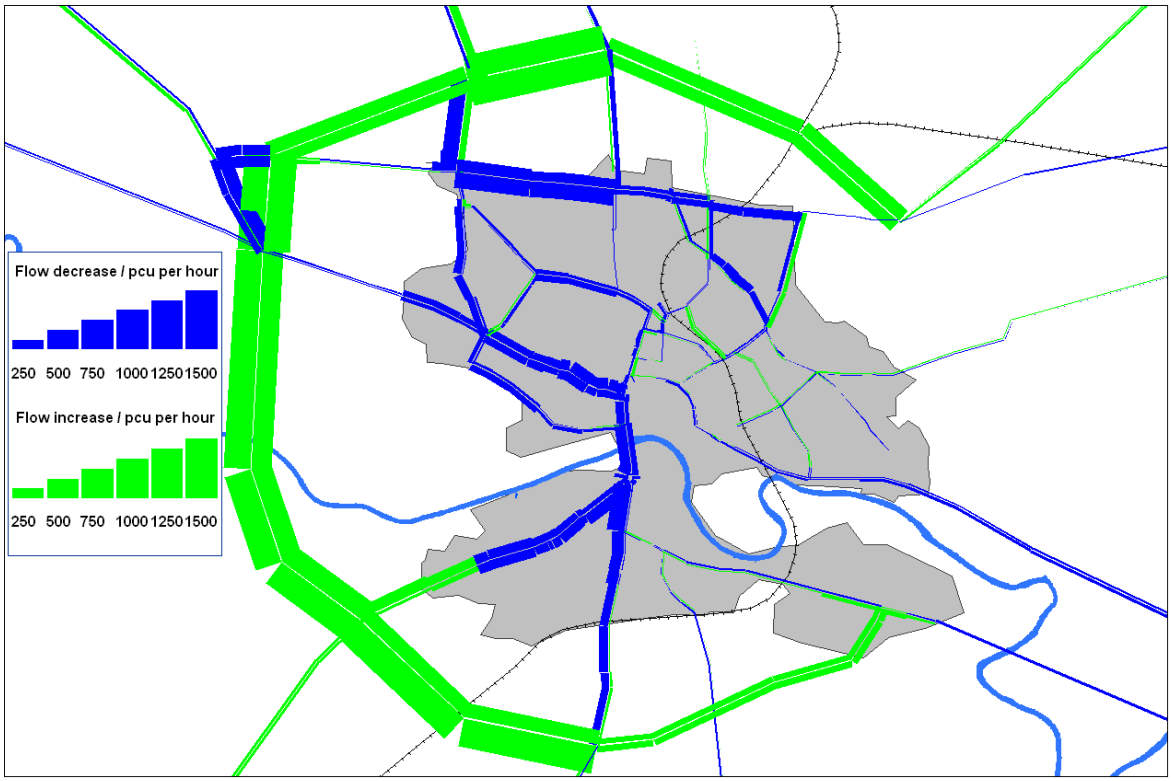
Link Flows: No ODR – Do-Minimum Demand: PM Peak



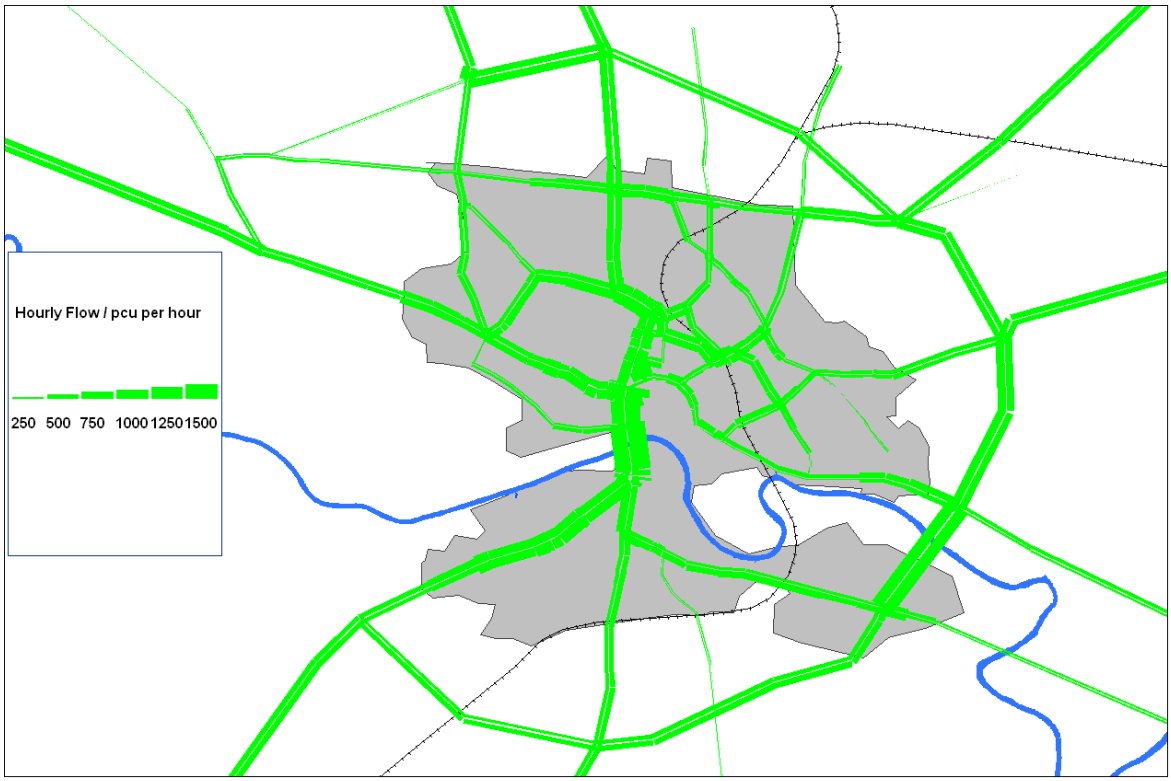
Link Flows: ODR West – Do-Minimum Demand: PM Peak



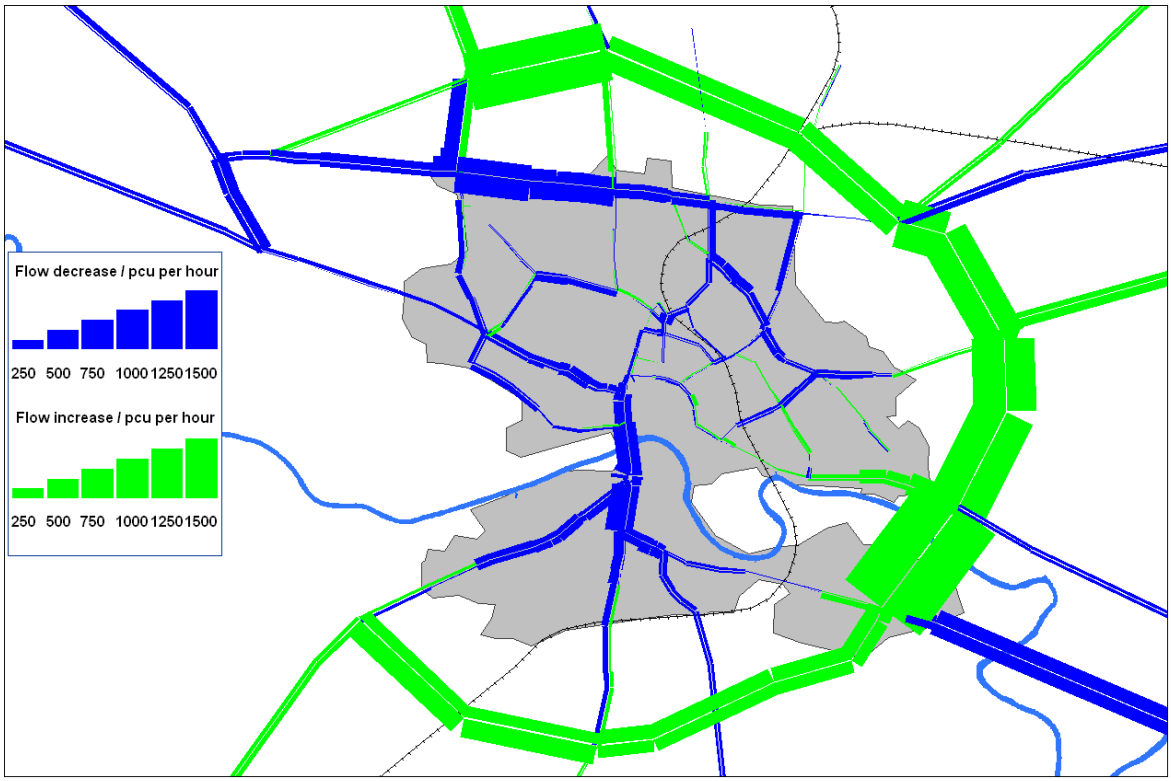
Link Flows Comparison: ODR West vs No ODR – Do-Minimum Demand: PM Peak



Link Flows: ODR East – Do-Minimum Demand: PM Peak

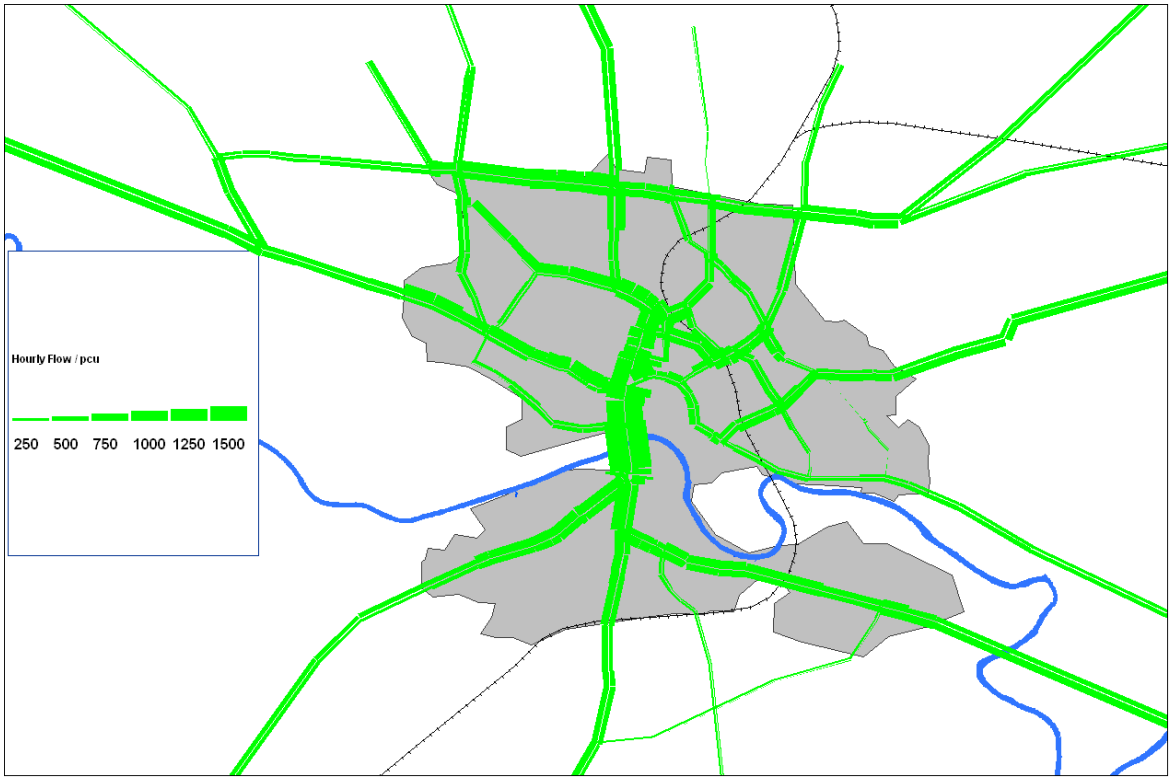


Link Flows Comparison ODR East vs No ODR – Do-Minimum Demand: PM Peak

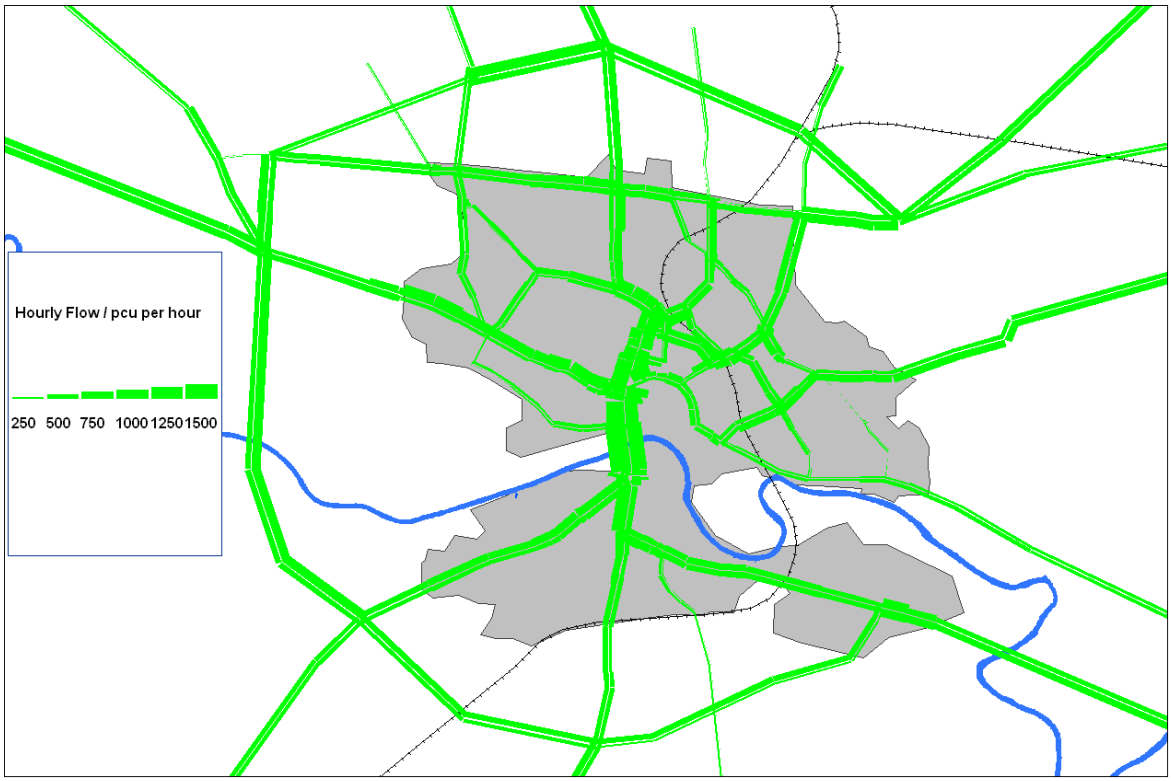


Do-Something Demand Option 1

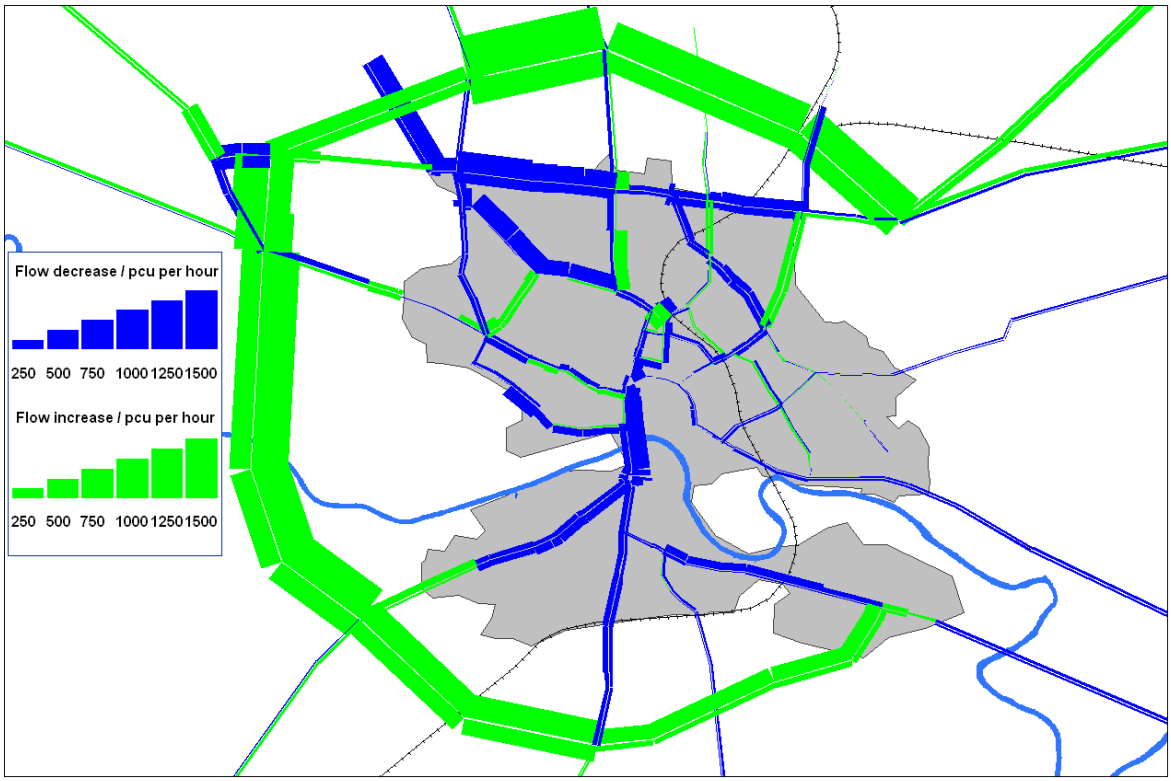
Link Flows: No ODR – Demand Option 1: AM Peak



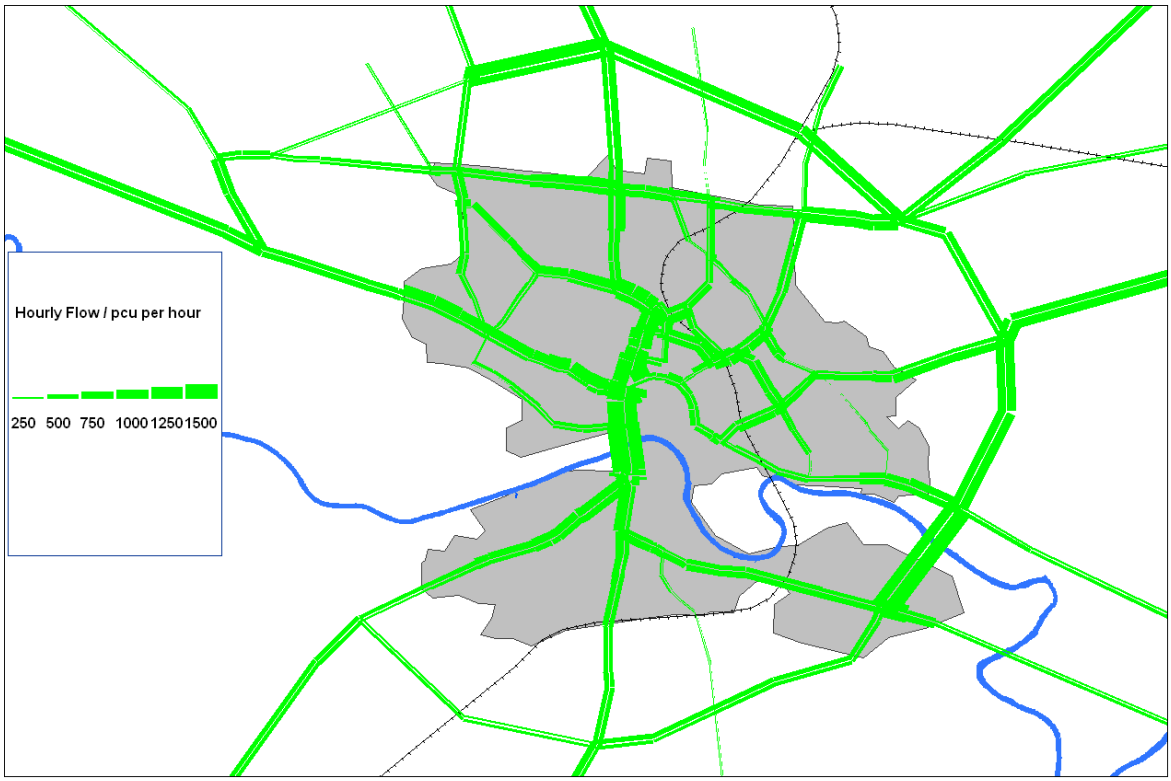
Link Flows: ODR West – Demand Option 1: AM Peak



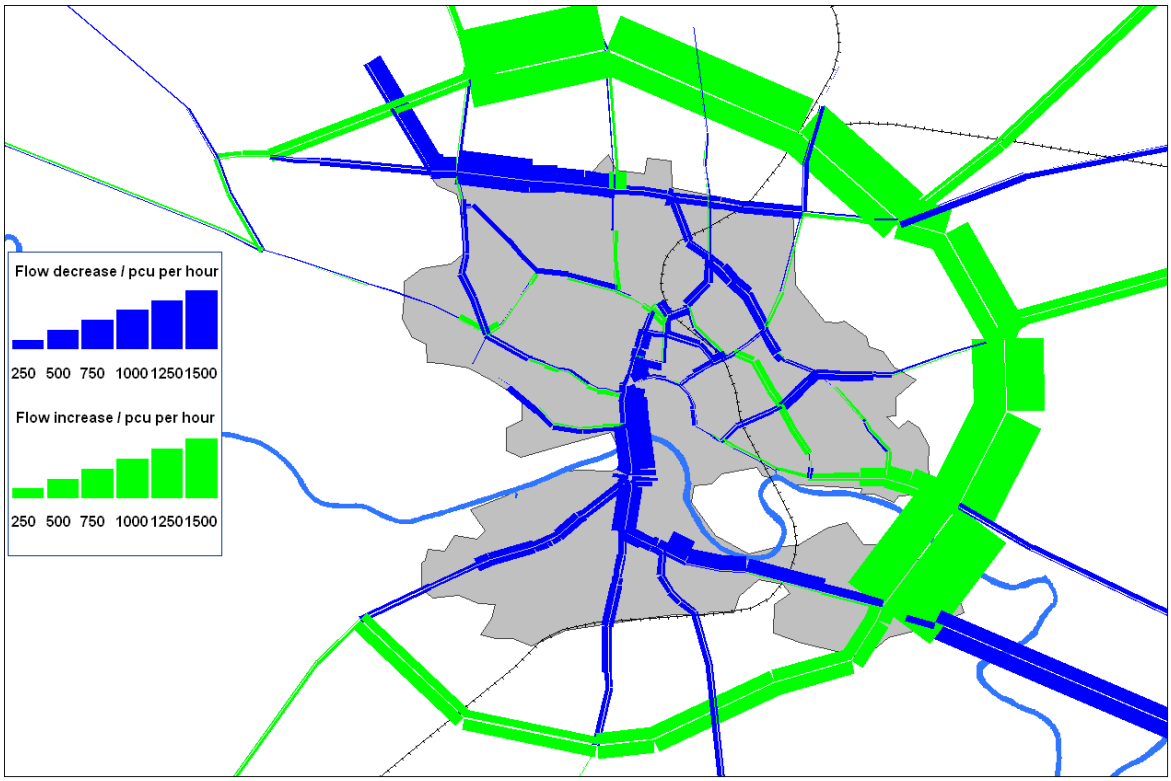
Link Flows Comparison: ODR West vs No ODR – Demand Option 1: AM Peak



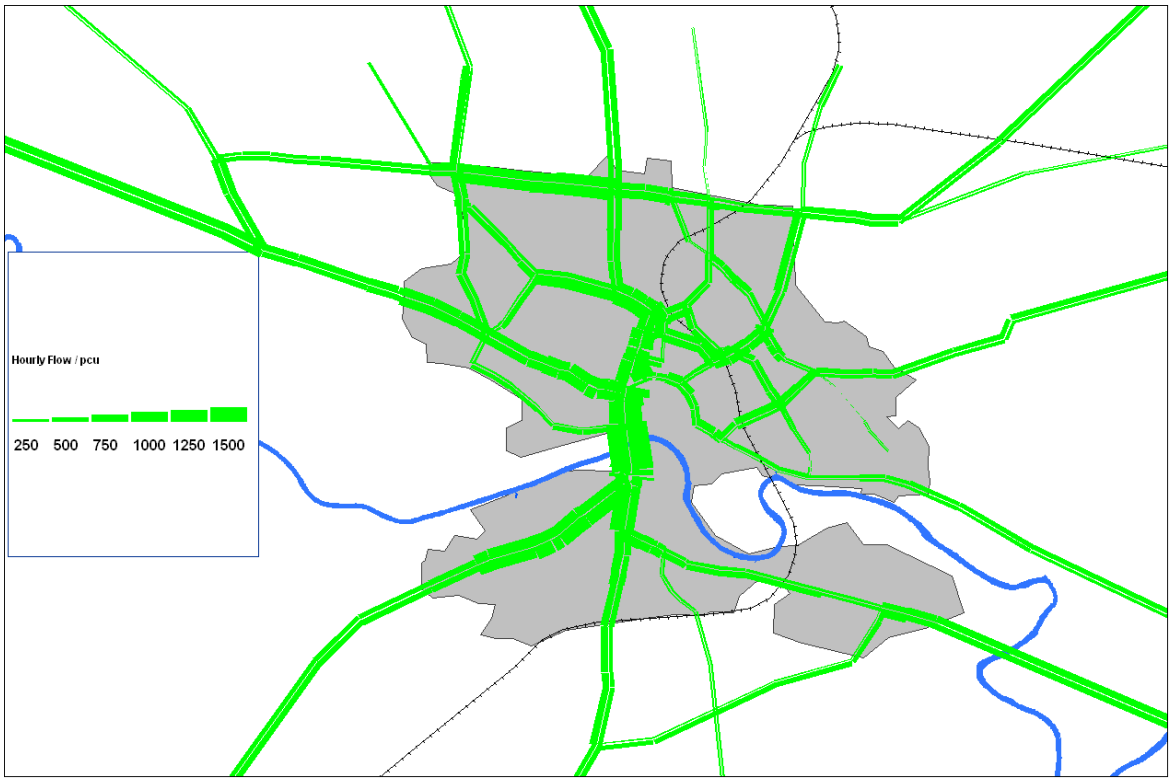
Link Flows: ODR East – Demand Option 1: AM Peak



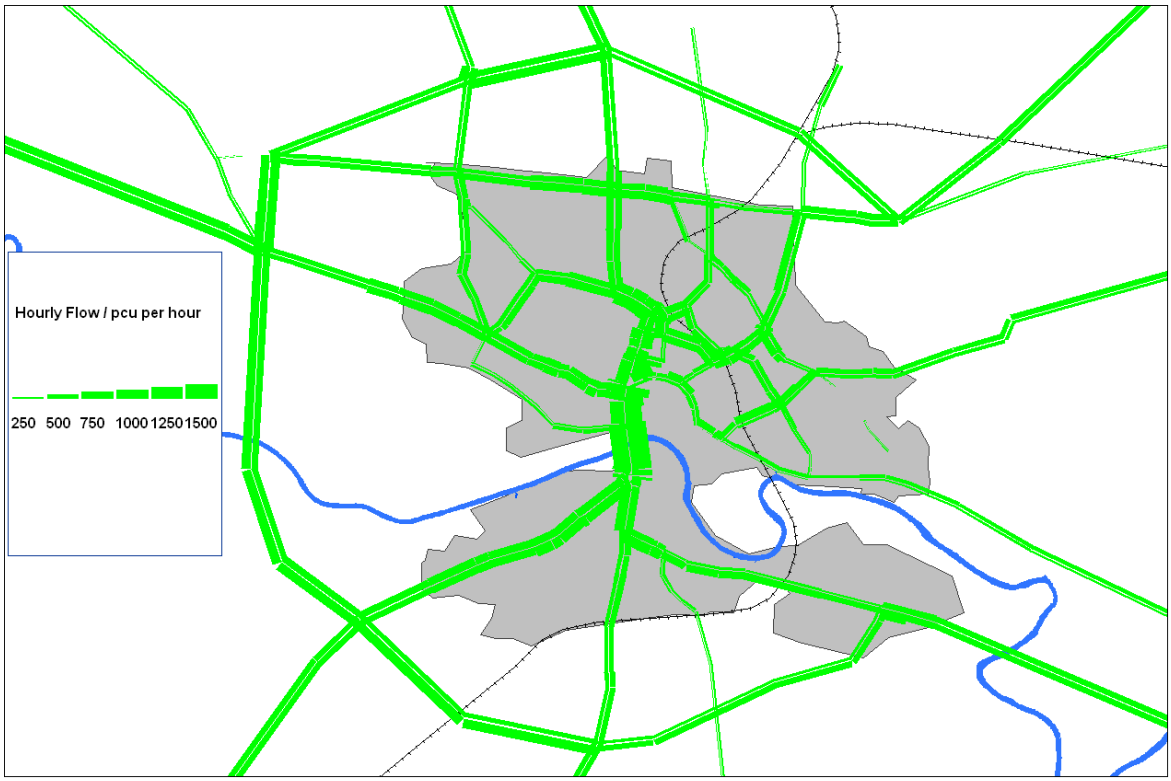
Link Flow Comparison – ODR East vs No ODR – Demand Option 1: AM Peak



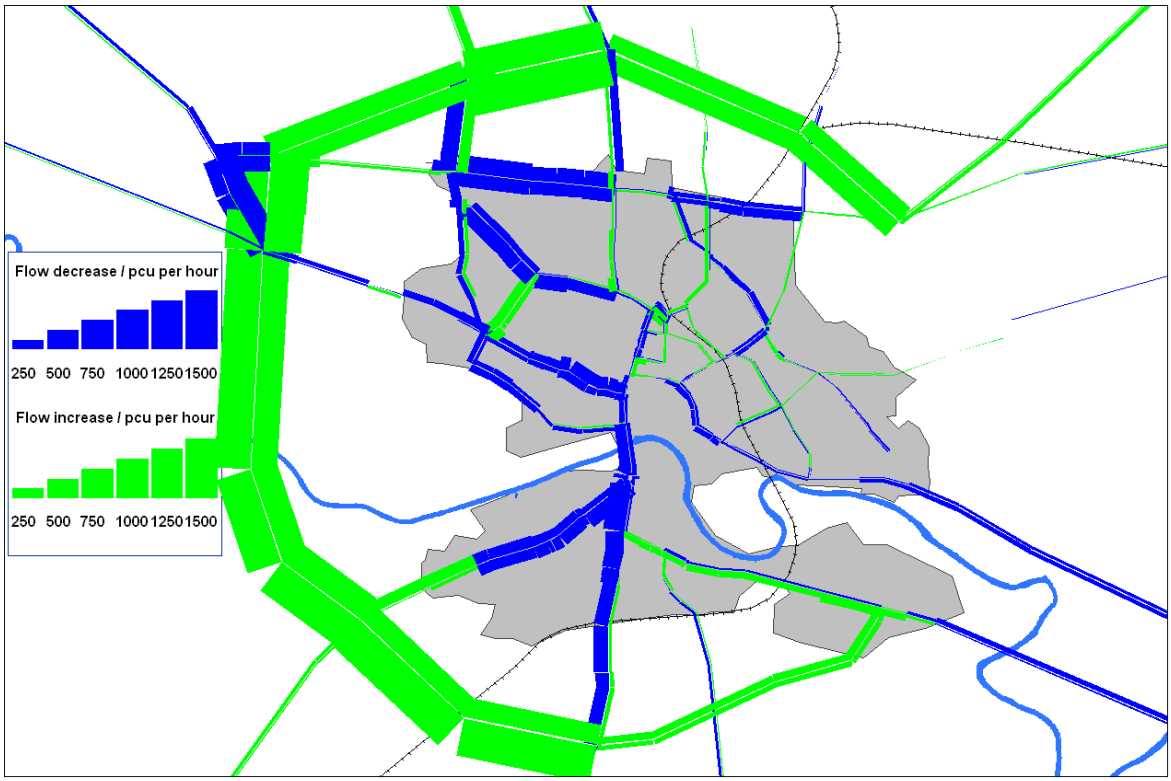
Link Flows: No ODR – Demand Option 1: PM Peak



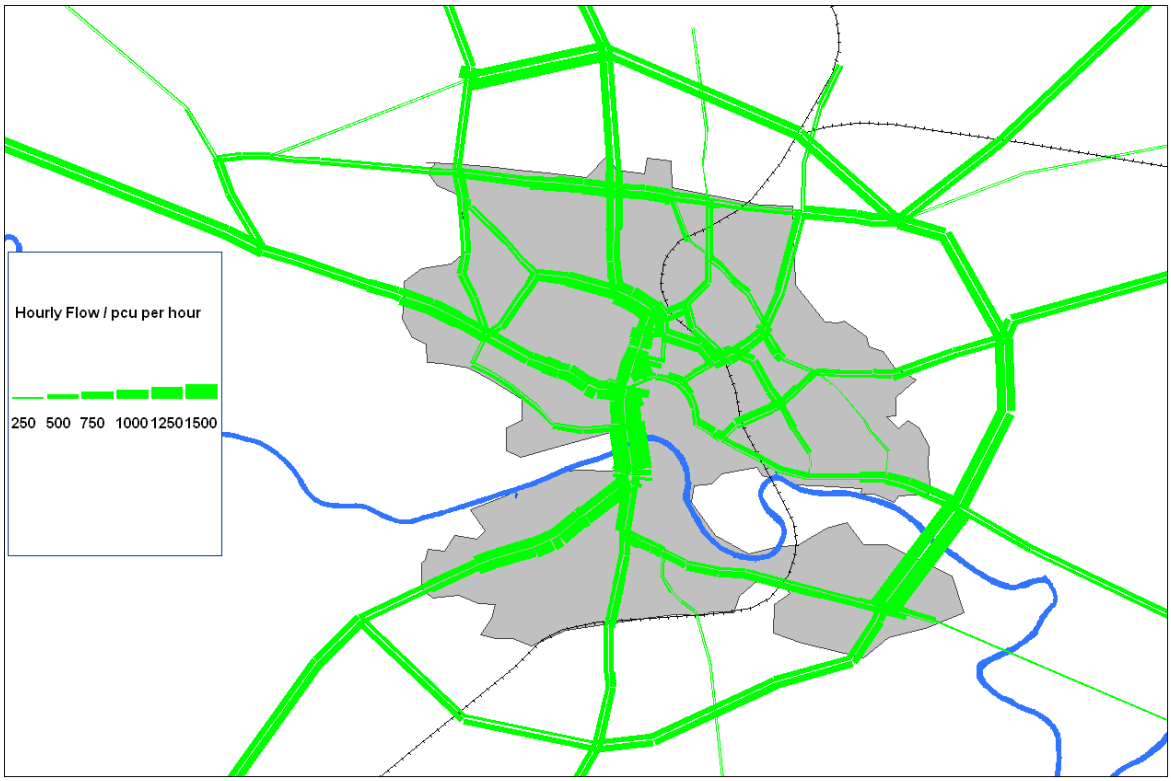
Link Flows: ODR West – Demand Option 1: PM Peak



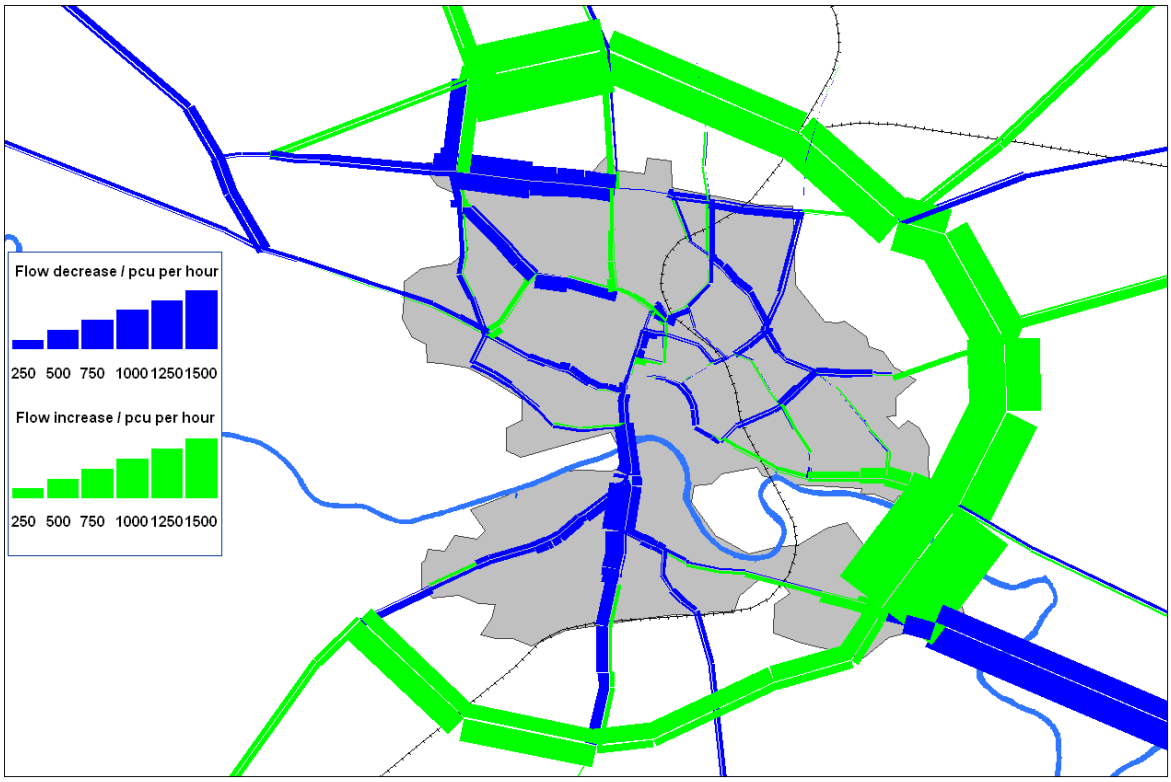
Link Flows Comparison: ODR West vs No ODR – Demand Option 1: PM Peak



Link Flows: ODR East – Demand Option 1: PM Peak

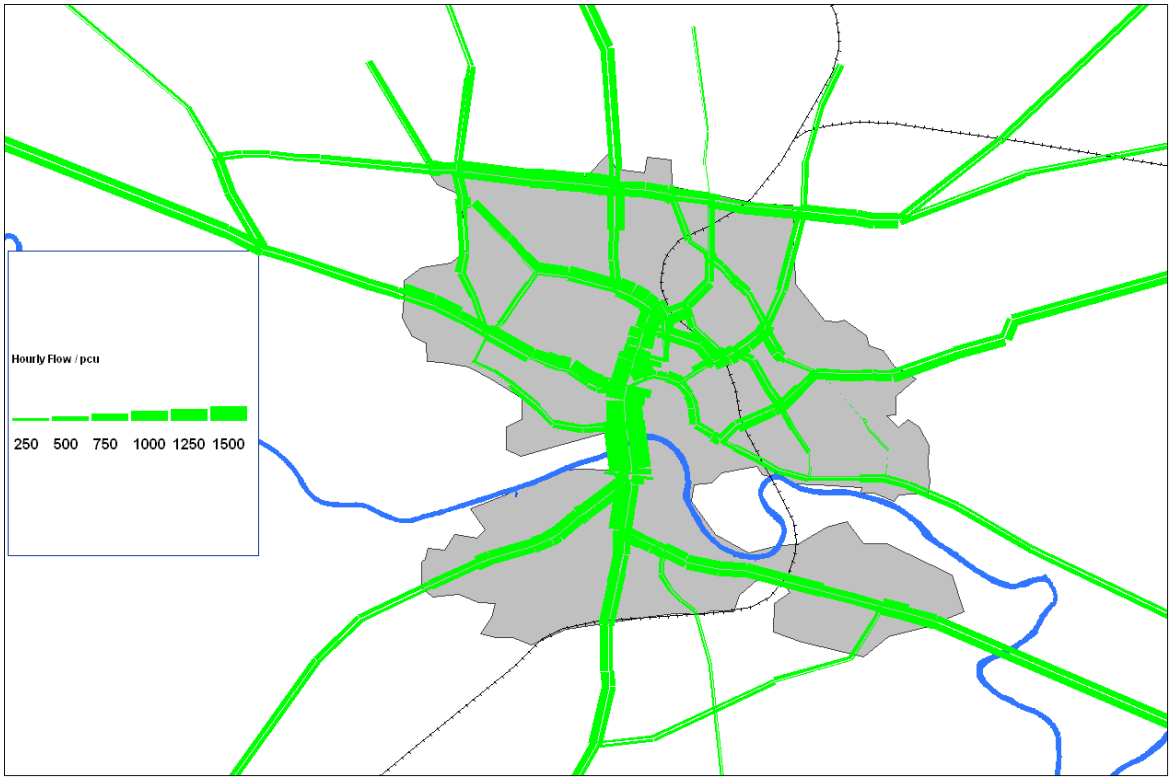


Link Flows Comparison ODR East vs No ODR – Demand Option1: PM Peak

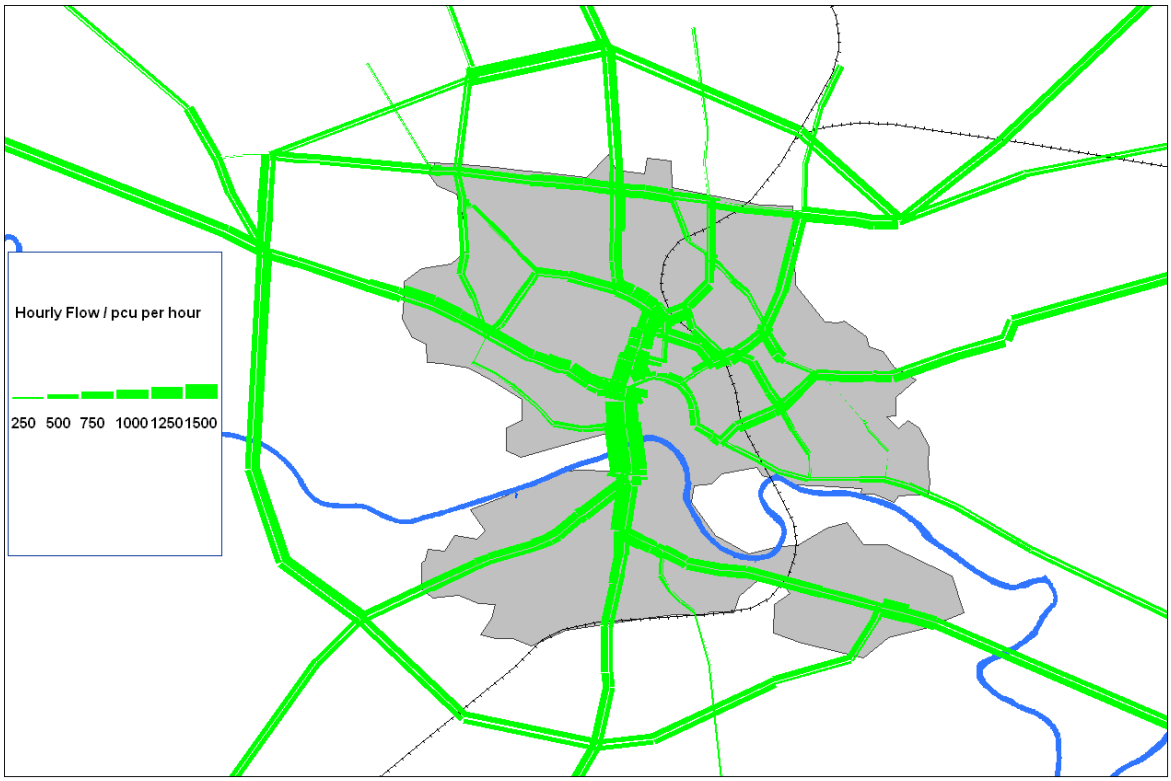


Do-Something Demand Option 2

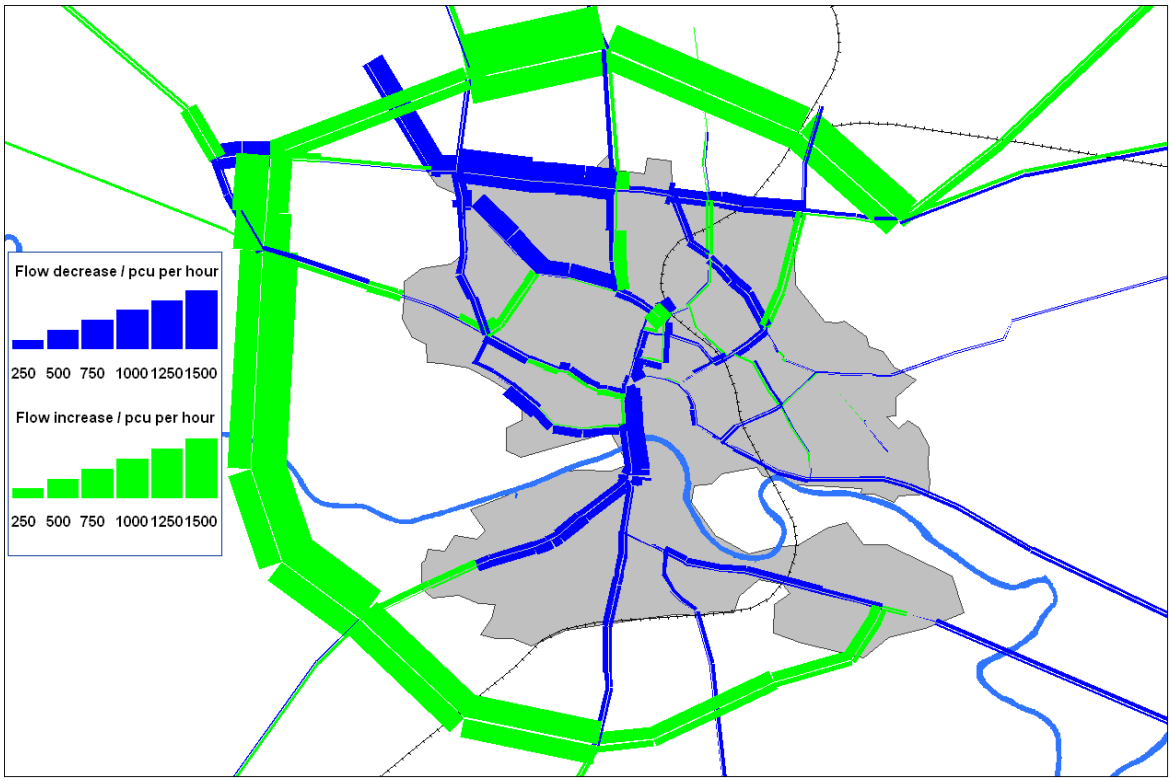
Link Flows: No ODR – Demand Option 2: AM Peak



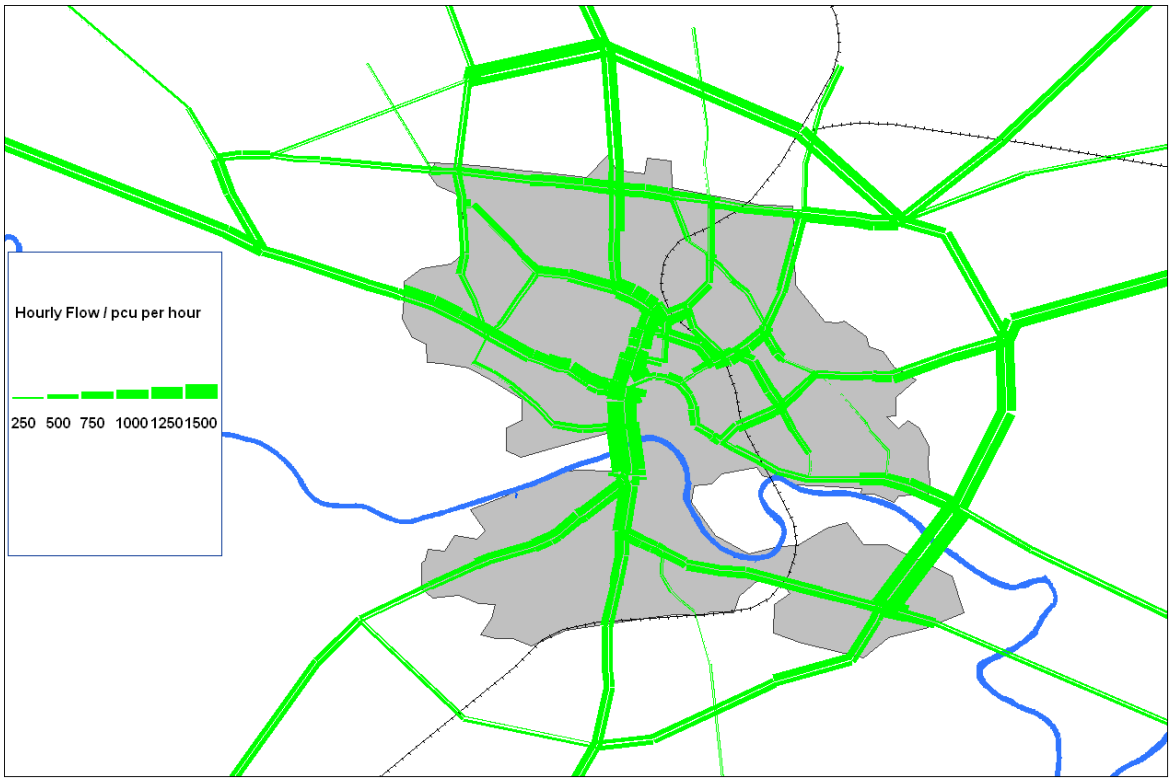
Link Flows: ODR West - Demand Option 2: AM Peak



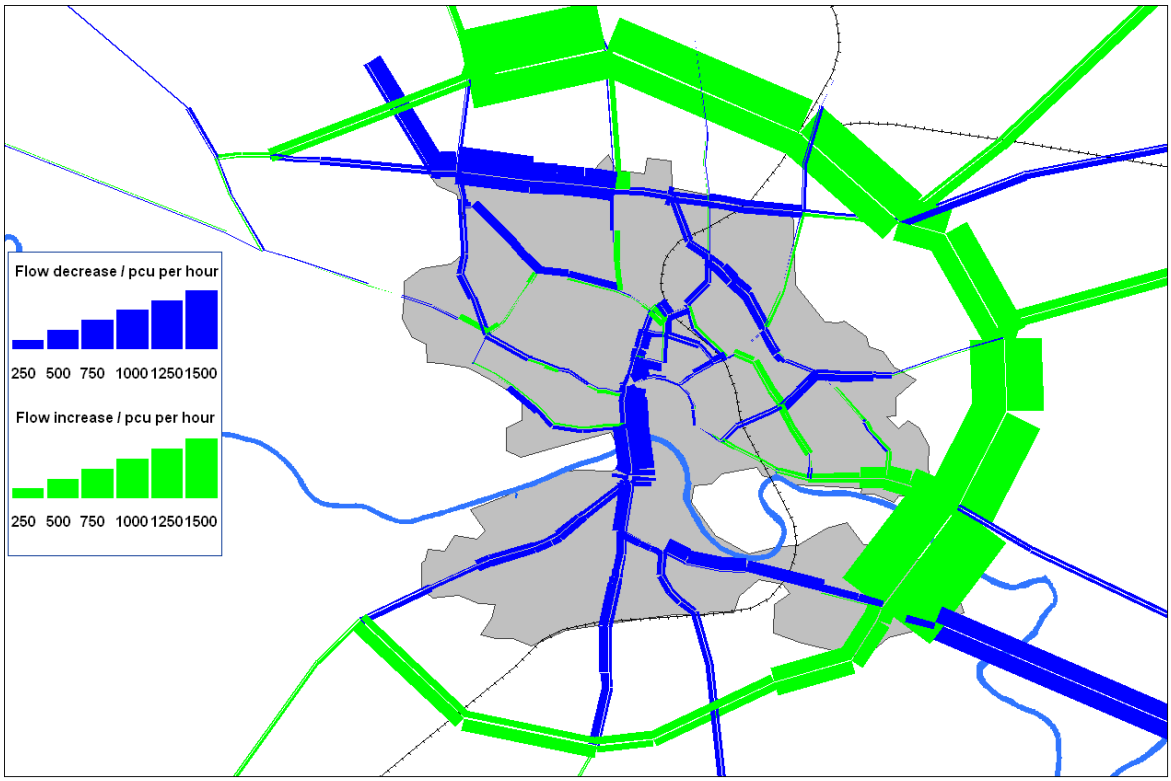
Link Flows Comparison: ODR West vs No ODR - Demand Option 2: AM Peak



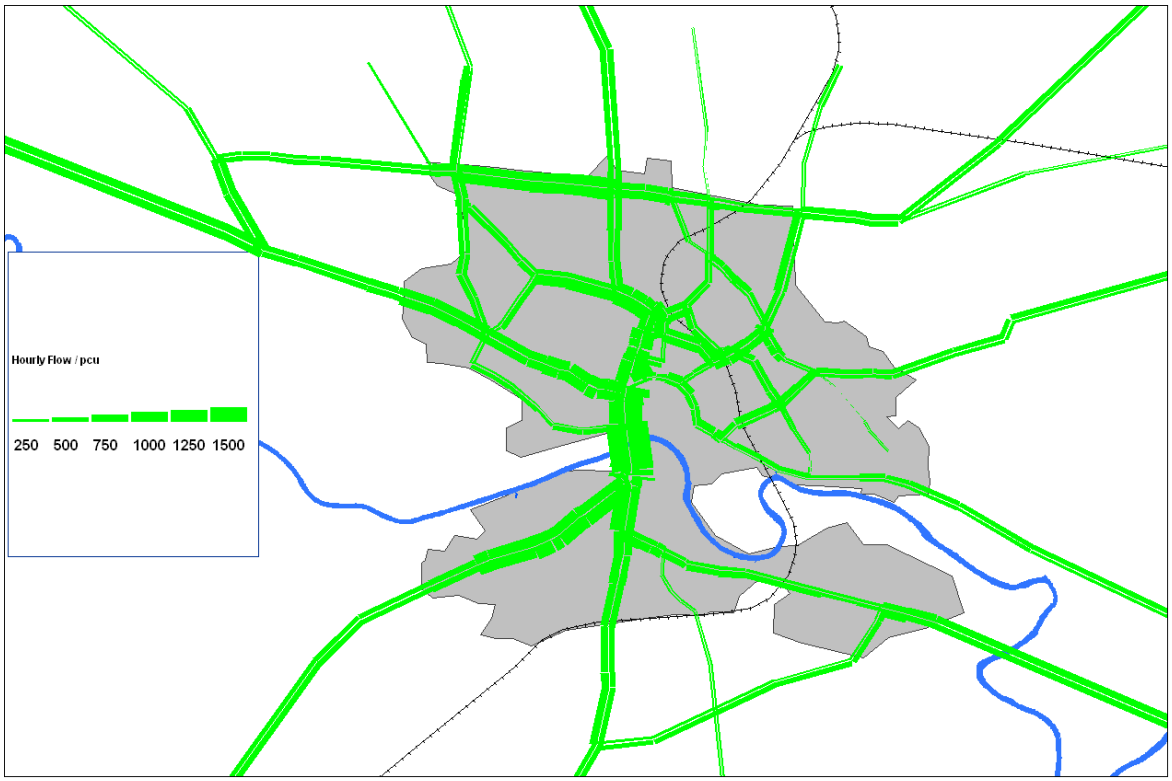
Link Flows: ODR East – Demand Option 2: AM Peak



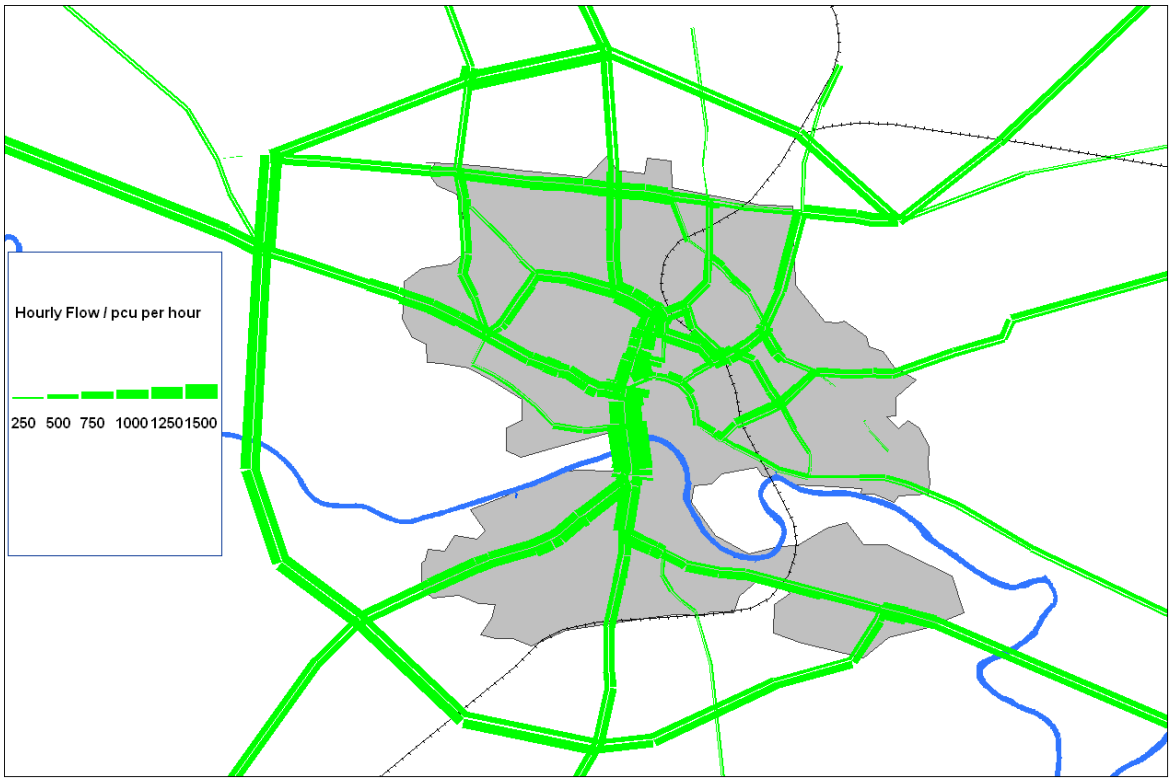
Link Flows Comparison – ODR East vs NO ODR – Demand Option 2: AM Peak



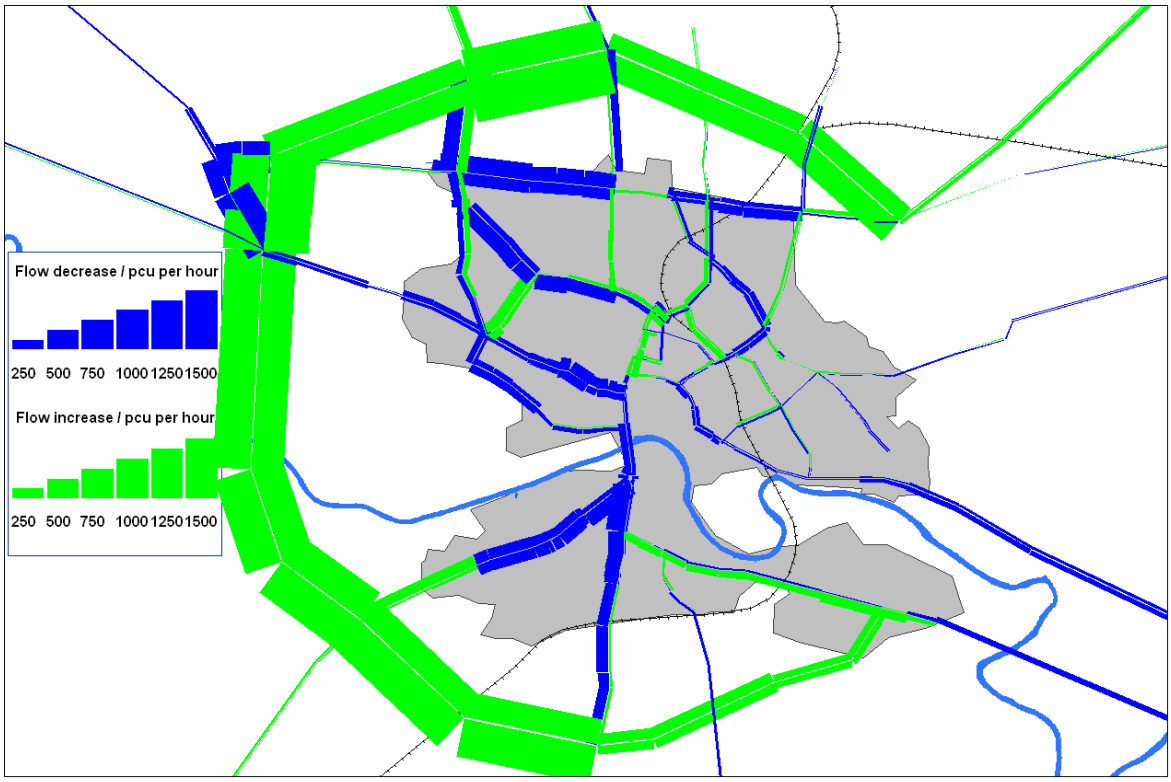
Link Flows: No ODR – Demand Option 2: PM Peak



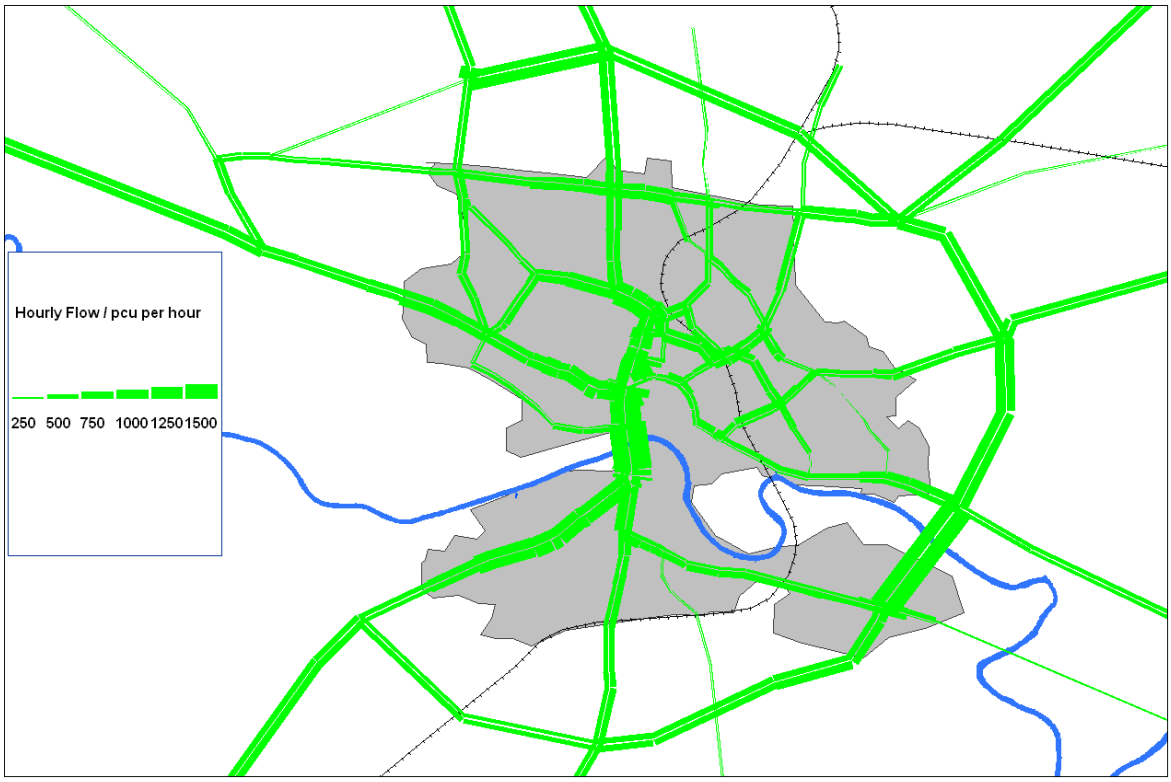
Link Flows: ODR West - Demand Option 2: PM Peak



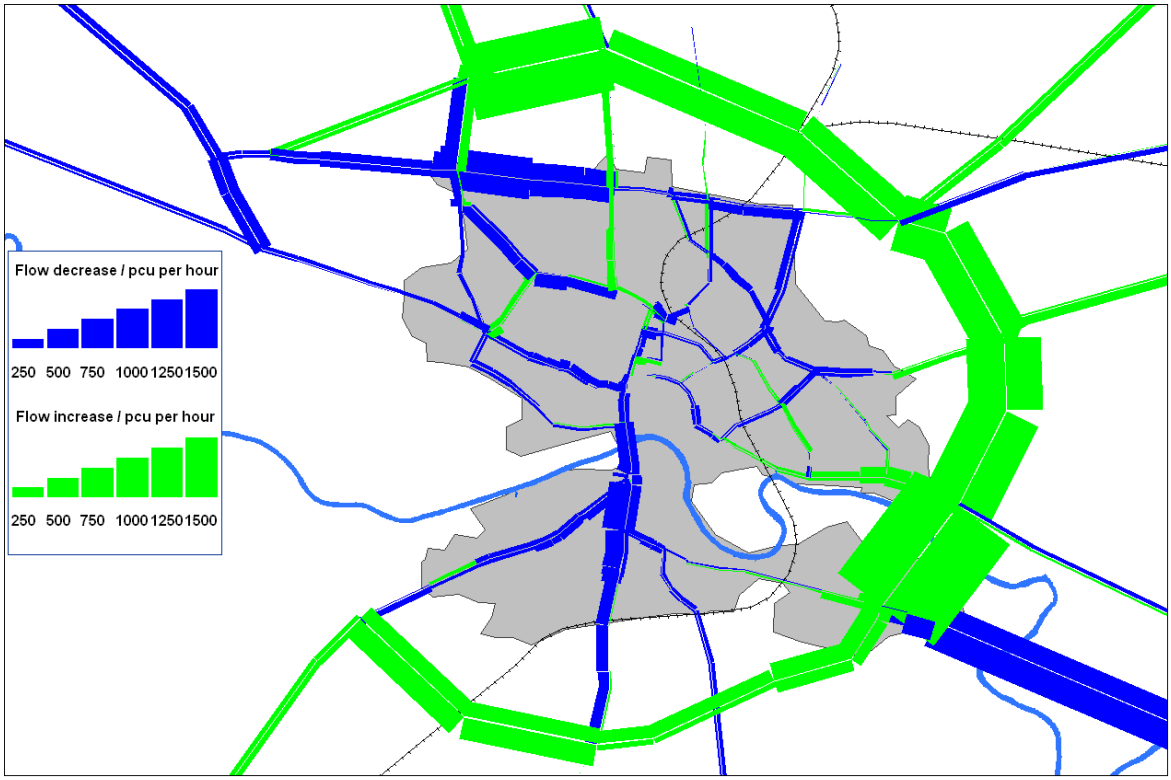
Link Flows Comparison: ODR West vs No ODR - Demand Option 2: PM Peak



Link Flows: ODR East – Demand Option 2: PM Peak

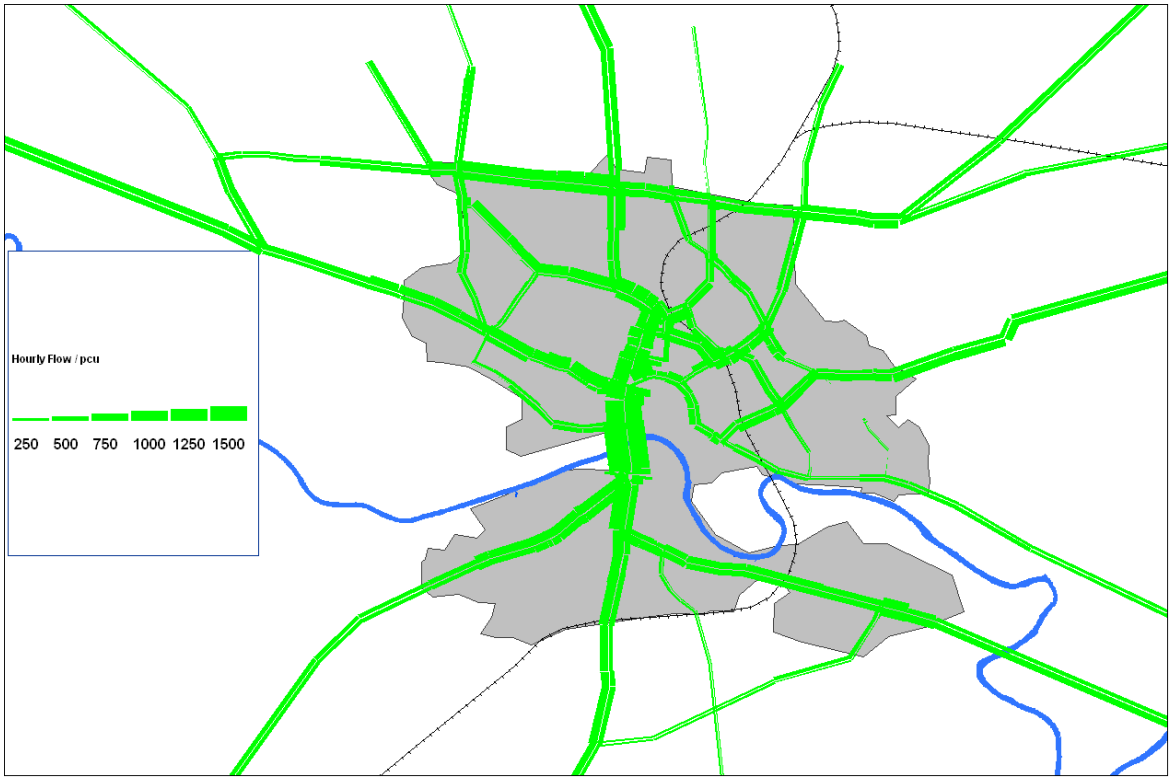


Link Flow Comparison: ODR East vs No ODR – Demand Option 2: PM Peak

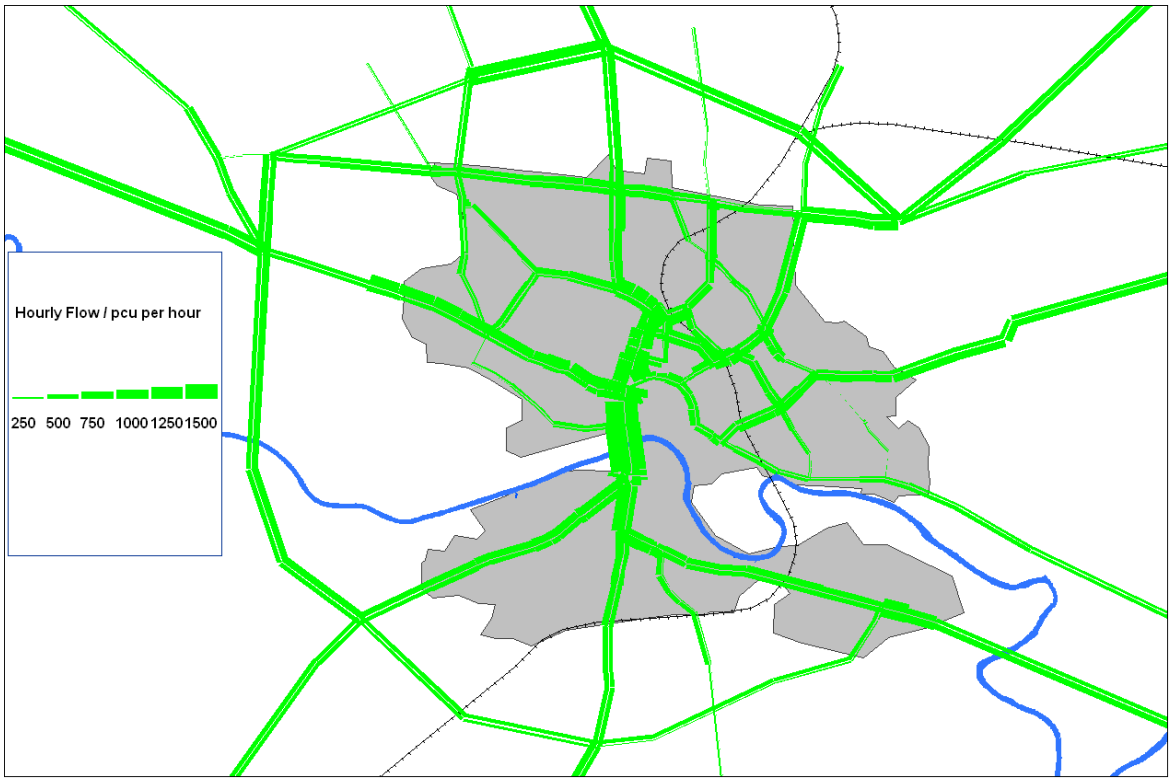


Do-Something Demand Option 3

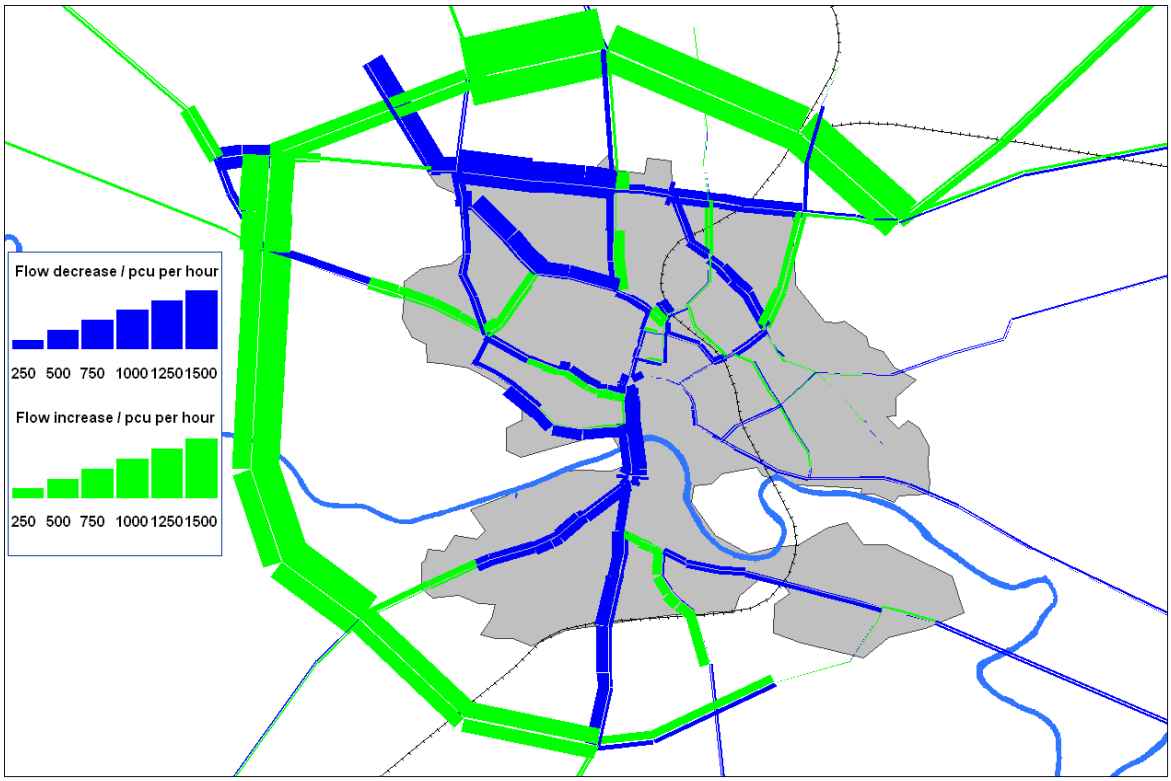
Link Flows: No ODR – Demand Option 3: AM Peak



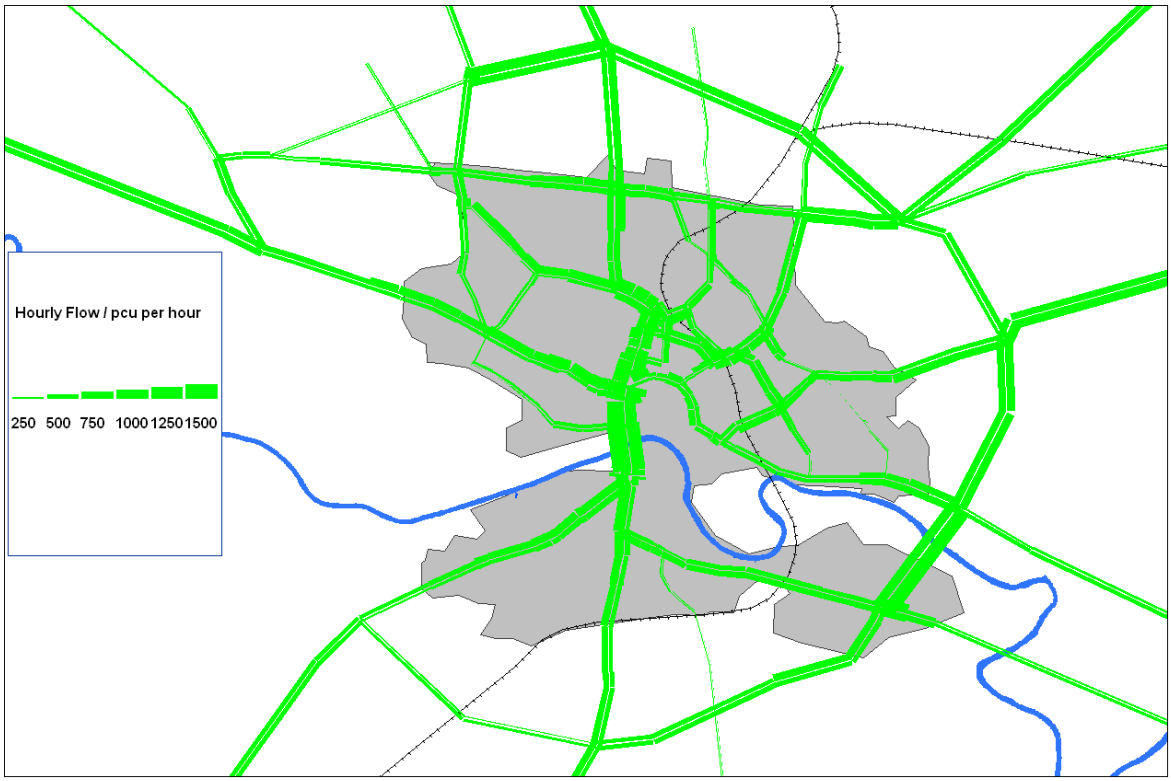
Link Flows: ODR West - Demand Option 3: AM Peak



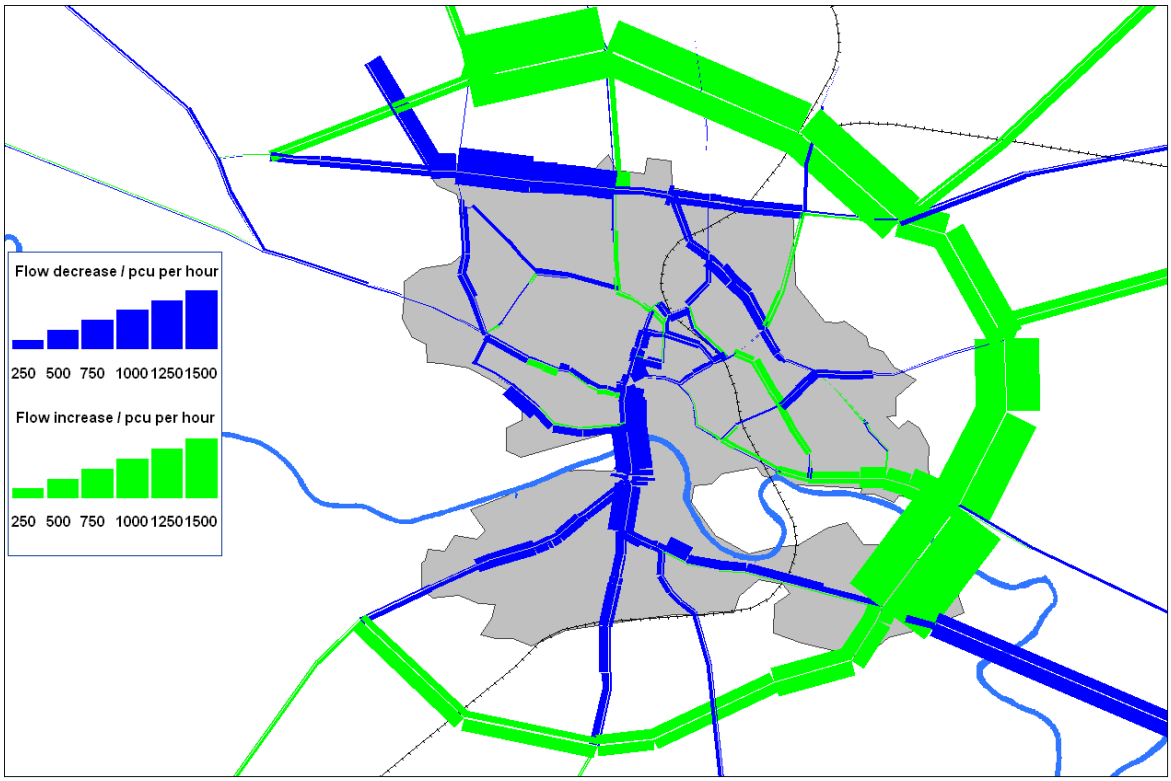
Link Flows Comparison: ODR West vs No ODR - Demand Option 3: AM Peak



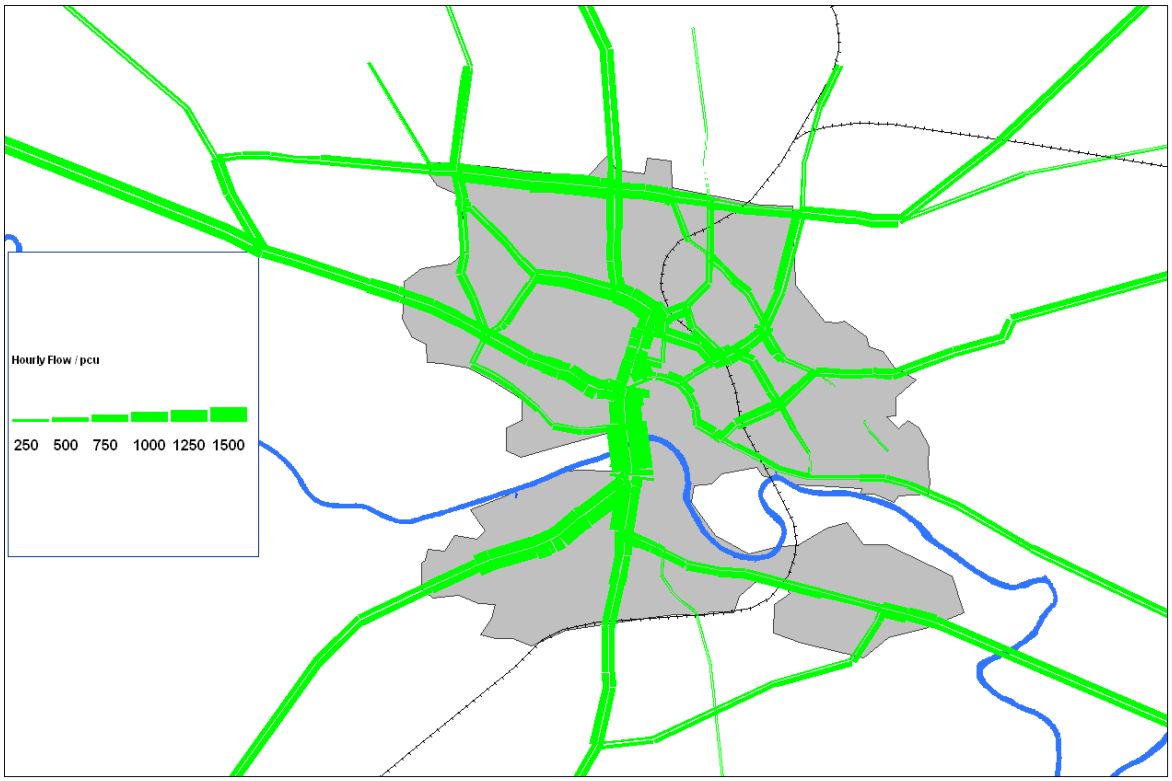
Link Flows: ODR East – Demand Option 3: AM Peak



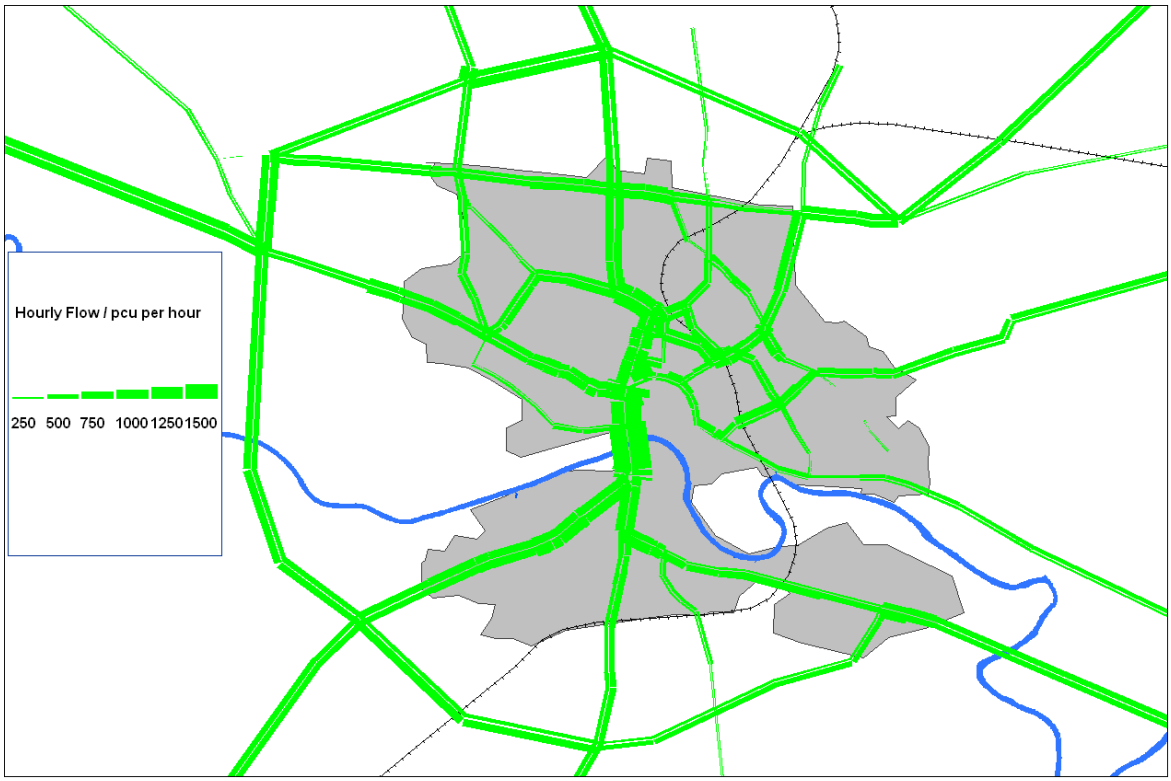
Link Flow Comparison: ODR East vs No ODR – Demand Option 3: AM Peak



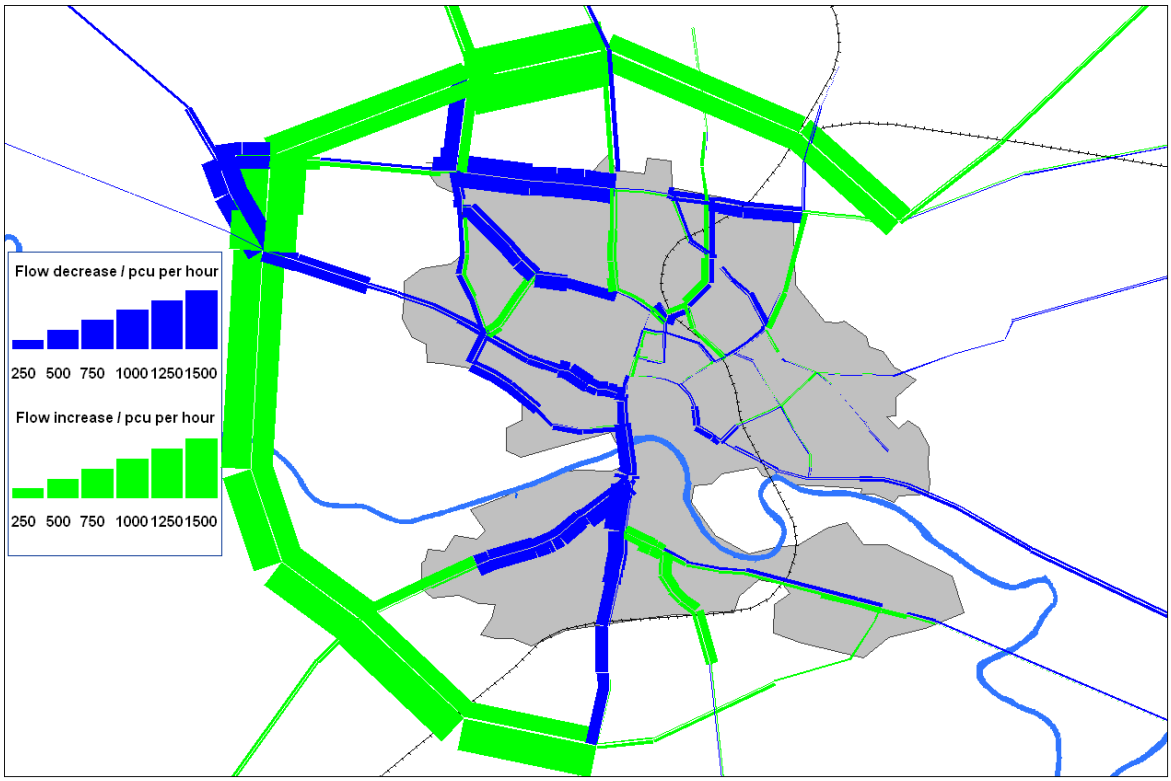
Link Flows: No ODR – Demand Option 3: PM Peak



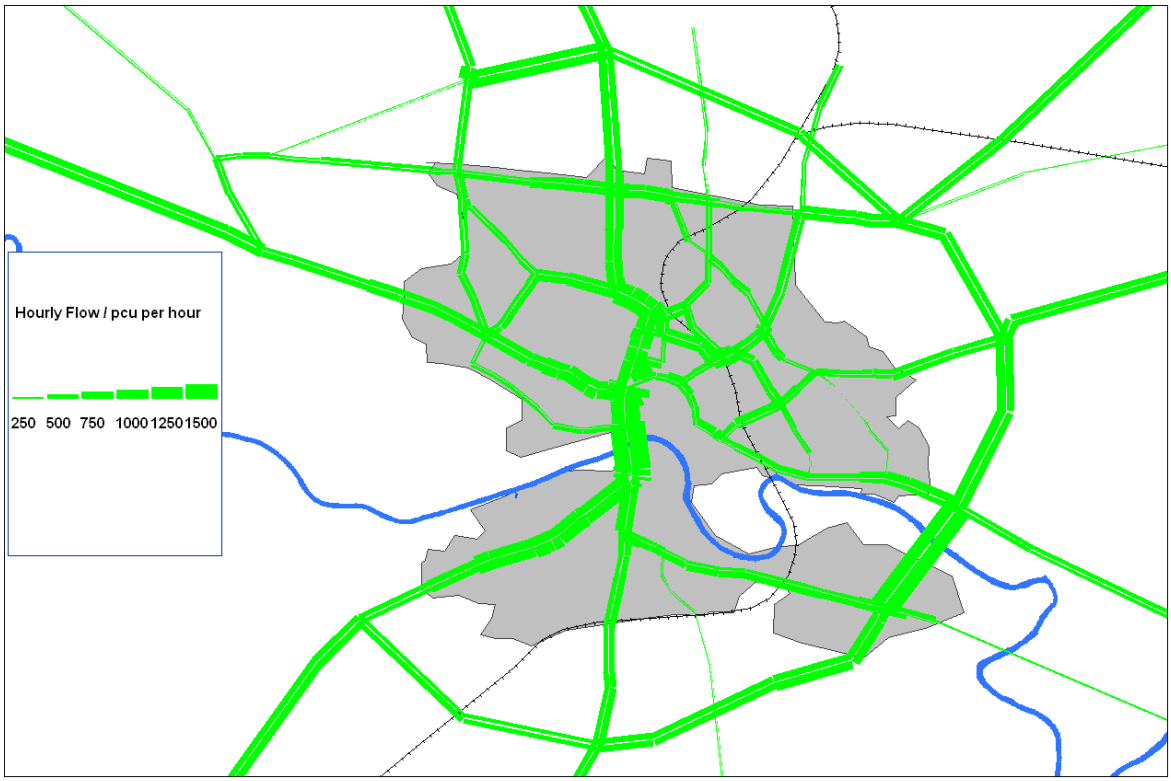
Link Flows: ODR West - Demand Option 3: PM Peak



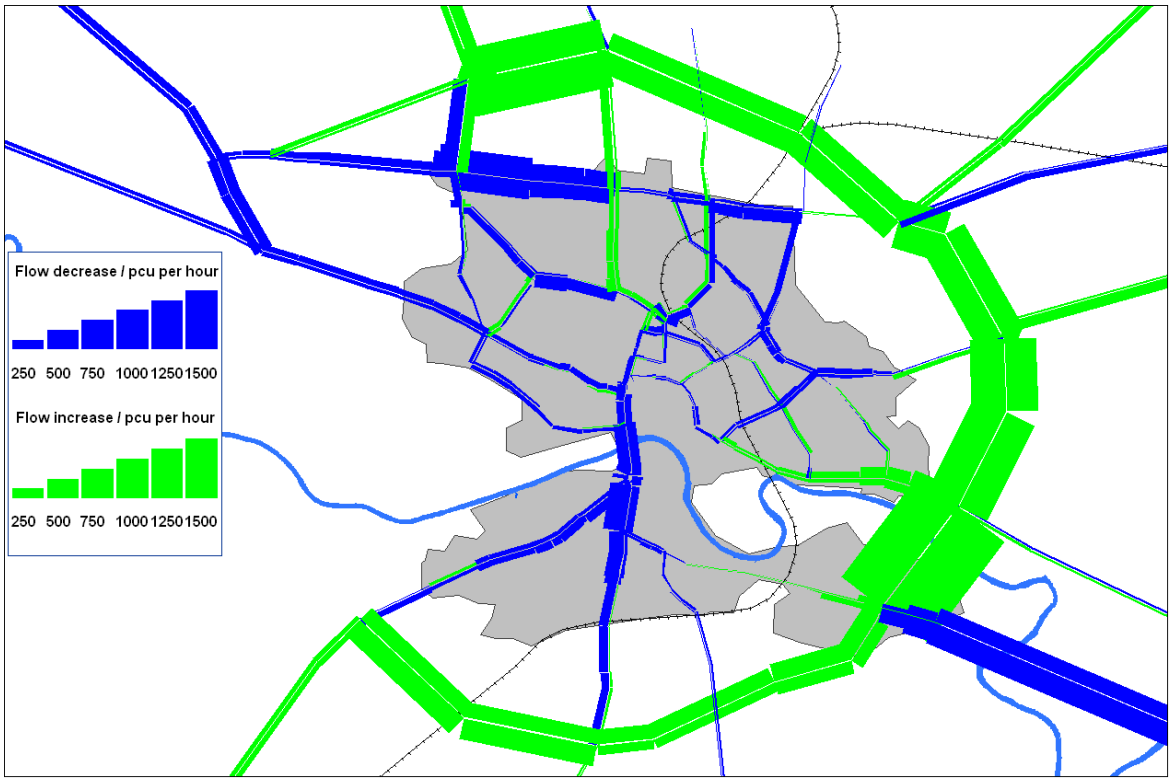
Link Flows Comparison: ODR West vs No ODR - Demand Option 3: PM Peak



Link Flows: ODR East – Demand Option 3: PM Peak

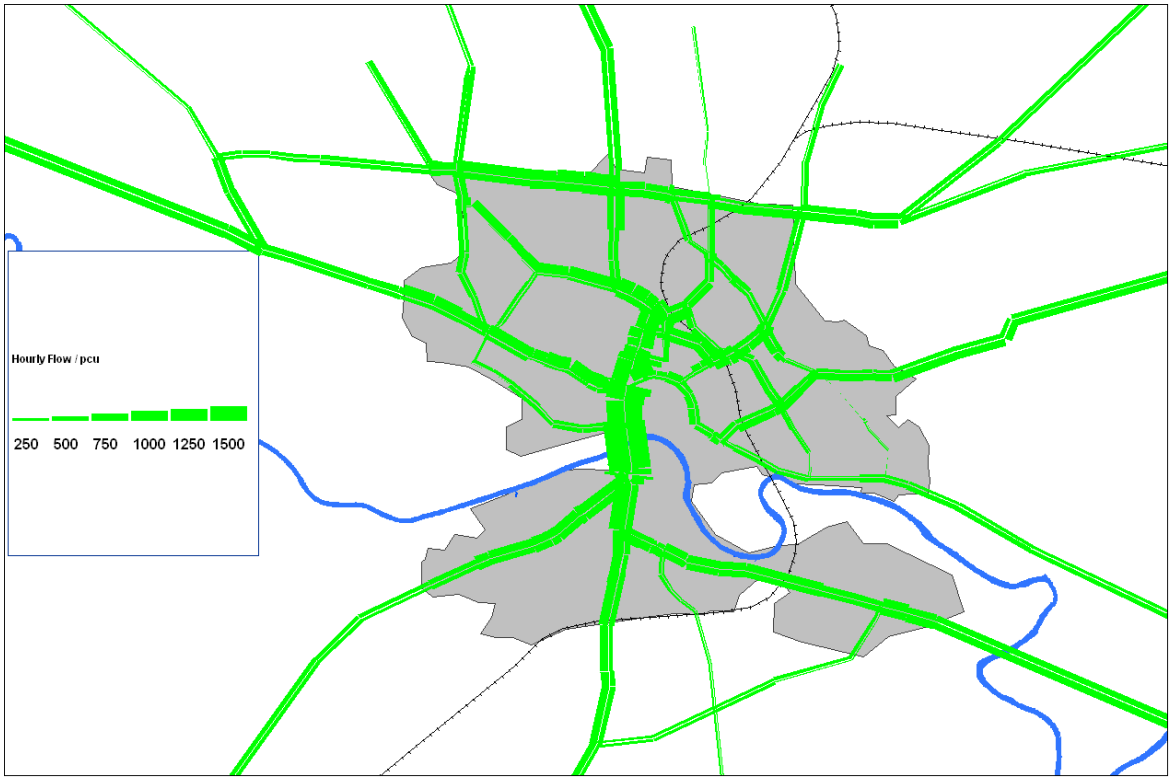


Link Flow Comparison: ODR East vs No ODR – Demand Option 3: PM Peak

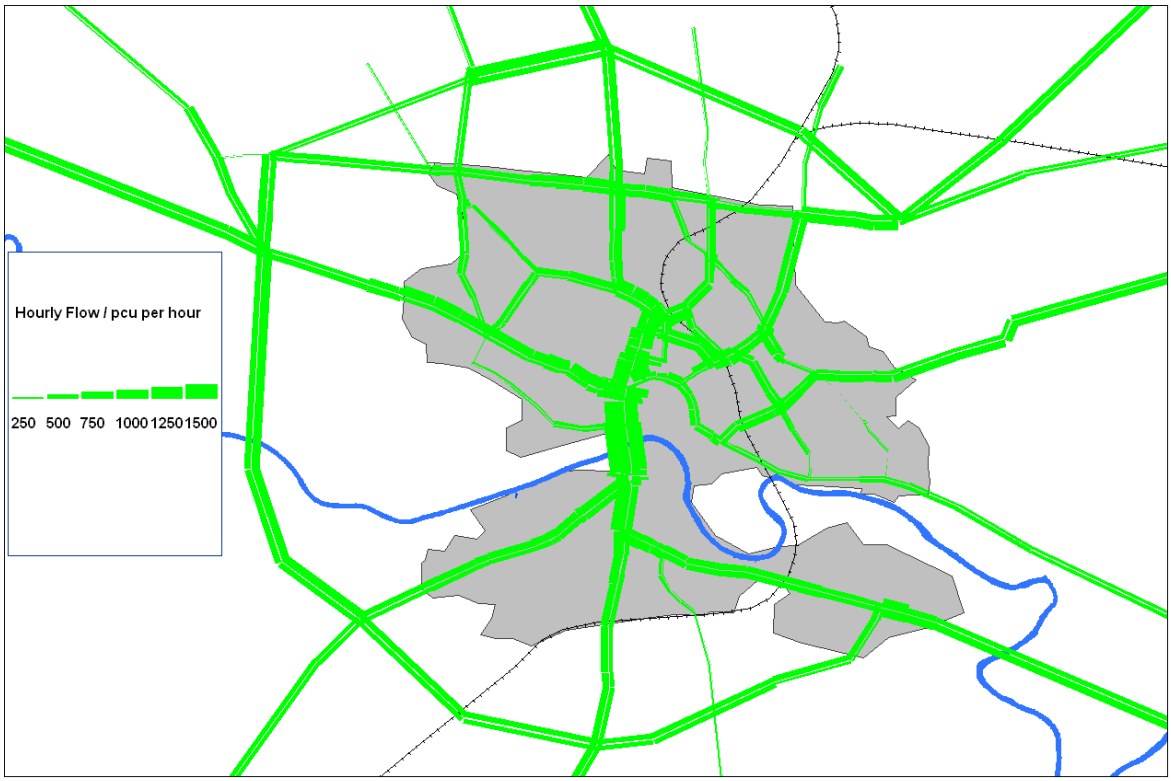


Do-Something Demand Option 4

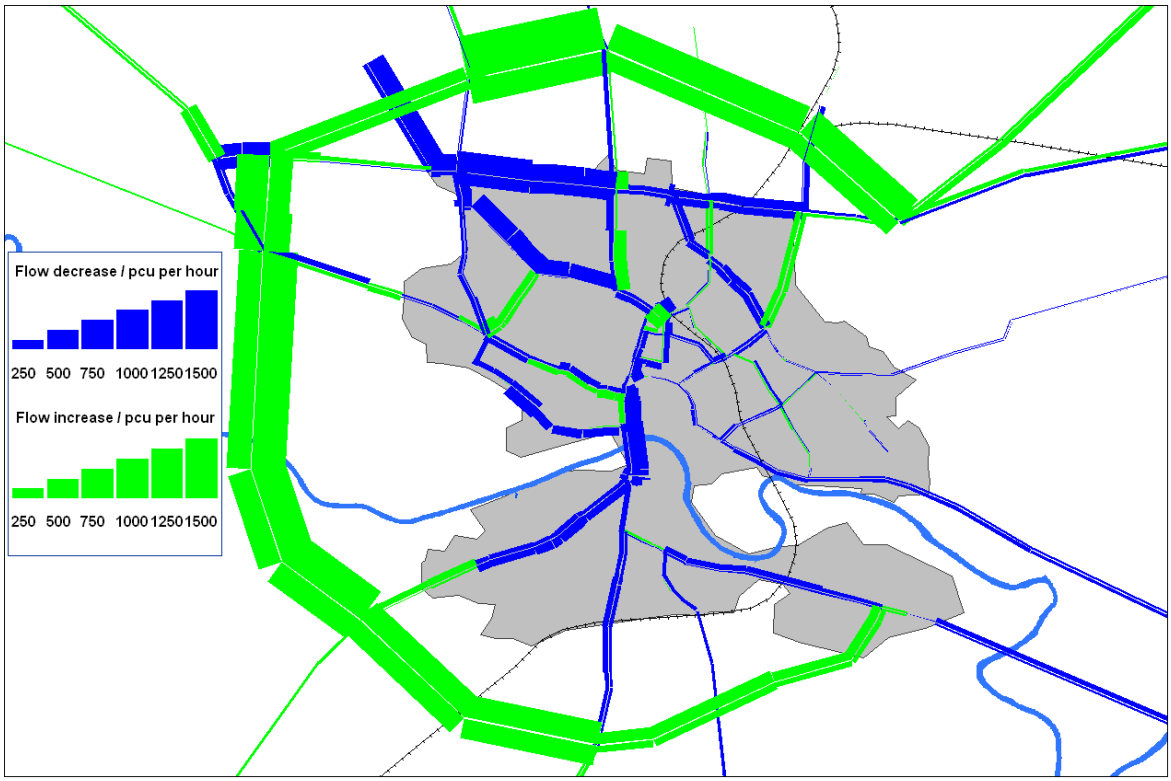
Link Flows: No ODR – Demand Option 4: AM Peak



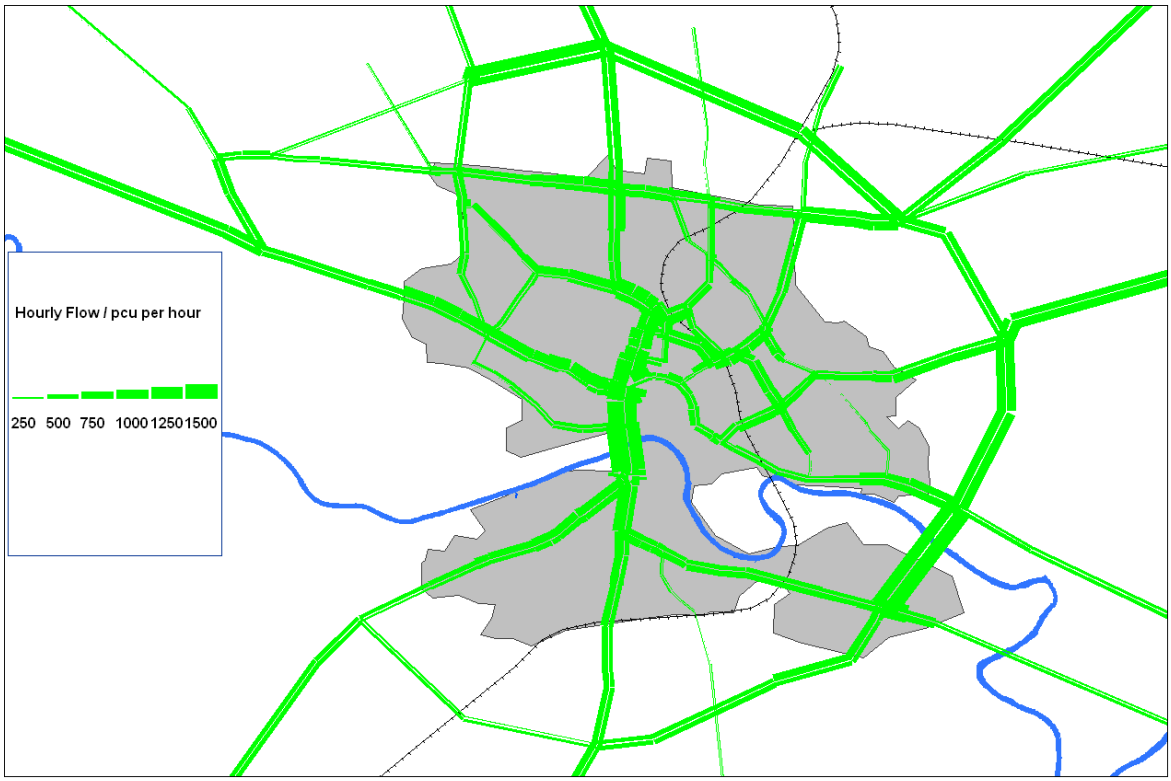
Link Flows: ODR West - Demand Option 4: AM Peak



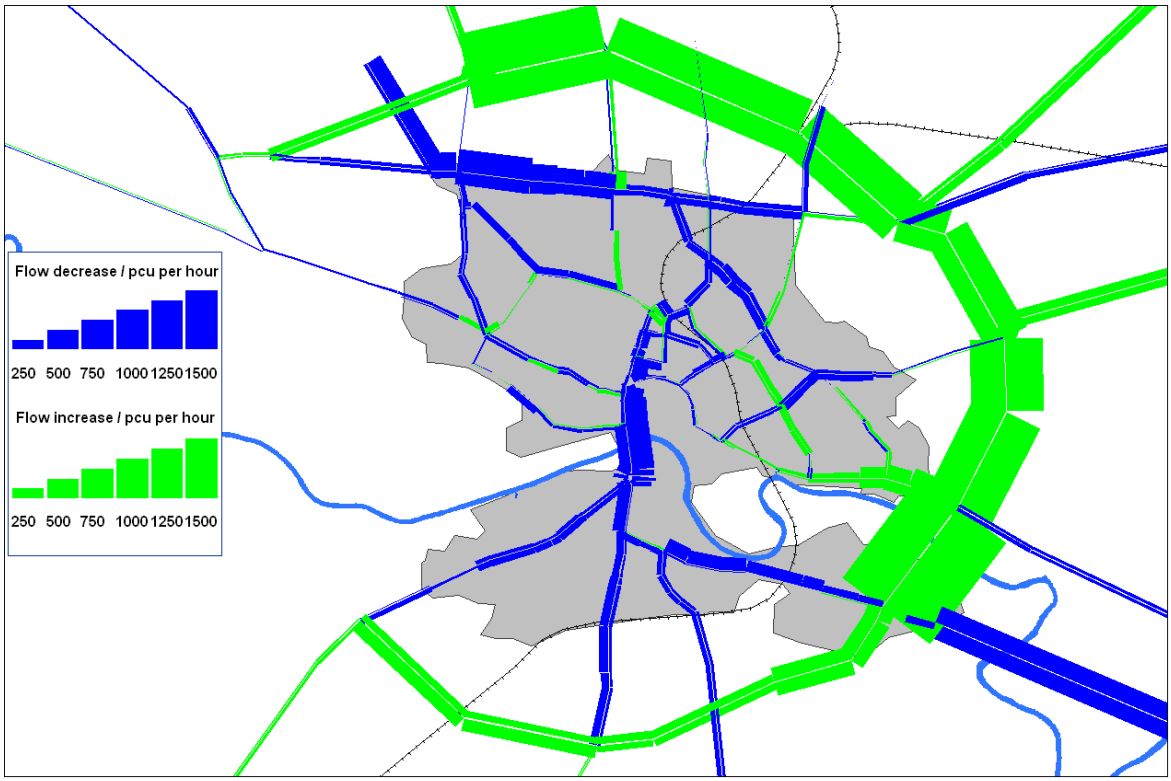
Link Flow Comparison: ODR West vs No ODR - Demand Option 4: AM Peak



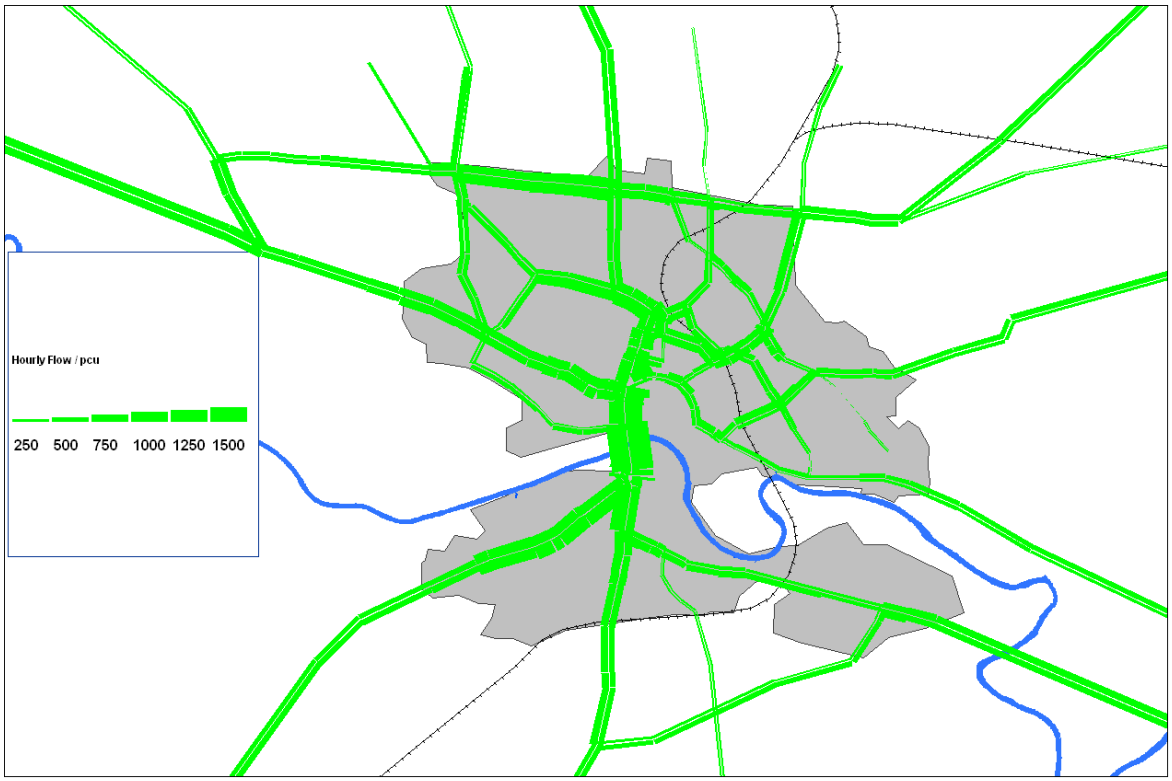
Link Flows: ODR East – Demand Option 4: AM Peak



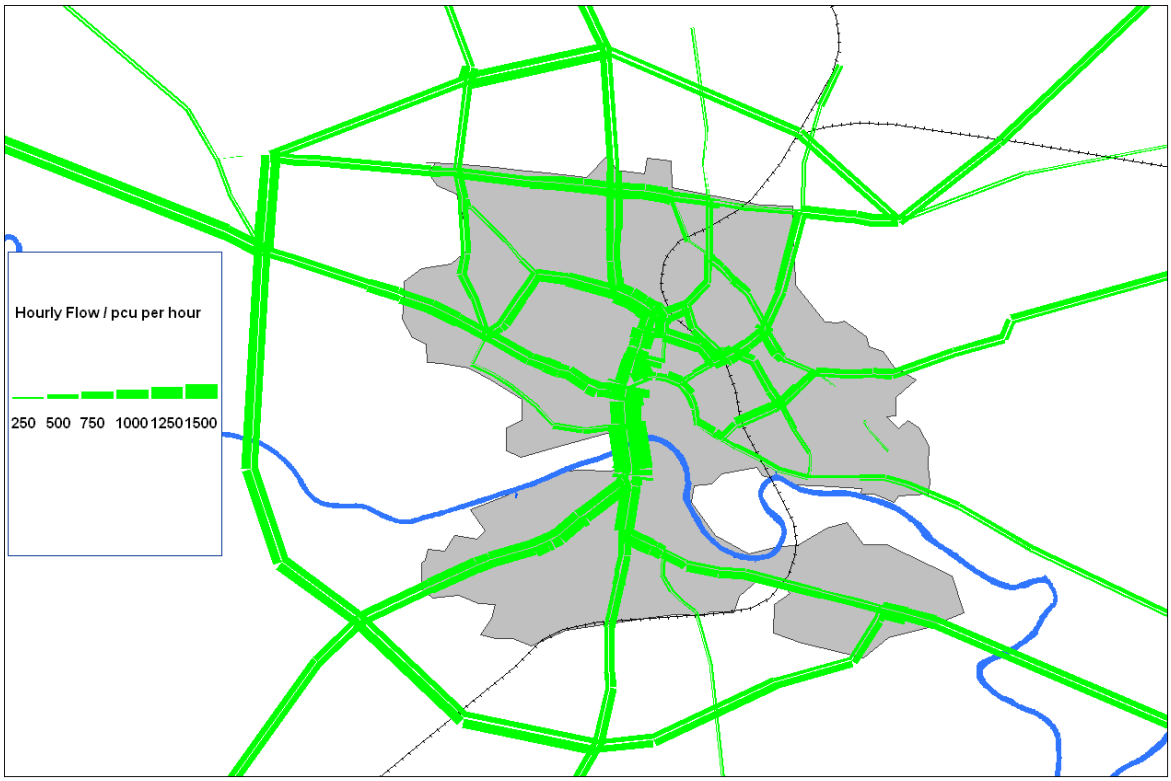
Link Flow Comparison: ODR East vs No ODR – Demand Option 4: AM Peak



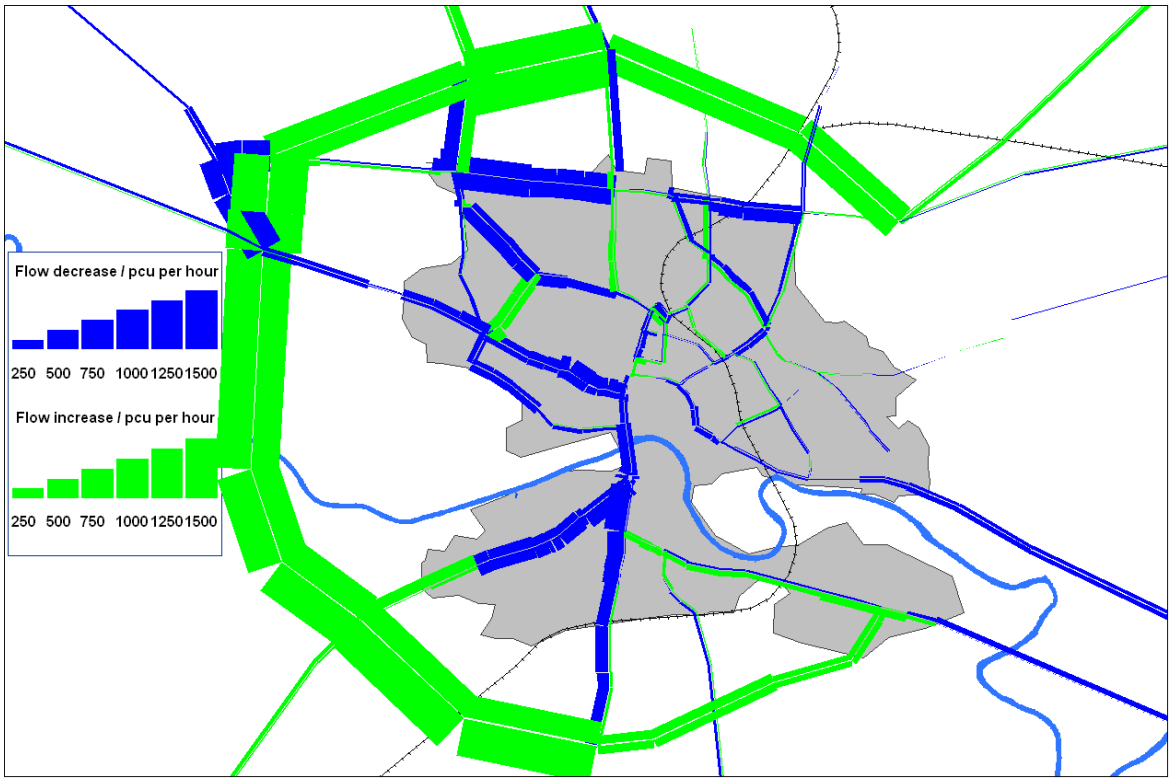
Link Flows: No ODR – Demand Option 4: PM Peak



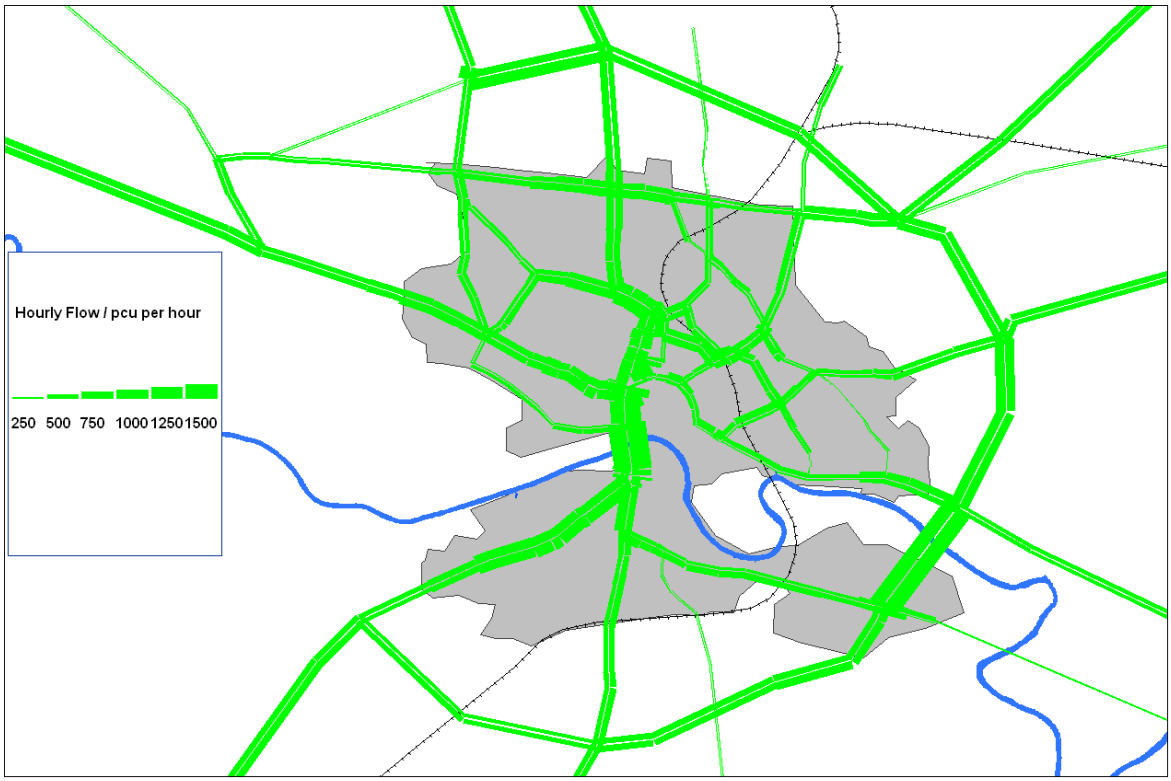
Link Flows: ODR West - Demand Option 4: PM Peak



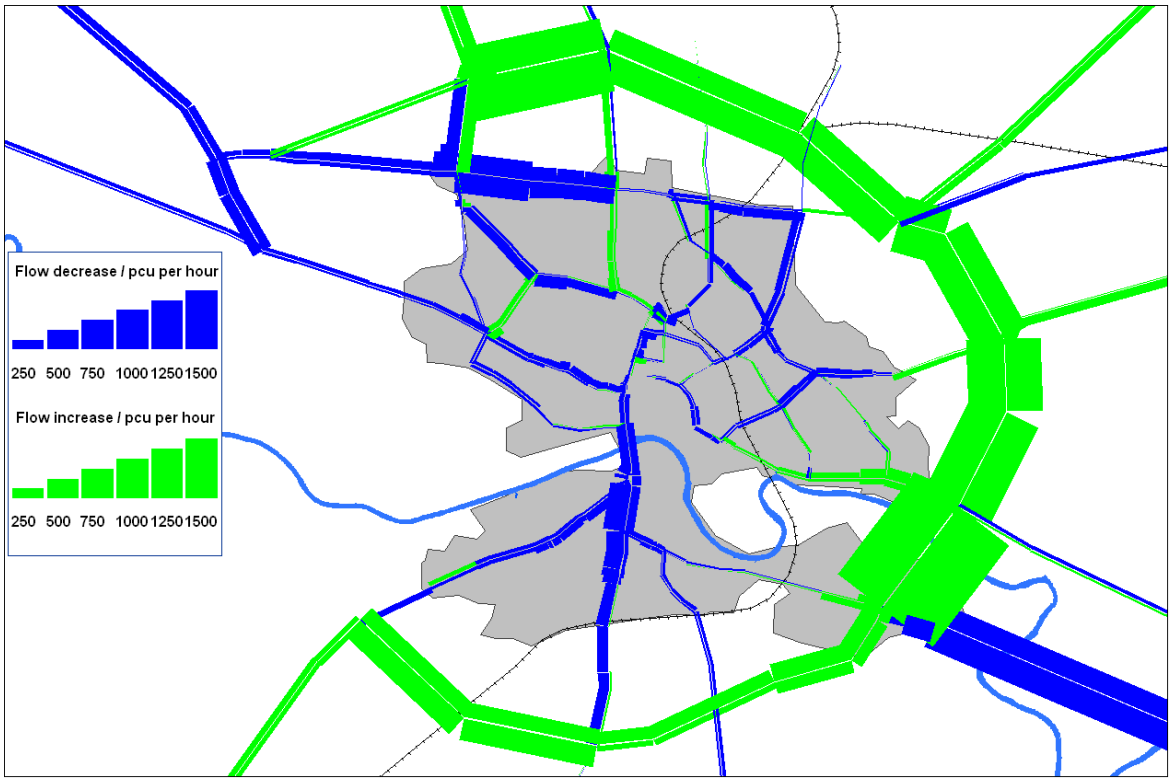
Link Flow Comparison: ODR West vs No ODR - Demand Option 4: PM Peak



Link Flows: ODR East– Demand Option 4: PM Peak



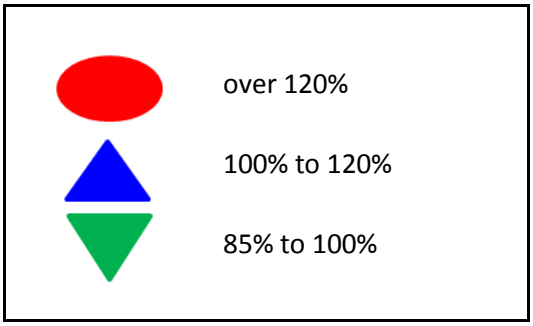
Link Flow Comparison: ODR East vs No ODR – Demand Option 4: PM Peak



Appendix D

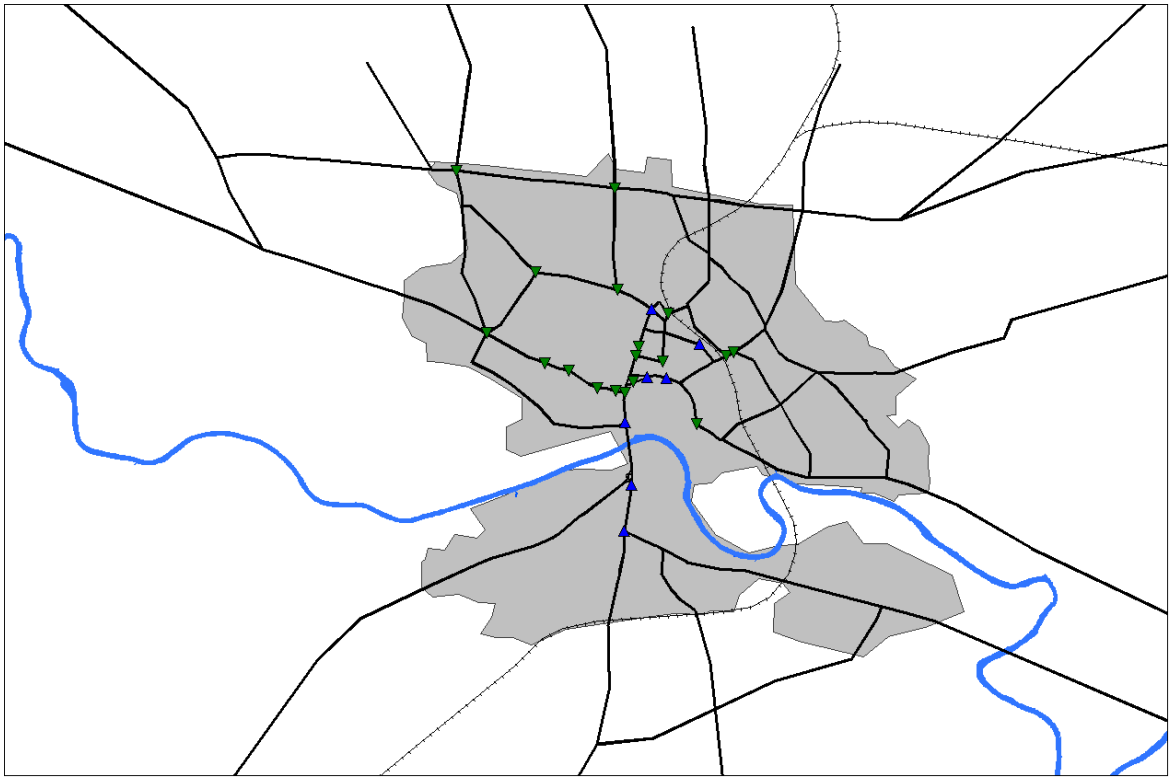
Stress (Volume/Capacity)

Key to Junction Stress Diagrams

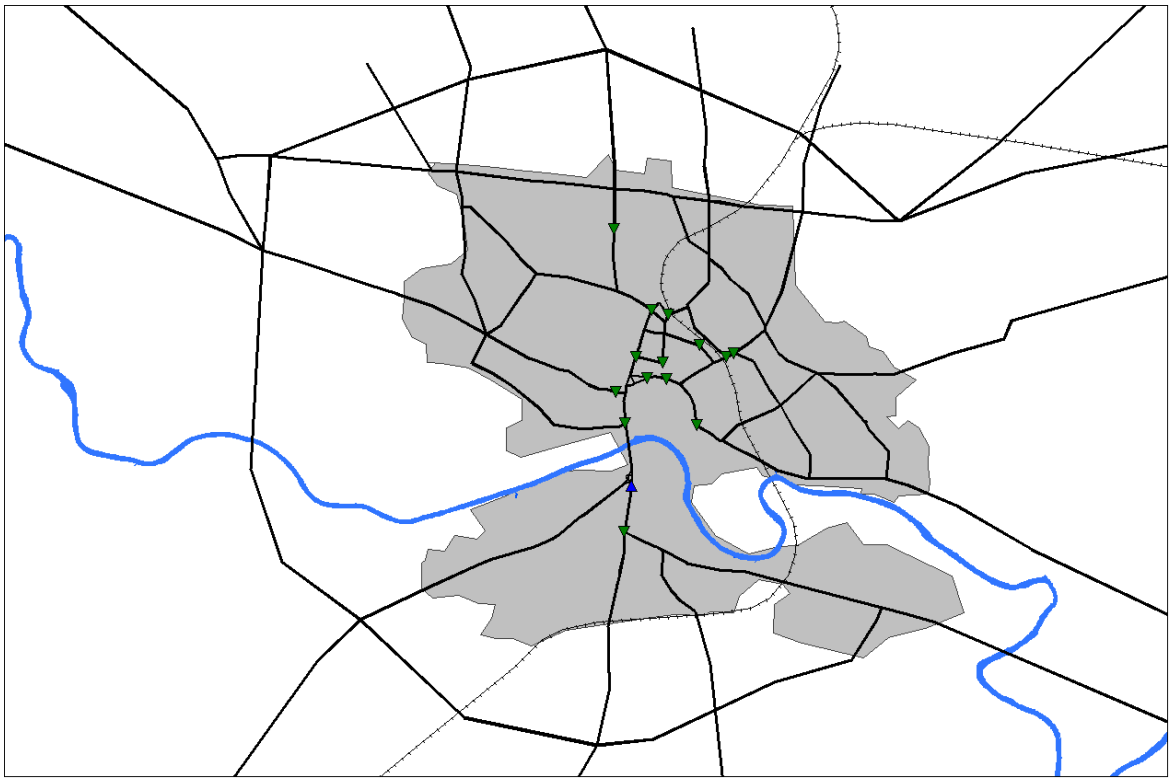


Do-Minimum Demand Option

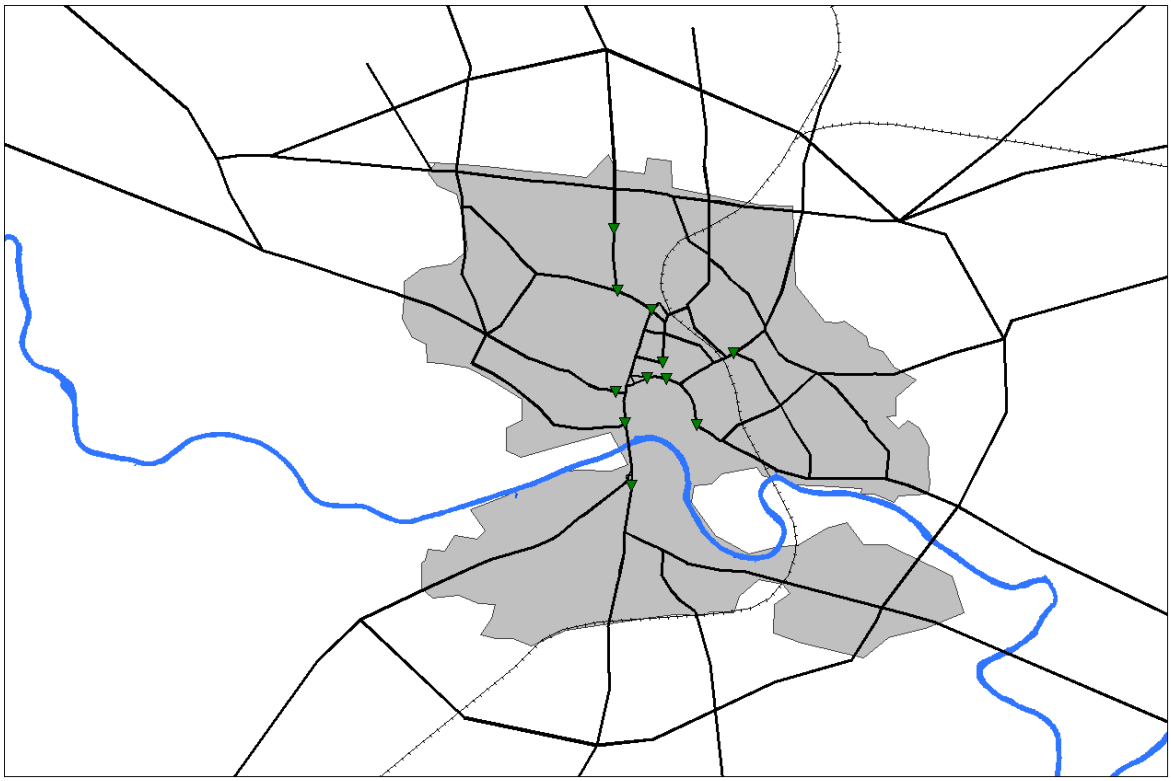
Volume-Capacity Ratio at Junctions – No ODR - Do-Minimum Demand – AM Peak



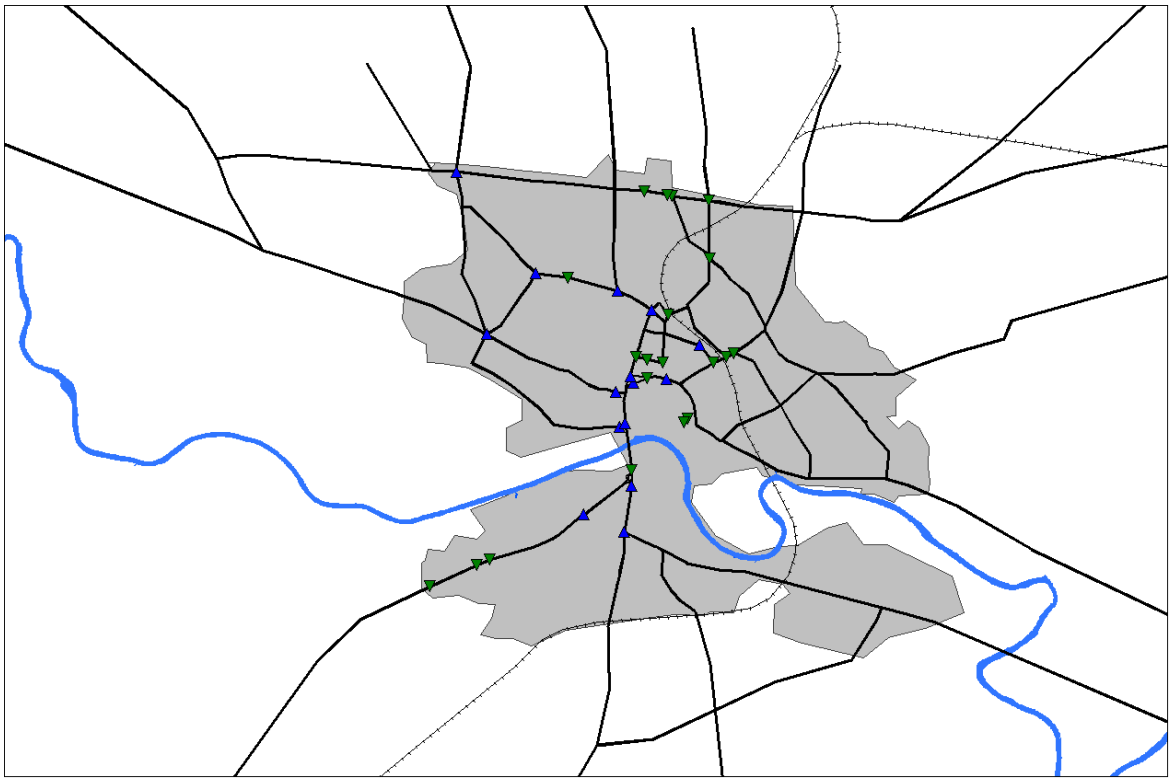
Volume-Capacity Ratio at Junctions –ODR West - Do-Minimum Demand – AM Peak



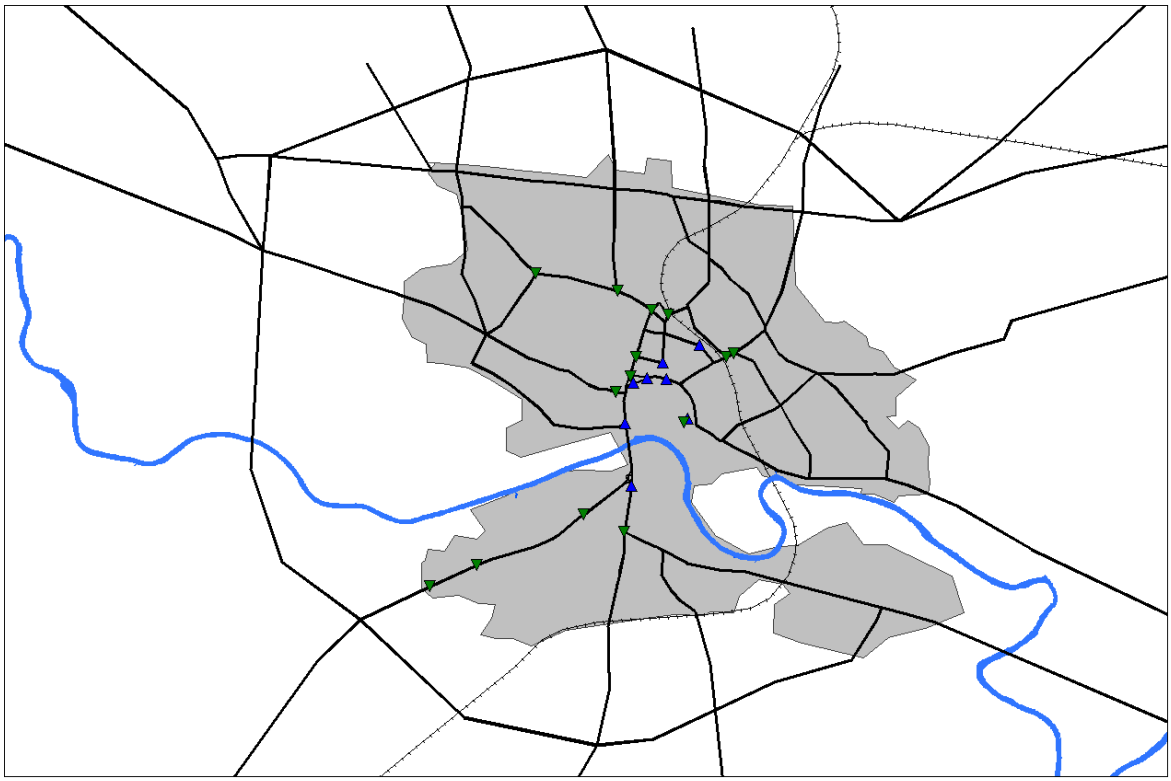
Volume-Capacity Ratio at Junctions – ODR East - Do-Minimum Demand – AM Peak



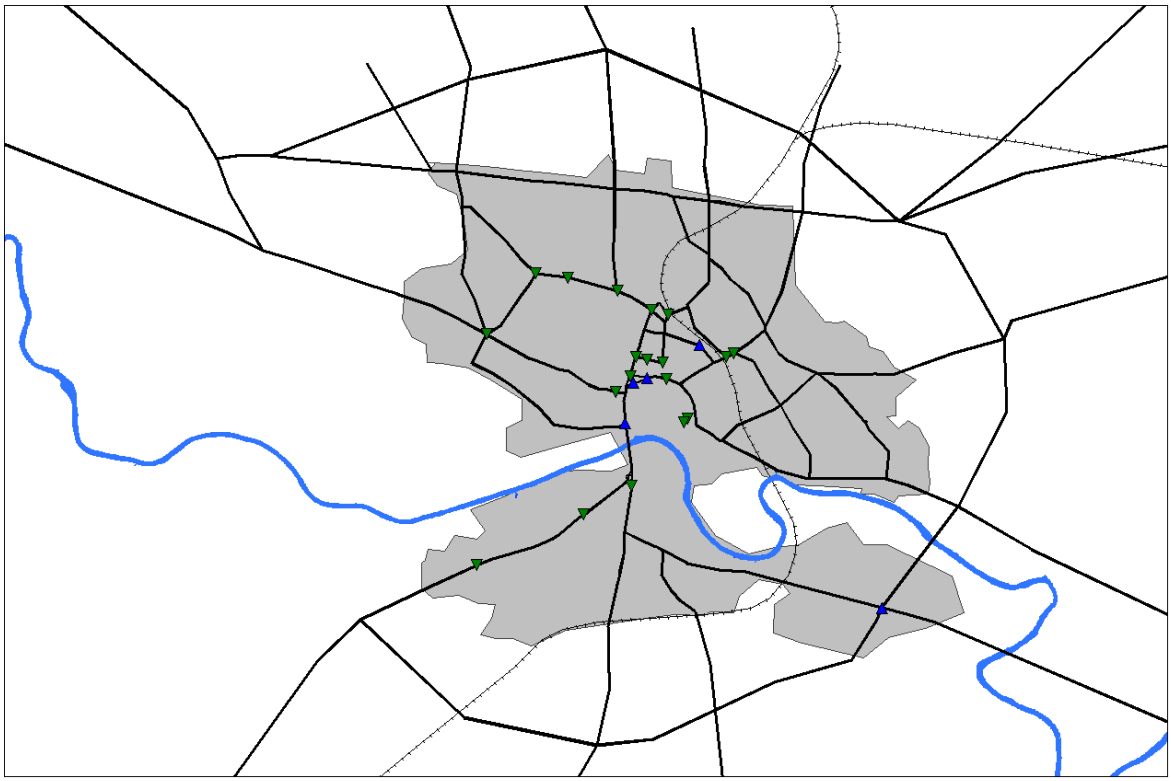
Volume-Capacity Ratio at Junctions - No ODR - Do-Minimum Demand – PM Peak



Volume-Capacity Ratio at Junctions - ODR West - Do-Minimum Demand – PM Peak

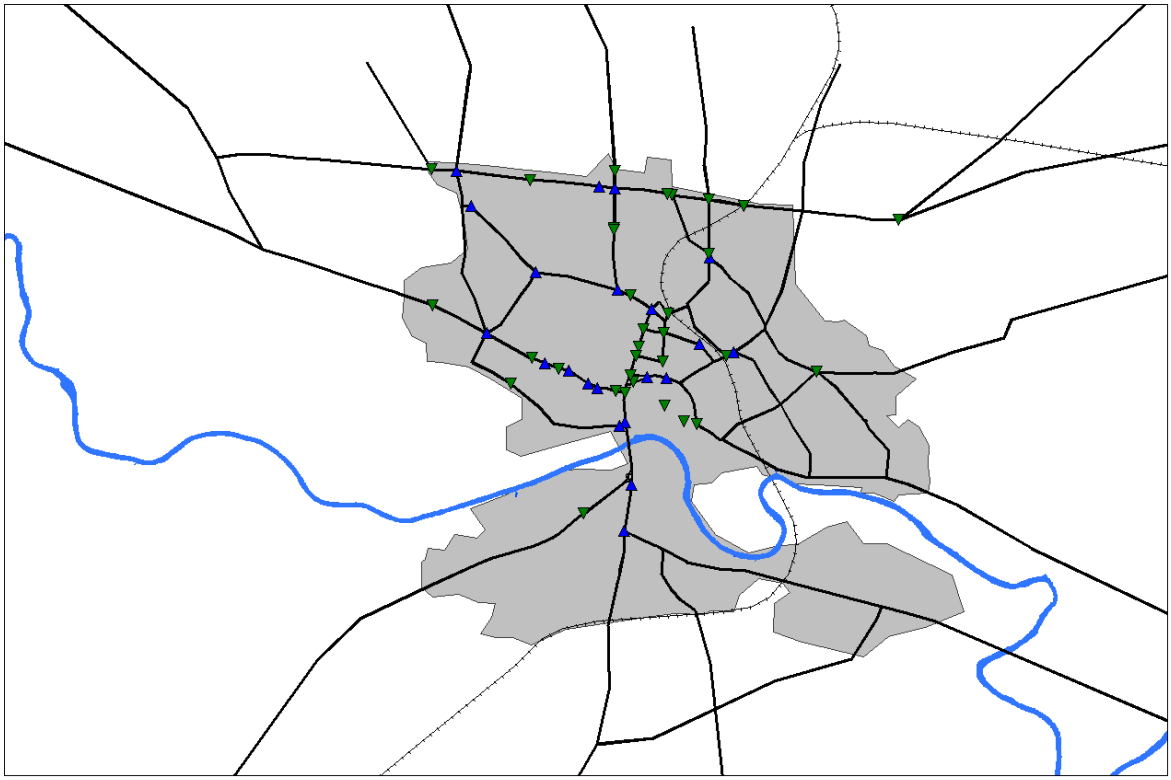


Volume-Capacity Ratio at Junctions - ODR East - Do-Minimum Demand – PM Peak

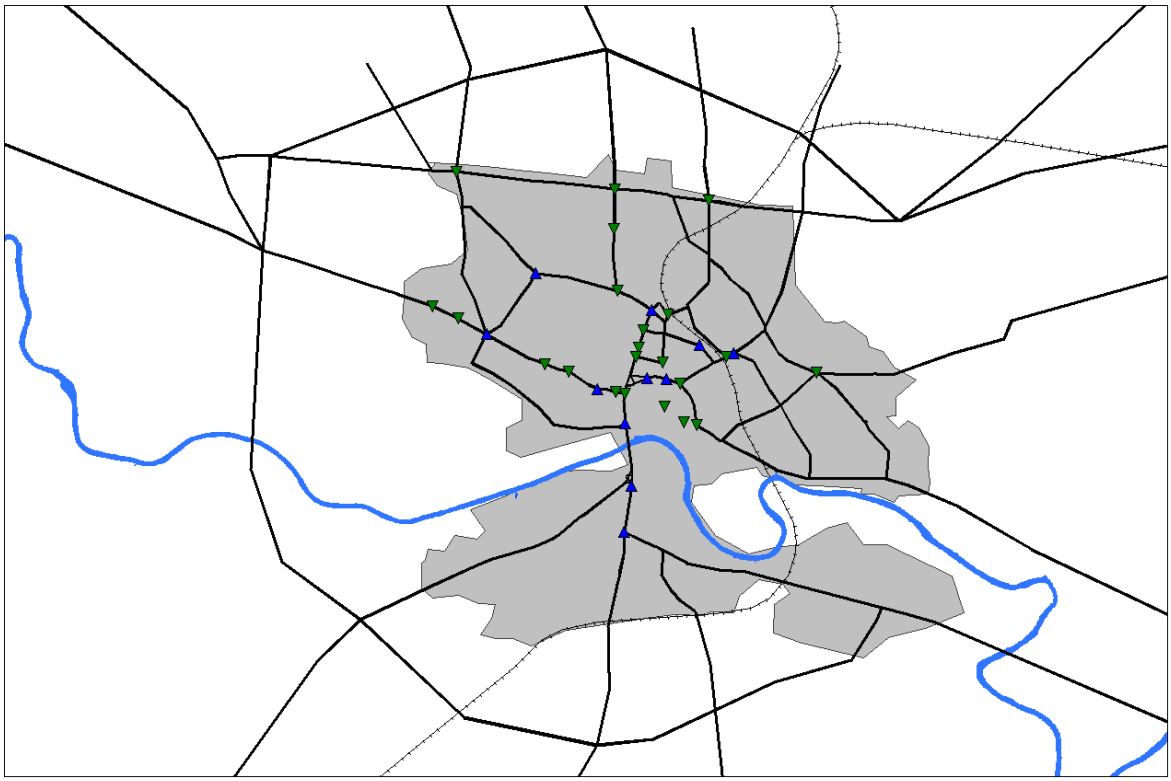


Do-Something Demand Option 1

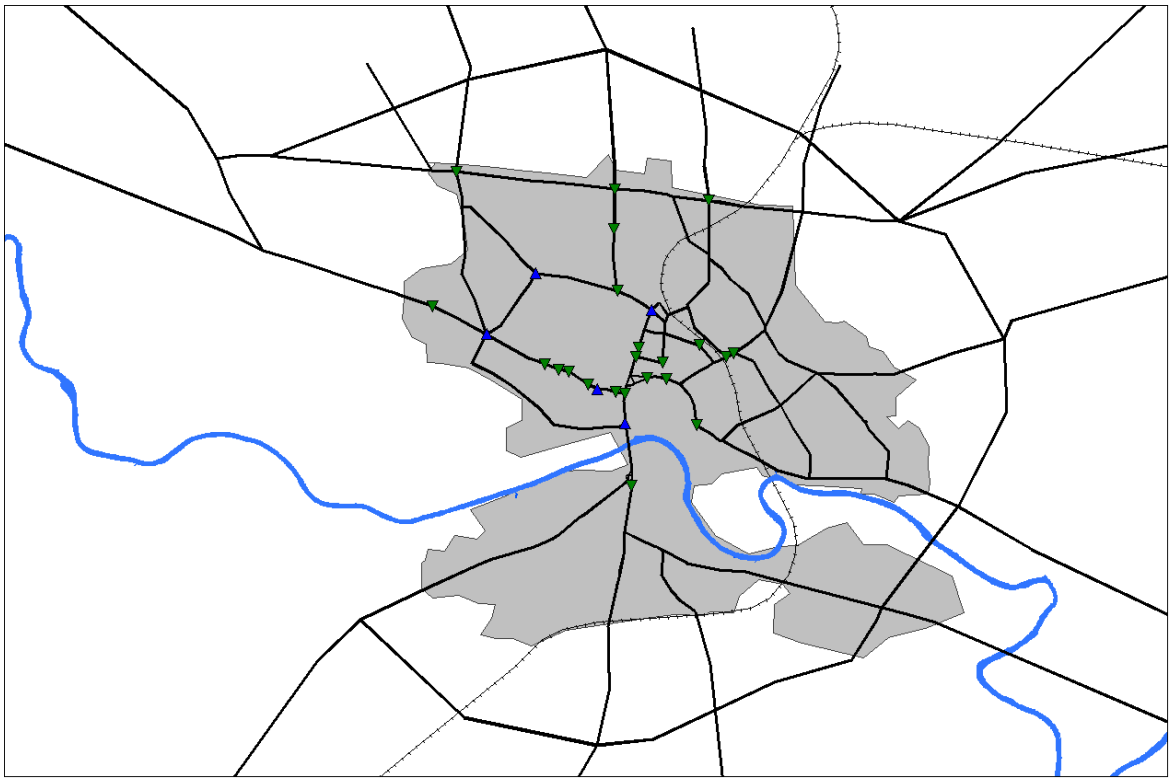
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 1 – AM Peak



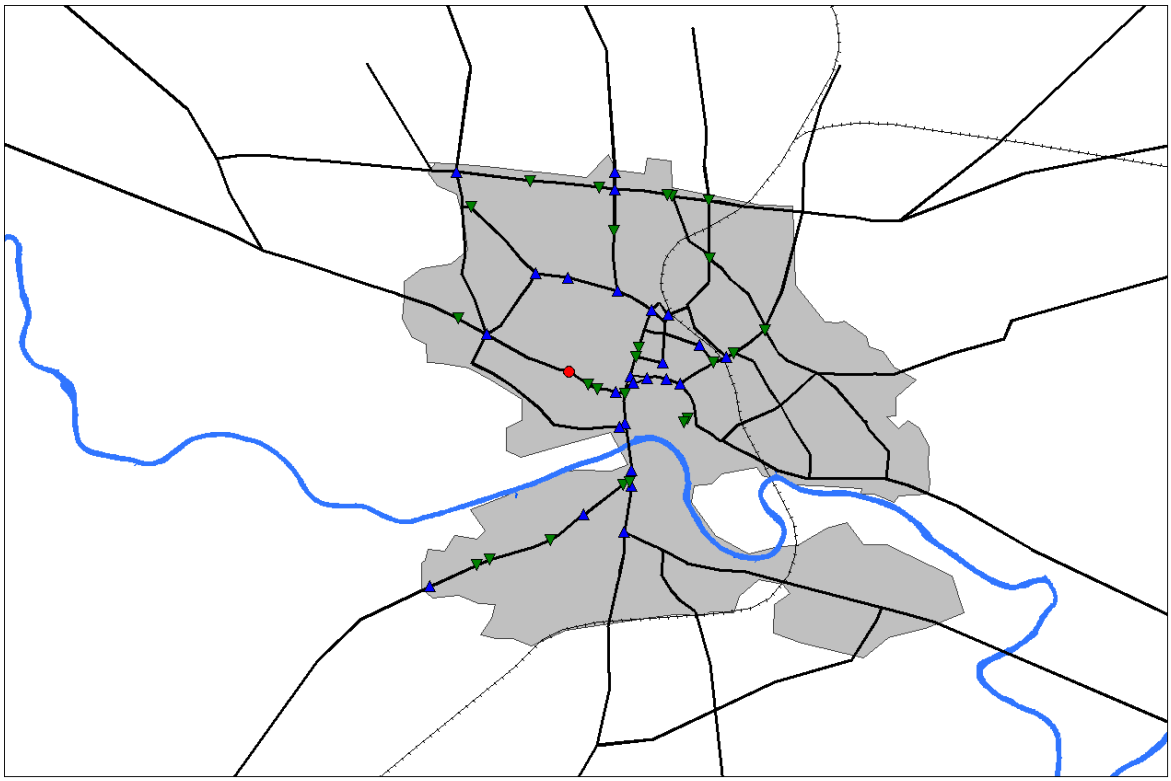
Volume-Capacity Ratio at Junctions – ODR West –Demand Option 1 – AM Peak



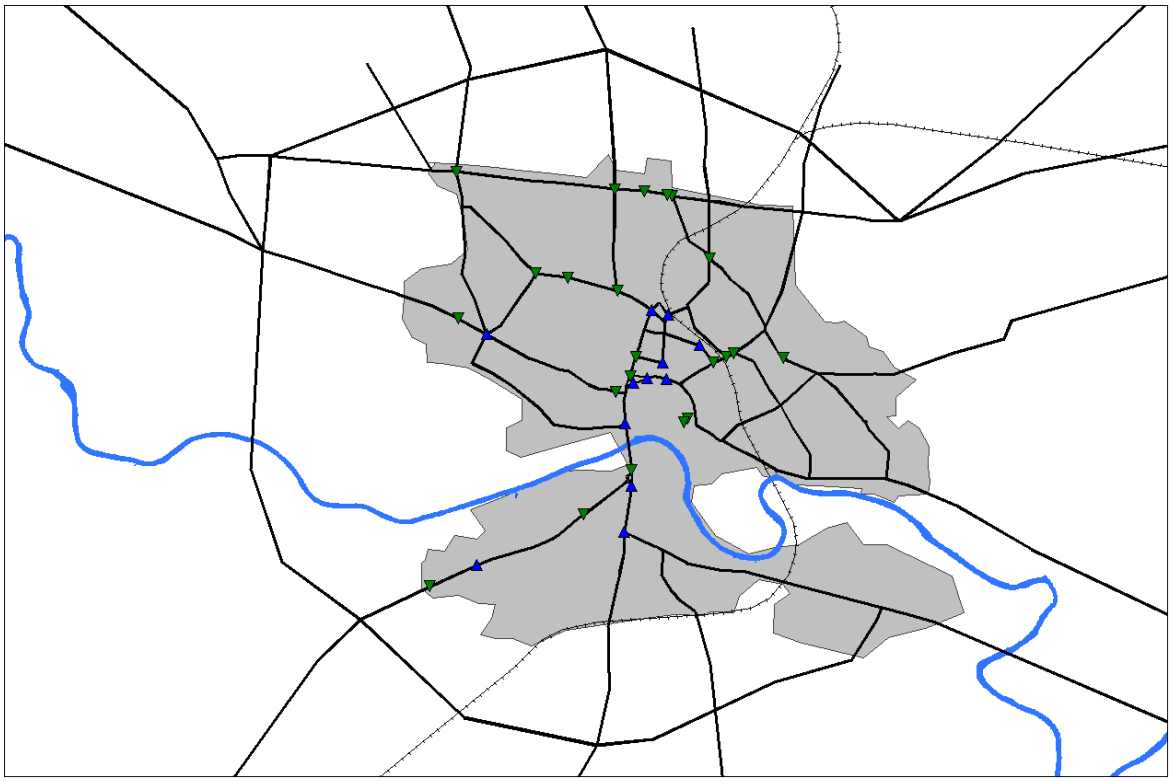
Volume-Capacity Ratio at Junctions – ODR East – Demand Option 1 – AM Peak



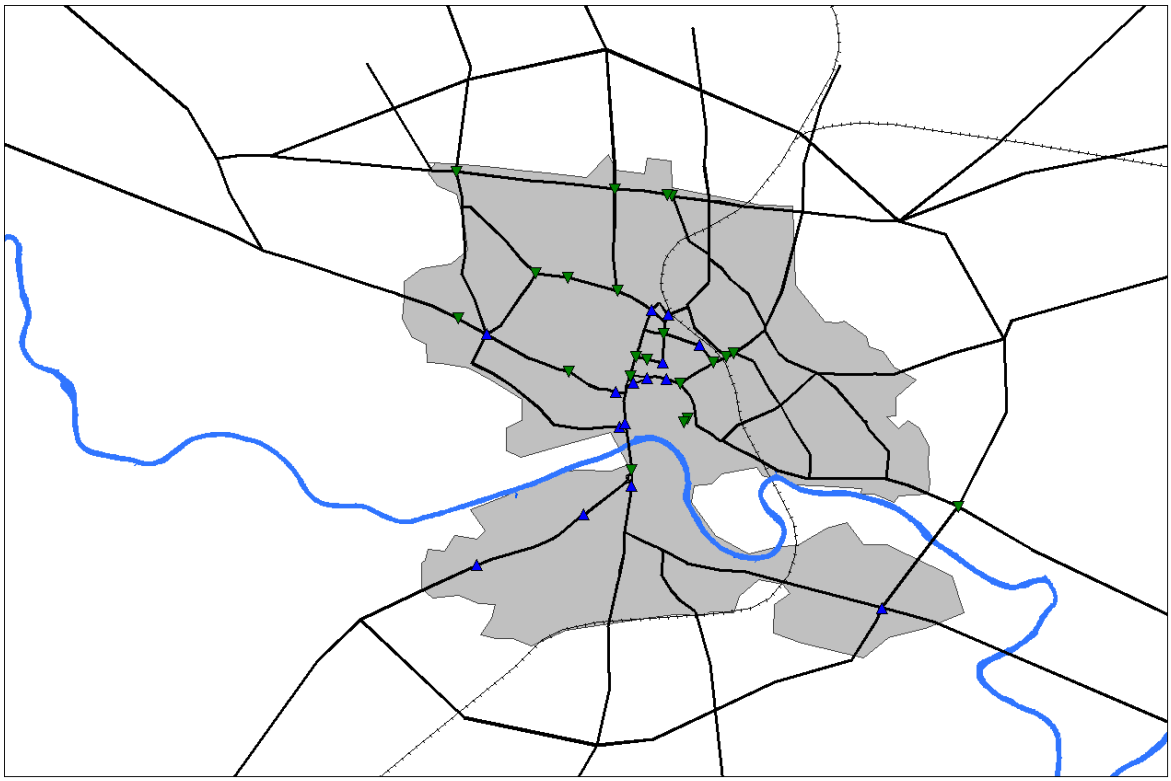
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 1 – PM Peak



Volume-Capacity Ratio at Junctions - ODR West –Demand Option 1 – PM Peak

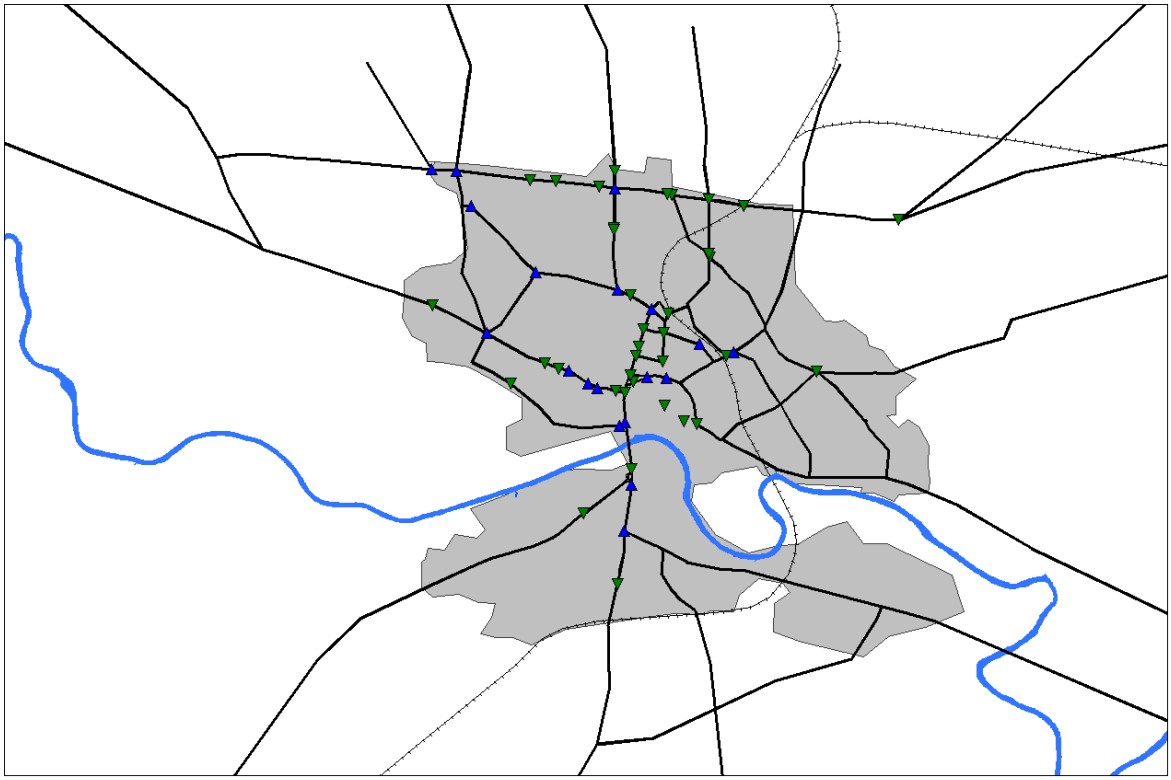


Volume-Capacity Ratio at Junctions - ODR East – Demand Option 1 – PM Peak

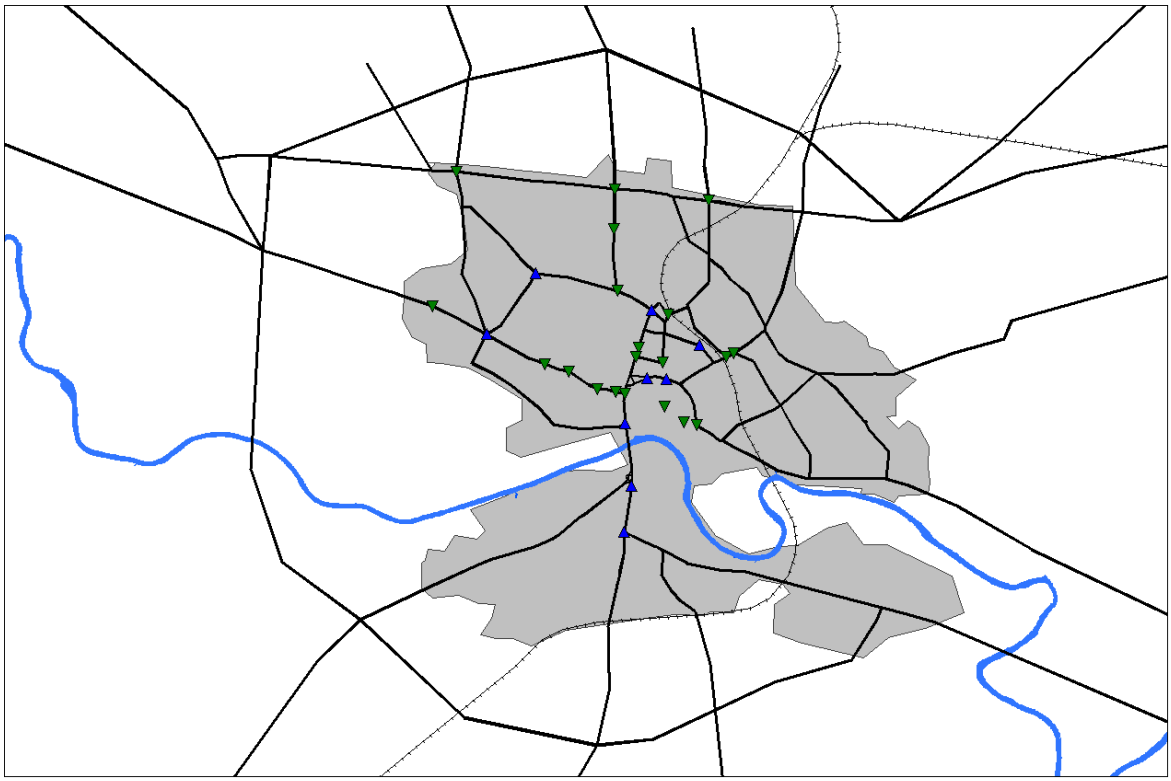


Do-Something Demand Option 2

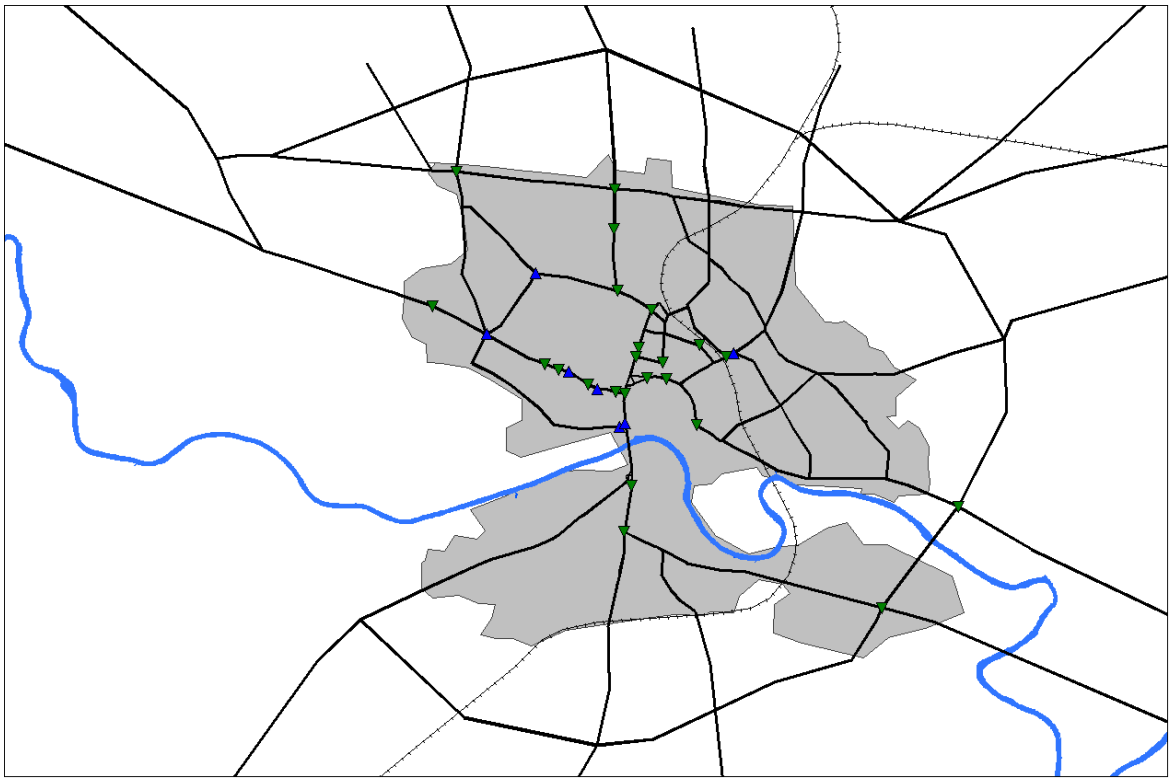
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 2 – AM Peak



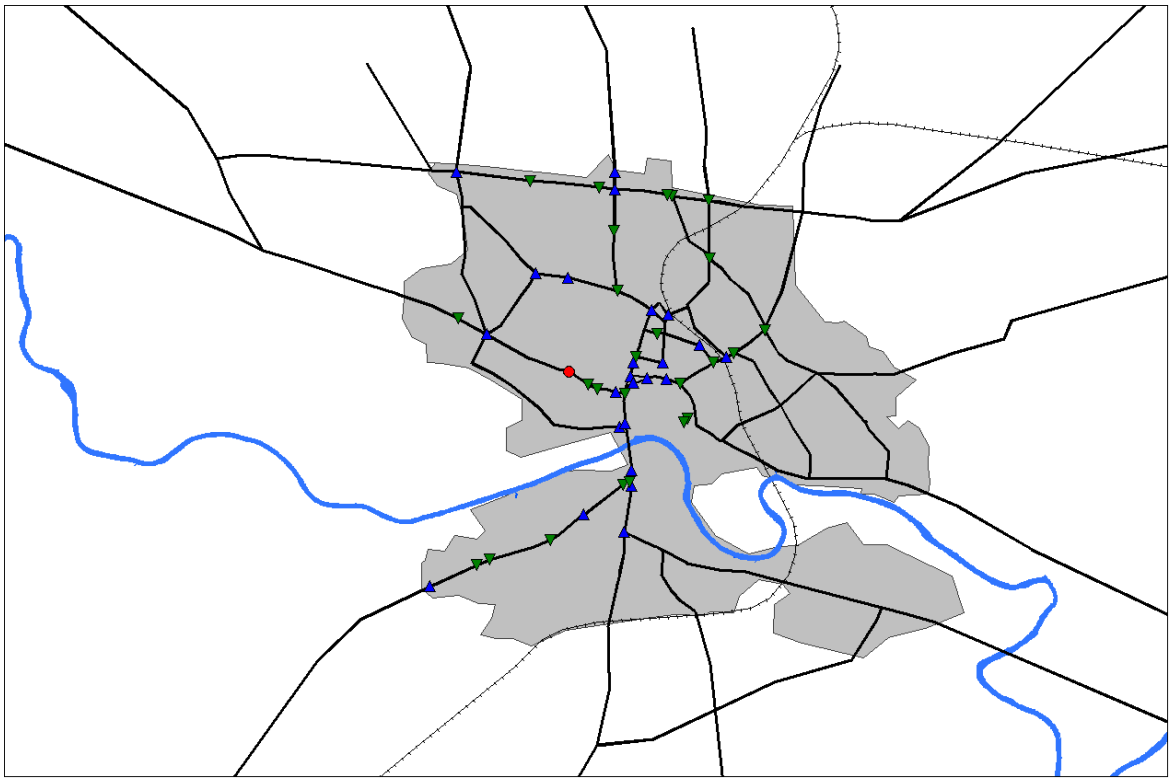
Volume-Capacity Ratio at Junctions – ODR West –Demand Option 2 – AM Peak



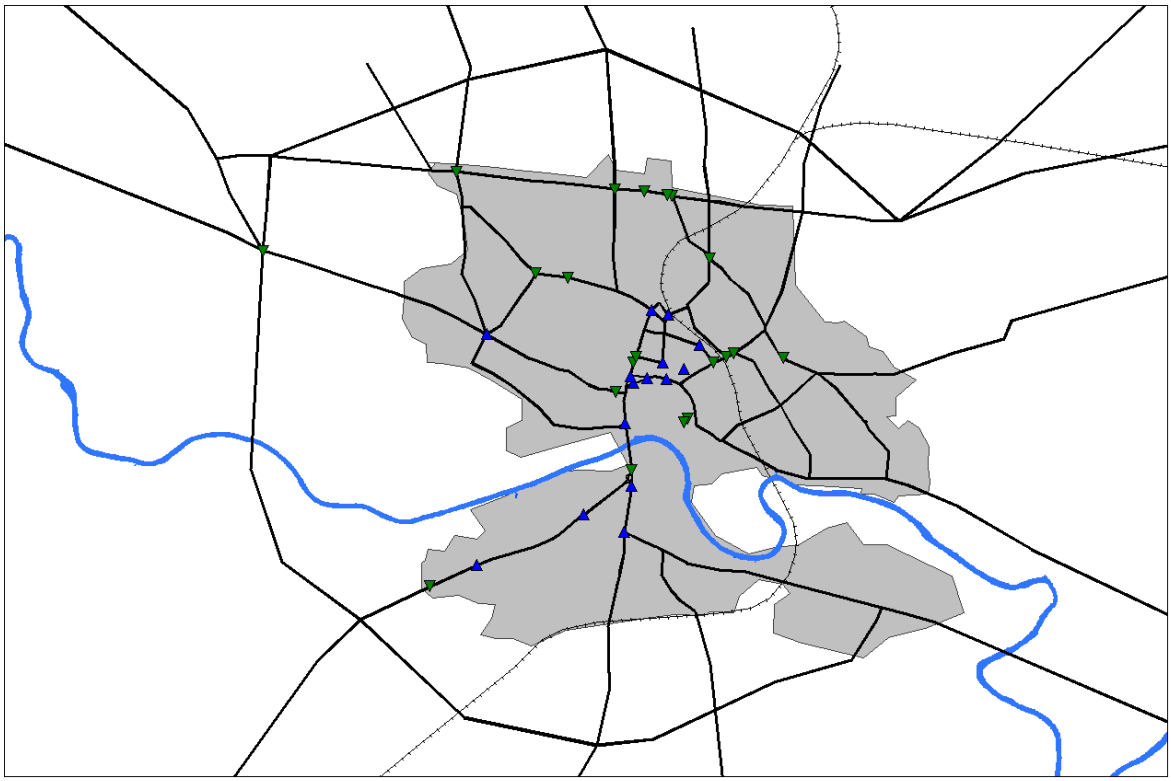
Volume-Capacity Ratio at Junctions – ODR East – Demand Option 2 – AM Peak



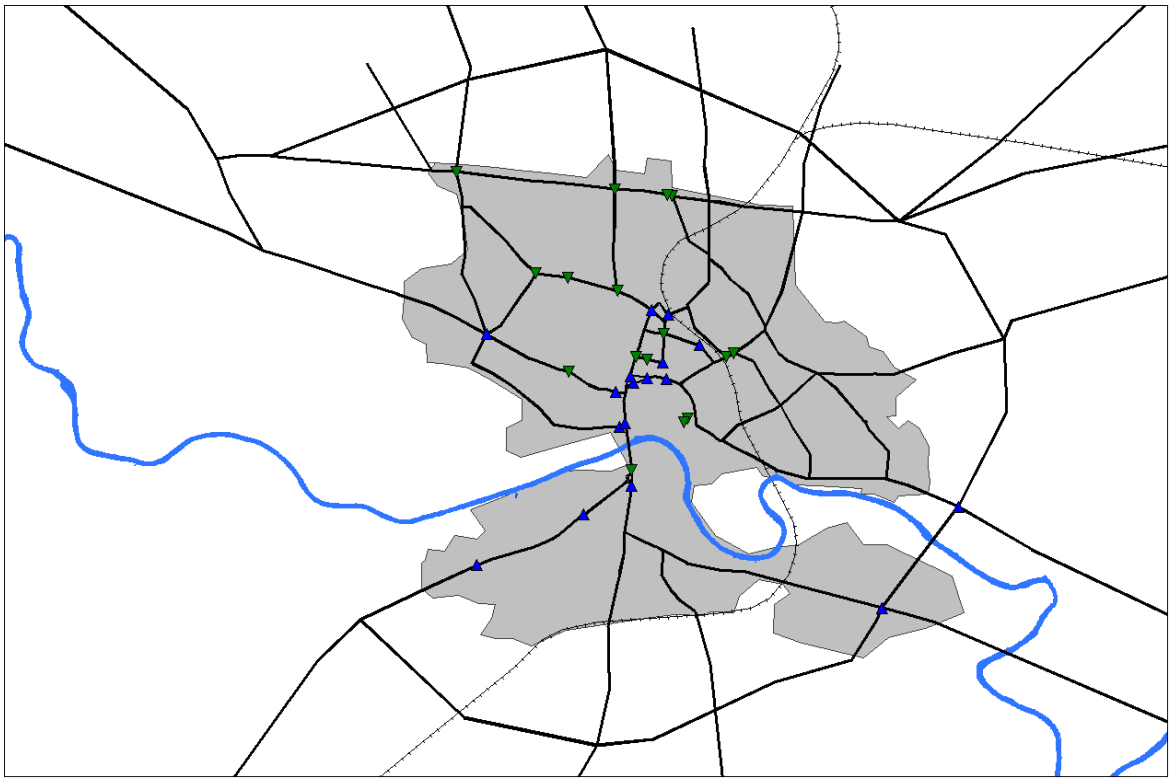
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 2 – PM Peak



Volume-Capacity Ratio at Junctions - ODR West –Demand Option 2 – PM Peak

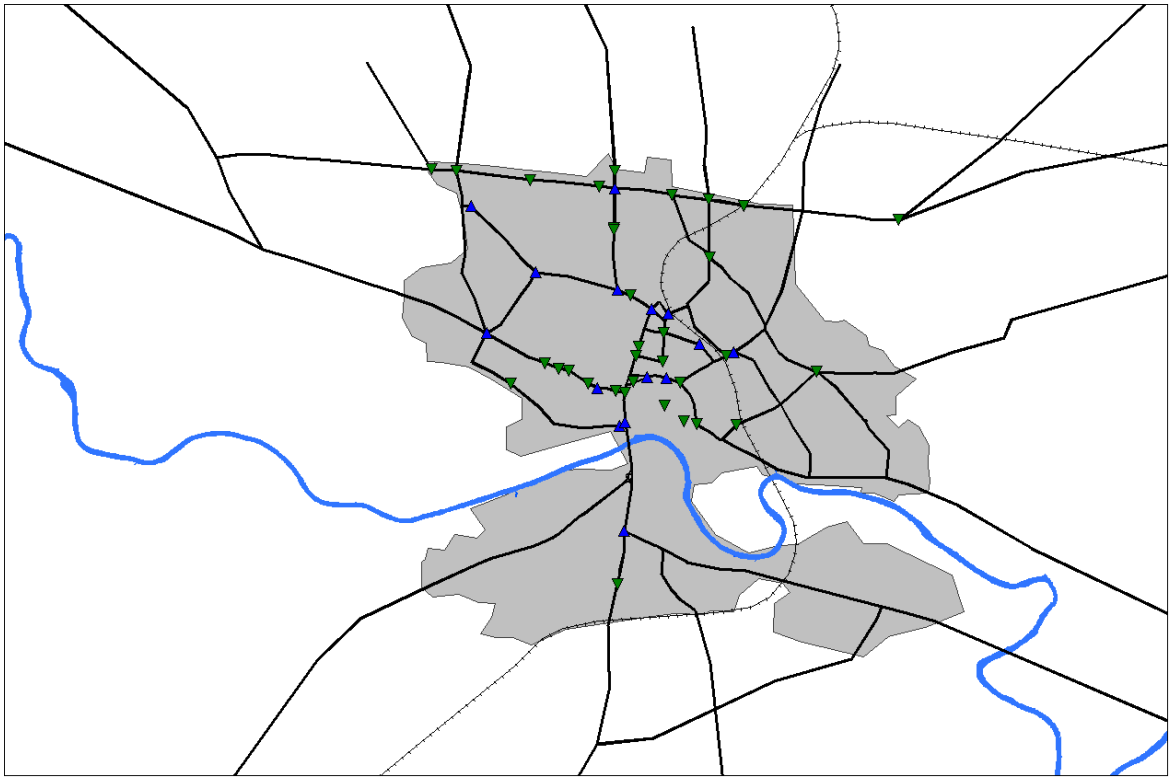


Volume-Capacity Ratio at Junctions - ODR East – Demand Option 2 – PM Peak

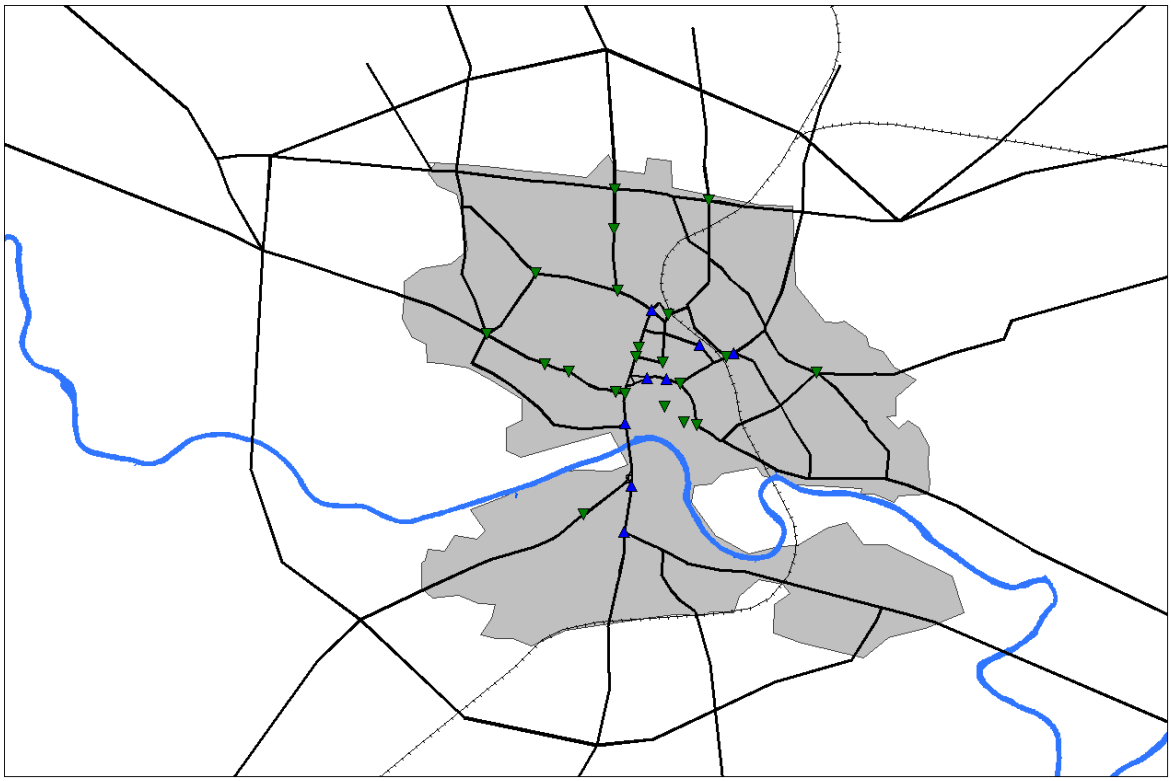


Do-Something Demand Option 3

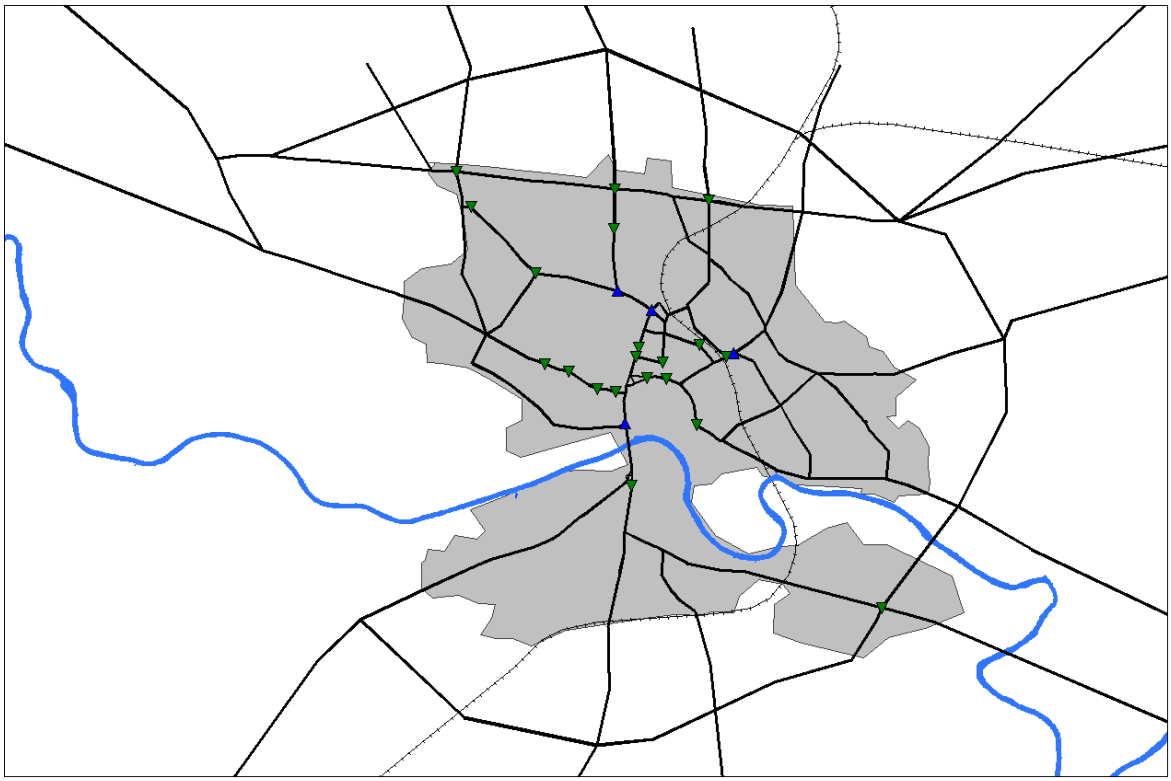
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 3 – AM Peak



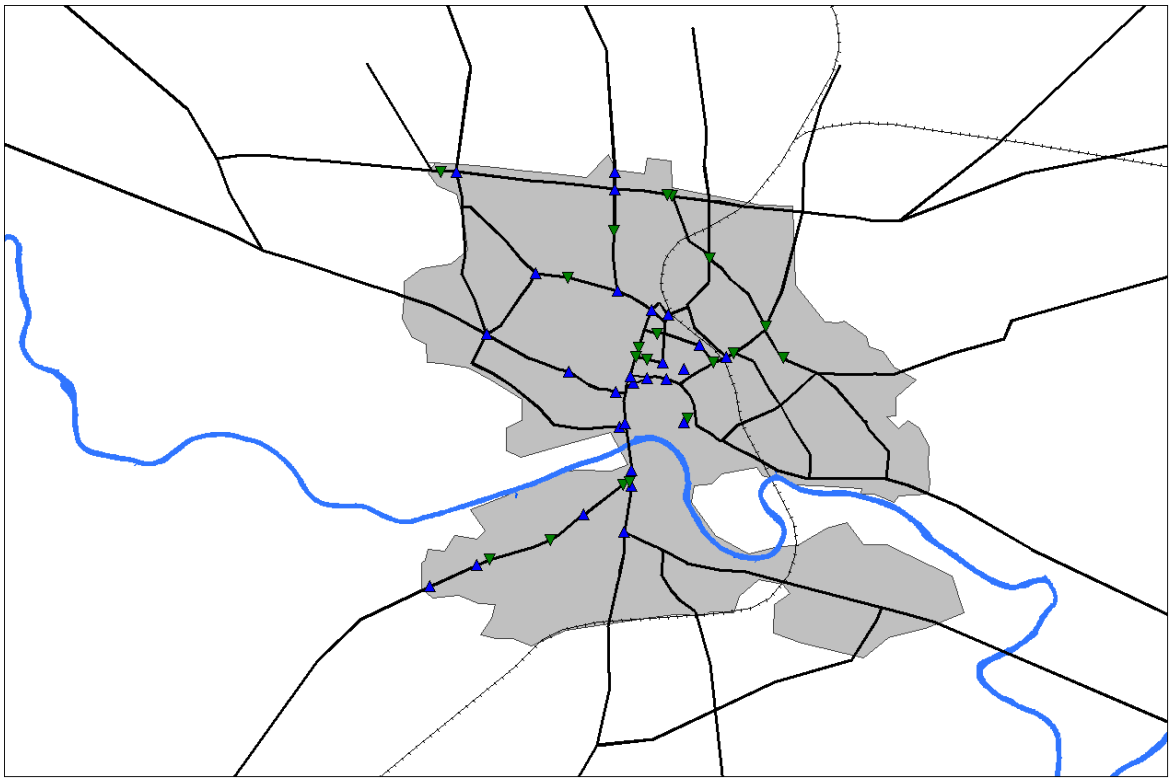
Volume-Capacity Ratio at Junctions – ODR West –Demand Option 3 – AM Peak



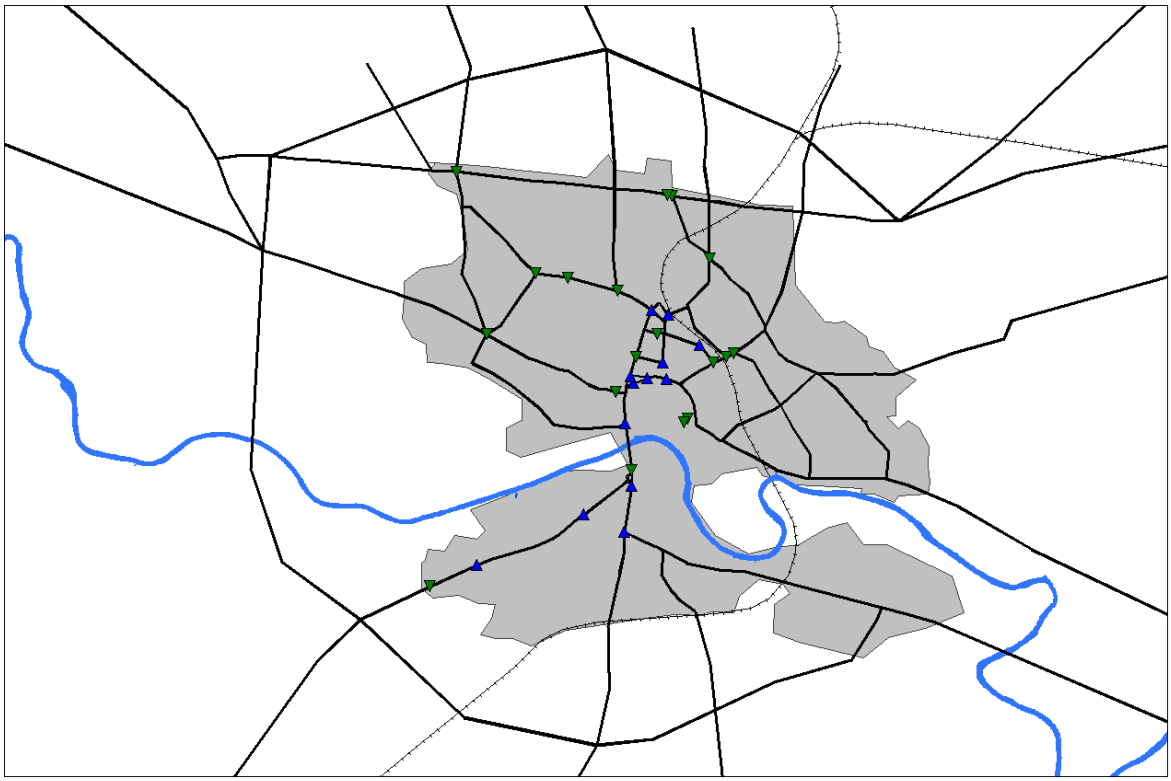
Volume-Capacity Ratio at Junctions – ODR East – Demand Option 3 – AM Peak



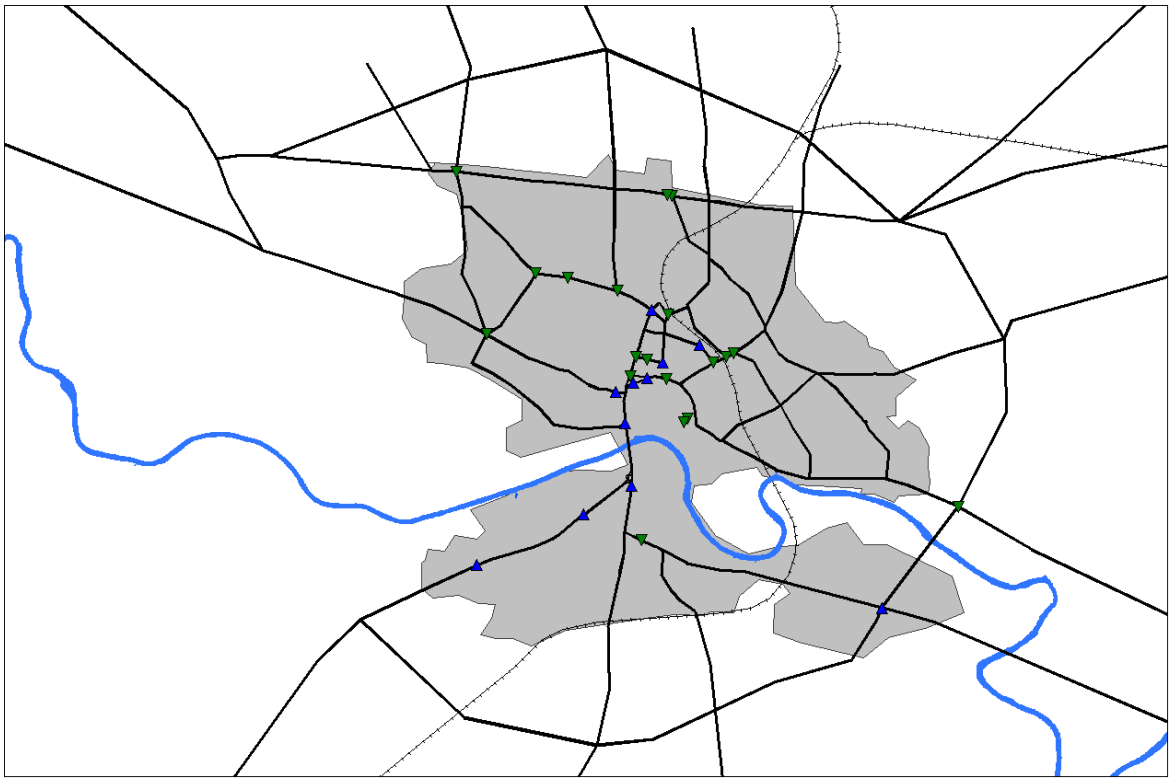
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 3 – PM Peak



Volume-Capacity Ratio at Junctions - ODR West –Demand Option 3 – PM Peak

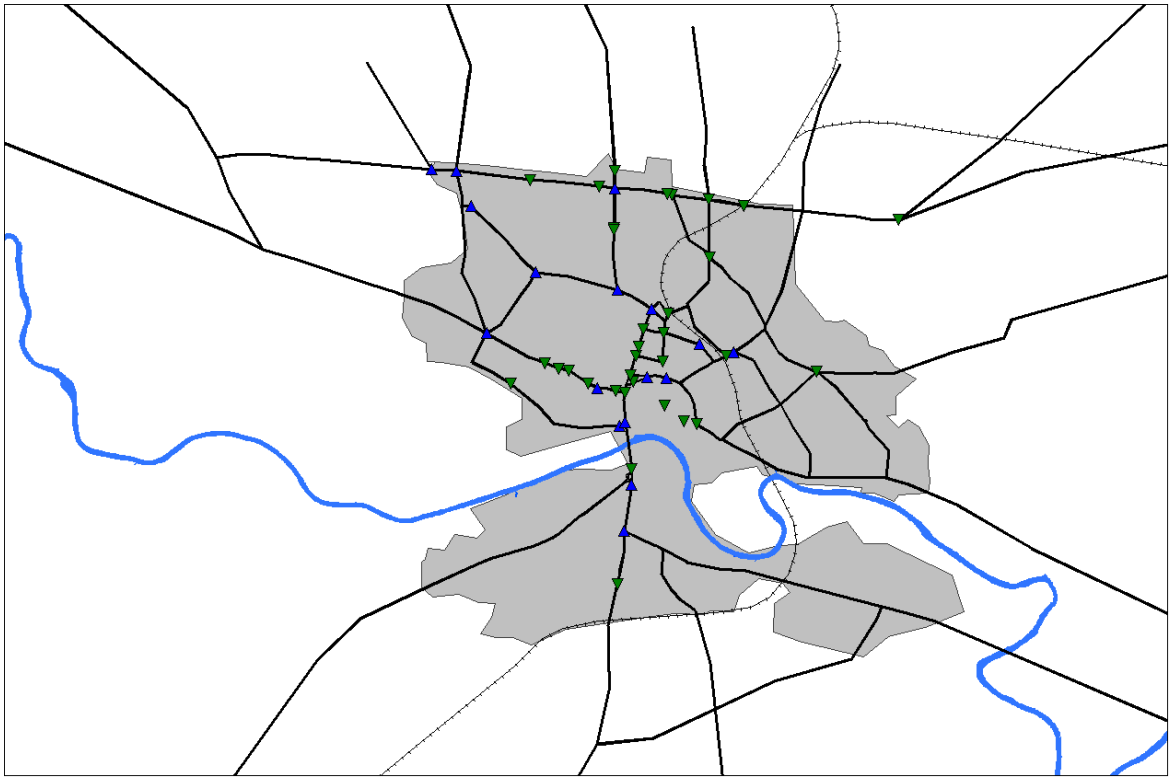


Volume-Capacity Ratio at Junctions - ODR East – Demand Option 3 – PM Peak

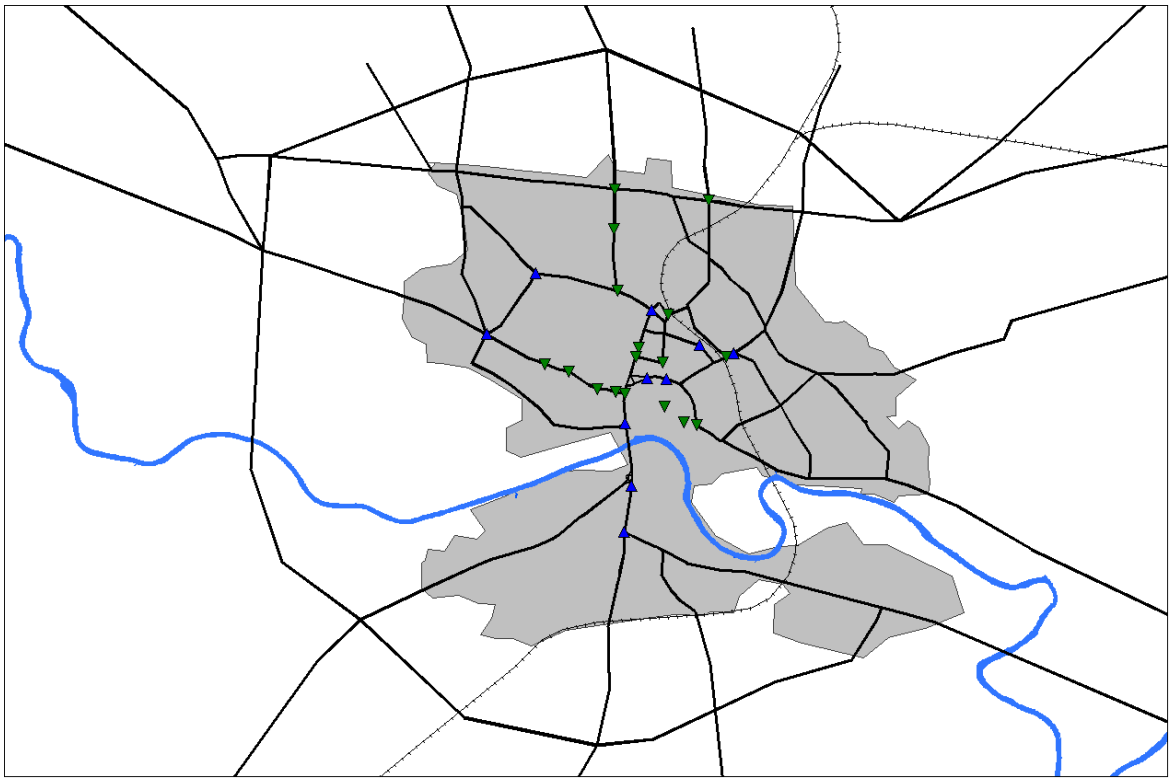


Do-Something Demand Option 4

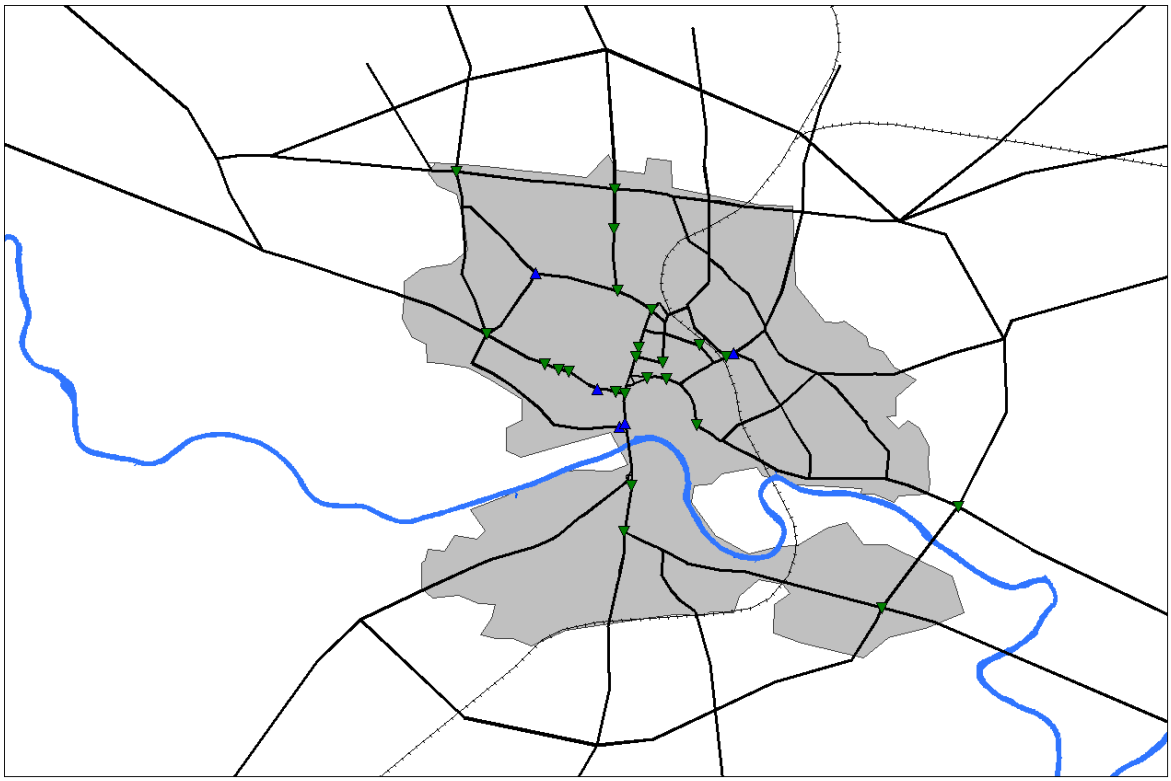
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 4 – AM Peak



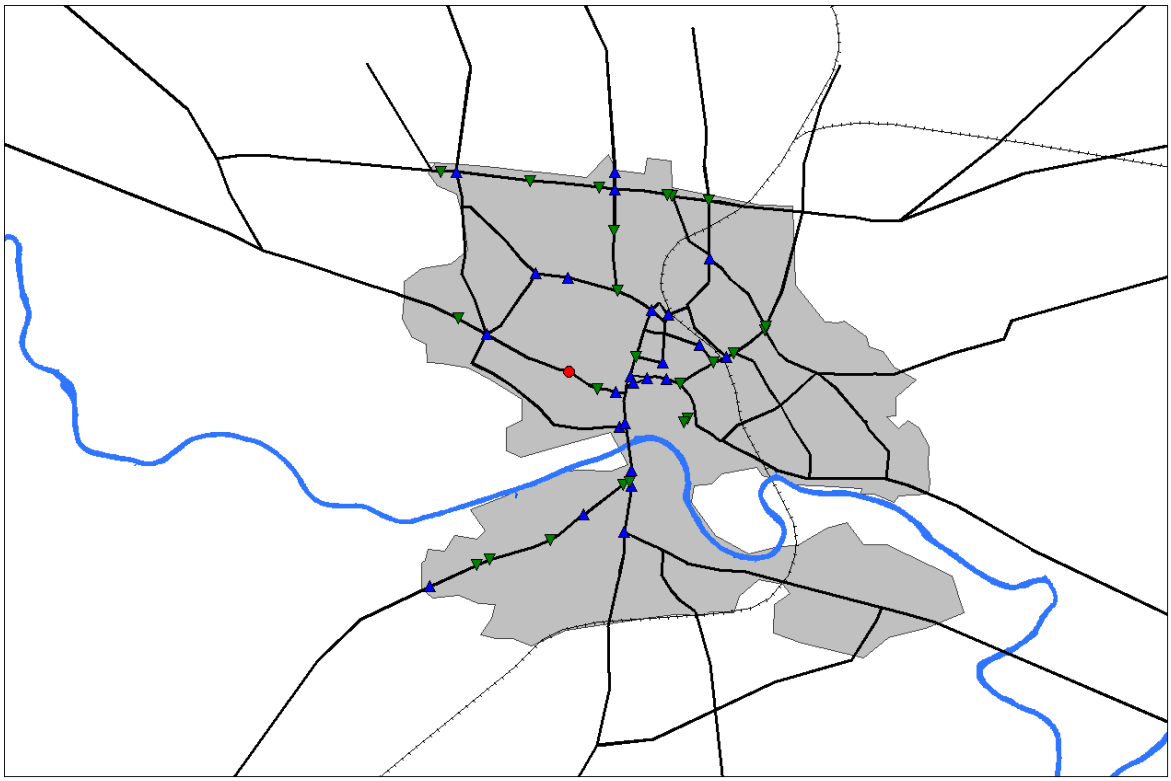
Volume-Capacity Ratio at Junctions – ODR West –Demand Option 4 – AM Peak



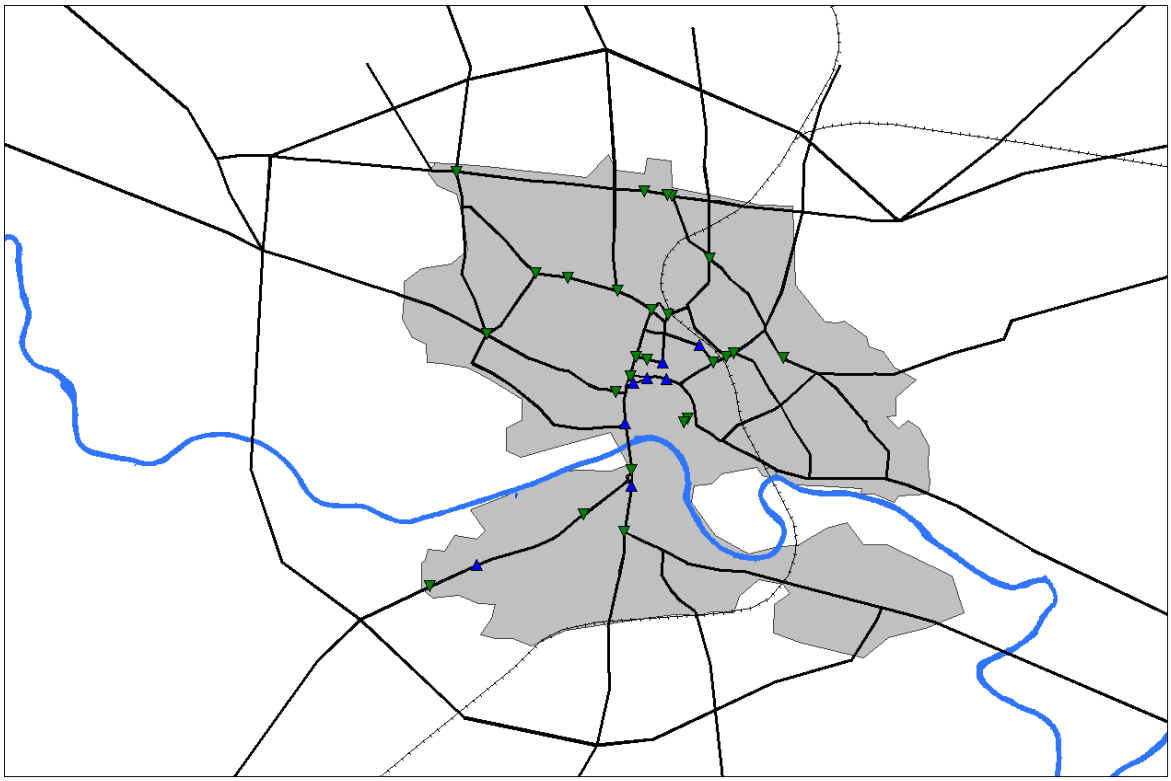
Volume-Capacity Ratio at Junctions – ODR East – Demand Option 4 – AM Peak



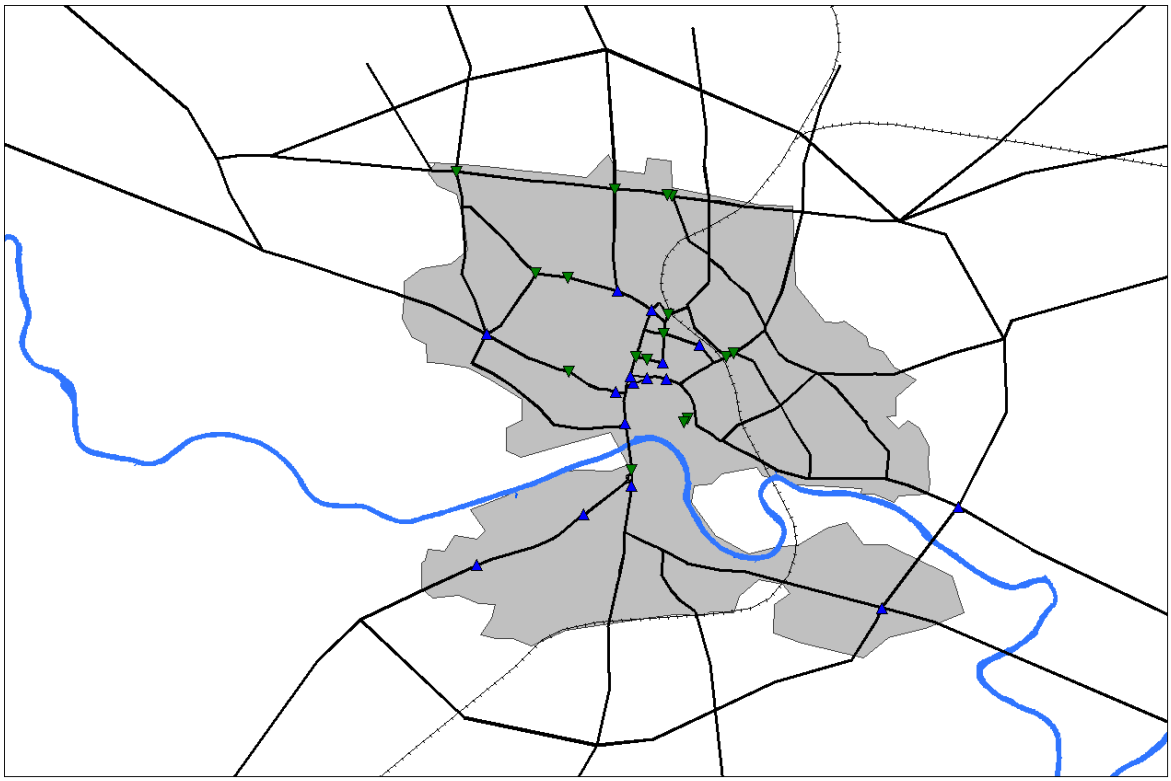
Volume-Capacity Ratio at Junctions – No ODR – Demand Option 4 – PM Peak



Volume-Capacity Ratio at Junctions - ODR West –Demand Option 4 – PM Peak



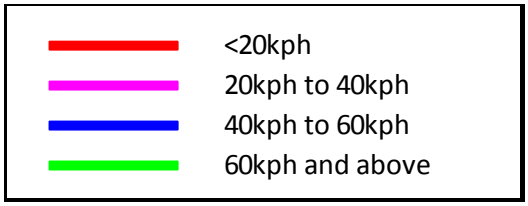
Volume-Capacity Ratio at Junctions - ODR East – Demand Option 4 – PM Peak



Appendix E

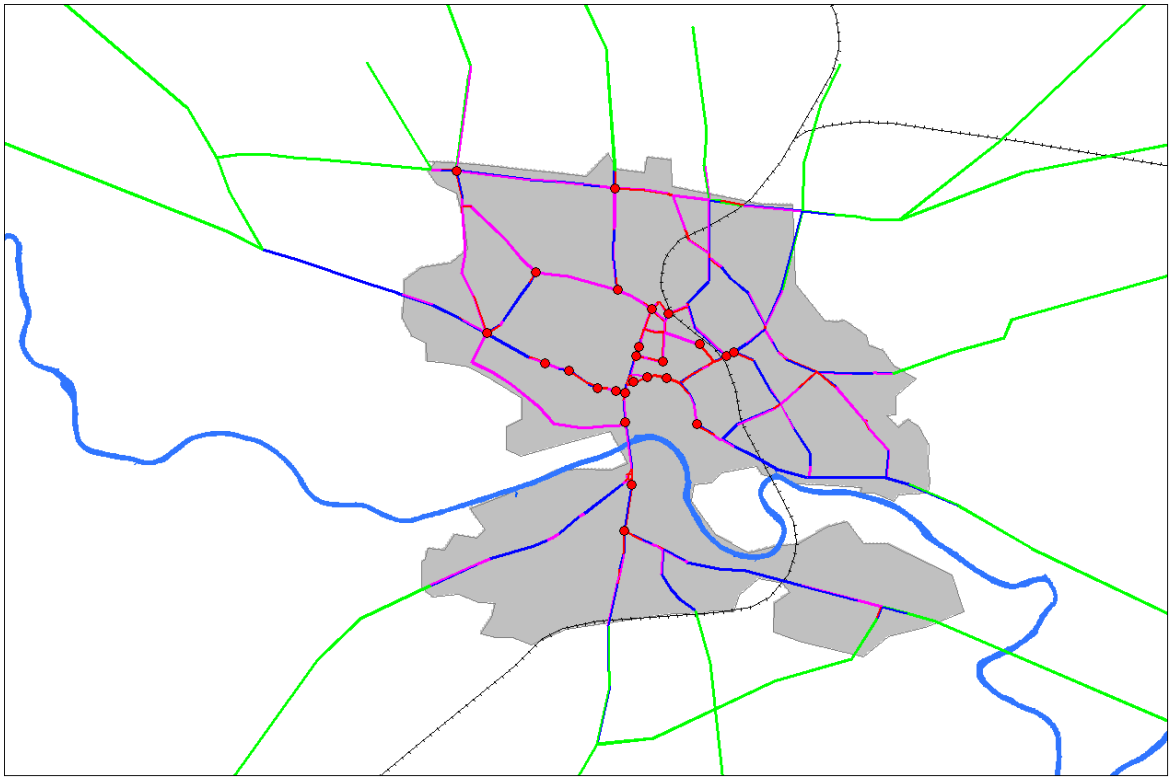
Link Speed

Key to Link Speed Diagrams

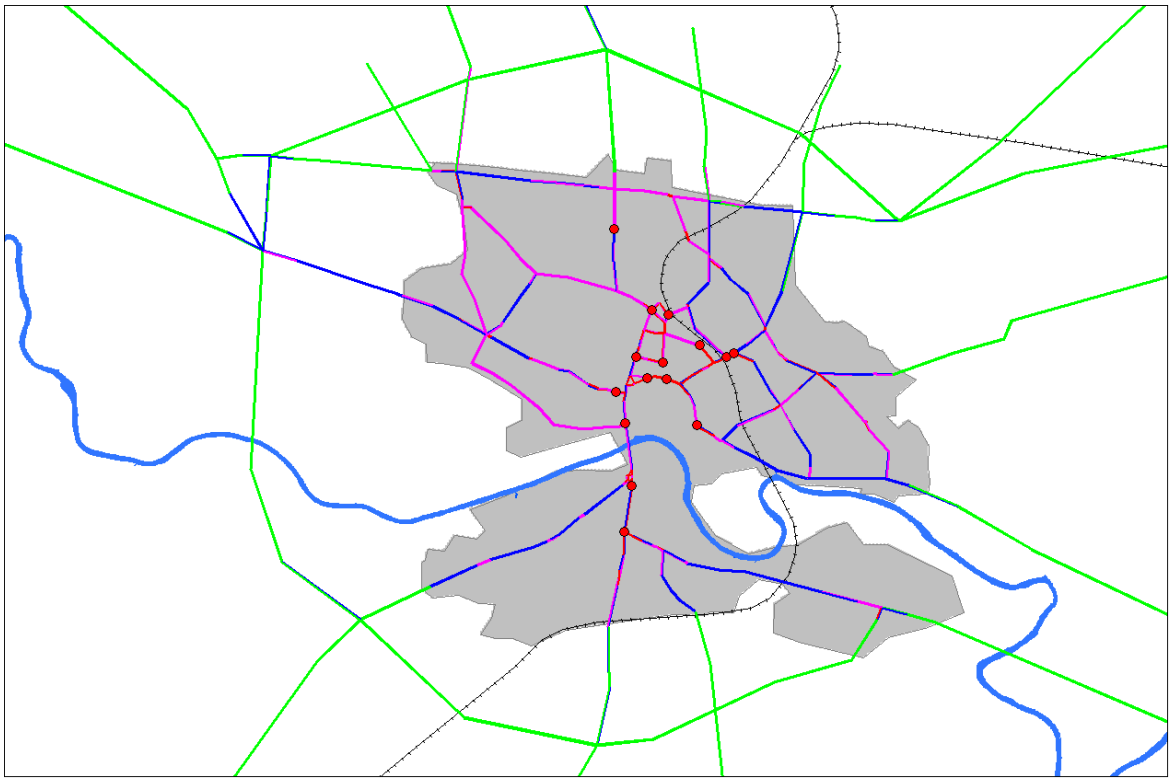


Do-Minimum Demand Option

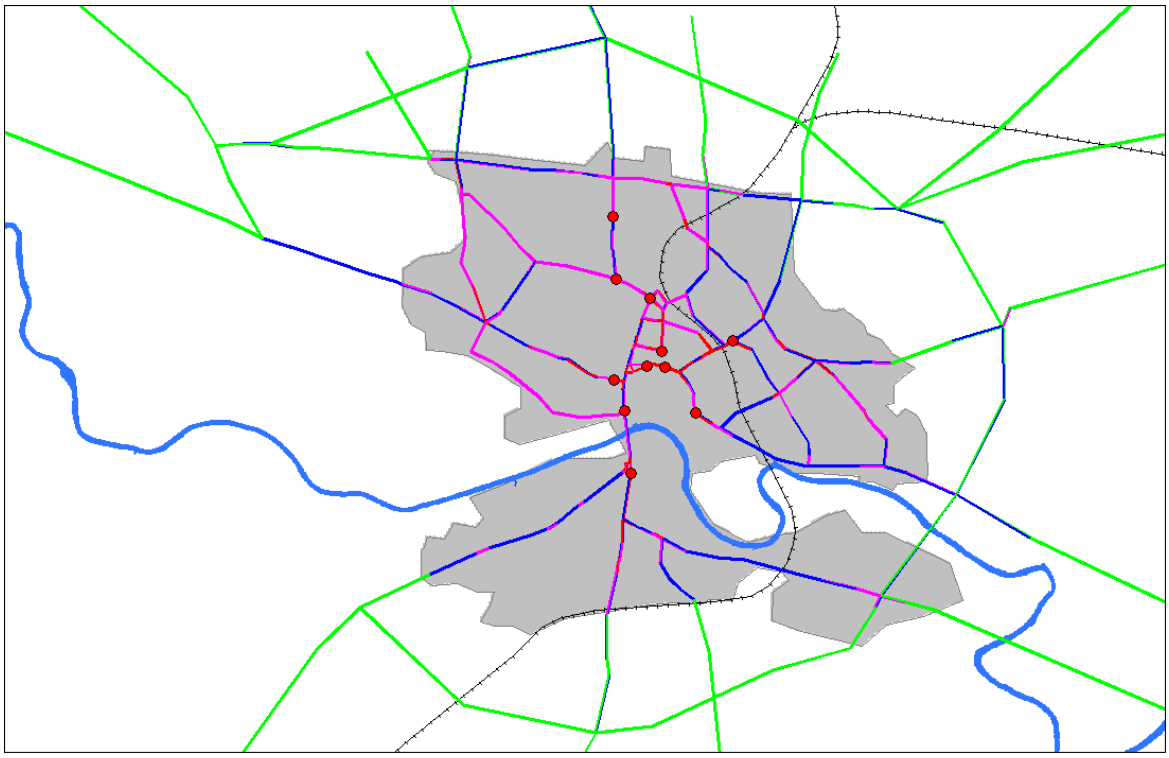
Link Speed: No ODR – Do-Minimum Demand: AM Peak



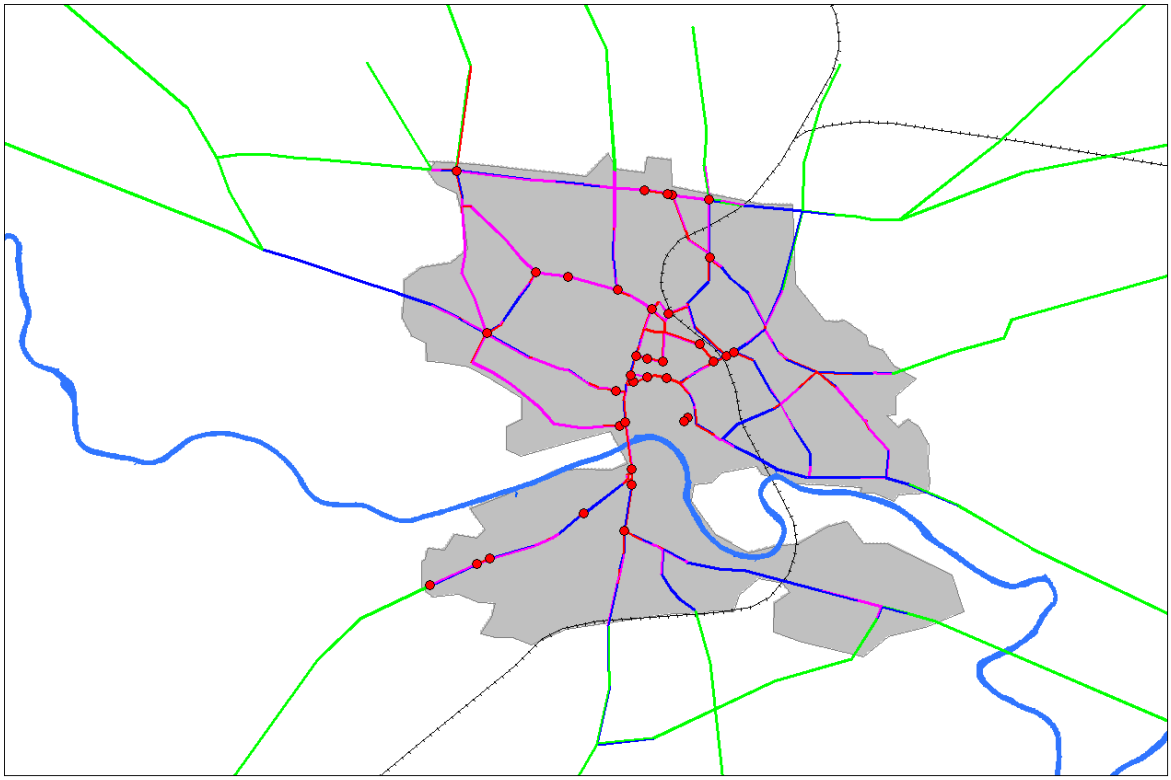
Link Speed: ODR West – Do-Minimum Demand: AM Peak



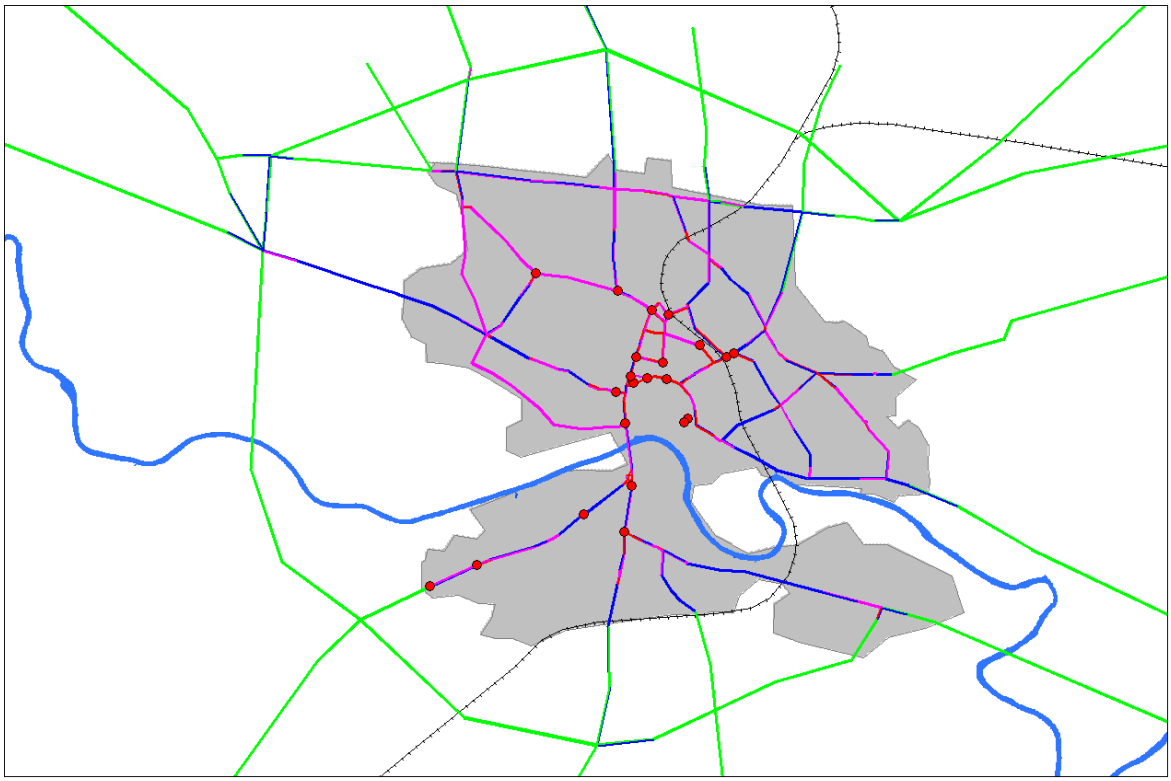
Link Speed: ODR East – Do-Minimum Demand: AM Peak



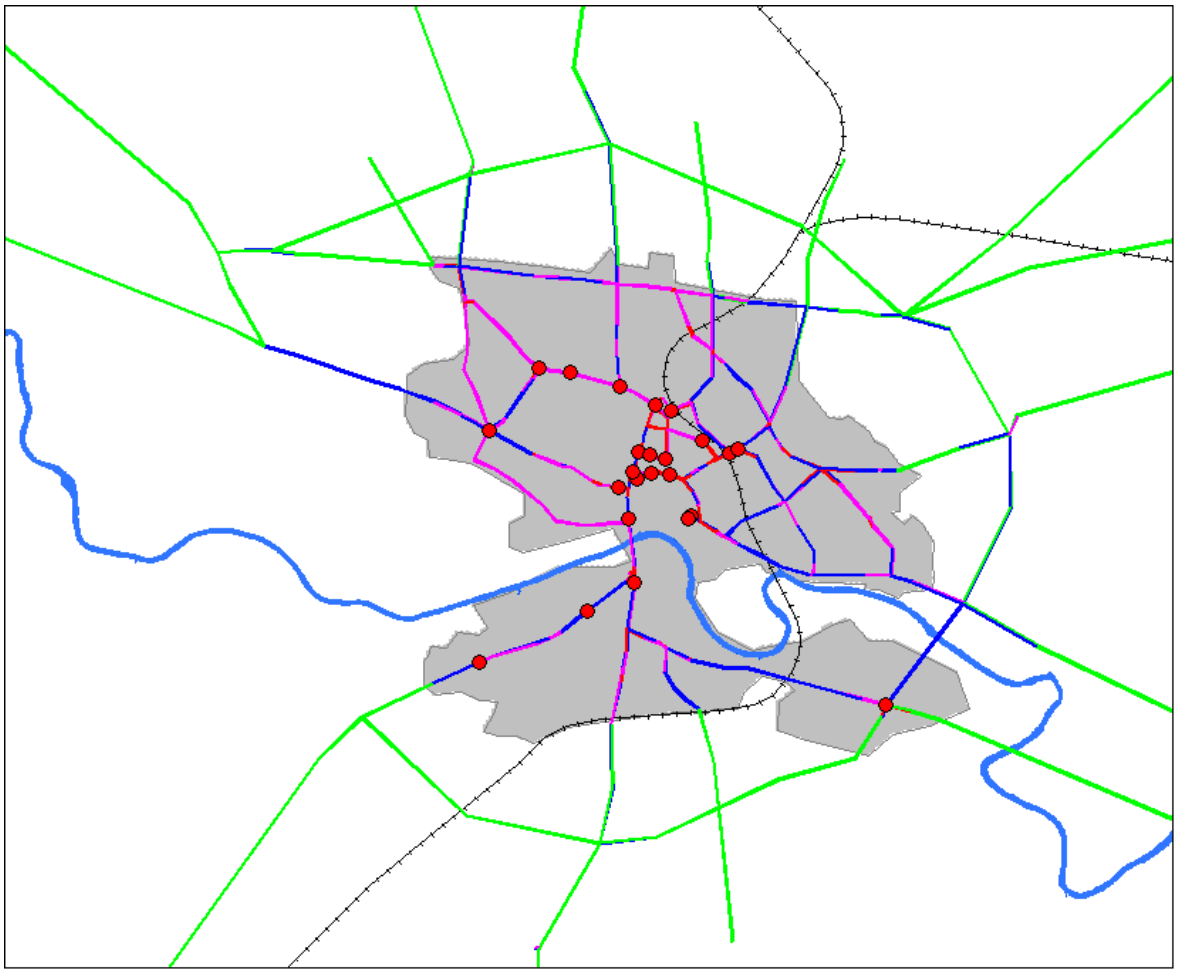
Link Speed: No ODR – Do-Minimum Demand: PM Peak



Link Speed: ODR West – Do-Minimum Demand: PM Peak

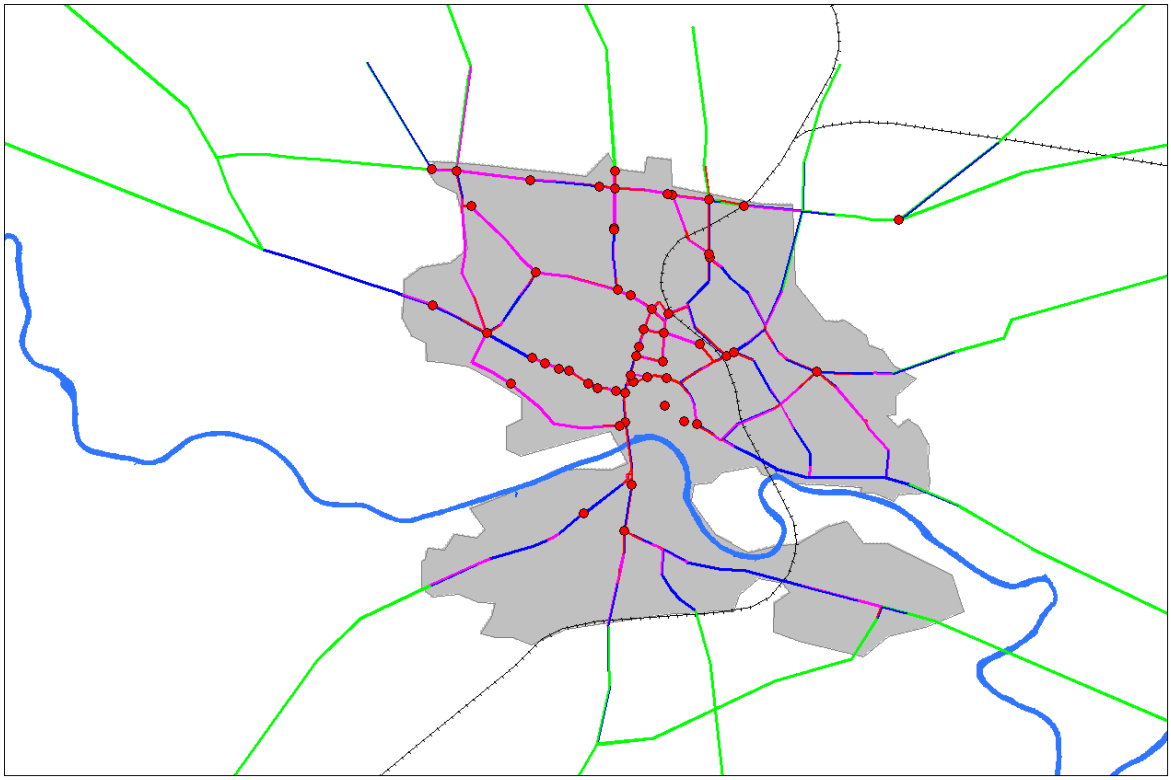


Link Speed: ODR East – Do-Minimum Demand: PM Peak

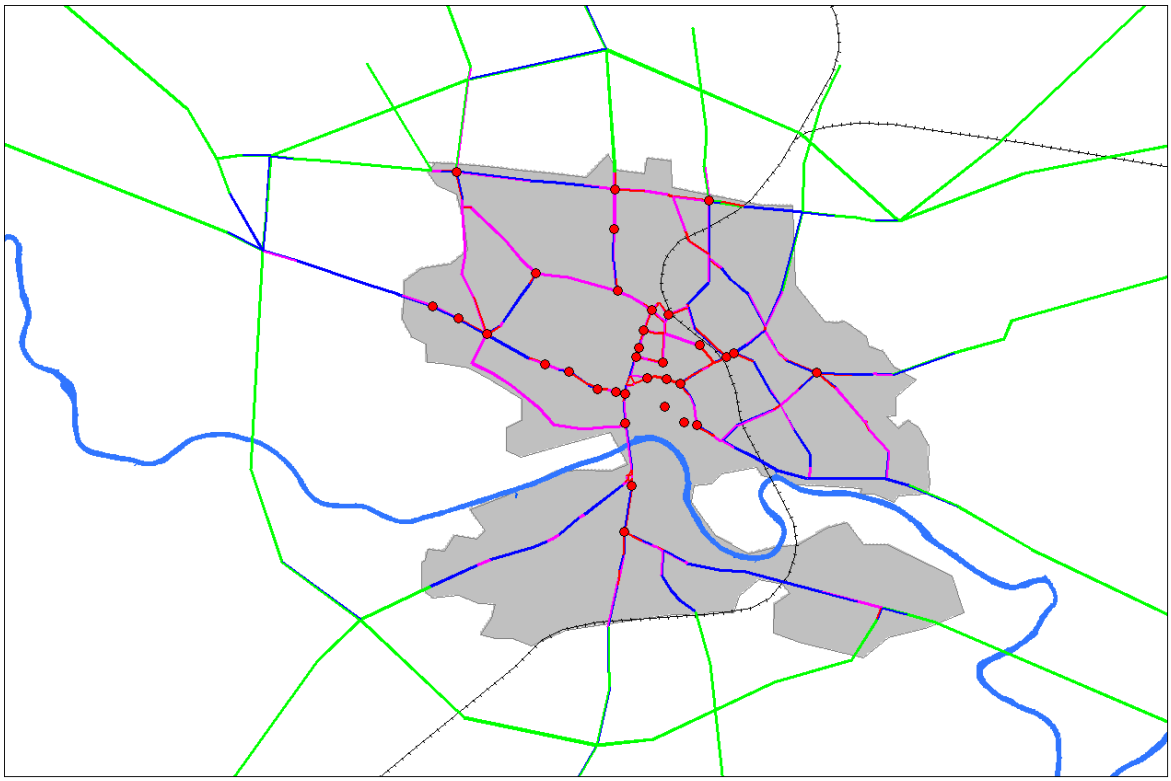


Do-Something Demand Option 1

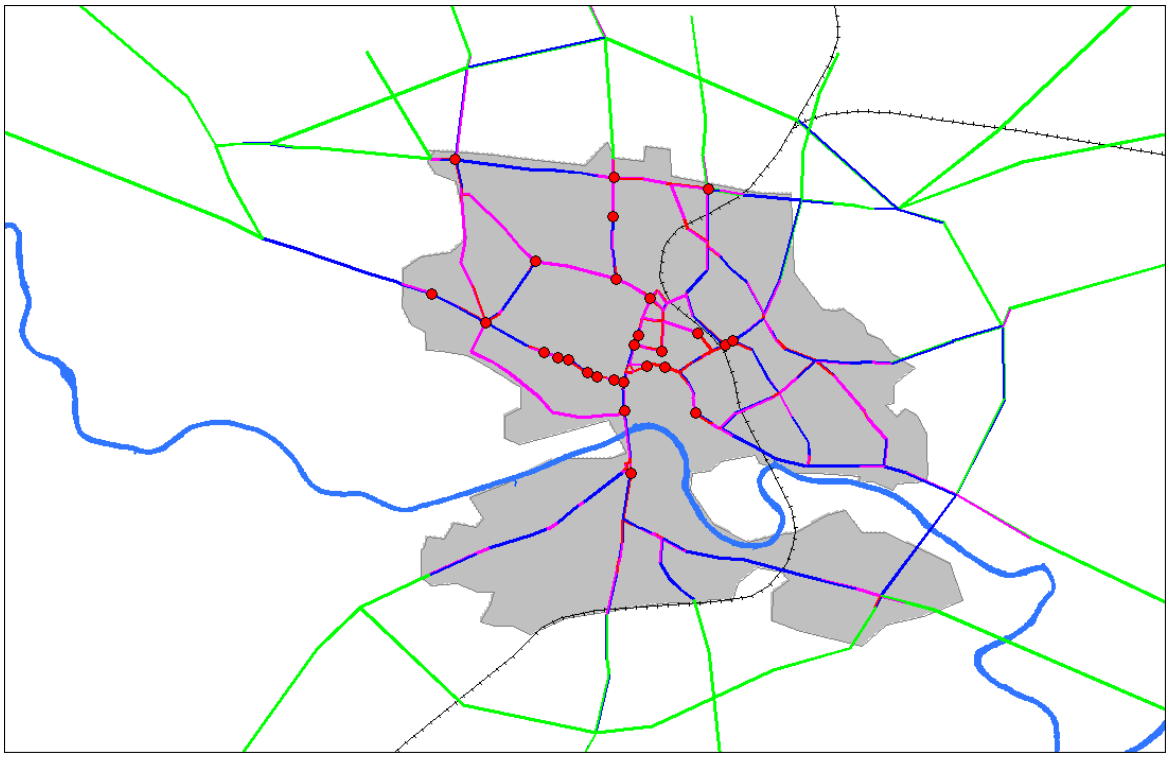
Link Speed: No ODR – Demand Option 1: AM Peak



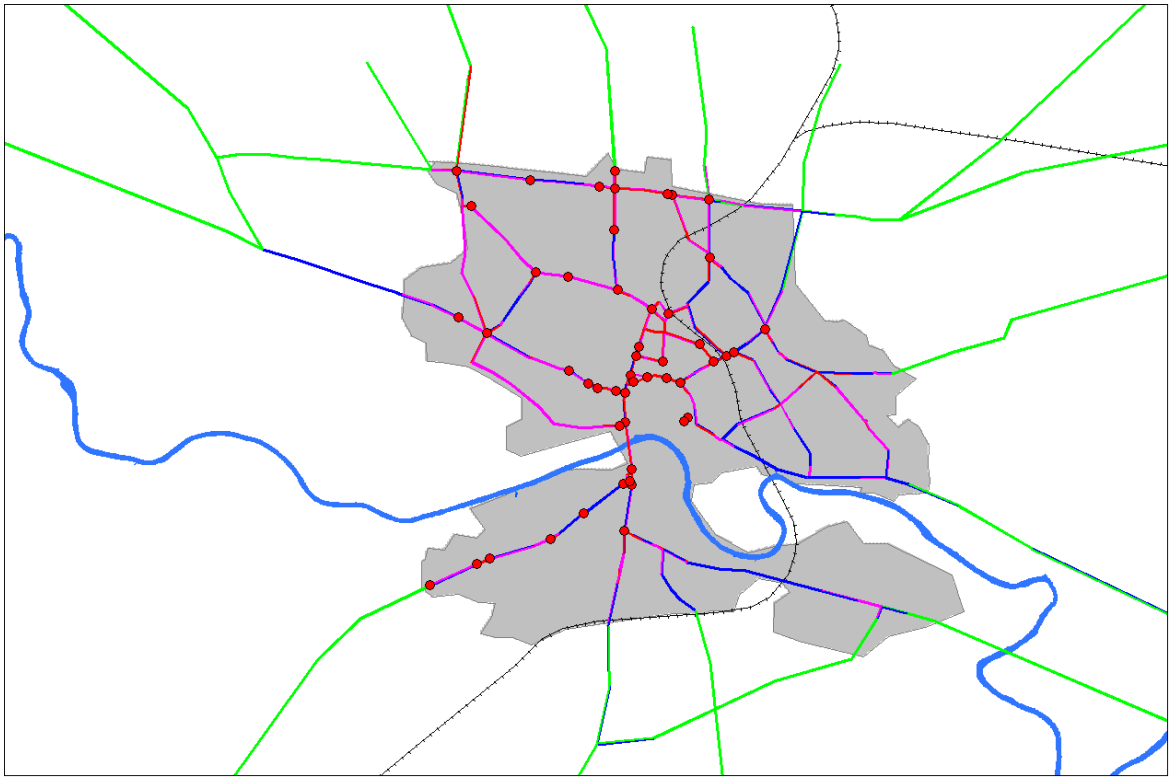
Link Speed: ODR West - Demand Option 1: AM Peak



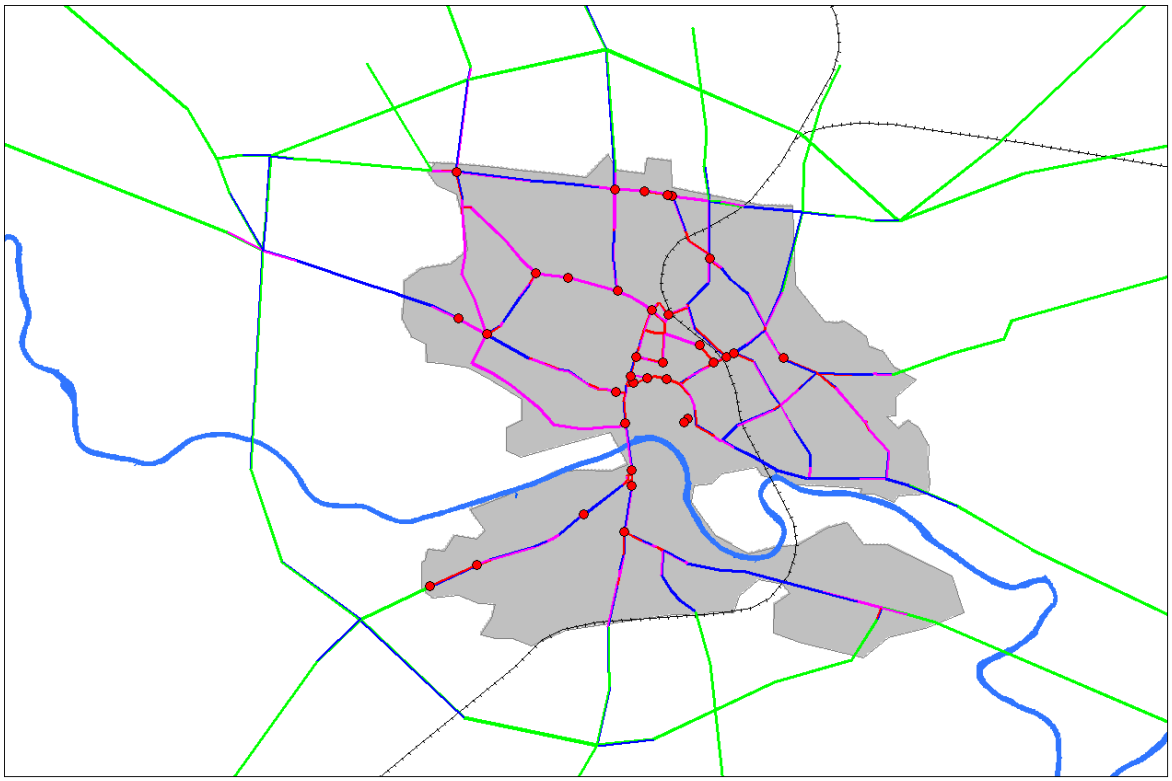
Link Speed: ODR East - Demand Option 1: AM Peak



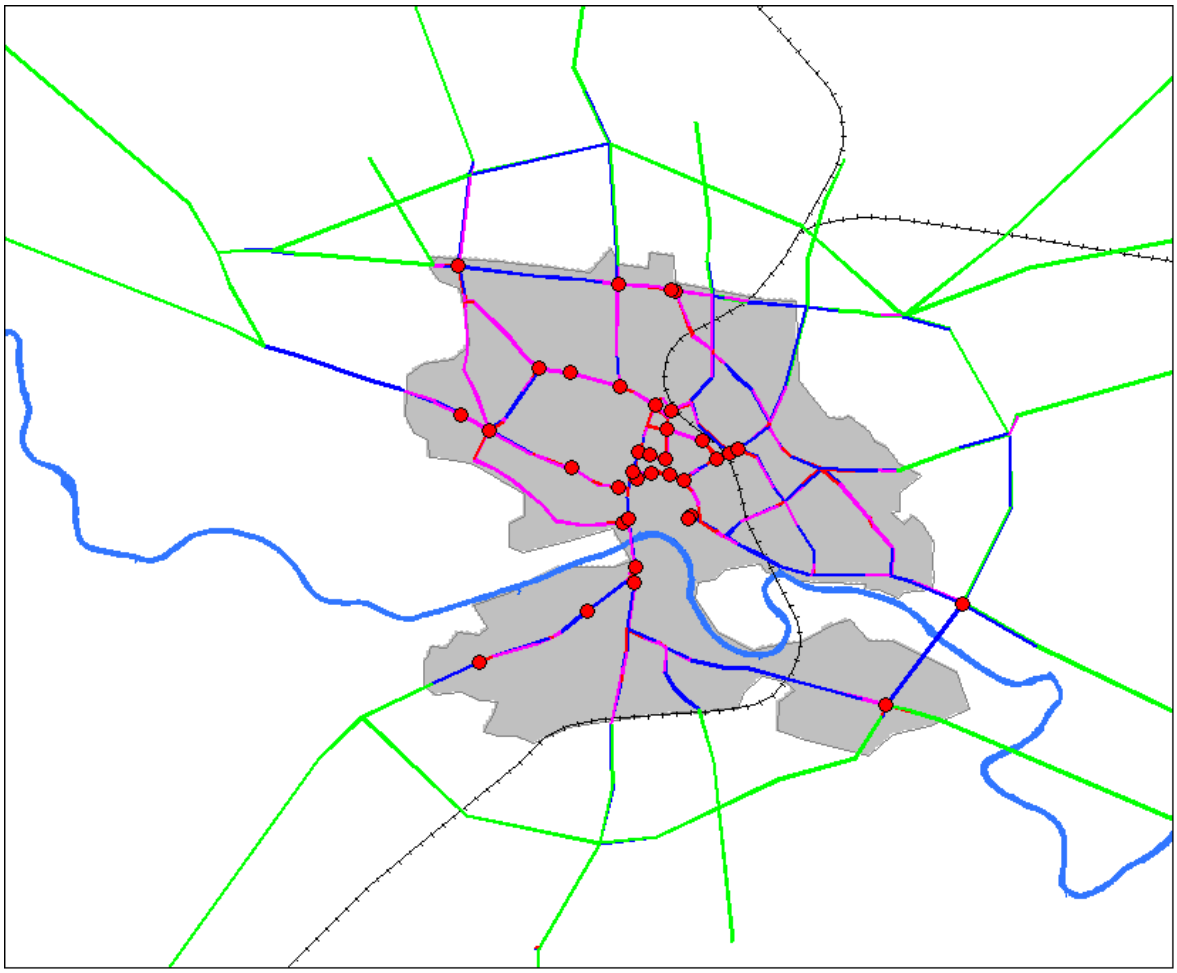
Link Speed: No ODR – Demand Option 1: PM Peak



Link Speed: ODR West - Demand Option 1: PM Peak

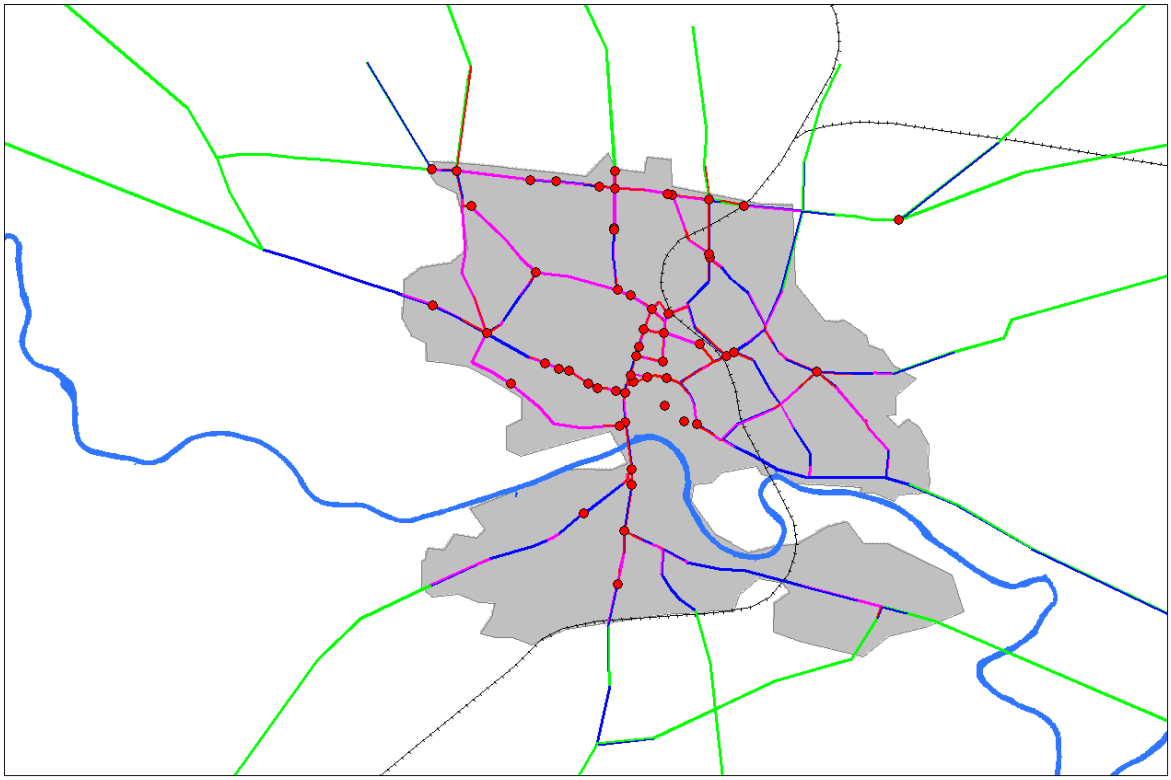


Link Speed: ODR East - Demand Option 1: PM Peak

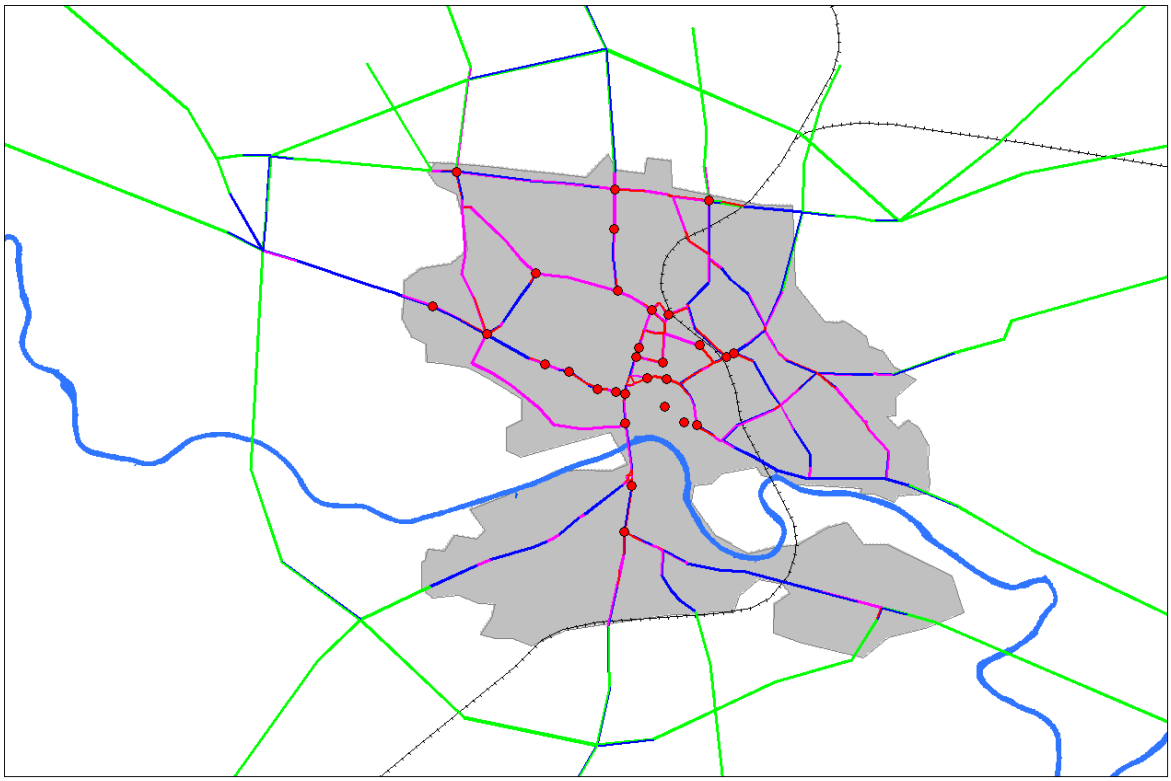


Do-Something Demand Option 2

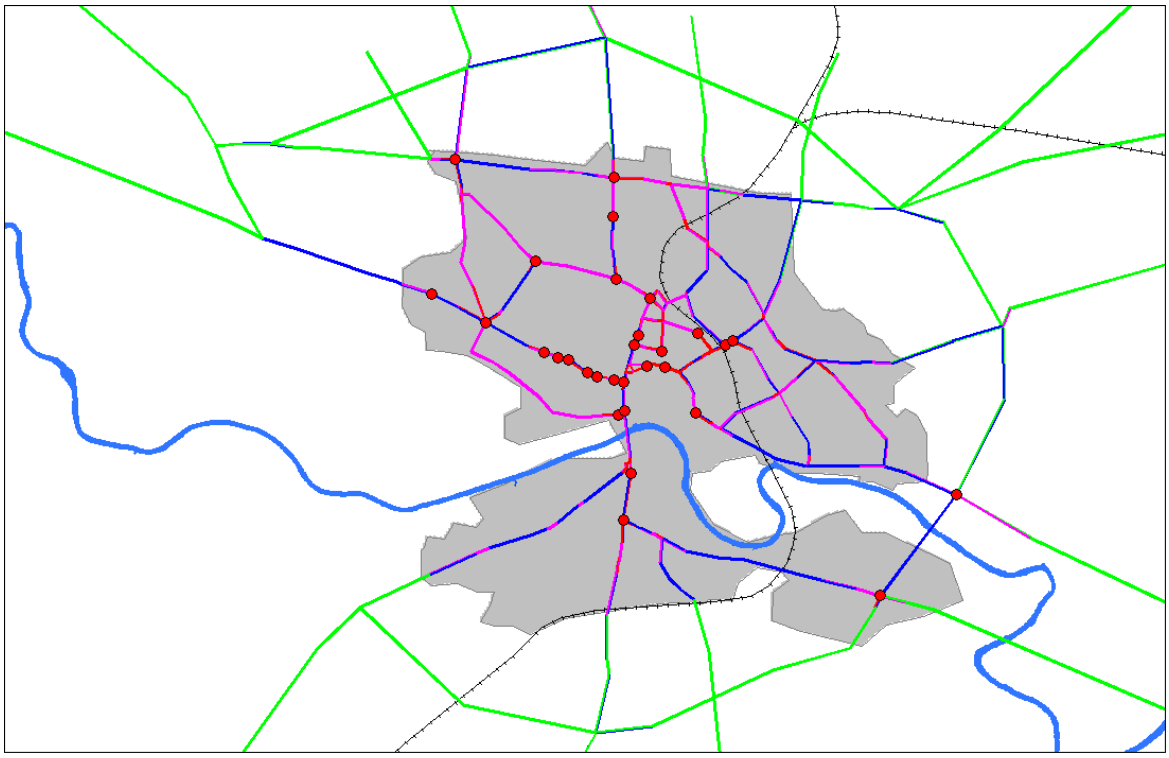
Link Speed: DMH2 scenario: AM Peak



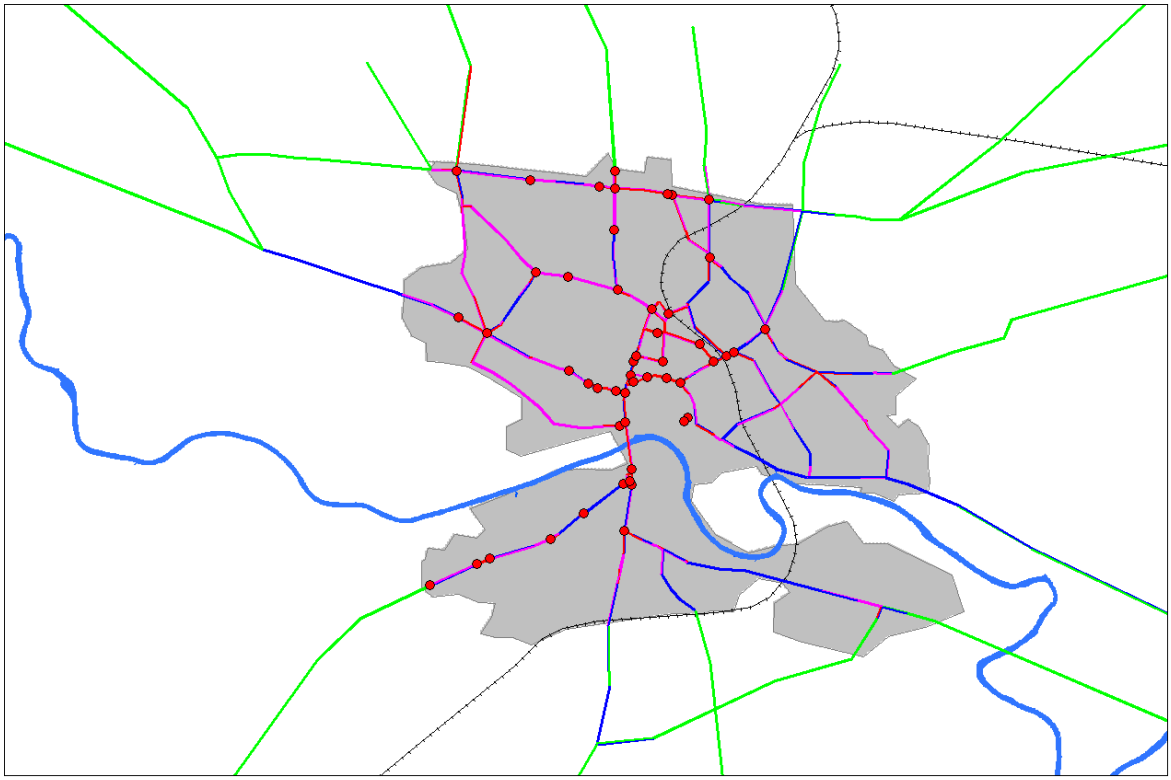
Link Speed: ODR West - Demand Option 2: AM Peak



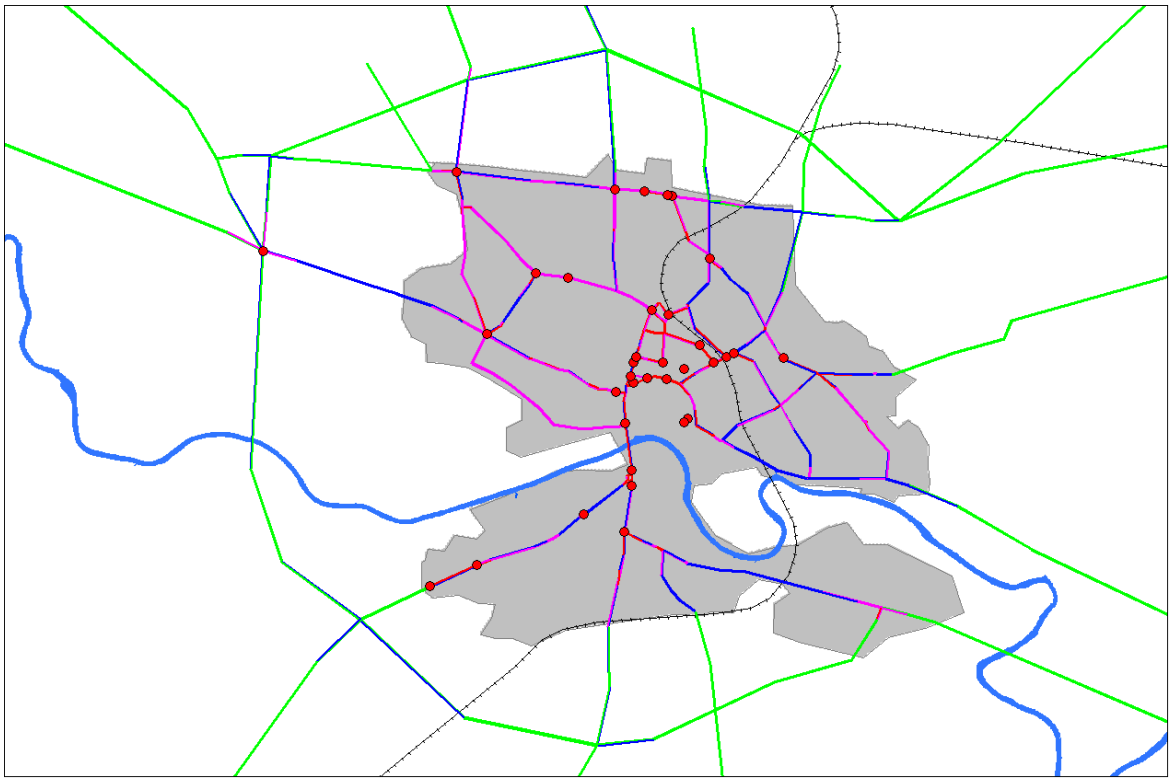
Link Speed: ODR East - Demand Option 2: AM Peak



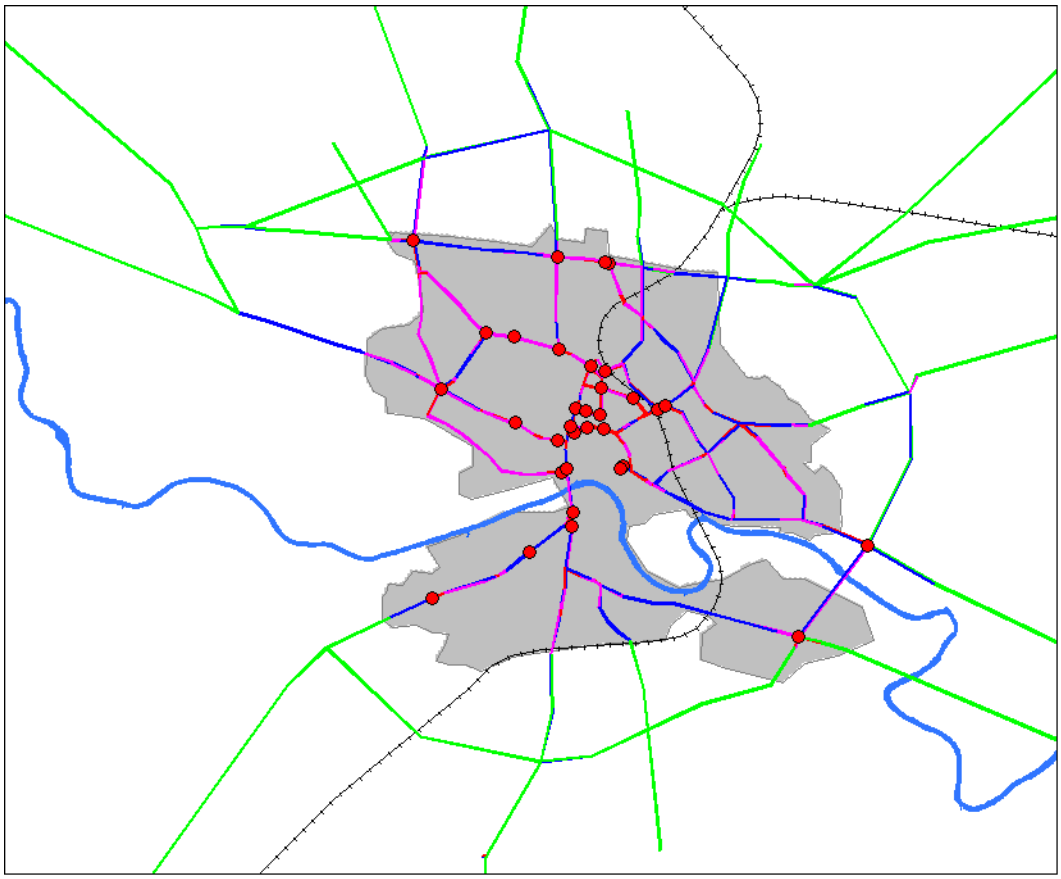
Link Speed: DMH2 scenario: PM Peak



Link Speed: ODR West - Demand Option 2: PM Peak

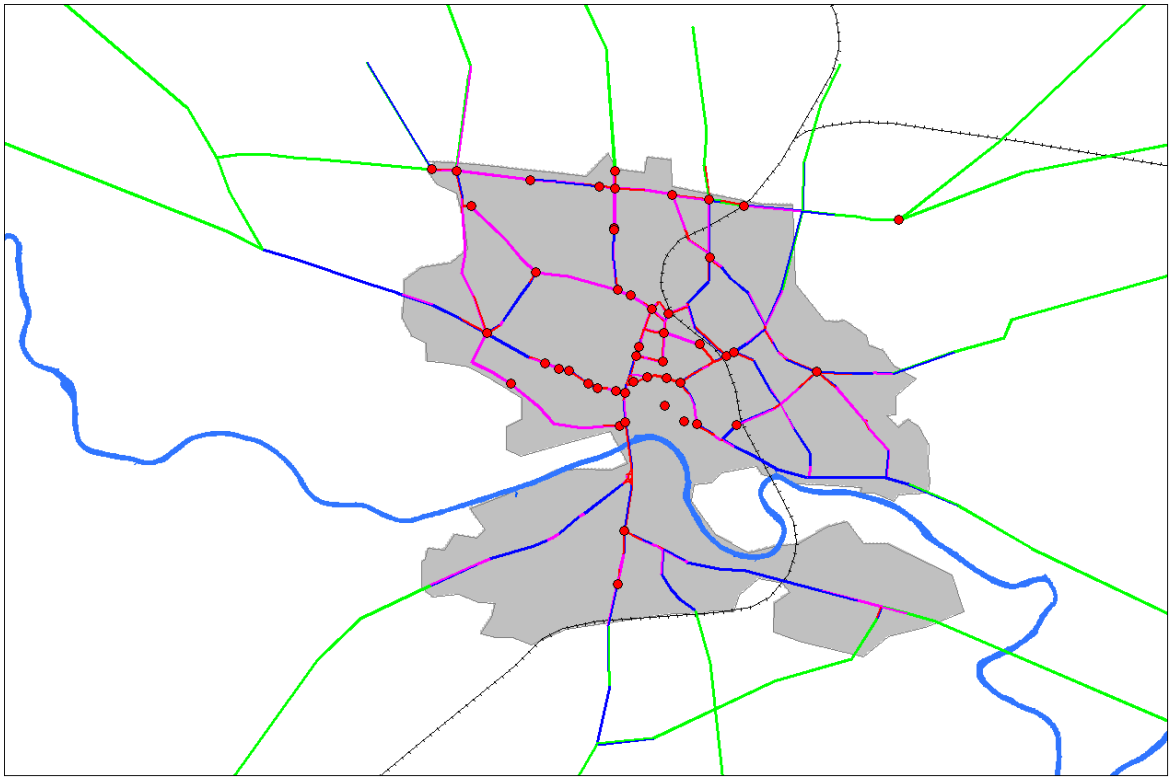


Link Speed: ODR East - Demand Option 2: PM Peak

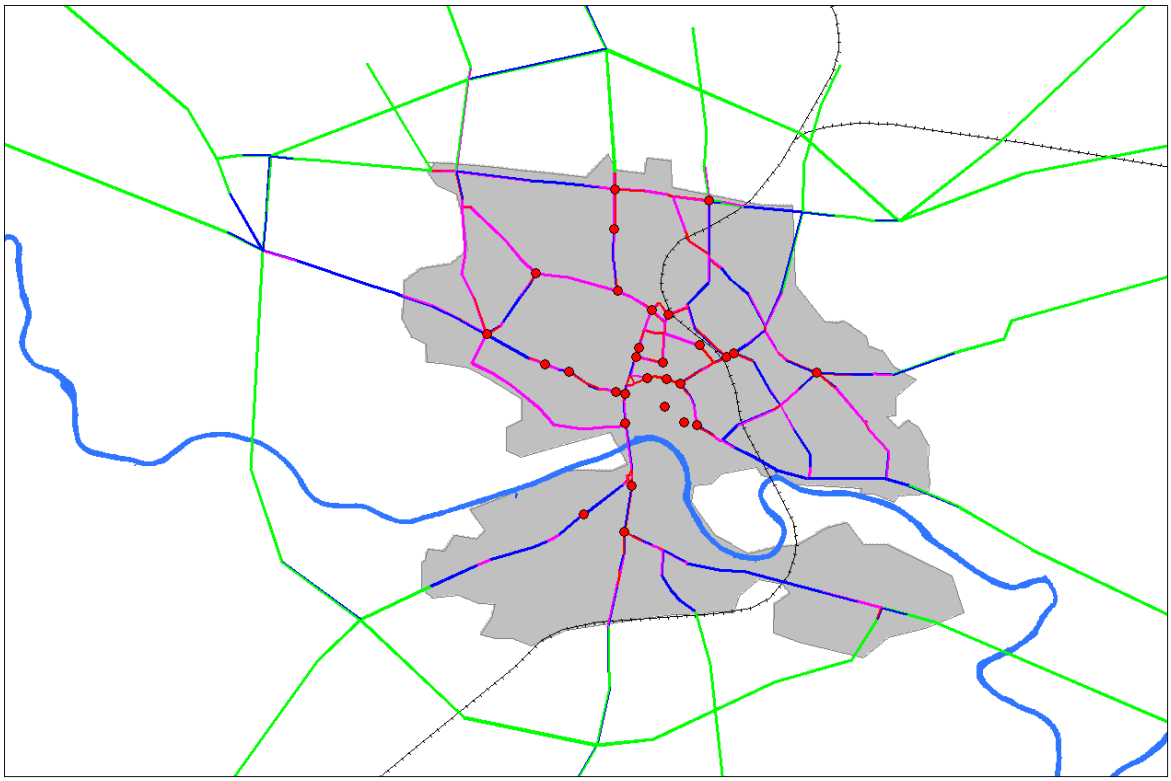


Do-Something Demand Option 3

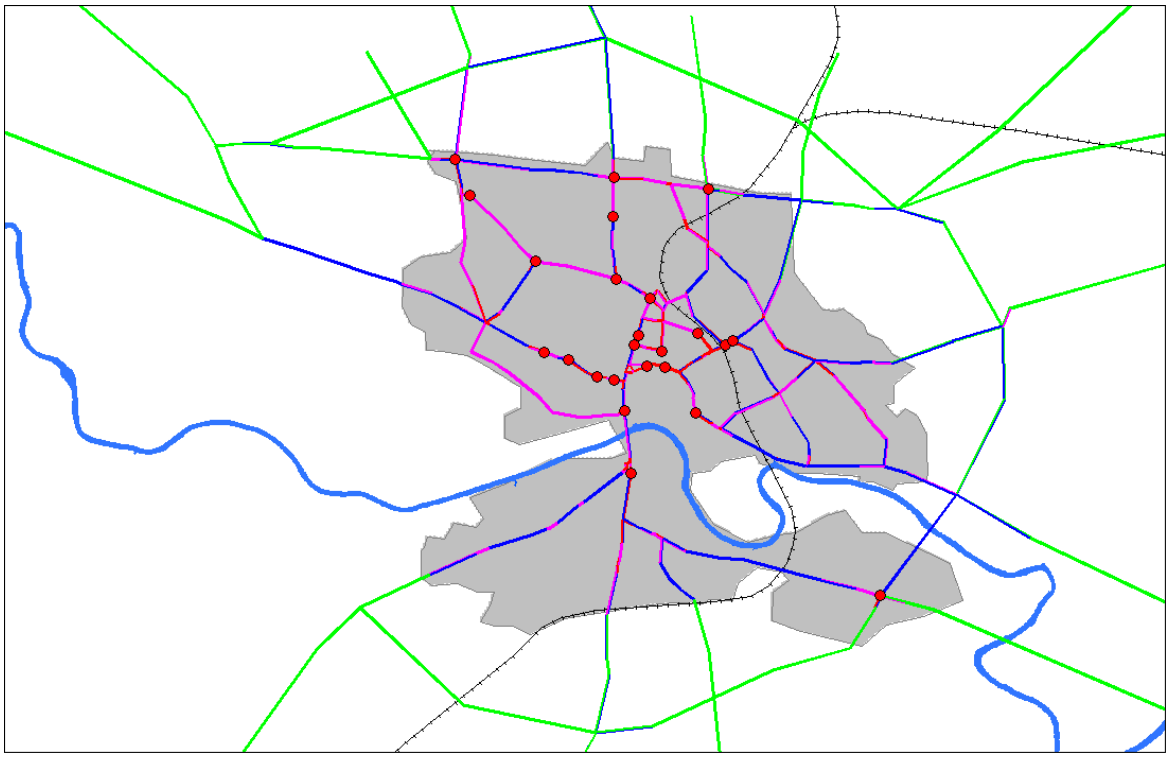
Link Speed: No ODR – Demand Option 3: AM Peak



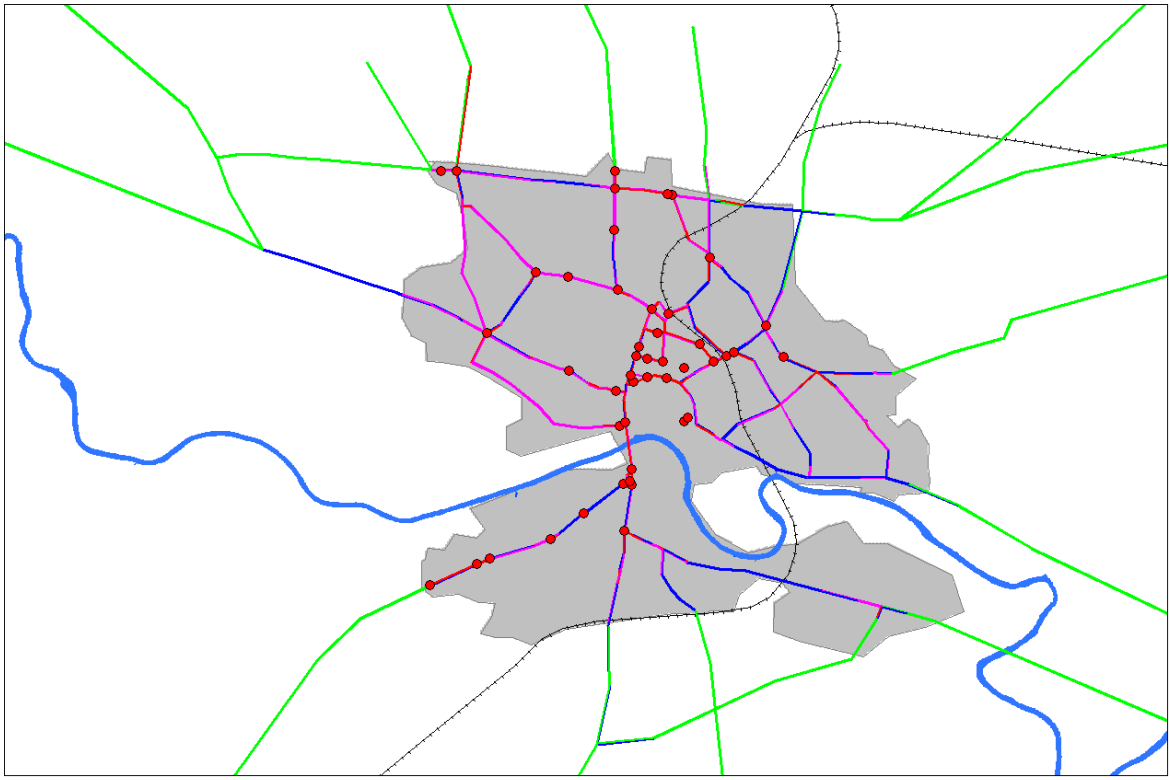
Link Speed: ODR West - Demand Option 3: AM Peak



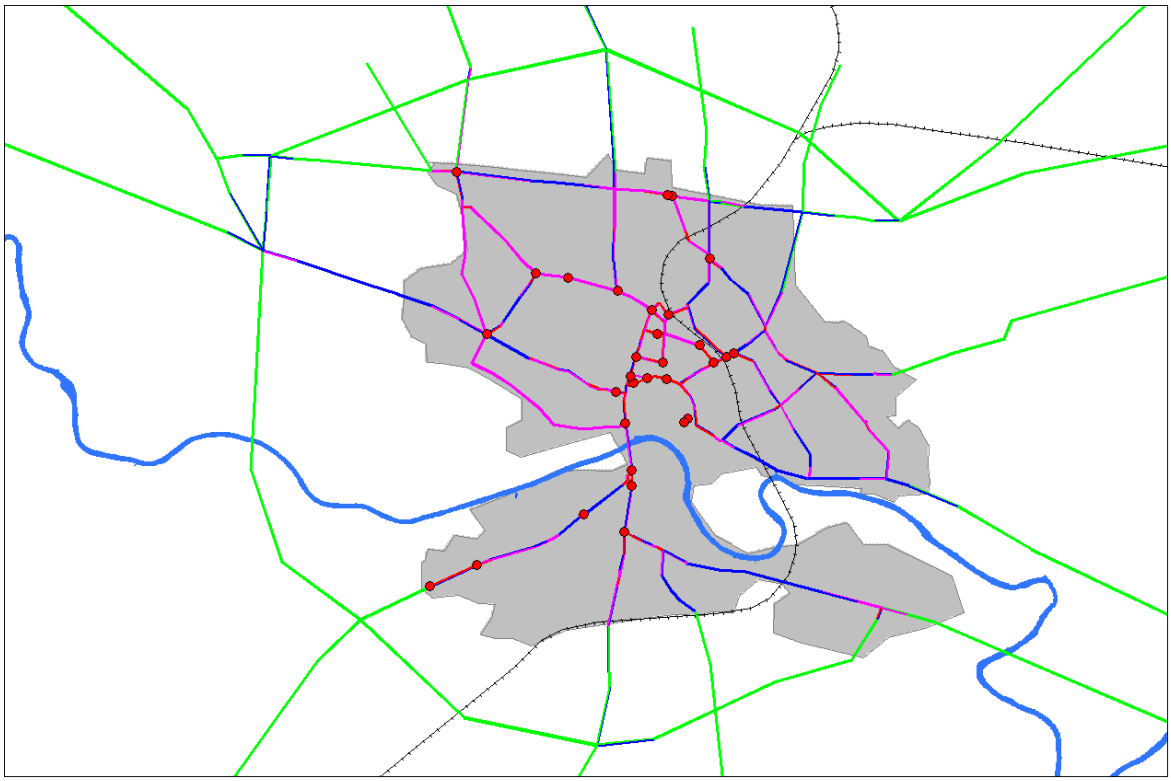
Link Speed: ODR East - Demand Option 3: AM Peak



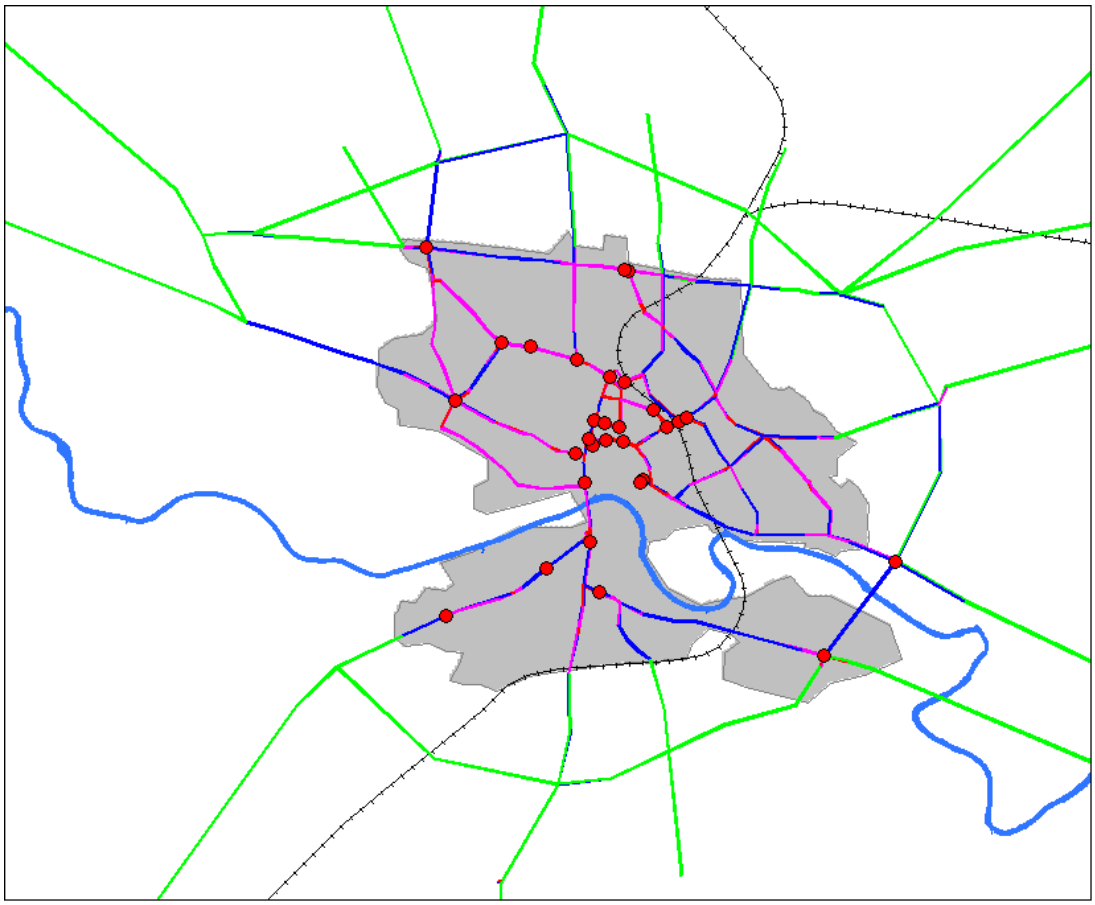
Link Speed: No ODR – Demand Option 3: PM Peak



Link Speed: ODR West - Demand Option 3: PM Peak

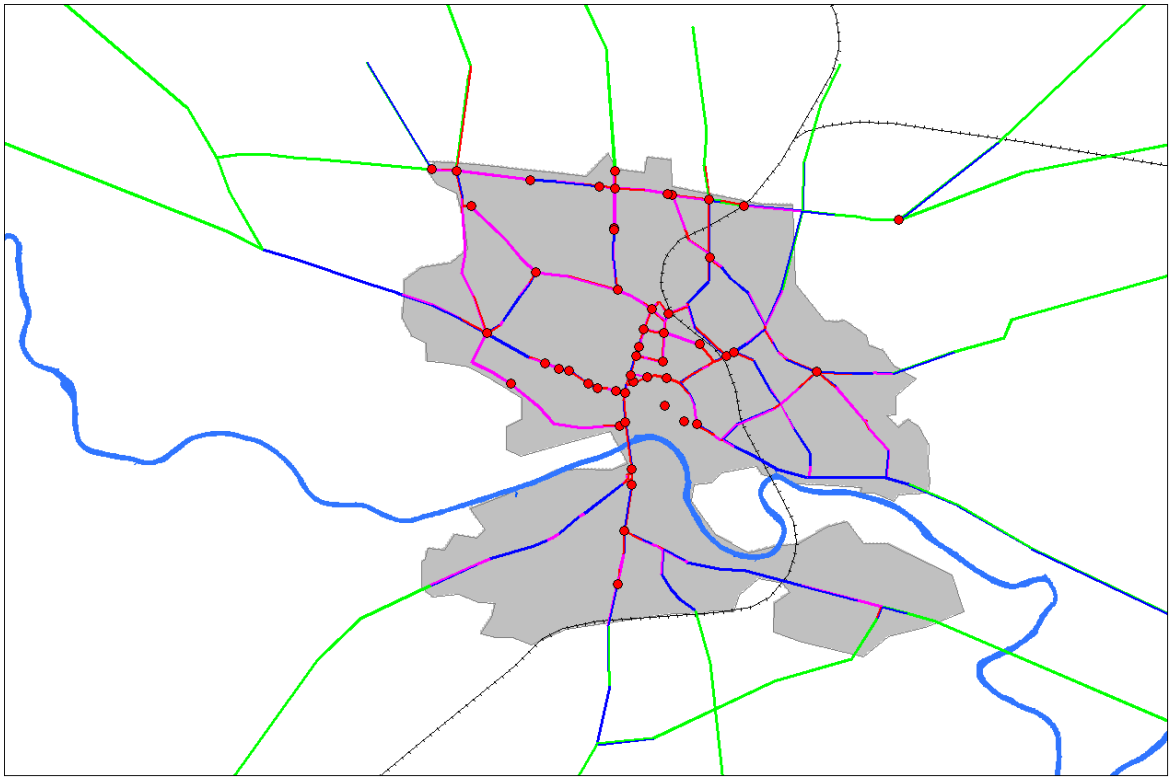


Link Speed: ODR East - Demand Option 3: PM Peak

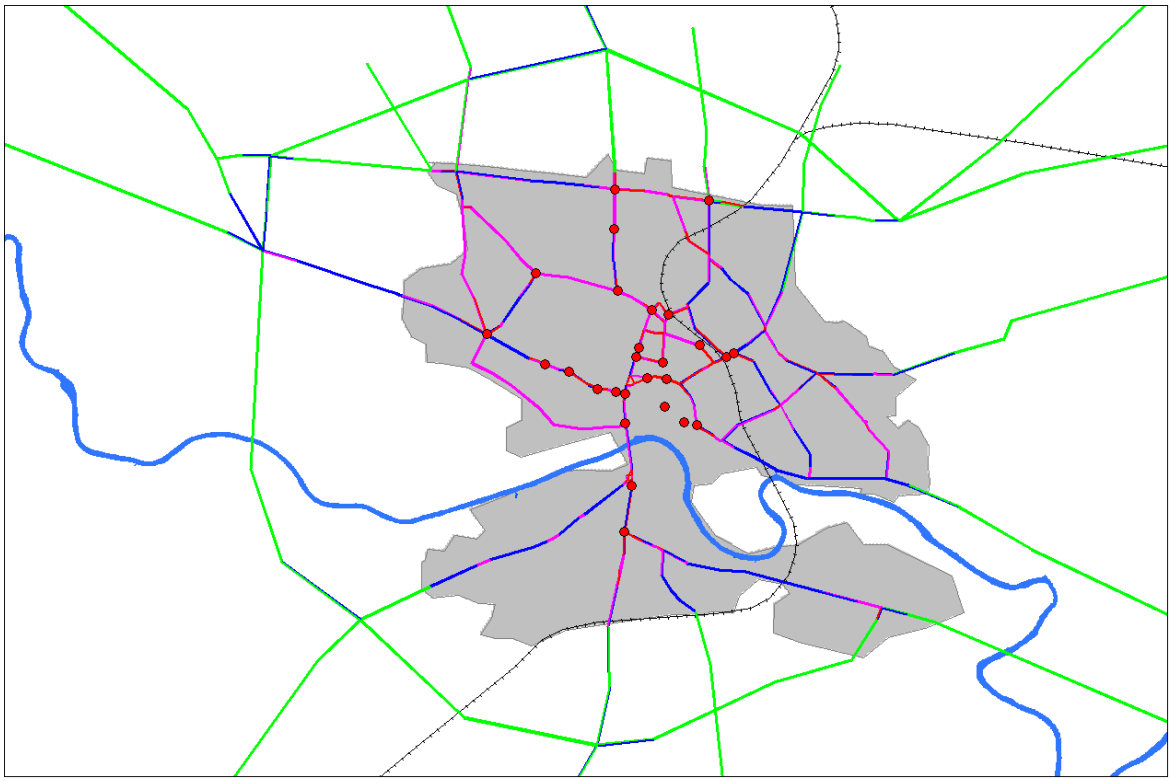


Do-Something Demand Option 4

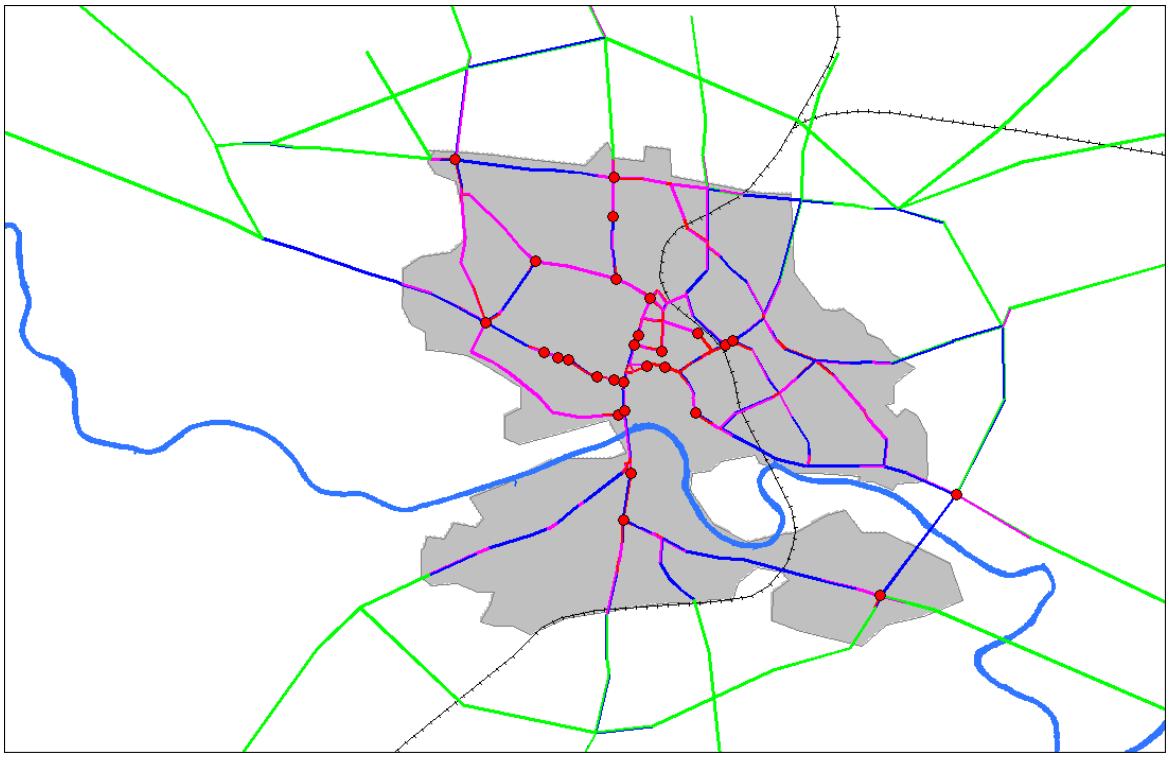
Link Speed: No ODR – Demand Option 4: AM Peak



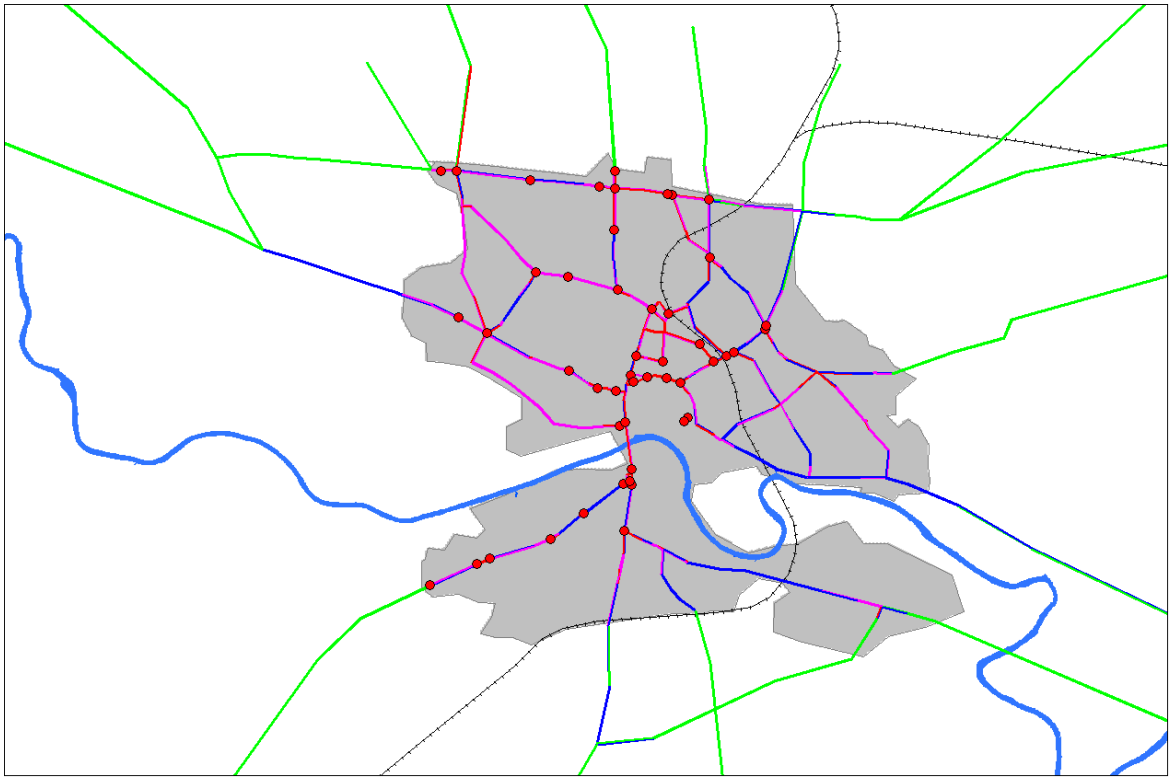
Link Speed: ODR West - Demand Option 4: AM Peak



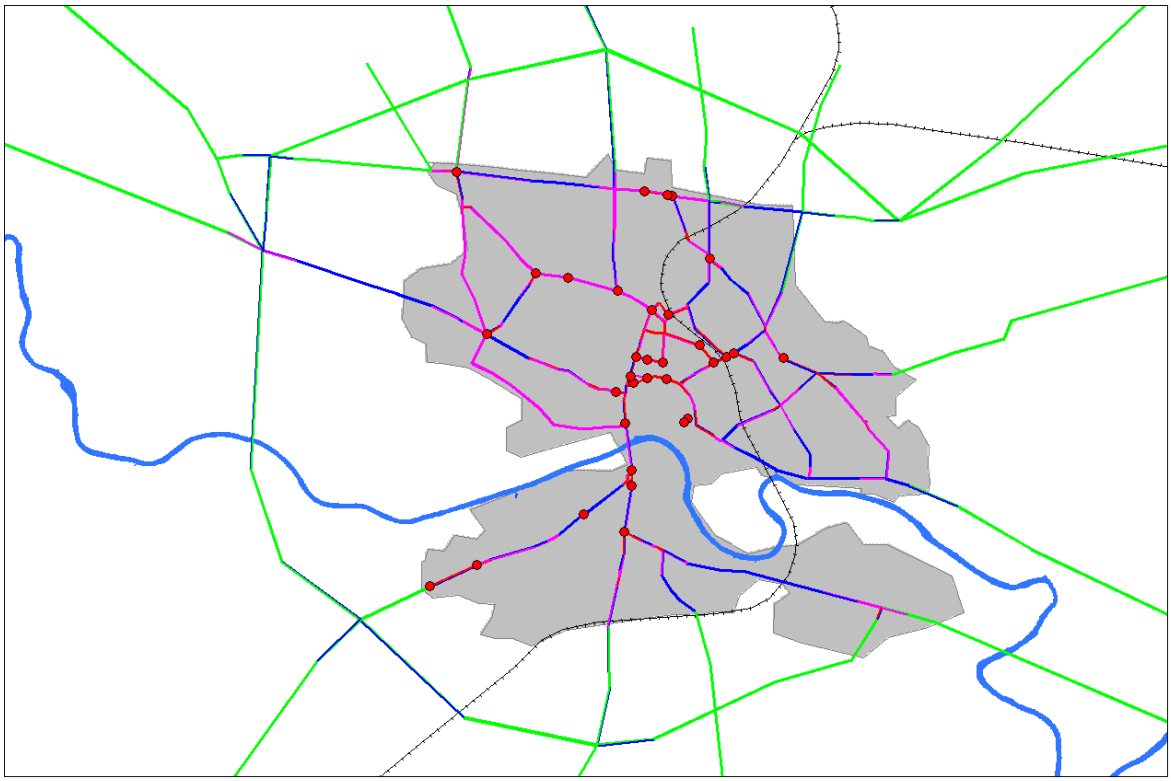
Link Speed: ODR East - Demand Option 4: AM Peak



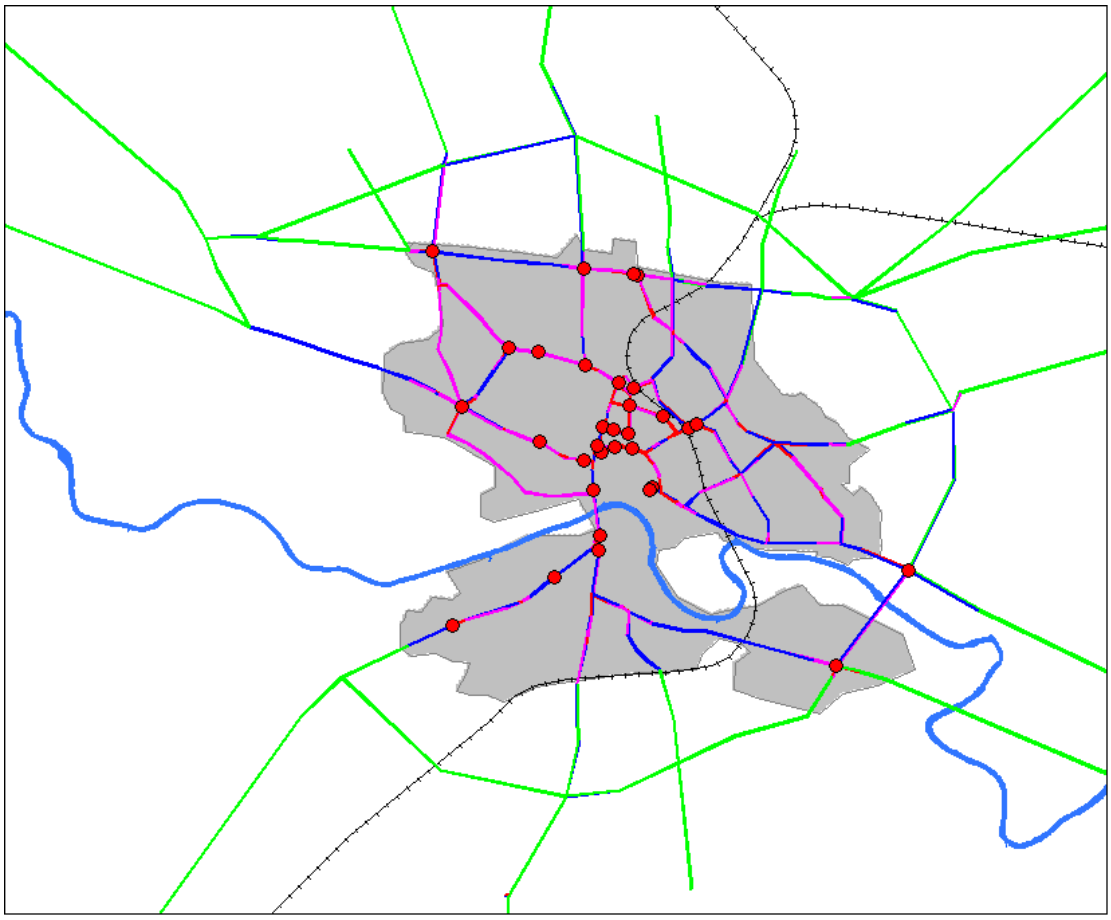
Link Speed: No ODR – Demand Option 4: PM Peak



Link Speed: ODR West - Demand Option 4: PM Peak



Link Speed: ODR East - Demand Option 4: PM Peak



Appendix F

ODR Impact Calculation

F.1 West ODR Impact Table during AM peak

				West ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	-146	-98	-121	-124	-119
1	A49 north of Holmer	A49	SB	41	49	99	82	61
2	Holmer Road opp Racecourse	A49	NB	-114	-176	-191	-205	-194
2	Holmer Road opp Racecourse	A49	SB	57	45	51	39	58
3	Newtown Road	A49	EB	-201	-78	-87	-26	-81
3	Newtown Road	A49	WB	-170	-98	-125	-135	-154
4	Edgar Street at Football Ground	A49	NB	-148	-6	-18	-31	-38
4	Edgar Street at Football Ground	A49	SB	-199	-236	-237	-73	-214
5	Victoria Street	A49	NB	-270	-151	-151	-215	-111
5	Victoria Street	A49	SB	-367	-457	-437	-371	-417
6	Ross Road nr Boycott Rd	A49	NB	-183	-120	-102	-237	-119
6	Ross Road nr Boycott Rd	A49	SB	-9	-74	-51	-19	3
7	Ross Road nr Mayberry Ave	A49	NB	-147	-147	-147	-320	-137
7	Ross Road nr Mayberry Ave	A49	SB	-67	-106	-90	-90	-90
9	A49 Ross Rd at Grafton	A49	NB	-26	-69	-57	-60	-59
9	A49 Ross Rd at Grafton	A49	SB	-106	-106	-112	-291	-105
	Total Flow Reduction	**A49**	**NB**	**-1204**	**-865**	**-912**	**-1327**	**-931**
		A49	**SB**	**-851**	**-963**	**-864**	**-749**	**-785**
10	Roman Road east of A49	A4103	EB	-316	-419	-490	-480	-428
10	Roman Road east of A49	A4103	WB	-205	-236	-275	-258	-285
11	Roman Road west of A49	A4103	EB	-137	-126	-107	-133	-116
11	Roman Road west of A49	A4103	WB	-121	-75	-41	-60	-77
12	Roman Road nr Staniers Way	A4103	EB	-245	-265	-273	-215	0
12	Roman Road nr Staniers Way	A4103	WB	-96	-175	-130	-141	0
	Total Flow Reduction	**A4103**	**EB**	**-698**	**-810**	**-870**	**-828**	**-544**
		A4103	**WB**	**-422**	**-486**	**-446**	**-459**	**-362**
13	Alyestone Hill	A465	NB	91	152	136	138	140
13	Alyestone Hill	A465	SB	36	120	95	112	123
14	Commercial Road at Bus Station	A465	NB	-21	-46	-69	-16	-68
14	Commercial Road at Bus Station	A465	SB	-35	2	-5	-14	-7
15	Belmont Road	A465	EB	-125	-126	-124	-138	-107
15	Belmont Road	A465	WB	-115	-152	-169	-159	-171
	Total Flow Reduction	**A49**	**N/EB**	**-55**	**-20**	**-57**	**-16**	**-35**
		A49	**S/WB**	**-114**	**-30**	**-79**	**-61**	**-55**
16	Ledbury Road nr Quarry Rd	A438	NB	-22	-21	-20	-23	-23
16	Ledbury Road nr Quarry Rd	A438	SB	13	4	7	2	12
17	Blue School Street	A438	EB	-43	5	17	-7	4

				West ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
17	Blue School Street	A438	WB	-24	-18	-27	-18	-22
18	Eign Street	A438	EB	-227	-61	-107	-125	-99
18	Eign Street	A438	WB	21	119	136	200	197
19	Kings Acre Road	A438	EB	-23	-140	-117	-188	-151
19	Kings Acre Road	A438	WB	42	76	118	-7	87
	Total Flow Reduction	**A49**	**N/EB**	**-315**	**-217**	**-227**	**-343**	**-269**
		A49	**S/WB**	**52**	**181**	**234**	**177**	**274**
20	Three Elms Road	A4110	NB	-88	-217	-239	-179	-204
20	Three Elms Road	A4110	SB	-268	-141	-132	-116	-192
21	ESG Link Road		EB	-83	-69	-38	-94	-60
21	ESG Link Road		WB	-33	-21	-30	-13	-26
22	Hampton Park Road		EB	-23	-48	-46	-42	-44
22	Hampton Park Road		WB	-22	-52	-71	-14	-80
23	Holme Lacy Road		EB	-203	-190	-148	-27	-138
23	Holme Lacy Road		WB	-48	-35	-43	-107	-43
24	Rotherwas Access Road		EB	269	374	244	-3	228
24	Rotherwas Access Road		WB	91	142	121	13	124
	Total Flow Reduction	**A49**	**EB**	**-40**	**67**	**12**	**-166**	**-14**
		A49	**WB**	**-12**	**34**	**-23**	**-121**	**-25**
25	ODR at Eastern river crossing		NB	0	0	0	0	0
25	ODR at Eastern river crossing		SB	0	0	0	0	0
26	ODR at Lugg Meadows		NB	0	0	0	0	0
26	ODR at Lugg Meadows		SB	0	0	0	0	0
27	ODR at New Court		NB	0	0	0	0	0
27	ODR at New Court		SB	0	0	0	0	0
28	ODR at Shelwick Green		EB	428	741	673	661	699
28	ODR at Shelwick Green		WB	361	468	448	495	448
29	ODR at Lyde Arundel		EB	762	1110	1115	1050	1088
29	ODR at Lyde Arundel		WB	424	625	599	647	610
30	ODR nr Towtree Lane		EB	183	359	343	279	329
30	ODR nr Towtree Lane		WB	147	239	235	256	239
31	ODR nr Swainshill		NB	478	875	853	683	813
31	ODR nr Swainshill		SB	447	599	552	612	567
32	ODR at Western river crossing		NB	418	526	573	467	589
32	ODR at Western river crossing		SB	580	931	883	713	867
33	ODR nr Grafton		EB	382	605	593	422	584
33	ODR nr Grafton		WB	306	407	487	342	499

F.2 East ODR Impact Table during AM peak

				East ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	-21	-38	-36	-31	-47
1	A49 north of Holmer	A49	SB	133	82	141	142	88
2	Holmer Road opp Racecourse	A49	NB	-62	-53	-98	-59	-76
2	Holmer Road opp Racecourse	A49	SB	52	-2	6	30	12
3	Newtown Road	A49	EB	-71	-19	-25	16	-22
3	Newtown Road	A49	WB	-58	58	34	80	36
4	Edgar Street at Football Ground	A49	NB	-316	-84	-87	-114	-56
4	Edgar Street at Football Ground	A49	SB	-421	-396	-407	-319	-378
5	Victoria Street	A49	NB	-409	-296	-318	-366	-276
5	Victoria Street	A49	SB	-570	-595	-566	-523	-556
6	Ross Road nr Boycott Rd	A49	NB	-390	-308	-299	-404	-300
6	Ross Road nr Boycott Rd	A49	SB	-146	-265	-47	-222	-23
7	Ross Road nr Mayberry Ave	A49	NB	-167	-156	-226	-230	-213
7	Ross Road nr Mayberry Ave	A49	SB	-69	-97	-79	-90	-82
9	A49 Ross Rd at Grafton	A49	NB	-24	-56	-59	-46	-64
9	A49 Ross Rd at Grafton	A49	SB	-119	-108	-203	-183	-192
	Total Flow Reduction	**A49**	**NB**	**-1447**	**-933**	**-1089**	**-1170**	**-996**
		A49	**SB**	**-1211**	**-1400**	**-1180**	**-1149**	**-1153**
10	Roman Road east of A49	A4103	EB	-335	-355	-437	-450	-369
10	Roman Road east of A49	A4103	WB	-297	-216	-283	-252	-258
11	Roman Road west of A49	A4103	EB	-109	-97	-66	-78	-119
11	Roman Road west of A49	A4103	WB	-162	-102	-108	-95	-121
12	Roman Road nr Staniers Way	A4103	EB	-178	-138	-168	-164	0
12	Roman Road nr Staniers Way	A4103	WB	-139	-159	-143	-159	0
	Total Flow Reduction	**A4103**	**EB**	**-622**	**-590**	**-671**	**-692**	**-488**
		A4103	**WB**	**-598**	**-477**	**-534**	**-506**	**-379**
13	Alyestone Hill	A465	NB	-87	-30	-22	28	-9
13	Alyestone Hill	A465	SB	9	40	58	56	58
14	Commercial Road at Bus Station	A465	NB	-80	-99	-95	-91	-102
14	Commercial Road at Bus Station	A465	SB	-27	-50	-41	-34	-49
15	Belmont Road	A465	EB	-98	-162	-113	-146	-94
15	Belmont Road	A465	WB	-115	-148	-164	-193	-161
	Total Flow Reduction	**A49**	**N/EB**	**-265**	**-291**	**-230**	**-209**	**-205**
		A49	**S/WB**	**-133**	**-158**	**-147**	**-171**	**-152**
16	Ledbury Road nr Quarry Rd	A438	NB	-86	-97	-91	-102	-98
16	Ledbury Road nr Quarry Rd	A438	SB	-76	-144	-155	-112	-151
17	Blue School Street	A438	EB	-40	12	8	-36	13

				East ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
17	Blue School Street	A438	WB	-37	-43	-40	-31	-41
18	Eign Street	A438	EB	-140	-22	-24	-90	-21
18	Eign Street	A438	WB	92	105	79	109	82
19	Kings Acre Road	A438	EB	20	-32	-33	-49	-43
19	Kings Acre Road	A438	WB	-51	5	3	-35	-9
	Total Flow Reduction	**A49**	**N/EB**	**-246**	**-139**	**-140**	**-277**	**-149**
		A49	**S/WB**	**-72**	**-77**	**-113**	**-69**	**-119**
20	Three Elms Road	A4110	NB	-69	-21	-110	-56	-81
20	Three Elms Road	A4110	SB	-310	-93	-135	-33	-140
21	ESG Link Road		EB	-66	-103	-83	-92	-81
21	ESG Link Road		WB	-113	-68	-72	-74	-72
22	Hampton Park Road		EB	272	265	274	283	274
22	Hampton Park Road		WB	171	176	228	236	223
23	Holme Lacy Road		EB	-319	-337	-296	-214	-294
23	Holme Lacy Road		WB	-35	20	0	21	-1
24	Rotherwas Access Road		EB	264	298	361	347	354
24	Rotherwas Access Road		WB	262	333	339	366	341
	Total Flow Reduction	**A49**	**EB**	**151**	**123**	**256**	**324**	**253**
		A49	**WB**	**285**	**461**	**495**	**549**	**491**
25	ODR at Eastern river crossing		NB	842	1052	1228	1014	1238
25	ODR at Eastern river crossing		SB	1241	1498	1492	1329	1497
26	ODR at Lugg Meadows		NB	687	815	862	752	865
26	ODR at Lugg Meadows		SB	797	960	935	846	941
27	ODR at New Court		NB	372	441	493	380	498
27	ODR at New Court		SB	543	642	623	512	632
28	ODR at Shelwick Green		EB	628	912	867	784	874
28	ODR at Shelwick Green		WB	446	565	611	580	609
29	ODR at Lyde Arundel		EB	928	1242	1254	1110	1178
29	ODR at Lyde Arundel		WB	544	702	733	705	723
30	ODR nr Towtree Lane		EB	102	179	179	122	162
30	ODR nr Towtree Lane		WB	104	143	144	139	141
31	ODR nr Swainshill		NB	0	0	0	0	0
31	ODR nr Swainshill		SB	0	0	0	0	0
32	ODR at Western river crossing		NB	0	0	0	0	0
32	ODR at Western river crossing		SB	0	0	0	0	0
33	ODR nr Grafton		EB	145	209	180	168	181
33	ODR nr Grafton		WB	239	286	311	328	311

F.3 West ODR Impact Table during PM peak

				West ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	52	84	47	132	84
1	A49 north of Holmer	A49	SB	-138	-219	-205	-124	-221
2	Holmer Road opp Racecourse	A49	NB	-27	60	92	93	73
2	Holmer Road opp Racecourse	A49	SB	-28	-35	-9	59	30
3	Newtown Road	A49	EB	-47	36	101	75	12
3	Newtown Road	A49	WB	-89	-53	-106	-32	-69
4	Edgar Street at Football Ground	A49	NB	-42	-28	75	11	-13
4	Edgar Street at Football Ground	A49	SB	73	94	164	74	79
5	Victoria Street	A49	NB	-266	-273	-172	-268	-235
5	Victoria Street	A49	SB	-147	-108	-90	-118	-126
6	Ross Road nr Boycott Rd	A49	NB	-428	-527	-449	-500	-508
6	Ross Road nr Boycott Rd	A49	SB	-26	-53	-47	-23	-41
7	Ross Road nr Mayberry Ave	A49	NB	-280	-425	-348	-375	-374
7	Ross Road nr Mayberry Ave	A49	SB	-28	17	-9	-60	-6
9	A49 Ross Rd at Grafton	A49	NB	49	99	61	11	69
9	A49 Ross Rd at Grafton	A49	SB	-195	-331	-264	-295	-288
	Total Flow Reduction	**A49**	**NB**	**-1031**	**-1063**	**-800**	**-928**	**-973**
		A49	**SB**	**-536**	**-599**	**-359**	**-412**	**-561**
10	Roman Road east of A49	A4103	EB	-245	-368	-369	-379	-347
10	Roman Road east of A49	A4103	WB	-407	-327	-281	-357	-390
11	Roman Road west of A49	A4103	EB	-107	-22	-10	-21	-17
11	Roman Road west of A49	A4103	WB	-100	34	56	42	31
12	Roman Road nr Staniers Way	A4103	EB	-13	-132	-128	-121	0
12	Roman Road nr Staniers Way	A4103	WB	-219	-225	-239	-276	0
	Total Flow Reduction	**A4103**	**EB**	**-365**	**-522**	**-507**	**-521**	**-364**
		A4103	**WB**	**-726**	**-518**	**-464**	**-591**	**-359**
13	Alyestone Hill	A465	NB	-109	8	65	1	-87
13	Alyestone Hill	A465	SB	117	53	29	135	53
14	Commercial Road at Bus Station	A465	NB	21	26	50	10	-14
14	Commercial Road at Bus Station	A465	SB	-6	-6	-30	-18	-29
15	Belmont Road	A465	EB	-232	-267	-262	-231	-249
15	Belmont Road	A465	WB	-240	-272	-265	-270	-274
	Total Flow Reduction	**A49**	**N/EB**	**-320**	**-233**	**-147**	**-220**	**-350**
		A49	**S/WB**	**-129**	**-225**	**-266**	**-153**	**-250**
16	Ledbury Road nr Quarry Rd	A438	NB	23	0	-3	16	-1
16	Ledbury Road nr Quarry Rd	A438	SB	-13	8	-13	5	-1
17	Blue School Street	A438	EB	12	17	16	0	30

				West ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
17	Blue School Street	A438	WB	-66	-90	-77	-28	-67
18	Eign Street	A438	EB	-276	-308	-255	-182	-294
18	Eign Street	A438	WB	-177	-160	-168	-165	-157
19	Kings Acre Road	A438	EB	-37	-109	-76	-180	-106
19	Kings Acre Road	A438	WB	-34	-67	-113	-261	-126
	Total Flow Reduction	**A49**	**N/EB**	**-278**	**-400**	**-318**	**-346**	**-371**
		A49	**S/WB**	**-290**	**-309**	**-371**	**-449**	**-351**
20	Three Elms Road	A4110	NB	-131	-320	-273	-228	-188
20	Three Elms Road	A4110	SB	73	102	174	12	60
21	ESG Link Road		EB	-14	36	-18	-55	-8
21	ESG Link Road		WB	12	-2	2	1	-18
22	Hampton Park Road		EB	-17	-22	-34	-34	-41
22	Hampton Park Road		WB	-67	-90	-101	-60	-102
23	Holme Lacy Road		EB	-56	-53	-45	-93	-52
23	Holme Lacy Road		WB	25	156	167	72	129
24	Rotherwas Access Road		EB	142	183	165	51	143
24	Rotherwas Access Road		WB	166	124	150	2	144
	Total Flow Reduction	**A49**	**EB**	**55**	**144**	**68**	**-131**	**42**
		A49	**WB**	**136**	**188**	**218**	**15**	**153**
25	ODR at Eastern river crossing		NB	0	0	0	0	0
25	ODR at Eastern river crossing		SB	0	0	0	0	0
26	ODR at Lugg Meadows		NB	0	0	0	0	0
26	ODR at Lugg Meadows		SB	0	0	0	0	0
27	ODR at New Court		NB	0	0	0	0	0
27	ODR at New Court		SB	0	0	0	0	0
28	ODR at Shelwick Green		EB	326	425	433	417	419
28	ODR at Shelwick Green		WB	308	498	645	460	488
29	ODR at Lyde Arundel		EB	609	719	749	717	710
29	ODR at Lyde Arundel		WB	663	921	1093	894	909
30	ODR nr Towtree Lane		EB	352	510	547	461	506
30	ODR nr Towtree Lane		WB	284	441	584	382	425
31	ODR nr Swainshill		NB	638	921	951	820	906
31	ODR nr Swainshill		SB	661	985	1151	915	968
32	ODR at Western river crossing		NB	666	891	947	725	880
32	ODR at Western river crossing		SB	513	661	820	544	702
33	ODR nr Grafton		EB	368	509	652	418	590
33	ODR nr Grafton		WB	716	955	980	815	969

F.4 East ODR Impact Table during PM peak

				East ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
1	A49 north of Holmer	A49	NB	155	164	185	222	175
1	A49 north of Holmer	A49	SB	34	-69	-15	54	-63
2	Holmer Road opp Racecourse	A49	NB	-21	94	123	130	97
2	Holmer Road opp Racecourse	A49	SB	-28	21	19	96	55
3	Newtown Road	A49	EB	61	109	84	127	88
3	Newtown Road	A49	WB	-8	12	-2	-25	-21
4	Edgar Street at Football Ground	A49	NB	-72	-76	-62	-134	-56
4	Edgar Street at Football Ground	A49	SB	20	17	53	19	18
5	Victoria Street	A49	NB	-321	-271	-275	-307	-236
5	Victoria Street	A49	SB	-237	-187	-180	-237	-189
6	Ross Road nr Boycott Rd	A49	NB	-485	-545	-551	-519	-536
6	Ross Road nr Boycott Rd	A49	SB	-186	-237	-238	-203	-231
7	Ross Road nr Mayberry Ave	A49	NB	-239	-405	-397	-328	-383
7	Ross Road nr Mayberry Ave	A49	SB	-10	4	-62	-52	-59
9	A49 Ross Rd at Grafton	A49	NB	92	117	40	57	46
9	A49 Ross Rd at Grafton	A49	SB	-123	-276	-278	-206	-263
	Total Flow Reduction	**A49**	**NB**	**-899**	**-910**	**-939**	**-904**	**-914**
		A49	**SB**	**-469**	**-618**	**-617**	**-402**	**-644**
10	Roman Road east of A49	A4103	EB	-285	-363	-408	-407	-340
10	Roman Road east of A49	A4103	WB	-431	-312	-368	-367	-369
11	Roman Road west of A49	A4103	EB	-139	-38	-45	-55	-34
11	Roman Road west of A49	A4103	WB	-197	0	-26	-41	-11
12	Roman Road nr Staniers Way	A4103	EB	23	-50	-41	-83	0
12	Roman Road nr Staniers Way	A4103	WB	-172	-179	-216	-290	0
	Total Flow Reduction	**A4103**	**EB**	**-401**	**-451**	**-494**	**-545**	**-374**
		A4103	**WB**	**-800**	**-491**	**-610**	**-698**	**-380**
13	Alyestone Hill	A465	NB	-162	-106	-171	-174	-186
13	Alyestone Hill	A465	SB	-11	-50	-72	4	-64
14	Commercial Road at Bus Station	A465	NB	21	2	-4	15	-4
14	Commercial Road at Bus Station	A465	SB	-8	-6	-15	-19	-19
15	Belmont Road	A465	EB	-147	-117	-113	-117	-96
15	Belmont Road	A465	WB	-126	-100	-94	-146	-106
	Total Flow Reduction	**A49**	**N/EB**	**-288**	**-221**	**-288**	**-276**	**-286**
		A49	**S/WB**	**-145**	**-156**	**-181**	**-161**	**-189**
16	Ledbury Road nr Quarry Rd	A438	NB	-67	-108	-85	-86	-109
16	Ledbury Road nr Quarry Rd	A438	SB	-73	-56	-62	-65	-66
17	Blue School Street	A438	EB	-27	-15	-22	-28	-5

				East ODR minus No ODR				
No	Location	Name	Dir	Do Min	DS1	DS2	DS3	DS4
17	Blue School Street	A438	WB	-58	-71	-54	-21	-64
18	Eign Street	A438	EB	-149	-156	-187	-134	-162
18	Eign Street	A438	WB	-37	16	2	58	11
19	Kings Acre Road	A438	EB	-95	-100	-87	-154	-94
19	Kings Acre Road	A438	WB	-19	-20	-44	-111	-82
	Total Flow Reduction	**A49**	**N/EB**	**-338**	**-379**	**-381**	**-402**	**-370**
		A49	**S/WB**	**-187**	**-131**	**-158**	**-139**	**-201**
20	Three Elms Road	A4110	NB	-164	-295	-296	-291	-178
20	Three Elms Road	A4110	SB	14	123	61	68	68
21	ESG Link Road		EB	-34	-33	-21	-69	-31
21	ESG Link Road		WB	-24	-44	-48	-30	-40
22	Hampton Park Road		EB	205	264	255	282	237
22	Hampton Park Road		WB	124	121	140	166	132
23	Holme Lacy Road		EB	-24	-16	-17	11	-20
23	Holme Lacy Road		WB	-5	110	38	14	32
24	Rotherwas Access Road		EB	361	412	445	457	450
24	Rotherwas Access Road		WB	307	189	286	327	294
	Total Flow Reduction	**A49**	**EB**	**508**	**627**	**662**	**681**	**636**
		A49	**WB**	**402**	**376**	**416**	**477**	**418**
25	ODR at Eastern river crossing		NB	1157	1333	1380	1272	1387
25	ODR at Eastern river crossing		SB	1170	1558	1612	1454	1602
26	ODR at Lugg Meadows		NB	822	926	946	866	952
26	ODR at Lugg Meadows		SB	744	867	903	788	905
27	ODR at New Court		NB	657	760	764	689	769
27	ODR at New Court		SB	555	619	638	546	636
28	ODR at Shelwick Green		EB	371	523	518	451	531
28	ODR at Shelwick Green		WB	471	738	696	560	725
29	ODR at Lyde Arundel		EB	673	796	813	778	804
29	ODR at Lyde Arundel		WB	778	1074	1057	939	1060
30	ODR nr Towtree Lane		EB	86	102	116	117	99
30	ODR nr Towtree Lane		WB	39	95	94	54	84
31	ODR nr Swainshill		NB	0	0	0	0	0
31	ODR nr Swainshill		SB	0	0	0	0	0
32	ODR at Western river crossing		NB	0	0	0	0	0
32	ODR at Western river crossing		SB	0	0	0	0	0
33	ODR nr Grafton		EB	290	370	388	391	394
33	ODR nr Grafton		WB	477	568	548	533	551

Appendix G

Rank Calculation

G.1 AM Rank Calculation

from Table 4.6		
Scenario	Speed	Rank
EastODRDS3	36	1
WestODRDS2	35.6	2
WestODRDS4	35.6	2
EastODRDS4	35.4	3
WestODRDS1	35.3	4
WestODRDS3	35.3	4
EastODRDS1	35.2	5
EastODRDS2	35.2	5
NOODRDS3	28.1	6
NOODRDS4	27.1	7
NOODRDS2	27	8
NOODRDS1	26.6	9

from Table 4.6		
Scenario	Link delay	Rank
NOODRDS3	66	1
NOODRDS4	72	2
NOODRDS1	73	3
NOODRDS2	73	3
WestODRDS3	74	4
WestODRDS4	88	5
WestODRDS2	90	6
WestODRDS1	93	7
EastODRDS3	93	7
EastODRDS1	115	8
EastODRDS4	117	9
EastODRDS2	119	10

from Table 4.6		
Scenario	Queues	Rank
EastODRDS3	814	1
EastODRDS4	865	2
EastODRDS1	867	3
EastODRDS2	884	4
WestODRDS3	885	5
WestODRDS2	902	6
WestODRDS4	903	7
WestODRDS1	915	8
NOODRDS3	1219	9
NOODRDS4	1347	10
NOODRDS2	1355	11
NOODRDS1	1363	12

from Table 5.7		
Scenario	Journ. Time	Rank
EastODRDS3	162:08	1
EastODRDS1	163:15	2
EastODRDS2	165:01	3
EastODRDS4	166:43	4
WestODRDS2	170:13	5
WestODRDS3	170:50	6
WestODRDS4	170:59	7
WestODRDS1	171:58	8
NOODRDS3	194:58	9
NOODRDS2	199:01	10
NOODRDS4	199:31	11
NOODRDS1	201:34	12

from Table 5.11		
Scenario	Junc. stress	Rank
EastODRDS3	24	1
EastODRDS1	28	2
WestODRDS2	29	3
WestODRDS4	29	3
WestODRDS3	30	4
EastODRDS4	30	4
EastODRDS2	32	5
WestODRDS1	35	6
NOODRDS3	50	7
NOODRDS4	53	8
NOODRDS2	56	9
NOODRDS1	57	10

from Table 5.9		
Scenario	JT_A49	Rank
EastODRDS2	1746	1
EastODRDS4	1753	2
WestODRDS2	1763	3
WestODRDS3	1767	4
WestODRDS1	1775	5
EastODRDS1	1777	6
EastODRDS3	1777	6
WestODRDS4	1782	7
NOODRDS3	2028	8
NOODRDS1	2056	9
NOODRDS2	2114	10
NOODRDS4	2115	11

From Table 6-1,6-2,6-3		
Scvenario	**Cost**	**Rank**
EastODRDS3	16,430	1
EastODRDS1	16,549	2
EastODRDS4	16,559	3
EastODRDS2	16,571	4
WestODRDS3	16,849	5
WestODRDS2	16,902	6
WestODRDS1	16,915	7
WestODRDS4	16,919	8
NOODRDS3	17,743	9
NOODRDS2	18,008	10
NOODRDS1	18,017	11
NOODRDS4	18,019	12

G.2 Final AM Ranking

Criteria		Av. Speed	Link Delays	Queues	Journey Time	Junction Stress	Impact on Trunk Rd as JT	Travel Cost	Total Score	Rank
No ODR	DS1	9	3	12	12	10	9	11	66	**10**
	DS2	8	3	11	10	9	10	10	61	**9**
	DS3	6	1	9	9	7	8	9	49	**8**
	DS4	7	2	10	11	8	11	12	61	**9**
Western ODR	DS1	4	7	8	8	6	5	7	45	**7**
	DS2	2	6	6	5	3	3	6	31	**4**
	DS3	4	4	5	6	4	4	5	32	**5**
	DS4	2	5	7	7	3	7	8	39	**6**
Eastern ODR	DS1	5	8	3	2	2	6	2	28	**3**
	DS2	5	10	4	3	5	1	4	32	**5**
	DS3	1	7	1	1	1	6	1	18	**1**
	DS4	3	9	2	4	4	2	3	27	**2**

G.3 PM Rank Calculation

from Table 4.7		
Scenario	Speed	Rank
WestODRDS4	34.1	1
EastODRDS3	33.7	2
WestODRDS1	33.5	3
EastODRDS1	33.3	4
WestODRDS3	33.1	5
EastODRDS4	32.9	6
EastODRDS2	32.8	7
WestODRDS2	32.4	8
NOODRDS3	26.4	9
NOODRDS1	25.5	10
NOODRDS4	25.5	10
NOODRDS2	25.3	11

from Table 4.7		
Scenario	Link delay	Rank
NOODRDS3	65	1
NOODRDS2	70	2
NOODRDS1	71	3
NOODRDS4	72	4
WestODRDS3	76	5
WestODRDS1	96	6
WestODRDS4	98	7
EastODRDS3	103	8
WestODRDS2	119	9
EastODRDS1	120	10
EastODRDS2	124	11
EastODRDS4	125	12

from Table 4.7		
Scenario	Queues	Rank
EastODRDS3	1013	1
WestODRDS4	1048	2
EastODRDS1	1069	3
WestODRDS3	1086	4
WestODRDS1	1088	5
EastODRDS4	1109	6
EastODRDS2	1117	7
WestODRDS2	1244	8
NOODRDS3	1430	9
NOODRDS1	1555	10
NOODRDS4	1572	11
NOODRDS2	1602	12

from Table 5.8		
Scenario	Journ. Time	Rank
EastODRDS3	177:55	1
EastODRDS1	182:53	2
WestODRDS4	187:36	3
EastODRDS4	188:03	4
EastODRDS2	188:33	5
WestODRDS1	189:37	6
WestODRDS3	193:42	7
WestODRDS2	204:57	8
NOODRDS3	217:40	9
NOODRDS1	226:18	10
NOODRDS2	228:20	11
NOODRDS4	229:56	9

from Table 5.12		
Scenario	Junc. stress	Rank
EastODRDS3	30	1
EastODRDS4	32	2
WestODRDS4	33	3
EastODRDS2	34	4
WestODRDS3	34	4
WestODRDS1	35	5
EastODRDS1	36	6
WestODRDS2	38	7
NOODRDS3	49	8
NOODRDS1	51	9
NOODRDS2	51	9
NOODRDS4	51	9

from Table 5.10		
Scenario	JT_A49	Rank
EastODRDS3	1807	1
WestODRDS1	1826	2
EastODRDS1	1830	3
WestODRDS4	1835	4
WestODRDS3	1866	5
EastODRDS2	1885	6
EastODRDS4	1902	7
WestODRDS2	1967	8
NOODRDS3	2042	9
NOODRDS1	2137	10
NOODRDS4	2213	11
NOODRDS2	2230	12

From Table 6-1,6-2,6-3		
Scenario	**Cost**	**Rank**
EastODRDS3	17,412	1
EastODRDS1	17,549	2
EastODRDS4	17,673	3
EastODRDS2	17,687	4
WestODRDS4	17,896	5
WestODRDS1	17,904	6
WestODRDS3	17,974	7
WestODRDS2	18,291	8
NOODRDS3	19,010	9
NOODRDS1	19,345	10
NOODRDS4	19,435	11
NOODRDS2	19,445	12

G.4 Final PM Ranking

Criteria		Av. Speed	Link Delays	Queues	Journey Time	Junction Stress	Impact on Trunk Rd as JT	Travel Cost	Total Score	Rank
No ODR	DS1	10	3	10	10	9	10	10	62	**10**
	DS2	11	2	12	11	9	12	12	69	**12**
	DS3	9	1	9	9	8	9	9	54	**8**
	DS4	10	4	11	12	9	11	11	68	**11**
Western ODR	DS1	3	6	5	6	5	2	6	33	**4**
	DS2	8	9	8	8	7	8	8	56	**9**
	DS3	5	5	4	7	4	5	7	37	**5**
	DS4	1	7	2	3	3	4	5	25	**2**
Eastern ODR	DS1	4	10	3	2	6	3	2	30	**3**
	DS2	7	11	7	5	4	6	4	44	**7**
	DS3	2	8	1	1	1	1	1	15	**1**
	DS4	6	12	6	4	2	7	3	40	**6**