Transport appraisal - updated

West Lothian Local Development Plan: background paper

Contents

1 Introduction and Need for Transport Appraisal

1.1 To inform the preparation of the *West Lothian Local Development Plan* (LDP) the council has undertaken transport appraisal and modelling. This has informed the development strategy which is set out in the *Proposed Plan* for the *West Lothian Local Development Plan*. *Transport appraisal and modelling* was undertaken at *Main Issues Report* (MIR) stage and has been reviewed as the LDP progressed to *Proposed Plan* stage.

1.2 The *Proposed Plan* for the LDP refers to the key improvements to the transport infrastructure to be provided for in conjunction with new development. This has been informed by a transport appraisal prepared by consultants (SYSTRA) in accordance with the Development Planning and Management Transport Appraisal Guidance (DPMTAG). Transport Scotland was consulted on the brief for this appraisal and at each stage in the appraisal process.

1.3 Transport Scotland welcomed the approach taken by the council, and has not raised any fundamental concerns about the road infrastructure proposals of the Plan.

1.4 DPMTAG is an objective-led approach which considers all modes of transport in generating and appraising appropriate transport interventions and mitigation of any consequential impact of planned growth identified through the development strategy.

2 Transport Appraisal for the West Lothian LDP

2.1 To support the preferred sites emerging through the plan preparation process traffic modelling was carried out to show the impact of the proposed developments on the transport infrastructure. *Transport Appraisal and Modelling* undertaken at *Main Issues Report* stage, is available at http://www.westlothian.gov.uk/media/4778/Transport-appraisal-and-modelling-background-paper/pdf/TransportApprisalandModelling-August_2014.pdf

2.2 In moving the LDP forward to *Proposed Plan* stage, further modelling has been undertaken, specifically in relation to Linlithgow – Appendix One refers.

2.3 This latest iteration of the *Transport Modelling and Appraisal* for the LDP describes the methods used in approaching assessment, the resulting impacts and suggested mitigation measures. It also provides details of the work undertaken in relation to development options in Linlithgow.

2.4 The modelling work was undertaken at MIR stage using the version of the SEStran Regional Transport Model (SRM) developed for the assessment of the SESplan Strategic Development Plan – SDP1. The housing allocation data for West Lothian was updated with the addition of the committed developments to produce a base case option. Three options, as set out in the MIR were then tested with the increased housing levels. These were:

- Scenario 1 base case plus additionally 2147 houses;
- Scenario 2 base case plus additionally 2678 houses; and
- Scenario 3 base case plus additionally 3492 houses.

2.5 Modelling has only been carried out for the AM peak period as the SRM model was only required to assess this period. The results indicate that there are some significant impacts locally where the developments feed onto the strategic network. The SRM network is congested by 2024 meaning small increases in traffic can lead to a disproportionate increase in congestion.

2.6 The Technical Note on the LDP assessment modelling results issued in May 2014 identified some key pressure points on the network where problems have been identified associated with each scenario. The results are diagrammatically presented in the additional document LDP modelling 2024 Forecasts.

Scenario 1:

- M8 Junction 3 Deer Park: more queuing at the A899 / M8 merge eastbound due to increased through and merging traffic. The through traffic queue by seven vehicles from Heartlands while the merging traffic queue increase from A899 was five vehicles from all sites in Livingston heading towards Edinburgh.
- A89 from Kilpunt roundabout towards Edinburgh queue increase two vehicles.
- A89 Bathgate town centre had a small queue increase by two vehicles.
- A706 Whitburn Cross northbound had a small queue increase by five vehicles.
- A71 Murieston / Lizzie Bryce roundabout queue increase by seven vehicles.
- A803 Linlithgow Low Port roundabout eastbound queue increase by two vehicles.

Scenario 2:

- Exactly the same as Scenario 1 apart from A803 Linlithgow.
- A803 Linlithgow Low Port roundabout eastbound queue increase by seven vehicles.

Scenario 3:

- M8 Junction 3 Deer Park: more queuing at the A899 / M8 merge eastbound due to increased through and merging traffic. The through traffic queue by 10 vehicles from Heartlands while the merging traffic queue increase from A899 was five vehicles from all sites in Livingston heading towards Edinburgh.
- A89 from Kilpunt roundabout towards Edinburgh queue increase two vehicles.
- A89 Bathgate town centre had a small queue increase by two vehicles.
- A706 Whitburn Cross northbound had a small queue increase by five vehicles.
- A71 Murieston / Lizzie Bryce roundabout queue increase by seven vehicles.
- A803 Linlithgow Low Port roundabout eastbound queue increase by two vehicles
- A800 at A801 junction north of Bathgate queue of two vehicles.
- Greendykes Road, Broxburn at Main Street junction a queue of two vehicles.

2.7 The above results show that when the additional traffic from the proposed developments within the LDP are added to the network queuing only increases marginally at specific pressure junctions.

2.8 It is clear that the impact of the proposed developments can be accommodated within the mitigation measures identified for each site.

2.9 Throughout the LDP process there has been a continuing refinement of the preferred sites. Following publication of the *Main Issues Report* (MIR) further refinement of the sites was required to accommodate the comments received. This resulted in another change to the location of some of the preferred sites. Therefore a check was carried out to identify what effects there could be to the transport model following replacement of some of the sites previously tested. New sites submitted during consultation on the MIR were also subjected to transport appraisal. These are set out in Appendix Two.

2.10 As the LDP moved forward from MIR to *Proposed Plan* stage, this resulted in the deletion of a number of proposed development sites. These are set out in Table 1.

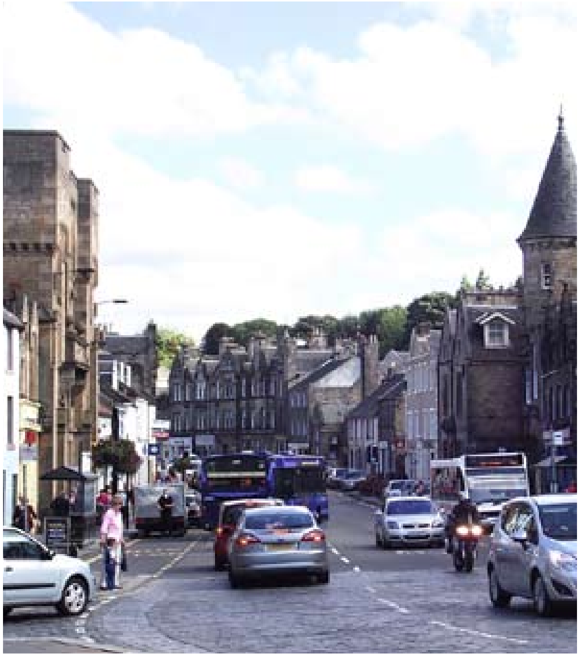
Table 1: Sites Deleted Post *Main Issues Report* Stage

Site Identification	No. of Housing Units	Location
BRO 3	18	Broxburn
LIV24 / COU35	20	James Young High School, Livingston
EOI 0149	10	Dunn Place, Winchburgh
EOI 0103	350	Burghmuir East
EOI 0165	150	Kingsfield Farm
EOI 0043	50	Kirkton Business Centre
LATE 0008	5	Muirhousedykes, Loganlea
EOI 0215	30	Blackhill Farm, Breich
EOI 0161	30	West Calder
EOI 0138 + EOI 0175	200	Strathbrock Estate, Uphall
EOI 0151	40	Hunter Grove, Whitburn
EOI 0118	30	Bentswood Inn, Stoneyburn
	Total = 933	

2.11 The removal of 500 units from Linlithgow and replacement from other sites in the town are described later in this report but suffice to say that the overall impact of development in Linlithgow on the network has not changed.

2.12 The other big change was relocation of the proposed housing from Strathbrock Estate, Uphall to the former Vion site in Broxburn (H-BU 14). This change results in different local movements in the Broxburn/Uphall area but from a strategic perspective does not greatly change the results. There will be a higher impact on the A89 towards Edinburgh with the site location change, but the increased traffic levels along this corridor can be accommodated in the local mitigation measures.

2.13 The *Proposed Plan* indicates that a total of 19, 811 units are proposed to be provided for over the period 2014- 2024 (Figure 5 of the *Proposed Plan* refers). The Proposed Plan also advises of a base supply of 26,073 houses. Having tested the scenarios at MIR stage as set out above it is not envisaged that the proposals set out in the *Proposed Plan* will have an additional impact than that already consented through the existing local plan and that such proposals can be managed through mitigation measures where required and developer contributions.



3 Transport Impacts for Linlithgow

3.1 One of the main questions for the MIR was whether Linlithgow should remain an "area of restraint" or that this approach be re-considered to allow for greenfield release of housing, employment and potential tourist related development. Should the area of restraint be removed, any development would be dependent upon the delivery of a new secondary school at Winchburgh and therefore would be focussed principally in latter plan period. Infrastructure and environmental issues would also require to be satisfactorily addressed.

3.2 Further detailed traffic modelling of the Linlithgow area was therefore undertaken to assist in identifying where the most appropriate areas for housing development might be should the 'area of restraint' be removed. The results of the modelling undertaken are presented in the Linlithgow Town Centre Development Testing Report attached as Appendix One.

3.3 Different scenarios were tested to assess the impact of new development on the town centre from sites which had been identified at MIR stage for possible housing development. The MIR had been informed by a 'call for sites' and it was these sites which were used in the traffic modelling set out in Linlithgow Town Centre Development Testing Report along with those sites already allocated in the adopted *West Lothian Local Plan*.

The modelling was undertaken to appraise local development and the potential impact on the transport network. A project brief was prepared and identified which developments would have least impact on the High Street.

3.4 The results of the modelling confirmed that there was a clear relationship between where development was located in relation to the impact on the network. The next question was if development was permitted were there any mitigation measures that could be applied to the network that would improve traffic flows. Having identified which sites the council would support if development was permitted in Linlithgow, further modelling was carried out to see the effect mitigation measures would have.

3.5 The final preferred development sites in Linlithgow resulted in a different scenario from any of those tested previously. Therefore the new scenario was run to allow for a comparison to be made. Should development in Linlithgow proceed, mitigation measures will be required to permit the proposed level of development. To understand what the impact of these measures would do to the network further testing was carried out. The three scenarios tested used the new base model with the addition of the following measures:

- Changing Junction 3 on the M9 to an all-ways junction by constructing west facing slip roads.
- Traffic signal improvements at Linlithgow Bridge and Back Station Road (i.e. the existing traffic signals which go under the railway bridge on Edinburgh Road with the side road to the Glasgow bound platform, Back Station Road) and introduction of a Toucan signalised crossing at West Port.
- Both the above options together.

3.6 Comparison of the results can best be seen in table 2.

Table 2: Results of Scenario Testing for Linlithgow

			WFS	MM	WFS+MM	WFS % Difference from 6b	MM % Difference from 6b	WFS+MM % Difference from 6e
	Scenario 6A	Scenario 6B	Scenario 6C	Scenario 6D	Scenario 6E	to Scenario 6D	to Scenario 6D	to Scenario 6b
Average delay time per vehicle[s], All Vehicle Types	311	286	189	169	141	-34%	-41%	-46%
Average number of stops per vehicles, All Vehicle Types	5	4	3.5	4	3.5	-21%	-9%	-22%
Average speed [km/h], All Vehicle Types	14	15	18	20	22	21%	32%	41%
Average stopped delay per vehicle [s], All Vehicle Types	220	206	126	94	79	-39%	-54%	-57%
Total Distance Travelled [km], All Vehicle Types	8,962	9,042	9,239	10,132	9,898	2%	12%	13%
Total travel time [s], All Vehicle Types	2,404,251	2,278,725	1,835,864	1,832,881	1,645,761	-19%	-20%	-24%
Total delay time [s], All Vehicle Types	1,675,520	1,539,153	1,084,212	997,296	835,127	-30%	-35%	-40%
Number of Stops, All Vehicle Types	29,634	24,626	19,934	23,513	20,701	-19%	-5%	-21%
Total stopped delay [s], All Vehicle Types	1,148,996	1,085,571	721,267	555,576	469,656	-34%	-49%	-52%
Number of vehicles in the network, All Vehicle Types	967	855	682	630	558	-20%	-26%	-35%
Number of vehicles that have left the network, All Vehicle Types	4,715	4,736	5,068	5,274	5,361	7%	11%	12%
Total Vehicles Loaded	5,682	5,591	5,750	5,904	5,919	3%	6%	4%

Source: *Linlithgow Town Centre – Development Testing, July 2015*

3.7 The comparison between the base modelling and the options of either the mitigation measures or the west facing slips show clearly there are benefits from their introduction. The mitigation measures can be introduced as part of planning conditions attached to any grant of planning approval and legal agreement. The west facing slips on the M9 would require supplementary guidance to link the area of development to a contribution level. Delivery of the slip roads is, however, a long term aspiration. The MIR identifies that developer contributions would be required to address infrastructure issues in Linlithgow.

3.8 Both the options set out in paragraph 3.5 above will relieve congestion along Linlithgow High Street and therefore are beneficial for environmental targets for air quality assessments. The proposals will reduce traffic queuing times at traffic lights and should help to provide the best reductions in annual mean NO2 and PM10 concentrations. The measures could be used to help the air quality management plan which may be required to be introduced in Linlithgow to reduce pollutant levels.

4 Summary

4.1 Transport modelling has been undertaken to inform the development strategy set out in the LDP. The modelling has identified where mitigation measures will be required across the transport network. These measures are reflected in the developer requirements set out in the LDP.

LINLITHGOW TOWN MODEL **09/07/2015**

Reference number 103531

LINLITHGOW TOWN CENTRE - DEVELOPMENT TESTING

LINLITHGOW TOWN MODEL

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IDENTIFICATION TABLE	
Client/Project owner	West Lothian Council
Project	LINLITHGOW TOWN MODEL
Study	LINLITHGOW town centre - development testing
Type of document	Final Draft Report
Date	09/07/2015
Reference number	103531
Number of pages	39

APPROVAL

Version	Name		Position	Date	Modifications
1	Author	Grant Paterson	Senior Consultant	02/07/2015	
	Checked by	Stephen Campopiano	Principal Consultant	06/07/2015	
	Approved by	David Connolly	Project Director	09/07/2015	
2	Author	Grant Paterson	Senior Consultant	22/07/2015	
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	Approved by			DD/MM/YY	

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1. INTRODUCTION

1.1 Overview of this Document

1.1.1 This document provides commentary on the development of an updated Linlithgow VISSIM Model and reports upon the predicted impacts of a number of developments in the town centre. Based on those modelled outputs, we have provided a package of potential mitigation measures that were discussed with West Lothian Council (WLC) and were then taken forward into the model scenarios. Analysis and commentary is provided on those mitigation measures.

1.1.2 Within this document we have set out the following topics:

- model inputs;
- methodology;
- model analysis;
- mitigation packages;
- mitigation analysis; and
- conclusions and recommendations.

1.2 Background to the Modelling

1.2.1 We have used the existing Linlithgow Town Centre Model for the basis of this study, taking Scenario 6A as a starting point to create new test scenarios based on revised level of developments.

1.2.2 We have provided commentary on the strengths and weaknesses of the original model in a previous MVA/SYSTRA report (Model Development Report, August 2014). For ease of reference, an electronic copy of this previous report is supplied with this report and can be found in Appendix A.

1.2.3 The existing model covers the AM Peak hour (08:00 – 09:00) only and so this is the only time period considered here.

1.2.4 At present Junction 3 of the M9 only has east facing slips. WLC have asked SYSTRA to investigate the impacts of modelling west facing slips at this junction.

2. METHODOLOGY

2.1 Model Inputs

2.1.1 Using the previous scenario 6A level of development as a base, we have revised the forecast development to represent the most up to date figures as shown in Table 1 below. This development scenario is used in all of the test scenarios being reported here.

2.1.2 Following communication from WLC, the following developments have been removed from the previous scenario 6A :

- Doomsdale, by Linlithgow Bridge Primary School;
- Edinburgh Road;
- Riccarton Farm/Porterside; and
- The Vennel.

Table 1. Scenario 6B Forecast Development

Site Ref	Location	Housing Units	Origin (trips)	Destination (trips)
EOI-0114	Wilcoxholm Farm/Pilgrims Hill	200	96	27
EOI-0131/COU7	Mill Road	15	7	2
EOI-0105	Land at BSW Timber, Falkirk Road	18	9	2
EOI-0184	Clarendon House	8	4	1
EOI-0210	Clarendon Farm	120	58	16
EOI-0015/20	Springfield South/Boghall East	50	24	7
HLI27	Bus Garage, High Street	41	20	5
HLI29	Stockbridge North (2)	14	7	2
EOI-0168	Land at Preston Farm	50	24	7
EOI-0045	Land east of Mains Road	45	22	6
NEW Oracle	Blackness Road	100	48	13
Total		661	317	88

2.1.3 The 'New Oracle' development of 100 units is assumed to load onto the road network close to the Oracle site on Blackness Road. We have represented this using a new VISSIM zone which uses the trip pattern from the existing zone.

2.1.4 As in the previous model development report, the TRICS database was used to determine the level of vehicle usage associated with the housing locations. Average trip rates were obtained for the AM Peak period, leading to the following values being used:

Arrival (Destination) Trip Rate 0.133 vehicle trips per household per hour; and

Departure (Origin) Trip Rate 0.480 vehicle trips per household per hour.

2.1.5 Table 2 provides an indication of the total number of trips that are to be loaded onto the network as a result of the levels of development. The values below are derived from the matrix creation process.

Table 2. Development Scenario Traffic Levels

Model	Traffic (Vehicles)
Scenario 6A	5,892
Scenario 6B (used in Scenario 6C)	5,767

2.1.6 The work programme containing 4 test scenarios identified in Table 3 below.

Table 3. Test Programme Matrix

Scenario ID	Revised Trip Matrix	M9 Westbound Slips	Mitigation Measures
6B	Yes	No	No
6C	Yes	Yes	No
6D	Yes	No	Yes
6E	Yes	Yes	Yes

2.2 M9 Junction 3 West Facing Slips (WFS)

2.2.1 One of the key aspects of the further tests is to determine what impacts the introduction of the additional westbound on/off slips at Junction 3 on the M9 will have on the town centre. However, the existing VISSIM model does not include the M9 and is therefore unable to predict the rerouting of strategic traffic.

2.2.2 We intended to use outputs from an assignment of the South East Scotland Transport Partnership (SEStran) Regional Model (SRM07) which included westbound on/off slips, to predict the relevant changes in strategic traffic travelling through the town centre. Permission was given from Transport Scotland to use these existing SRM07 model results in this way.

2.2.3 In order to determine the level of trips attracted to use the new on/off slips, we undertook two assignments of the SRM07 model. The existing 2024 model does not have the Winchburgh junction modelled on the M9, therefore we intended to create one scenario containing the new junction, on the back of this is another scenario which contains both the Winchburgh junction and the M9 Junction 3 WFS.

2.2.4 Upon further investigation of the SRM, we have decided to source another method of understanding the attraction of the WFS. The SRM contains a very coarse zone system of the Linlithgow area, therefore the results did not provide valuable levels of rerouting to and from the new M9 Junction 3 slips roads.

2.2.5 In order to overcome this issue, we created a new additional intermediate test scenario within VISSIM, which extended the coverage of modelled area to include the M9 Junction 4 and the A803 access to Linlithgow. The zone that originally represented the A803 at the western edge of the model was moved onto the M9 to the west of Junction 4 and adjoining westbound slip roads. We have assumed that all the traffic that was allocated to the A803 West zone is bound for the motorway and surrounding area.

2.2.6 As we have not modelled any additional traffic on the M9 or approaching the arms of the M9 Junction roundabout, there will be no interaction between motorway based trips and our Linlithgow town trips. The point of this intermediate test scenario was to determine the change in existing trips within our model that would reroute to the M9 Junction 3 WFS.

2.2.7 Analysis from the intermediate test shows in Table 4, the percentages of trips from the various zones predicted to use the WFS. Ten runs of the VISSIM model with different random seeds were used to predict the average change in traffic patterns generated by the WFS. This average revised travel pattern was then used as the basis for the matrices taken forward and used in scenario 6C.

2.2.8 Note that the SRM07 model was designed to model strategic traffic movements, so its representation and impact of local traffic movements should be treated with caution.

Table 4. Patterns of Trips Using the West-Facing Slips

Zone	% of origin trips using M9 WFS	% destinating trips using M9 WFS
1 A803 North of M9 Junction 3	100%	98%
4 – Kingsfield	100%	55%
5 – Springfield Road East	77%	100%
6 – Existing Oracle	100%	63%
34 – Oracle Development	60%	100%
7 – Grange Knowe	0%	66%
8 – Road to Muirhouse	18%	100%
9 – Springfield Road West	72%	70%
10 – Baron's Hill Ave	0%	78%
11 – Regent Square	69%	77%
12 – B9080 Back Station Road	28%	54%
13 – Claredon Road	18%	31%

2.2.9 Within the VISSIM model, two new zones have been created to represent the M9 Junction 3 on slip and off slip. Using the above methodology, we have estimated the traffic using the ramps will be as follows within our AM peak:

> Zone 35 Destinating: 34 vehicles per hour use the Junction 3 to travel west on the M9; and
>
> Zone 36 Originating: 84 vehicles per hour use the Junction 3 to enter our modelled area from the eastbound M9.

2.2.10 When comparing with the previous test, which did not include the M9, we have used this assignment pattern above to split traffic associated with traffic to and from the west between these two alternative routes.

2.2.11 Figure 1 shows the area which this route choice is applied to.

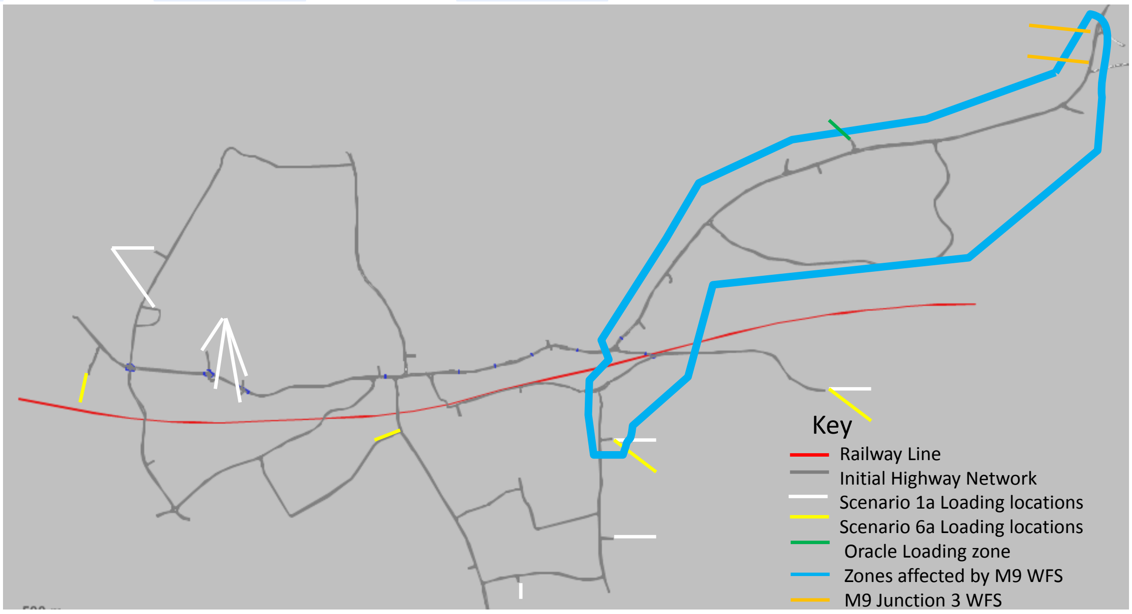

Figure 1. Attraction of M9 J3 WFS Zone

2.3 Route Choice in the VISSIM Model

2.3.1 In order to maintain consistency with the previous results, we have used the same version of VISSIM (V6.00-15) and the same approach to route choice as was used in the previous project.

2.3.2 The Dynamic Assignment is calculated in VISSIM using an iterative simulation. The modelled drivers choose their paths through the network based on the journey times predicted by the preceding simulations. This route choice includes some random variation, so that different drivers will choose different routes, rather than all vehicles following the shortest-path route.

2.3.3 In order to model the variation in daily traffic, each model time period has been assigned ten times, with an average of these ten runs used as the basis for the network performance analysis.

3. ANALYSIS

3.1 Introduction

3.1.1 To remain consistent, the same analysis has been undertaken as per previous study, namely:

- Key Performance Indicators;
- Journey Time Analysis; and
- Queue Lengths.

3.1.2 We have focused upon the change between scenario 6C (With WFS) and scenario 6B (without WFS).

3.2 Key Performance Indicators

3.2.1 In order to quantify the overall network performance, key indicators are extracted from the model. Table 5 below summarises the overall network conditions. Key performance indicators are derived from an average of the ten assignments. The parameters contained in Table 5 are used to assess the planned development test scenarios.

3.2.2 It should be noted that if queues extend back beyond the start of the modelled network, the additional demand cannot join the modelled network and is excluded from link-based statistics in the table below.

Table 5. Key Performance Indicator Summary

Parameter	6A	6B (No WFS)	6C (WFS)	WFS Change	WFS % Change
Average delay time per vehicle [s], All Vehicle Types	311	286	189	-97	-34%
Average number of stops per vehicles, All Vehicle Types	5	4	3	-1	-21%
Average speed [km/h], All Vehicle Types	14	15	18	3	21%
Average stopped delay per vehicle [s], All Vehicle Types	220	206	126	-80	-39%
Total Distance Travelled [km], All Vehicle Types	8,962	9,042	9,239	197	2%
Total travel time [s], All Vehicle Types	2,404,251	2,278,725	1,835,864	-442,860	-19%
Total delay time [s], All Vehicle Types	1,675,520	1,539,153	1,084,212	-454,941	-30%
Number of Stops, All Vehicle Types	29,634	24,626	19,934	-4,692	-19%
Total stopped delay [s], All Vehicle Types	1,148,996	1,085,571	721,267	-364,304	-34%
Number of vehicles in the network, All Vehicle Types	967	855	682	-173	-20%
Number of vehicles that have left the network, All Vehicle Types	4,715	4,736	5,068	332	7%
Total Vehicles Loaded	5,682	5,591	5,750	159	3%

3.2.3 Overall, the results demonstrate the benefits upon the local road network as a result of the amended traffic developments against the original scenario 6a. These benefits are further enhanced with the introduction of the M9 Junction 3 WFS. When comparing scenario 6C and 6B (with and without the M9 Junction 3 WFS), the following conclusions can be drawn from the analysis:

- Inclusion of the M9 Junction 3 WFS is predicted to produce a 34% reduction in average delay time per vehicle;

- The inclusion of M9 Junction 3 WFS is predicted to reduce the average number of stops per vehicle by 21%;
- An average speed increase of 3kph is predicted between 6B (15kph) and 6C (18kph);
- The revised development results in minor reductions in the average stopped delay per vehicle;
- The addition of the M9 Junction 3 WFS results in a 39% reduction in the **average** stopped delay per vehicle, vehicles are still coming to a stop within 6C, however, not as much as 6B;
- The total distance travelled (km) in the modelled hour, generally increases, trips are able to travel further within the hour as a result of the decreasing level of delay;
- The introduction of the M9 Junction 3 WFS is predicted to generate a 19% reduction in the average time for trips to complete their journey within the modelled network;
- Total delay time (s) shows a 30% reduction in delay, consistent with other key performance indicators, highlighting the benefits of the new west-facing motorway slips;
- **Total** stopped delays (s) indicates a 34% reduction in the total vehicle delay with the introduction of the motorway slips;
- The number of vehicles in the network is a key indicator for traffic still routeing to their destination. The results show that scenario 6C has a 20% reduction in traffic still on the network at the end of the modelled hour when compared with scenario 6B. This provides further evidence, along with reductions in delay and queuing, of the benefits that the M9 junction 3 WFS has on the network;
- The number of vehicles that have left the network is another key indicator determining the number of vehicles that have finished their journey, the results show that 7% more journeys have been completed within the modelled hour when the motorway slips are included; and
- The total vehicles loaded onto the network is calculated by summing the number of vehicles that are still in the network at the end of the model time period and the number that have left the network. This shows that scenario 6C has loaded 3% more vehicles onto the network when compared to scenario 6B, meaning that Scenario 6C can accommodate more vehicles loading onto the network. This additional traffic is included in the performance statistics above.

3.3 Journey Time Analysis

3.3.1 Figure 2 provides an illustration of the journey time routes; these match the previous study.

Figure 2. Journey Time Routes

3.3.2 Modelled end-to-end journey time measurements for these routes are reported in Table 6 below.

Table 6. Journey Time Summary (seconds)

Route	6A	6B (No WFS)	6C (WFS)	WFS Change	WFS % Change
A803 Linlithgow Bridge to A803 M9 J3	790	691	664	-28	-4%
A803 M9 J3 to A803 Linlithgow Bridge	939	965	N/A	-965	N/A
A706 St Ninian's Rd to A706 Mains Road	442	470	411	-59	-13%
A706 Mains Road to A706 St Ninian's Rd	750	1200	863	-338	-28%
B825 to St Michael's Hospital	797	751	621	-130	-17%
St Michael's Hospital to B825	795	755	568	-187	-25%

3.3.3 Comparing the changes in journey times due to the new development pattern (ie 6B versus 6A) shows a mixture of increasing and decreasing times. However, for the purposes of this study we have focussed on the differences in journey time route when west facing slips at the M9 Junction 3 are modelled.

Route 1 A803 Linlithgow Bridge - A803/M9 Junction 3

3.3.4 The comparison shows overall journey time savings with the introduction of slips roads. Analysis of the route between the A803 Linlithgow Bridge to the A803/M9 Junction 3 predicts a 28 second reduction in average journey time for this route, equating to a 4% average journey time saving. However, further analysis reveals that only one vehicle is making this particular movement in the model. Our matrix manipulation process determines the level of trips switching to use the M9 Junction 3 WFS, and reroutes the vast majority of trips onto the motorway off ramp zone. Previously in scenario 6B, 20 vehicles were shown to be using this route, however, this is reduced to just one in scenario 6C. Therefore caution should be used when interpreting and comparing this route with previous times.

3.3.5 In the reverse direction, the A803/M9 Junction 3 to the A803 Linlithgow Bridge, no journey time is recorded as no vehicles are undertaking this movement, as they choose to reroute via the motorway on ramp, rather than routeing through the town centre.

3.3.6 Table 4 shows that 100% of trips route via the M9 from zone 1 (A803 North of J3) to Linlithgow Bridge, therefore no trips are recorded routeing through Linlithgow Town centre. The same table shows that 98% of trips from Linlithgow Bridge to zone 1 are to be moved, hence one vehicle has been identified as routeing along this path.

Route 2 A706 St Ninian's Rd - A706 Mains Road

3.3.7 Journey times on this route decrease by 28% in the northbound direction and by 13% southbound. The changes in traffic flows through the town centre reduce delays along this route.

Route 3 B825 - St Michael's Hospital

Journey times on this route decrease by 17% in the eastbound direction and by 25% westbound. The changes in traffic flows through the town centre reduce delays along this route.

3.4 Queue Lengths

3.4.1 Queue length analysis has been undertaken at 36 locations on approaches to salient junctions across the model. An aggregated summary for each main junction is reported in Table 7 below. Appendix B contains further information regarding queue lengths.

Table 7. Average Queue Length Summary (metres)

Location	6A	6B (No WFS)	6C (WFS)	WFS Change	WFS % Change
A803/Mill Rd	561	543	349	-195	-36%
A803/Sainsbury's	138	191	111	-80	-42%
A803/East Mill Rd	88	116	84	-32	-27%
A803/A706	344	281	220	-61	-22%
A706 Railway Bridge	151	163	119	-44	-27%
Preston Road	49	45	11	-34	-75%
St Ninian's Road	274	77	16	-61	-79%
St John's Ave	18	15	3	-13	-82%
A803/High Port Rd/Blackness Rd	507	324	127	-198	-61%
High Port Rd/Back Stn Rd	371	451	416	-35	-8%
A803/Springfield Rd	62	33	10	-23	-70%
A706/B8029	120	140	129	-11	-8%

3.4.2 Overall the impacts of the slips continue to show town centre benefits, with reduced queue lengths at all of the locations reported in Table 7.

3.4.3 The largest predicted percentage reduction in average queue length is at St John's Avenue (82%), note however this is on a small queue originally. The largest absolute change is noted at A803/High Port Rd/Blackness Rd where 198 meters are removed from the average queue length, resulting in a 61% reduction at this location.

3.5 Network Flow Analysis

3.5.1 Analysis has been undertaken to determine the change in average flows between the scenario 6B and 6A, then 6C vs 6B (Showing the impact of the M9 Junction 3 WFS). Illustrations contained in Appendix C provide an indication of flow change on the modelled network. Where flows from one junction leading in to another junction differ, this provides an indication that traffic is queued. Table 8 below compares the aggregated (in and out of the junction) changes in network flow at the major junctions within the network. The values contained in the table below are made up of combined inbound and outbound traffic volumes.

3.5.2 Traffic levels within the town centre in the peak hour remain broadly consistent with the previous values, as the traffic rerouted via the M9 WFS is replaced by other vehicles which were previously stuck in queues.

3.5.3 Analysis shows the reduction of traffic at the A803 entering in the west of the model and this can be traced towards the town centre. The westbound route through Linlithgow reveals increases in traffic levels, primarily from the signalised junction of Back Station Road, and from the B9080 to the Mill Road junction. The increases originate from the zone loading locations, which is taking the place of traffic that used to route from the east of the town. The largest percentage change is noted at the Railway Bridge on the A706, where a 20% increase in trips is noted. Another noticeable percentage increase is on Preston Road, south of the High Street, where 17% more traffic is noted. St Ninian's Road shows the highest absolute increases in vehicle numbers.

Table 8. Change in Network Flow Summary (vehicles)

Location	6A	6B (No WFS)	6C (WFS)	WFS Change	WFS % Change
A803/Mill Rd	2984	2928	3010	82	3%
A803/A706	2762	2966	3014	48	2%
A706 Railway Bridge	358	351	421	70	20%
Preston Road South of High St	660	656	770	114	17%
St Ninian's Road	2748	3092	3228	136	4%
A803/High Port Rd/Blackness Rd	3140	3376	3412	36	1%
High Port Rd/Back Stn Rd	1820	1676	1786	110	7%
A706/B8029	1572	1490	1568	78	5%

3.6 Modelling Issues Associated with Network Loading

3.6.1 Table 9 below indicates the number of vehicles unable to load onto the network due to queues extending to the edge of the modelled area. It reveals that with the introduction of the M9 Junction 3 WFS, more trips can be loaded onto the network; however there are still issues with loading all the trips contained in the matrix.

3.6.2 VISSIM provides an error file which notifies the user if traffic cannot load onto the network, for example traffic cannot load due to excessive queues. All scenarios indicate that some traffic is unable to load onto the network during the modelled time period. Analysis suggests that loading issues occur consistently at the following locations:

- Kettleston Mains;
- A706;
- Avonton Park;

- B825; and
- A803 West.

3.6.3 Chapter 4 considers a variety of partial mitigation measures, which may enable the modelled network to accommodate more of this traffic demand.

Table 9. Change in Network Flow Loading (vehicles)

Scenario	6A	6B (No WFS)	6C (WFS)	WFS Change	WFS % Change
	539	492	324	-168	-34%

4. MITIGATION PACKAGES

4.1 Introduction

4.1.1 The results in the previous section suggest that there are enhancements within the performance of the network; the M9 WFS gives further improvements, but residual capacity issues remain. In this section we consider mitigation measures which may help deal with these issues.

4.2 Potential Mitigation Measures

4.2.1 Our analysis of model outputs suggest that several issues still exist within Linlithgow town centre, namely excessive queues which prevent vehicles entering the modelled network and other delays within the network. Issues with queuing are noted at the following locations:

- A803 Falkirk Road/Mill Road;
- A803 High Street/High Port Road/Blackness Road;
- roundabout of the A803 Falkirk Road and A706 Mains Road; and
- signalised junction of High Port Road and Back Station Road.

4.2.2 Figure 3 below provides an illustration of the problem locations, where potential mitigation measures may be required.

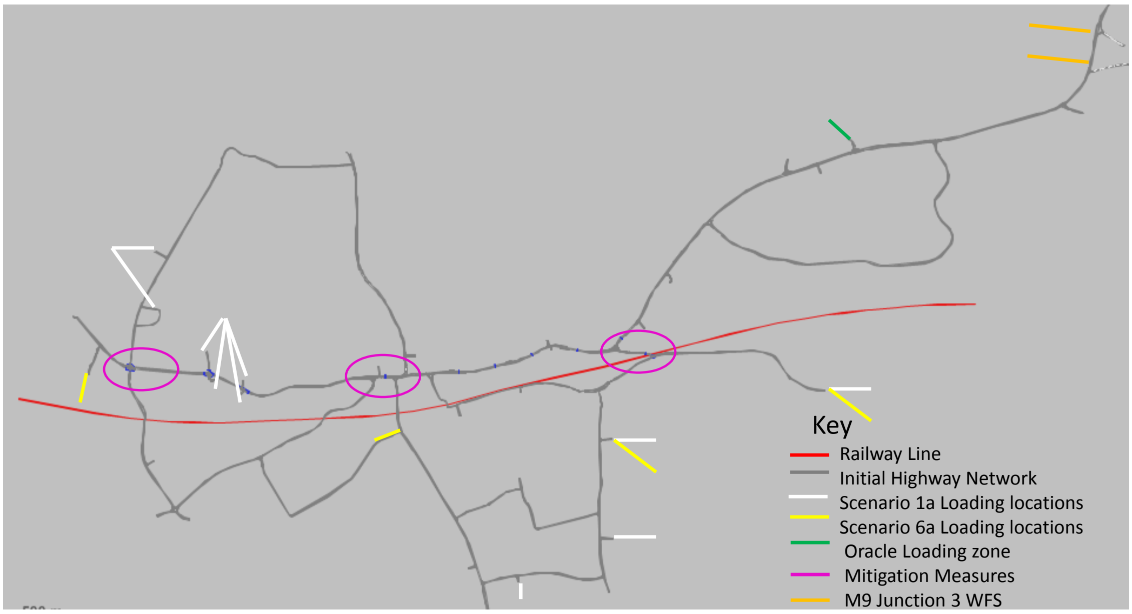

Figure 3. Potential Mitigation Measures

4.2.3 In order to combat the issues described above, we have identified a number of potential mitigation measures which could be considered.

Preston Road and A706/A803 junction

4.2.4 At present, Preston Road permits traffic only to turn left on the A803, which means that all traffic must pass through or circulate the roundabout of A706 Mains Road and A803 Falkirk Road. Traffic on A706 Mains Road has to give way to traffic on the A803 Falkirk Road, which creates long queues on Mains Road which can impact on the signal under the railway bridge, which in turn leads to more queuing.

4.2.5 Permitting right turning vehicles at this junction would reduce the amount of circulating traffic at the A706/A803. This would also reduce pedestrian and vehicle interaction at the pelican crossing location outside the West Port Hotel. Additional detailed analysis of vehicle swept paths (eg using AUTOtrack or equivalent) would be required to check that the pedestrian refuge on the main road does not prevent longer vehicles making this right turn movement. The cost of AUTOtrack is not included as part of this project, but can be provided on request.

4.2.6 Further proposals include widening the approaches of A706 Mains Road and A803 High Street (westbound) approaching the junction of A706 Mains Road and A803 Falkirk Road. These approaches would be widened from the current one lane approaching the roundabout to two lanes. An additional lane on the approach from A706 Mains Road would require some realignment of that approach and the junction.

B9080 Back Station Road/High Port Signalised Junction

4.2.7 This signalised junction has significant delays as a result of the amount of traffic it serves. The junction is physically constrained by the railway bridge, in addition to only one stream of traffic being permitted under the bridge at one time.

4.2.8 We have ruled out the possibility of expanding the junction due to these constraints. However, we would look to amend the signal timings to take into account the revised predicted future-year traffic levels.

4.2.9 Given the close proximity of the roundabout on A803 High Street/Blackness Road, care must be taken so that traffic is not forced through this signalised junction to queue up at the roundabout. N.B. Standard junction optimisation software does not take into consideration the interaction of adjacent junctions, as such, it is advisable to use micro-simulation modelling to determine the performance of alternative signal settings and/or junction arrangements at this location, in terms of the wider network.

A803 Blackness Road/High Street/B9080 High Port Roundabout

4.2.10 The model output shows that traffic trying to head southbound to go under the railway bridge at the signalised junction above can queue back to this roundabout which affects circulating traffic and causes delays on Blackness Road and the High Street.

4.2.11 There is scope to widen the approaches on the B9080 High Port and the A803 western arm to two lanes, to provide additional turning capacity. However this may have a detrimental impact on pedestrians trying to cross the two lanes of traffic compared to the current one-lane approach.

Signalised Junction along A803 Main Street

4.2.12 There are three sets of signalised junctions located in close proximity along the A803 Main Street between Lennox Gardens/ALDI/East Mill Road, Sainsbury's/Stockbridge Retail Park and Mill Road. The model shows delays at the junction of the A803 Main Street and Mill Road, this is one area where development trips are due to load, although this has been reduced slightly with the inclusion of the M9 Junction 3 WFS.

4.2.13 We reviewed the signal operations along the A803 Main Street (Linlithgow Bridge) to determine if improvements can be made to reduce delays and improve the performance of the signalised junctions. The software LINSIG was used to link the signals together, delivering platoon movement of trips along the A803 in addition to providing enough time for traffic joining the network at the various minor signalised arms.

Measures considered but not taken forward

4.2.14 We have considered further potential options for mitigation, however, we do not feel that they are options to be taken forward.

4.2.15 Opening up Provost Road to allow traffic (in one direction only) to pass under the railway, through the car park to either Regent Square or continue along Provost Road. We have dismissed this option as although it will remove traffic from the busy junction of B9080 Back Station Road and High Port, the movement would bring opposition from residents living on these streets (Regent Square and Provost Road), not to mention the tight turning manoeuvres.

4.2.16 The canal crossing and railway bridges are seen as pinch points within the town centre: any changes to these locations would involve large scale mitigation measures and therefore have been discounted.

4.2.17 As this model is an AM Peak network, we draw your attention that mitigation measures suggested above may only work within the AM Peak and that the results should be treated with caution in regards that they have not been tested in an inter peak or PM Peak periods. Traffic patterns will be different from the AM Peak and therefore the mitigation packages may not be suitable or appropriate for other time periods.

4.2.18 We have not undertaken any detailed consideration of the cost or availability of any additional land needed to accommodate the various mitigation schemes being considered here.

4.2.19 We have also excluded consideration of significant 'bypass' schemes diverting traffic from the town centre.

4.2.20 While we have given some consideration to the needs of pedestrians and cyclists within the preliminary design of our proposed mitigation measures, more-detailed modelling (supported by additional data gathering) would be required to fully incorporate these active modes within the relevant scheme designs.

4.3 Mitigation Measures taken forward

4.3.1 Following discussion with WLC, three areas were taken forward for testing within the VISSIM models:

- Preston Road / A706 / A803 junction;
- B9080 / Back Station Road; and
- A803 Linlithgow Bridge.

4.3.2 In each of locations above, we have investigated the merits of optimising the signal settings using LINSIG, with any amended signal settings used into the VISSIM models. Within LINSIG, we have aimed to get the Practical Reserve Capacity (PRC) as close to zero as possible. PRC is the practical capacity threshold for a signalised junction and is taken as 90%. Therefore, the reserve is the difference between the estimated capacity / over capacity of the junction relative to 90%. It should be noted that signalised junctions generally operate close to 90% as this is the most efficient operation of the junction; this maximum is maintained by adjusting the cycle time up to a standard maximum of 120 seconds per cycle when the 90% level is exceeded.

Preston Road / A706 / A803 junction

4.3.3 In the case of Preston Road/A706/A803 junction, the roundabout was signalised along with the existing priority junctions of Preston Road and the A706. These signals were then linked together to find an optimum solution for through traffic and traffic entering from the side roads. After investigating numerous stages and cycle times, we were unable to come up with a beneficial solution due to the number of stages required, this resulted in a too short allocation of green time on the main road. Therefore the length of queuing traffic makes signalising of this junction impracticable on the main through west-east movements.

4.3.4 An additional measure will be the introduction of a signalised crossing in place of the existing zebra crossing outside the West Port Pub. We have used signal settings from existing crossing facilities located along the High Street, with the assumption that the pedestrian phase will be called every cycle. When the pedestrian phase is operational, this will give traffic on Philip Avenue and the A706 Mains Road an additional opportunity to access the High Street.

B9080 / Back Station Road

4.3.5 With regards to B9080 / Back Station Road, changes have been made to the cycle time and the green time allocated to each movement. By analysing the flows now routing through this junction, Back Station Road caters for more traffic than in the base, due to the developments. This results in more green time given to this movement. Table 10 below presents the changes made to this junction. The physical constraints at this location, coupled with the travel demands, have led to the conclusion that no changes to the phasing are possible. We have kept the same inter-green settings as provided. We had considered double cycling this junction, with the pedestrian phase dropped in the second cycle, but given the close proximity to Linlithgow train station, shopping facilities and the residential housing, we felt that at present this would not be advisable without investigating the pedestrian usage.

Table 10. B9080/Back Station Road Signals

Arm	Existing Green time (S)	Amended Green time (S)
B9080 High Port	22	20
B9080 Edinburgh Road	22	7
Back Station Road	22	18
Pedestrian Phase	7	7
Cycle Time	110	99

A803 Linlithgow Bridge

4.3.6 The existing signalised junction of A803 Linlithgow Bridge and Mill Road was amended to shorten the cycle time and also reduce the amount of stages. The existing phase diagram sheet provided made use of a A803 right turning stage for both arms, in addition to a separate right turning stage for traffic from the A803 East. Additionally, traffic from both north and south Mill Road operated in the same phase. The existing signals had a low pedestrian usage and therefore were omitted from the original VISSIM Model, to maintain consistency we have not modelled the pedestrian phase in the amended setup. After analysing the traffic patterns at this junction, we have amended the staging as illustrated in Figure 4 below. Table 11 presents the changes in green times.

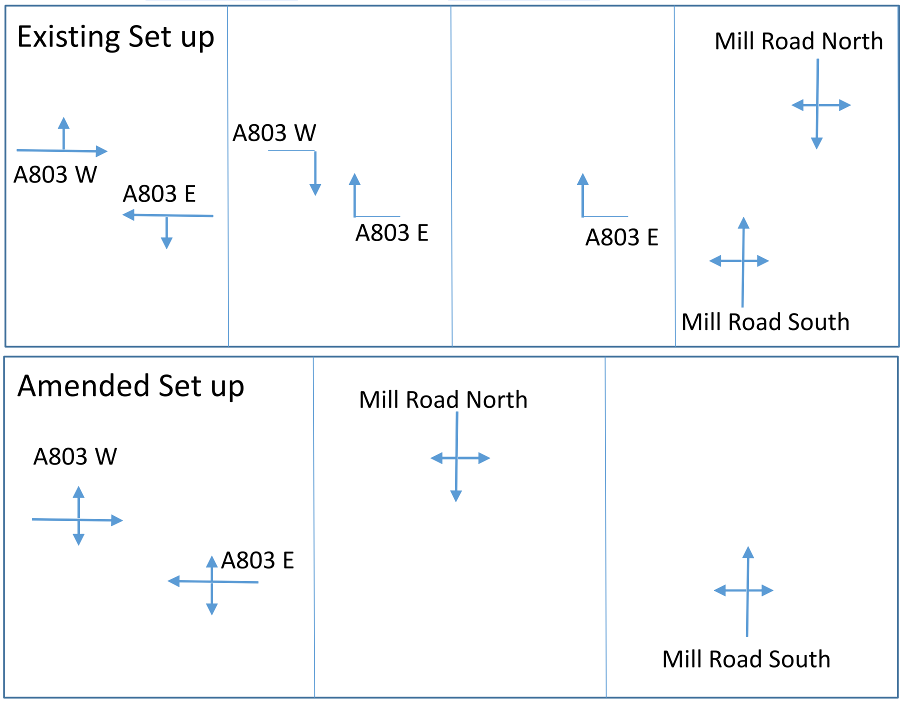

Figure 4. A803 Linlithgow Bridge Stage Changes

Table 11. A803 Linlithgow Bridge Signals

Arm	Existing Green time (S)	Amended Green time (S)
A803 West/East (Left turn/ahead only)	36	N/A
A803 West/East (Right Turn only)	14	N/A
A803 East (Right Turn only)	14	N/A
A803 West/East (all movements)	N/A	20
Mill Road North/South	26	N/A
Mill Road North	N/A	14
Mill Road South	N/A	10
Cycle Time	100	67

4.3.7 We have investigated the A803 Linlithgow Bridge signalised corridor including the junctions at Sainsbury's and Linlithgow Bridge Primary School/ALDI to determine if linking the signals together on a common cycle time would reduce the delay and improve the performance of the network. Due to the distance between the Mill Road and Sainsbury's junction we were unable to create a signal plan which linked the three junctions together to provide a suitable performance in LINSIG. Therefore we have linked the junctions of Sainsbury's and Linlithgow Bridge Primary School/ALDI together.

4.3.8 Table 12 below presents the change in green time for Linlithgow Bridge Primary School/ALDI signals, no changes to the staging was undertaken.

Table 12. A803 Linlithgow Bridge Primary School Signals

Arm	Existing Green time (S)	Amended Green time (S)
A803 West/East	33	31
Linlithgow Bridge Primary School	8	8
ALDI	13	7
Cycle Time	102	91

4.3.9 No changes in terms of stage operation have been made to the signals at Sainsbury's/A803. Table 13 below highlights the change in green times at the junction of Sainsbury's and the A803.

Table 13. A803/Sainsbury's Signals

Arm	Existing Green time (S)	Amended Green time (S)
A803 West/East	38	42
Sainsbury's	18	7
Retail Park	18	7
Cycle Time	96	91

4.3.10 As instructed by WLC, no mitigation amendments were made to the junction of A803 Blackness Road / High Street / Low Port roundabout due to bus turning and high pedestrian crossing usage.

4.3.11 The mitigation measures are based on their existing junction layouts, no additional lanes of traffic will be modelled, the focus is to get the optimum settings based on current layouts. The LINSIG models are based on our engineering judgement to determine settings that will improve performance of the network.

4.4 Scenarios 6D and 6E

4.4.1 Using the mitigation measure discussed above, we have modelled them within the existing scenarios, this results in two mitigation scenarios being modelled and analysed:

Scenario 6D = Scenario 6B + mitigation measures; and

Scenario 6E = Scenario 6C + mitigation measures.

5. MITIGATION ANAYLSIS

5.1 Introduction

5.1.1 This section reports on the impact of the mitigation measures. As before we will use the following analysis datasets:

- Key Performance Indicators;
- Journey Time Analysis; and
- Queue Lengths.

5.1.2 We have focused upon the impact of the mitigation measures, therefore scenario 6E is compared with scenario 6C, both these include the WFS. Scenario 6D is compared with scenario 6B, both without WFS.

5.2 Key Performance Indicators

5.2.1 In order to quantify the overall network performance, key indicators are extracted from the model. Table 14 below summarises the overall network conditions. Key performance indicators are derived from an average of the ten assignments.

5.2.2 It should be noted that if queues extend back beyond the start of the modelled network, the additional demand cannot join the modelled network and is excluded from link-based statistics in the table below.

Table 14. Key Performance Indicator Summary

Parameter	6A	6B No WFS	6C WFS	6D No WFS + MP	6E WFS + MP	% Change in No WFS (6D-6B)	% Change in WFS (6E-6C)
Average delay time per vehicle [s], All Vehicle Types	311	286	189	169	141	-41%	-25%
Average number of stops per vehicles, All Vehicle Types	5	4	3	4	3.5	-9%	1%
Average speed [km/h], All Vehicle Types	14	15	18	20	22	32%	18%
Average stopped delay per vehicle [s], All Vehicle Types	220	206	126	94	79	-54%	-37%
Total Distance Travelled [km], All Vehicle Types	8,962	9,042	9,239	10,132	9,898	12%	7%
Total travel time [s], All Vehicle Types	2,404,251	2,278,725	1,835,864	1,832,881	1,645,761	-20%	-10%
Total delay time [s], All Vehicle Types	1,675,520	1,539,153	1,084,212	997,296	835,127	-35%	-23%
Number of Stops, All Vehicle Types	29,634	24,626	19,934	23,513	20,701	-5%	4%
Total stopped delay [s], All Vehicle Types	1,148,996	1,085,571	721,267	555,576	469,656	-49%	-35%
Number of vehicles in the network, All Vehicle Types	967	855	682	630	558	-26%	-18%
Number of vehicles that have left the network, All Vehicle Types	4,715	4,736	5,068	5,274	5,361	11%	6%
Total Vehicles Loaded	5,682	5,591	5,750	5,904	5,919	6%	3%

5.2.3 When analysing the impact of the mitigation measures when no WFS are present (6D-6B), the following conclusions can be drawn from the analysis:

- Average delay time per vehicle (s) reduces by 41%;
- Minor reduction in the average number of stops per vehicle by 9%;
- Average speed increases by 32% from 15kph to 20kph;
- Large reductions in the average stopped delay per vehicle down by 54%;
- The total distance travelled (km) in the modelled hour, increases by 12%, trips are able to travel further within the hour as a result of the decreasing level of delay;
- The mitigation measures are predicted to generate a 20% reduction in the average time for trips to complete their journey within the modelled network;
- Total delay time (s) shows a 35% reduction in delay, consistent with other key performance indicators;
- **Total** stopped delays (s) indicates a 49% reduction in the total vehicle delay;
- The number of vehicles in the network is a key indicator for traffic still travelling to their destination. The results show that the mitigation measures have a 26% reduction in traffic still on the network at the end of the modelled hour. This provides further evidence along with reductions in delay and queuing of the benefits of optimising signal settings;
- The number of vehicles that have left the network is another key indicator determining the amount of vehicles that have finished their journey, 11% more journeys have been completed within the modelled hour; and
- The total vehicles loaded onto the network is calculated by summing the number of vehicles that are still in the network at the end of the model time period and the number that have left the network. The mitigation package shows that an additional 6% more vehicles are loaded onto the network when compared to scenario 6B.

5.2.4 When analysing the impact of the mitigation measures when the WFS are present (6E-6C), the following conclusions can be drawn from the analysis:

- Average delay time per vehicle (s) reduces by 25%;
- Minor increase in the average number of stops per vehicle by 1% (note that this is only by a very small absolute value);
- Average speed increases by 18% from 18kph to 22ph;
- Large reductions in the average stopped delay per vehicle down by 37%;
- The total distance travelled (km) in the modelled hour, increases by 7%, trips are able to travel further within the hour as a result of the decreasing level of delay;
- The mitigation measures are predicted to generate a 10% reduction in the average time for trips to complete their journey within the modelled network;
- Total delay time (s) shows a 23% reduction in delay, consistent with other key performance indicators;
- **Total** stopped delays (s) indicates a 35% reduction in the total vehicle delay;
- The number of vehicles in the network is a key indicator for traffic still routeing to their destination. The results show that the mitigation measures have a 18% reduction in traffic still on the network at the end of the modelled hour. This provides further evidence along with reductions in delay and queuing of the benefits of optimising signal settings;

- The number of vehicles that have left the network is another key indicator determining the amount of vehicles that have finished their journey, 6% more journeys have been completed within the modelled hour; and
- The total vehicles loaded onto the network is calculated by summing the number of vehicles that are still in the network at the end of the model time period and the number that have left the network. The mitigation package shows that an additional 3% more vehicles are loaded onto the network when compared to scenario 6C.

5.3 Journey Time Analysis

5.3.1 Figure 2 in chapter 3 above provides an illustration of the journey time routes. Modelled end-to-end journey time measurements for these routes are reported in Table 15 below. Commentary is provided on the impacts of the mitigation measures firstly for the scenarios without the WFS, then with the inclusion of the WFS.

Table 15. Journey Time Summary (seconds)

Route	6A	6B No WFS	6C WFS	6D No WFS + MP	6E WFS + MP	Change in No WFS (6D-6B)	% Change in No WFS (6D-6B)	Change in WFS (6E-6C)	% Change in WFS (6E-6C)
A803 Linlithgow Bridge to A803 M9 J3	790	691	664	701	656	10	1%	-8	-1%
A803 M9 J3 to A803 Linlithgow Bridge	939	965	N/A	687	N/A	-278	-29%	N/A	N/A
A706 St Ninian's Rd to A706 Mains Road	442	470	411	292	286	-179	-38%	-125	-30%
A706 Mains Road to A706 St Ninian's Rd	750	1200	863	688	529	-513	-43%	-334	-39%
B825 to St Michael's Hospital	797	751	621	760	679	9	1%	59	9%
St Michael's Hospital to B825	795	755	568	890	744	135	18%	176	31%

5.3.2 When analysing the impact of the mitigation measures when no WFS are present (6D-6B), the following conclusions can be drawn from the analysis.

Route 1 A803 Linlithgow Bridge - A803/M9 Junction 3

5.3.3 Analysis of the route between the A803 Linlithgow Bridge to the A803/M9 Junction 3 predicts an increase of 10 seconds in average journey time, equating to a 1% average journey time rise. The journey time route is set up to provide results from the whole route and is not segmented, therefore we are unable to pinpoint an exact area where the additional delay is collected.

5.3.4 In the reverse direction (A803/M9 Junction 3 to the A803 Linlithgow Bridge), the package of mitigation measures including the additional pedestrian crossing is shown to have recorded a saving of 278 seconds, equating to a 29% reduction in journey time.

Route 2 A706 St Ninian's Rd - A706 Mains Road

5.3.5 Journey times on this route decrease by 43% in the northbound direction and by 38% southbound. We are unable to determine if the signalised pedestrian crossing outside the West Port Pub is responsible for the majority of the journey time savings or whether the optimising and re-phasing of the signals at the A803 Linlithgow Bridge/Mill Road has the greatest impact on the journey time improvements as a result of traffic rerouting.

Route 3 B825 - St Michael's Hospital

5.3.6 Journey times on this route increase by 1% in the eastbound direction and by 18% westbound. The mitigation measures seem to have a detrimental effect upon the journey times, westbound green times at the junction of the B9080 and Back Station Road have been reduced (for Edinburgh Road) in an effort to cater for the level of traffic from Back Station Road. The signalised crossing outside the West Port Pub can be seen as creating an increased level of delay for traffic, as the pedestrians are assumed to be called every cycle.

5.3.7 When analysing the impact of the mitigation measures when the WFS are present (6E-6C), the following conclusions can be drawn from the analysis.

Route 1 A803 Linlithgow Bridge - A803/M9 Junction 3

5.3.8 Analysis of the route between the A803 Linlithgow Bridge to the A803/M9 Junction 3 predicts a decrease of 8 seconds in average journey time, equating to a 1% average journey time saving. Caution should be used when interpreting and comparing this route with previous times - as highlighted previously, only one vehicle makes this journey as a result of the WFS.

5.3.9 In the reverse direction, the A803/M9 Junction 3 to the A803 Linlithgow Bridge, no journey time is recorded as no vehicles are undertaking this movement as they choose to reroute via the motorway on ramp, rather than routeing through the town centre.

Route 2 A706 St Ninian's Rd - A706 Mains Road

5.3.10 Journey times on this route decrease by 39% in the northbound direction and by 30% southbound. The impacts of mitigation measures have previously been discussed above, the measures indicate that for this particular route they will have a negative impact on journey times.

Route 3 B825 - St Michael's Hospital

Journey times on this route increase by 9% in the eastbound direction and by 31% westbound. The impacts of mitigation measures have previously been discussed above, the measures indicate that for this particular route they will have a negative impact on journey times.

5.4 Queue Lengths

5.4.1 Queue length analysis has been undertaken at 36 locations on approaches to salient junctions across the model. An aggregated summary for each main junction is reported in Table 16 below. Appendix B contains further information regarding queue lengths. Commentary is provided on the impact of the mitigation measures when no WFS is present, the following conclusions can be drawn from the analysis.

5.4.2 Overall the impacts of the mitigation measures continue to show town centre benefits, with reduced queue lengths at the vast majority of the locations reported in Table 14. There are locations where increases in queue lengths are expected, mainly due to the optimisation of signal settings which generate benefits to certain approaches.

5.4.3 The predicted percentage reduction in average queue length is close to or exceeds 90% at the following locations:

- Preston Road;
- St Ninian's Road;
- St John's Ave;
- A803/Springfield Rd; and
- A706/B8029 Kettil'Stoun Mains Road

5.4.4 Signalising the crossing facility outside the West Port Pub, seems to provide Preston Road and St Ninian's Road with a large reduction in queue, by disrupting the traffic flow, and creating more opportunity for traffic to access the High Street.

5.4.5 The largest absolute change in queue length is forecast at the junction of A803 Linlithgow Bridge/Mill Road, due to signal optimisation, this also has an effect in other areas of the network such as the reduction in queue lengths at A706/B8029 Kettil'Stoun Mains Road roundabout.

5.4.6 Analysis of the queues at the railway bridge on the A706 indicate significant reductions in queues as a result of the optimisation of the signal timings and the signalised crossing outside the West Port Pub.

5.4.7 Another large absolute change in queue length is forecast at the junction of A803/High Port Rd/Blackness Rd as a result of optimising the signals at High Port/B9080 Back Station Road. However, optimising the signals at High Port/B9080 Back Station Road increases the queue length on both approaches of Back Station Road. The High Port queue reduces, this reduction gives operational benefits to the roundabout further north (see Appendix B for more information).

5.4.8 Commentary is provided below on the impact of the mitigation measures when the WFS are present, the following conclusions can be drawn from the analysis.

5.4.9 Generally the mitigation measures provide a reduction in queue lengths, however increases are noted at the following junctions:

- Preston Road (note this is a very small value);
- A803/A706; and
- High Port Rd/Back Station Rd

5.4.10 As for the 'no WFS' analysis, significant improvements are shown at the following junctions:

- A803/Mill Rd;
- A706 Railway Bridge;
- St Ninian's Road;
- St John's Ave;
- A803/High Port Rd/Blackness Rd;
- A803/Springfield Rd; and
- A706/B8029.

5.4.11 The queue reductions shown in the WFS scenario comparison (6E-6C) may not be of the magnitude of the without WFS (6D-6B), as a result of the benefits already incorporated as part of the WFS scenario.

Table 16. Average Queue Length Summary (metres)

Location	6A	6B No WFS	6C WFS	6D No WFS + MP	6E WFS + MP	Change in No WFS (6D-6B)	% Change in No WFS (6D-6B)	Change in WFS (6E-6C)	% Change in WFS (6E-6C)
A803/Mill Rd	561	543	349	254	215	-289	-53%	-134	-38%
A803/Sainsbury's	138	191	111	99	75	-93	-48%	-36	-32%
A803/East Mill Rd	88	116	84	61	57	-55	-47%	-27	-33%
A803/A706	344	281	220	353	252	72	26%	32	15%
A706 Railway Bridge	151	163	119	66	50	-97	-59%	-69	-58%
Preston Road	49	45	11	8	14	-37	-82%	3	30%
St Ninian's Road	274	77	16	8	8	-69	-90%	-7	-47%
St John's Ave	18	15	3	2	2	-14	-90%	0	-15%
A803/High Port Rd/Blackness Rd	507	324	127	90	42	-234	-72%	-85	-67%
High Port/Back Stn Rd	371	451	416	620	472	169	38%	55	13%
A803/Springfield Rd	62	33	10	3	3	-30	-90%	-6	-65%
A706/B8029	120	140	129	8	9	-132	-94%	-120	-93%

5.5 Network Flow Analysis

5.5.1 Analysis has been undertaken to determine the impact of the mitigation measures. Illustrations contained in Appendix C provide an indication of flow change on the modelled network. Where flows from one junction leading in to another junction differ, this provides an indication that traffic is queued. Table 17 below compares the aggregated (in and out of the junction) changes in network flow at the major junctions within the network. The values contained in the table below are made up of combined inbound and outbound traffic volumes.

5.5.2 Analysis shows that when comparing the impact of the mitigation measures large increases in traffic volumes can be achieved by signal optimisation. The comparison of the 'without WFS' shows that throughput at the A706 Railway Bridge can increase by 43%, large absolute increases occur at the junctions of the A706 and B8029 Kettil'Stoun Mains, and at the junction of A803/High Port Rd/Blackness Rd. The roundabout of the A803 High Street and A706 Mains Road also witnesses an increase in vehicle throughput.

5.5.3 The impact of the mitigation measure upon the WFS scenarios indicate general increases in network flows, although not of the same percentage magnitude as the without WFS. The same junctions highlighted above demonstrate the largest percentage increases.

Table 17. Change in Network Flow Summary (vehicles)

Location	6A	6B No WFS	6C WFS	6D No WFS + MP	6E WFS + MP	Change in No WFS (6D-6B)	%Change in No WFS (6D-6B)	Change in WFS (6E-6C)	% Change in WFS (6E-6C)
A803/Mill Rd	2984	2928	3010	3378	3160	450	15%	150	5%
A803/A706	2762	2966	3014	3394	3332	428	14%	318	11%
A706 Railway Bridge	358	351	421	503	524	152	43%	103	24%
Preston Road South of High St	660	656	770	758	778	102	16%	8	1%
St Ninian's Road	2748	3092	3228	3494	3300	402	13%	72	2%
A803/High Port Rd/Blackness Rd	3140	3376	3412	3818	3678	442	13%	266	8%
High Port Rd/Back Stn Rd	1820	1676	1786	1766	1762	90	5%	-24	-1%
A706/B8029	1572	1490	1568	1932	2018	442	30%	450	29%

5.6 Modelling Issues Associated with Network Loading

5.6.1 Table 18 below indicates the number of vehicles unable to load onto the network due to queues extending to the edge of the modelled area. It reveals that with the introduction of the mitigation measures almost all vehicles can be loaded onto the network, on average only 177 vehicles are unable to be loaded. The combination of the WFS and the mitigation measures show that only 144 are unable to load. The mitigation measures indicate that around 60% more unloaded vehicles can now be loaded.

Table 18. Change in Network Flow Loading

Scenario	6A	6B No WFS	6C WFS	6D No WFS + MP	6E WFS + MP	Change in No WFS (6D-6B)	% Change in No WFS (6D-6B)	Change in WFS (6E-6C)	% Change in WFS (6E-6C)
	539	492	324	177	144	-315	-64%	-180	-56%

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 The mitigation measures have been modelled on their existing junction layout, and we have amended the cycle timings and stages of operation to get the junctions to operate at their fullest capacity.

6.1.2 The performance of the Linlithgow Town Centre model is predicted to improve significantly with the addition of the mitigation packages, benefits are shown in terms of reduced delays, higher vehicle speeds and journey time savings. However there would still be residual traffic issues that would need to be addressed at various key junctions within the town centre. The mitigation measures are affected by the physical conditions imposed by the junction layouts, railway bridges in addition to the canal crossing which only allow one way flow at a time, have a detrimental impact of the performance of the network.

6.2 Recommendations

6.2.1 Within this consideration of mitigation measures, it may be advisable to undertake more consideration of active modes of travel, such as pedestrian and cyclists.

6.2.2 It would also be useful to consider the impact which the predicted changes in traffic patterns would have on emissions and air quality within the town centre. This would be facilitated by the inclusion of additional modelled time periods.

6.2.3 The mitigation packages have been reviewed within the AM Peak, with scope existing to determine their appropriateness in other time periods.

6.2.4 Pedestrian facilities have an effect on traffic signal operation. Given these constraints in addition to the traffic levels, it may be worthwhile looking into pedestrian usage and whether some signal can run 'double-cycled' but without the second pedestrian stage.

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Appendix A – Model Development Report, August 2014

MODEL REPORT

LINLITHGOW DEVELOPMENT PLAN

LINLITHGOW VISSIM MODEL

IDENTIFICATION TABLE	
Client/Project owner	West Lothian Council
Project	Linlithgow Development Plan
Title of Document	Linlithgow VISSIM Model
Type of Document	Model Report
Date	29/08/2014
Reference number	102529
Number of pages	22

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1. LINLITHGOW VISSIM MODEL

1.1 Introduction

1.1.1 This document provides commentary on the development of the Linlithgow VISSIM Model and reports on the predicted impacts of a number of developments upon the town centre.

1.1.2 Within this document we have set out the following topics:

- model inputs;
- methodology; and
- model analysis.

1.2 Background

1.2.1 As part of recent work undertaken using the South East of Scotland Transport Partnership (SEStran) Regional Transport Model (SRM) to appraise the West Lothian Local Development Plan, a number of transport impact issues were identified in Linlithgow. As a consequence, West Lothian Council (WLC) required more detailed analysis to be undertaken in the Linlithgow area to appraise local development and the potential impact on the transport network. As the SRM is a strategic transport and demand model of the whole of the SEStran area, it was agreed that a more detailed micro-simulation model (using VISSIM software) of the Linlithgow area would be required to be developed to enable such an appraisal.

1.2.2 VISSIM (version 6.00-15) was used to create the micro-simulation model of Linlithgow. The following streets were included in the model development:

- A803 West towards the M9;
- Mill Road (linking to A706);
- A706 St Ninian's Road;
- A803 East towards the M9 Junction 3;
- B9080 towards Kingscavil;
- Manse Road;
- Friars Brae/Friars Way;
- Preston Road;
- A706 Mains Road; and
- B825.

1.2.3 In addition to the streets noted above, some of the smaller residential streets were also represented in the model to provide road users with an appropriate choice of routes. This allowed us to determine if road users are using these roads depending on the level of development being modelled.

1.2.4 Figure 1 illustrates the modelled area where green links highlight the road links represented in the VISSIM model.

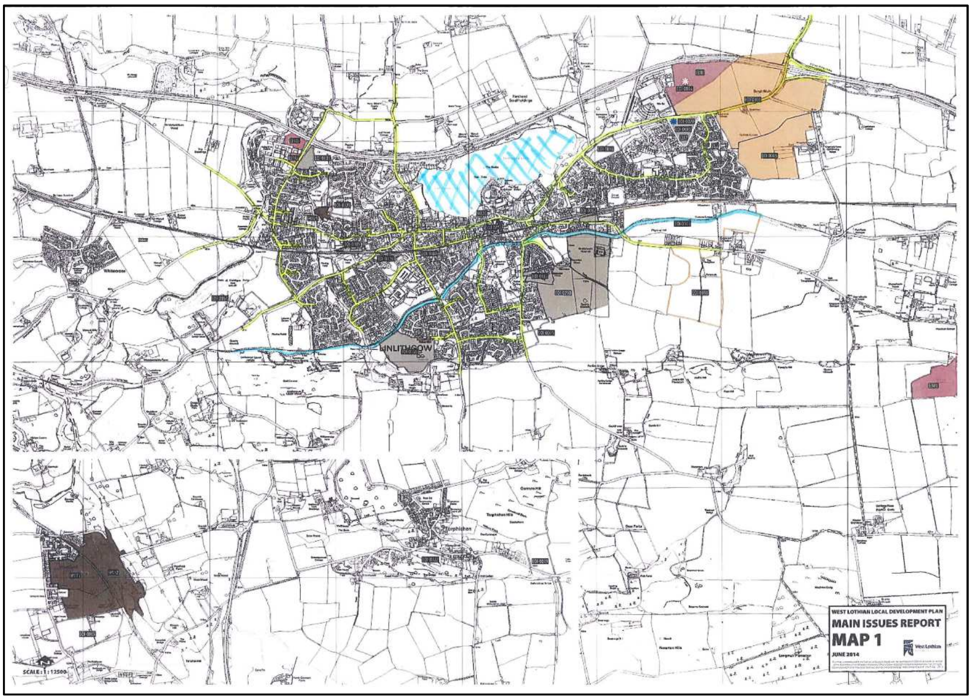

Figure 1. Model Area

1.3 Model Inputs

1.3.1 We have utilised the following data in the production of the VISSIM model:

- aerial photography (built in with VISSIM); and
- junction and network inventories, including photographic records.

1.3.2 West Lothian Council provided traffic signal information for the following locations:

- Mill Road/Main Street;
- Sainsbury's/Main Street;
- Aldi/Falkirk Road;
- High Port/Back Station Road; and
- St Michaels Hospital/Edinburgh Road.

1.3.3 Further points to note in relation to model inputs:

- where traffic signals exist for single lane roads, we have assumed traffic signal settings;
- given the urban nature of pedestrian crossings in Linlithgow, it is assumed that pedestrian crossings will be called every cycle; and
- WLC informed of limited use of Mill Road pedestrian facilities. We have incorporated this accordingly into the model.

1.3.4 Information on speed limits in the network area was collected. Using these data, speed distributions were defined in the model for each speed restriction and vehicle type.

1.3.5 Bus services in the modelled network are coded as fixed route services with designated start times and a frequency. A comprehensive review of all public bus services in the model area was undertaken using timetable data. As no data was available for the amount of time buses remained at bus stops, we have assumed VISSIM global parameters for each of the stops.

1.3.6 Parking provisions have been taken into consideration in terms of cars parked on nearside lanes to reduce the capacity of two lane approaches to junctions. Actual parking spaces are not modelled. Car parks within Linlithgow are modelled as 'zones', allowing traffic to enter and exit the network.

1.3.7 The model covers the AM Peak hour (08:00 – 09:00) as this is the only peak for which data were available. The model development programme did not allow for a comprehensive data collection exercise, therefore we have used existing traffic counts from a variety of sources as illustrated in Figure 2 below.

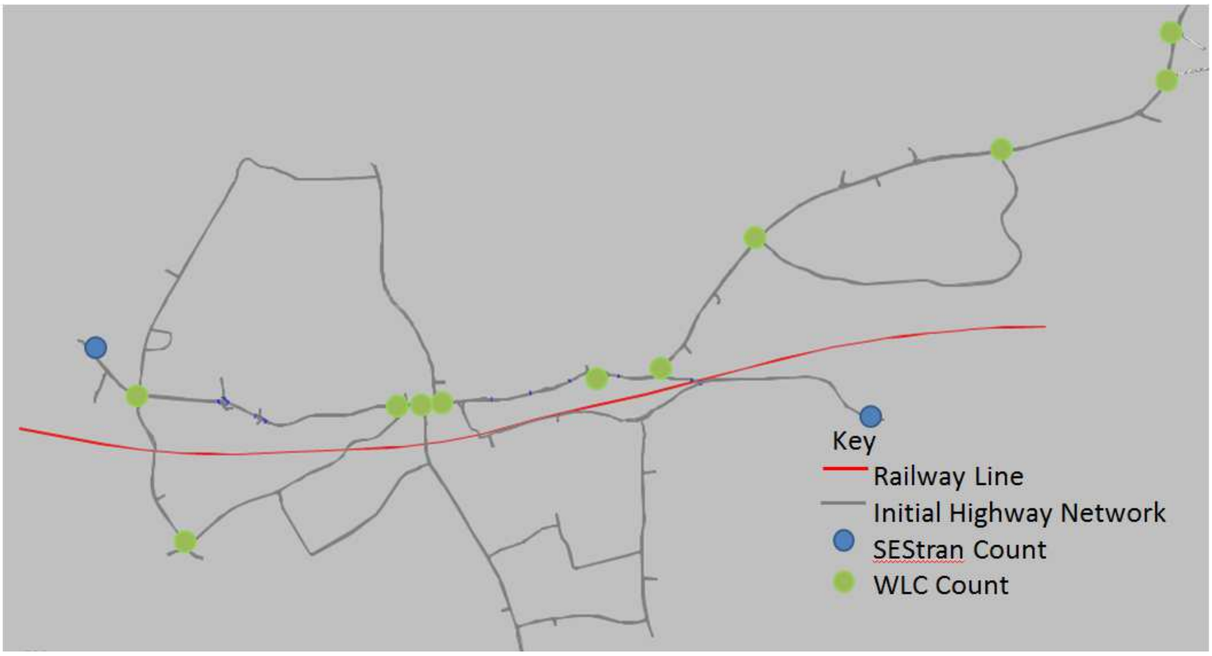

Figure 2. Traffic Counts

1.4 Methodology

1.4.1 Using the data above, a spreadsheet based routing tool was created to determine turning count proportions to represent traffic routing from housing estates. A zone system was created based on the model extent and populated with cars/light goods vehicles, light and heavy goods vehicle matrices from the traffic counts. VISSIM automatically uses the following split for traffic: 98% Cars/Lights and 2% HGVs. We have assumed this to be representative of current traffic conditions within the town centre.

1.4.2 Traffic matrices were prepared using the available count data. The traffic counts vary by year and by type of count, therefore using West Lothian specific traffic growth records, we normalised all count data to a common base year of 2014.

1.4.3 Dynamic assignment was used to allow vehicle route choice. In order to model the variation in daily traffic, each model time period was assigned 10 times, with an average taken through to the results stage.

1.4.4 The models incorporate a preload period of 15 minutes, which facilitates a robust representation of traffic conditions at the beginning of the peak hour.

2. MODEL CALIBRATION AND VALIDATION

2.1 Calibration Criteria

2.1.1 The criteria set out in the Design Manual for Roads and Bridges (DMRB) Volume 12, Section 2, Part 1 Chapter 4 were used when evaluating the model. The DMRB criterion makes use of the GEH summary statistic, which is defined as:

$$GEH = \sqrt{\frac{(observed - modelled)^2}{0.5 * (observed + modelled)}}$$

2.1.2 In order to calibrate the model the automatic traffic surveys were used, and Table 2 summarises the required DMRB criteria.

Table 1. Calibration Criteria

	GEH <5	GEH <7	GEH <10	Flows within 100 for less than 700vph	Flows within 15% for flows 700 – 2700vph
DMRB Criteria	>85%	n/a	n/a	>85%	>85%

2.2 Model outputs

2.2.1 The following model outputs are summarised to provide information as to the performance of the network:

- Key performance indicators:
  - Average delay time per vehicle [s];
  - Average number of stops per vehicles;
  - Average speed [km/h];
  - Average stopped delay per vehicle [s];
  - Total Distance Travelled [km];
  - Total travel time [s];
  - Total delay time [s];
  - Number of Stops;
  - Total stopped delay [s];
  - Number of vehicles in the network;
  - Number of vehicles that have left the network; and
  - Total Vehicles loaded.
- Journey Time Route Analysis;
- Queue Length Analysis; and
- Network Flow Analysis.

2.3 Link Flow Statistics

2.3.1 Table 2 summarises the link flow comparisons for all traffic flows and compares them against the DMRB criteria. The results indicate that the DMRB criteria for all vehicle classes have been fully satisfied.

2.3.2 Closer inspection of the link flow comparisons demonstrate that the modelled flows are well matched to observed data throughout the modelled area. At a number of locations where the observed counts and modelled traffic flows differ, this can sometimes be attributed to variations in traffic count data at adjacent junctions. As a result of the matrix creation process whereby different data sources were used, we are unable to exactly match the link counts used in the calibration process.

2.3.3 In reviewing the model, we believe that it meets the general perception of how traffic Linlithgow generally operates on an average morning peak, and as a result we conclude that the model is appropriate to proceed to testing the proposed development scenarios. Appendix A contains a list of all observed count and modelled flow comparisons.

Table 2. Link Flow Calibration Summary

	GEH <5	GEH <7	GEH <10	Flows within 100 for less than 700vph	Flows within 15% for flows 700 – 2700vph
DMRB Criteria	>85%	n/a	n/a	>85%	>85%
AM Peak					
Total	87%	96%	100%	97%	100%

2.4 Key Performance Indicators

2.4.1 In order to quantify overall network performance, key indicators are extracted from the model. Table 3 below summarises the overall network conditions. Key performance indicators are derived from an average of the 10 assignments, therefore average conditions are shown. The parameters contained in Table 3 are used to assess the planned development test scenarios.

Table 3. Key Performance Indicatory Summary

Parameter	Base
Average delay time per vehicle [s], All Vehicle Types	133
Average number of stops per vehicles, All Vehicle Types	3
Average speed [km/h], All Vehicle Types	23
Average stopped delay per vehicle [s], All Vehicle Types	78
Total Distance Travelled [km], All Vehicle Types	8,990
Total travel time [s], All Vehicle Types	1,417,244
Total delay time [s], All Vehicle Types	677,888
Number of Stops, All Vehicle Types	15,625
Total stopped delay [s], All Vehicle Types	396,829
Number of vehicles in the network, All Vehicle Types	448
Number of vehicles that have left the network, All Vehicle Types	4,640
Total Vehicles Loaded	5,088

2.5 Journey Time Analysis

2.5.1 Modelled end-to-end journey time measurements are reported in Table 4 below. The journey times contained in Table 4 are then used to assess the planned development test scenarios.

Table 4. Journey Time Summary (seconds)

Route	AM
A803 Linlithgow Bridge to A803 M9 J3	649
A803 M9 J3 to A803 Linlithgow Bridge	663
A706 St Ninian's Rd to A706 Mains Road	321
A706 Mains Road to A706 St Ninian's Rd	566
B825 to St Michael's Hospital	604
St Michael's Hospital to B825	575

2.6 Queue Lengths

2.6.1 Queue length analysis has been undertaken at 36 locations on approaches to salient junctions across the model. An aggregated summary for each main junction is reported in Table 5 below. Appendix B contains further information regarding queue lengths.

Table 5. Average Queue Length Summary (meters)

Location	Queue
A803/Mill Rd	296
A803/Sainsbury's	75
A803/East Mill Rd	73
A803/A706	245
A706 Railway Bridge	77
Preston Road	1
St Ninian's Road	15
St John's Ave	1
A803/High Port Rd/Blackness Rd	22
High Port Rd/Back Stn Rd	98
A803/Springfield Rd	2
A706/B8029	26

3. DEVELOPMENT SCENARIOS

3.1.1 As identified within previous email correspondence (Scenarios for Transport Testing in Linlithgow V3 29 January 2014), seven development scenarios for the forecast year of 2024 were prepared by adding them to the base year as follows:

- Scenario 1a - All sites within the Linlithgow/Linlithgow Bridge settlement boundary;
- Scenario 2a (+1a) – Sites closer to Linlithgow Town Centre and Rail station;
- Scenario 3a (+1a) – Western Expansion Options;
- Scenario 4a (+1a) – Eastern Expansion Options;
- Scenario 5a (+1a) - Southern Expansion Options;
- Scenario 6a (+1a) - Southern Expansion Options; and
- Scenario 7 (+1a) – Combination of Southern and Eastern Expansion Options.

3.1.2 Development scenario loading maps are provided in Appendix C. They illustrate the VISSIM network with loading points used to add the development traffic.

3.2 Matrix Totals

3.2.1 TRICS database was used to determine the level of car usage associated with the housing locations. Average trip rates were obtained for the AM Peak period, leading to the following values being used:

Arrival (Destination) Trip Rate 0.133; and

Departure (Origin) Trip Rate 0.480.

3.2.2 The trip pattern of the new development sites is based on an existing trip pattern of a similar area within the model, using the existing zone loading points. Trips from the new development sites are assessed to determine their loading points onto the network and added to the existing model matrices.

3.2.3 Background traffic growth has been assumed to be a 10% uplift based on SESplan SDP Modelling from the SEStran Regional Model (SRM). This uplift has been reduced from its original value of 15%, as it was perceived that it would have already included some of the developed associated with the development scenarios. We have assumed that developments will be completed by 2024, therefore background growth has been applied to represent this year.

3.2.4 Table 6 below provides an indication of the total number of trips loaded onto the network as a result of the development scenarios. Note that the values contained in Table 6 differ from those in table 3 (Key Performance Indicators), as this table does not include preload traffic.

Table 6. Development Scenario Traffic Levels

Model	Traffic
Calibrated Base	4,875
Scenario 1a	5,540
Scenario 2a	5,799
Scenario 3a	5,773
Scenario 4a	5,846
Scenario 5a	5,759
Scenario 6a	5,892
Scenario 7a	6,211

3.3 Key Performance Indicators

3.3.1 Using the same key performance indicators as used previously, Table 7 compares the results of all development scenarios in comparison to the base.

3.3.2 Overall, the results of all scenarios predict:

- an increase in delay;
- a reduction in average speed;
- an increase in number of stops made by vehicles; and
- increased travel times.

3.3.3 The following comments can be drawn from the results:

- Average delay time per vehicle increases the most in scenario 6a by 133%. All other scenarios indicate increases associated with the additional traffic, however scenario 7a exceeds an increase of 100%.;
- Analysis of the average number of stops per vehicle shows that scenarios 6a and 7a will be the worst performing, which is consistent with the average delay time;
- Average speed decreases across all scenarios when compared to the base model, again scenarios 6a and 7a demonstrate the largest reductions.;
- Average stopped delay per vehicle increases in all scenarios, with the largest increase from scenario 6a, which indicates an increase of 182%. Other scenarios which exceed 100% increases are scenarios 7a and 4a.;
- Total Distance Travelled generally increases across all scenarios with growth expected up to 8% for scenarios 1a, 2a, and 7a. Scenario 6a provides a minor reduction indicating issues with queuing.;
- Total travel time is an indicator to demonstrate the length of time it take for journey to be completed. The results show that increases are expected across all scenarios. However, scenarios 6a and 7a both increase in the magnitude of 70%.;

- Analysis of Total delay time shows consistency with total travel time in that scenarios 6a and 7a indicate delays exceeding 140%.;
- The Number of Stops is shown to increase over all scenarios, however scenario 7a indicates the greatest increase of 111%.;
- Results for Total stopped delay shows that scenario 6a has the greatest increase of 190%. The results for this indicator are consistent with the results obtained for the average stopped delay per vehicle. All scenarios with the exception of scenario 1a show increase exceeding 100%.;
- The Number of vehicles in the network is a key indicator for traffic still routing to their destination, the results show that scenario 6a has the largest number, backing up previous issues identified with queuing and delay.;
- The number of vehicles that have left the network is another key indicator determining the amount of vehicles that have finished their journey. The results demonstrate that scenario 6a although shows an increase in journeys being completed, the increase is the smallest of all scenarios.;
- The Total Vehicles Loaded onto the network is calculated by summing the number of vehicles that are still in the network at the end of the model time period and the number that have left the network. This shows that scenario 7a has the highest amount of traffic being loaded onto the network, which also provides a reason as to why the performance indicators for this scenario demonstrate the largest increase. Scenario 6a also demonstrated increases in delay. However, the amount of traffic being loaded is not as high as scenario 7a or other scenarios. This indicates that the pattern of traffic being loaded onto the network results in network performance issues;
- VISSIM provides an error file which notifies the user if traffic cannot access the network, for example traffic cannot load due to delays. All scenarios indicate that some traffic is unable to load onto the network during the modelled time period.

Table 7. Key Performance Indicatory Change Summary

Parameter	Base	1a	2a	3a	4a	5a	6a	7a
Average delay time per vehicle [s], All Vehicle Types	133	38	100	87	110	100	**178**	140
Average number of stops per vehicles, All Vehicle Types	3	1	**2**	1	1	**2**	**2**	**2**
Average speed [km/h], All Vehicle Types	23	3	7	6	6	7	**9**	8
Average stopped delay per vehicle [s], All Vehicle Types	78	25	65	61	93	70	**142**	93
Total Distance Travelled [km], All Vehicle Types	8,990	733	682	572	400	567	**28**	730
Total travel time [s], All Vehicle Types	1,417,244	352,755	742,645	619,947	711,463	703,261	987,007	**1,017,527**
Total delay time [s], All Vehicle Types	677,888	294,366	689,436	574,856	694,912	656,542	**997,632**	970,596
Number of Stops, All Vehicle Types	15,625	5,805	12,864	9,369	7,909	11,153	14,009	**17,355**
Total stopped delay [s], All Vehicle Types	396,829	186,582	438,255	394,857	549,571	452,678	**752,167**	629,154
Number of vehicles in the network, All Vehicle Types	448	176	327	260	393	275	**519**	444
Number of vehicles that have left the network, All Vehicle Types	4,640	426	439	339	329	367	**75**	528
Total Vehicles Loaded	5,088	602	766	599	722	642	594	**972**

3.4 Journey Time Analysis

3.4.1 Figure 3 below, provides an illustration of the journey time routes used in the analysis.

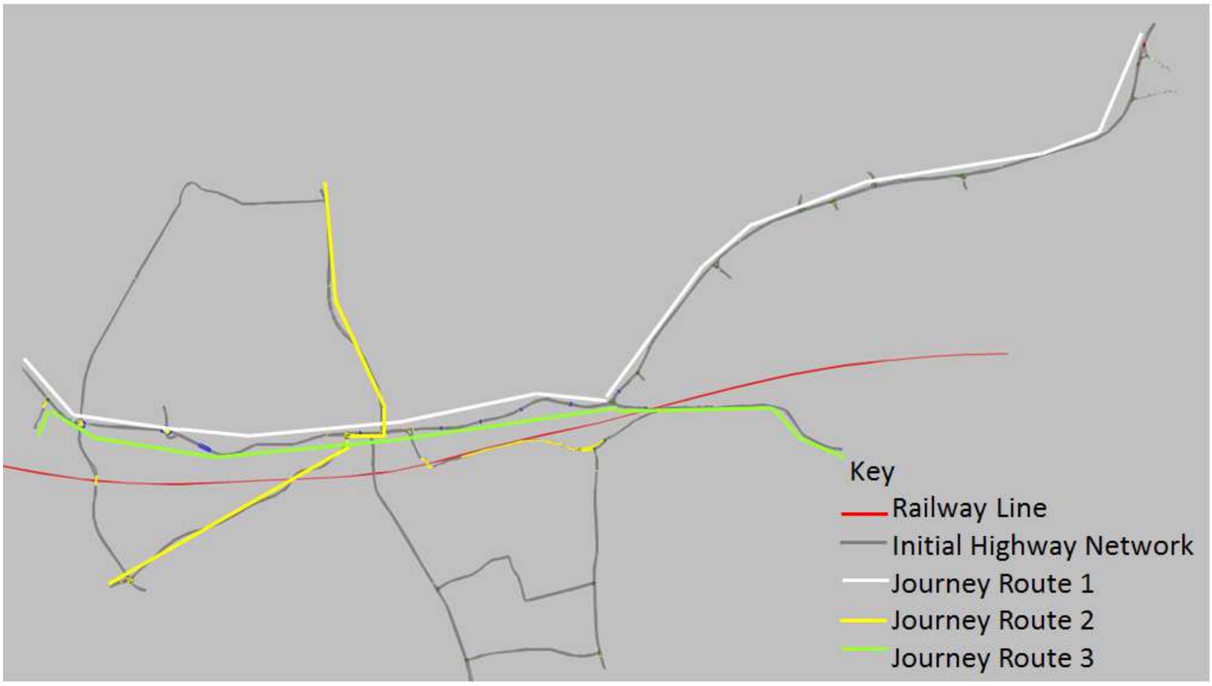

Figure 3. Traffic Counts

3.4.2 Table 8 compares the journey time route results of all development scenarios.

Table 8. Change in Journey Time Summary (seconds)

Route	Base	Scenario 1a	Scenario 2a	Scenario 3a	Scenario 4a	Scenario 5a	Scenario 6a	Scenario 7a
A803 Linlithgow Bridge to A803 M9 J3	649	-46	155	12	-11	91	141	176
A803 M9 J3 to A803 Linlithgow Bridge	663	52	100	126	132	23	276	229
A706 St Ninian's Rd to A706 Mains Road	321	-6	27	114	121	33	121	55
A706 Mains Road to A706 St Ninian's Rd	566	393	104	157	217	355	185	581
B825 to St Michael's Hospital	604	57	141	31	50	163	193	299
St Michael's Hospital to B825	575	74	154	137	159	145	220	62

3.4.3 Analysis of the journey time routes are discussed below:

- A803 Linlithgow Bridge to A803 M9 J3 – generally shows increase in journey time, however scenarios 1a and 4a both indicate minor decreases. It is assumed that the change of traffic patterns in these scenarios provides small journey time benefits. Where increases in journey times are noted, scenarios 2a, 6a and 7a are the largest.;

- A803 M9 J3 to A803 Linlithgow Bridge – Increases in journey times are predicted for all scenarios, with 6a being the highest of 42%.;
- A706 St Ninian's Rd to A706 Mains Road – general increases in journey are indicated, with only a minor reduction in scenario 1a. Where increases are noted, scenarios 3a, 4a and 6a are consistent with increase of around 38%.;
- A706 Mains Road to A706 St Ninian's Rd – increases are predicted for all scenarios, the highest increase in scenario 7a of 103%. Scenarios 1a and 5a also demonstrate increases in excess of 60%.;
- B825 to St Michael's Hospital – this route duplicates the main route through Linlithgow as the first route, however it branches off to the B9080. All scenarios show increases, with scenarios 7a providing the largest increase in journey time of 50%.; and
- St Michael's Hospital to B825 - increases are predicted across all scenarios, however scenario 6a indicates the largest increase of 38%.

3.5 Queue Lengths

3.5.1 Table 9 provides a comparison of the aggregated queue lengths at key junctions throughout the network. Appendix B provides a detailed breakdown of queues on approaches, the analysis discussed below takes the whole junction into consideration. Queue length analysis, comparing the base with the future year scenarios, provides the following key points:

- A803 Main Street/Mill Road – this junction indicates substantial increase in queue lengths across all scenarios, with the largest increase in scenario 7a (104%). Other noticeable increases occur in scenarios 5a and 6a, around 90%.;
- A803/Sainsbury's – increases in queue lengths are predicted for this junction, scenario 7a illustrates an increase of 206%. Scenario 5a also provides a significant increase on 195%.;
- A803/East Mill Rd - increases in queue lengths are predicted for this with scenarios 3a, 5a and 7a all being consistent around 60%.;
- A803/A706 – largest increase is predicted in scenario 6a of 41%.;
- A706 Railway Bridge – substantial increase in queuing are predicted in all scenarios, with scenario 2a showing increases of 170%.;
- The approach of Preston Road to the High Street shows increases in queuing from a relatively low queue in the base with scenarios 4a and 6a indicating the largest percentage growths.;
- The approach of St Ninian's Road to the High Street shows that scenarios 4a and 6a provide the largest increases from a low level of queuing in the base model. Scenario 1a shows a minor reduction of -15%.;
- The dual approach of St John's Ave to the High Street show that scenarios 4a and 6a provide the largest increases.;
- A803/High Port Rd/Blackness Rd – this roundabout demonstrates large increases in traffic, particularly in scenarios 6a and 7a.;
- High Port Rd/Back Stn Rd – these signals indicate that scenarios 5a and 7a will increase the largest when compared with the base model.;
- A803/Springfield Rd – this roundabout rarely has much of a queue in the base model and most scenarios, however the introduction of scenarios 6a and 7a

indicate that significant increase in queuing will develop.; and

- A706/B8029 – All scenarios indicate increase in queuing traffic, with scenario 3a showing the largest increase.

Table 9. Aggregated Change in Queue Length Analysis (meters)

Route	Base	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
A803/Mill Rd	296	78	190	167	211	260	265	307
A803/Sainsbury’s	75	46	121	87	36	146	63	154
A803/East Mill Rd	73	16	28	44	26	47	16	43
A803/A706	245	22	83	12	25	6	100	45
A706 Railway Bridge	77	65	132	73	57	70	74	52
Preston Road	1	3	4	17	43	11	48	10
St Ninian’s Road	15	-2	16	19	87	0	259	51
St John's Ave	1	1	1	2	22	2	17	7
A803/High Port Rd/Blackness Rd	22	143	382	235	337	220	485	610
High Port Rd/Back Stn Rd	98	104	302	163	109	363	273	399
A803/Springfield Rd	2	2	7	1	24	1	60	61
A706/B8029	26	10	44	172	130	115	94	106

3.6 Network Flow Analysis

3.6.1 Analysis has been undertaken to determine the change in average flows between the 2024 development scenarios and the 2014 base model. Illustrations contained in Appendix D provide an indication of flow change on the modelled network. Where flows from one junction leading in to another junction differ, this provides an indication that traffic is queued. Table 10 below compares the aggregated changes in network flow at the major junctions within the network. The values contained in the table below are made up of combined inbound and outbound traffic volumes. Some key points to note are:

- The junction of High Port and Back Station Rd demonstrates the highest increase due to development traffic. Preston Road also demonstrates an increase in traffic levels.;
- A803/Mill Road – general increase in traffic in all scenarios with the exception of scenario 4a. The traffic flow at this junction increases as a result of additional development traffic generated from the northern section of Mill Road.;
- A803/A706 Mains Road – general increase in traffic with the exception of scenarios 4a and 6a. The reduction is primarily due to lower levels of traffic routing along High Street.;
- The signals on the A706 at the Railway Bridge show a pattern of reduced traffic flow primarily due to queuing, a pattern which is a characteristic in all development scenarios. The primary reason for the reduction in modelled volume is attributed to the increase in queuing traffic at this area, particularly routing northbound to the A803 High Street.;
- Traffic levels on Preston Road generally increase, particularly in the northbound direction in most scenarios. This is primarily due to the prediction of development traffic using this road to travel west and potentially route using the U-turn facility of the roundabout in close proximity on High Street. Scenario 4a demonstrates a reduction in flow, again highlighting potential issues on High Street.;
- St Ninian’s Road junction with High Street generally demonstrates an increase in traffic levels, with the exception of scenarios 4a and 6a. These scenarios have been noted previously as having a lower flow in areas of the network linked to an increase in queueing.;
- The roundabout junction of the A803 and High Port demonstrates an increase in traffic levels. Scenario 4a demonstrates minimal change, whereas scenario 6a shows a reduction in flow. Both of these scenarios have previously indicated issues with increased queuing.;
- The signalised junction of High Port and Back Station Road indicates increases in traffic volume in all scenarios, particularly 4a and 6a. This increase suggests that increased traffic at this location in these two scenarios affects the performance of the network along the High Street.; and
- The roundabout of the A706 and B8029 experiences a reduction in traffic levels in all scenarios with the exception of scenario 1a. This junction is particularly susceptible to delays from the junction at the A706 Railway Bridge and A803 Mill Road.

Table 10. Change in Network Flow Summary (vehicles)

Location	Base	Scenario 1a	Scenario 2a	Scenario 3a	Scenario 4a	Scenario 5a	Scenario 6a	Scenario 7a
A803/Mill Rd	2868	7%	4%	5%	-1%	7%	4%	7%
A803/A706	3032	7%	8%	6%	-9%	7%	-9%	4%
A706 Railway Bridge	451	-2%	-8%	-22%	-16%	-16%	-21%	-16%
Preston Road South of High St	659	6%	11%	13%	-7%	7%	0%	6%
St Ninian’s Road	3196	7%	9%	6%	-6%	5%	-14%	2%
A803/High Port Rd/Blackness Rd	3474	9%	8%	7%	0%	9%	-10%	3%
High Port Rd/Back Stn Rd	1669	14%	14%	14%	5%	16%	9%	16%
A706/B8029	1710	2%	-4%	-13%	-11%	-9%	-8%	-10%

4. CONCLUSIONS AND RECOMENDATIONS

4.1 Model Performance

4.1.1 The VISSIM model has been created with limited and mixed source traffic count data with infilling undertaken to create a matrix based on a broad zone system and for a road network which is broadly representative of key road links in and around Linlithgow Town.

4.1.2 The model meets DMRB criteria, but a case can be made for more data to be gathered (for example classified traffic counts, queue lengths and actual journey time recordings) to further improve the model. This would have allowed the model to be created with more confidence in the data inputs and permitted the ability to more robustly model traffic patterns.

4.2 Conclusions and Recommendation

4.2.1 The road network can broadly accommodate the extra traffic associated with background traffic growth and development traffic. However, specific and local issues do exist in terms of increased journey times, delays and queues. **The network performance statistics highlight that development plan scenarios 6a and 7a show the highest level of predicted disbenefit (eg delays\queues) to vehicles.** It is also important to note that the number of vehicles loaded onto the network is highest in scenario 7a as this includes a combination of Southern and Eastern Expansion Options with respect to the development plan scenario.

4.2.2 Linlithgow Town centre is a constrained section of urban roads whereby the addition of developments will have an impact upon the roads user's ability to route around the town centre.

4.2.3 The corridor between the Low Port Roundabout and the junction of St Ninian's Road/High Street is a key route through the town centre. **The model results indicate that Scenario 1a will have less of an impact over the entire modelled area.** The benefits of this scenario are demonstrated by having the least impact in terms of average delay per vehicle (38s) and the smallest increase in average speed (3km/h) when compared with the calibrated base model.

4.2.4 Analysis of the journey times demonstrates that scenario 1a provides the least amount change in travel times throughout the network. Although we have not extracted segmented journey time analysis for the key area described above, Routes 1 and 3 both cover the area in question. Route 1 eastbound indicates a reduction in journey time of 7%, whereas the westbound route only increases by 8%. Analysis of Route 3 shows an eastbound increase of 9%, whereas westbound noted a 13% increase when compared to base times.

4.2.5 Queue length analysis has been undertaken at five locations along the key corridor. Scenario 1a indicates the least impact in terms of additional queuing at these junctions, minimal increases are noted at Preston Road, St Ninian's Road and St John's Avenue with the A803. Low Port roundabout demonstrates a predicted increase in queuing traffic. However, it is the lowest increase of all scenarios. In terms of traffic routing along this corridor, eastbound increases are noted coming from St Ninian's Road turning left on the High Street and routing through the town centre. This is partially as a result of the development located to the west of Linlithgow. Analysis of the westbound direction demonstrates a predicted increase in traffic coming from High Port and Blackness Road routing the town centre to Linlithgow Bridge. Appendix D provides a more detailed analysis of the traffic flows.

4.3 Next Steps

4.3.1 Should a decision be made regarding the most likely development plan scenario to be taken forward, an investigation could be undertaken to determine potential mitigation measures to enhance the performance of the network.

APPROVAL

Version	Name		Position	Date	Modifications
1	Author	Grant Paterson	Senior consultant	29/05/2014	Final Report
	Checked by	Scott Leitham	Managing Consultant	29/05/2014	
	Approved by	Kevin Lumsden	Project Director	27/08/2014	
2	Author			DD/MM/YY	
	Checked by			DD/MM/YY	
	Approved by			DD/MM/YY	

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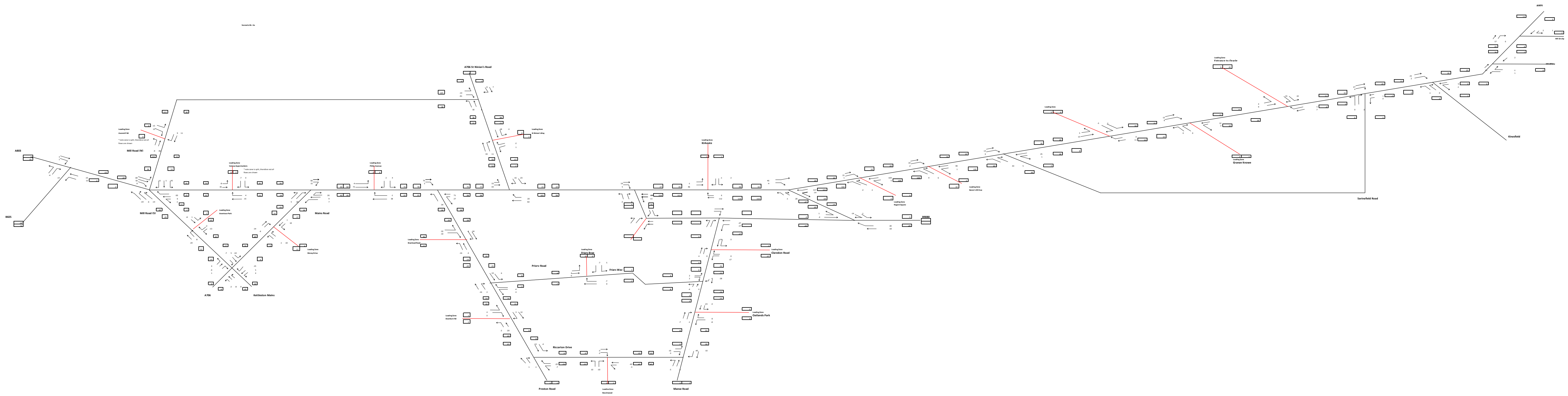
SYSTRA

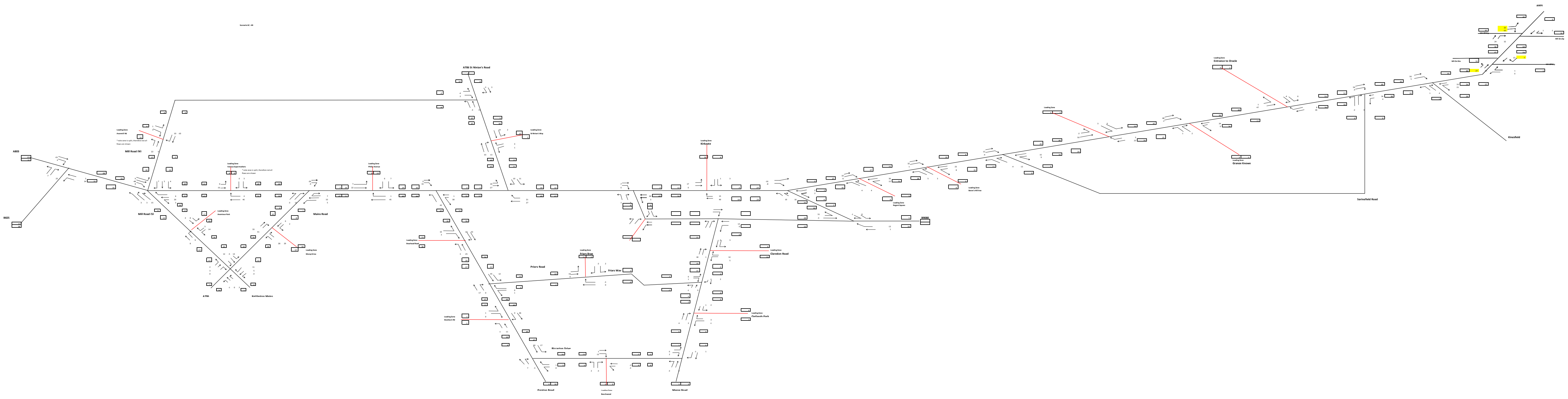
Appendix B – Queue Lengths

	scenario 6A			scenario 6B			scenario 6C			scenario 6D			scenario 6E		
Location	QLEN	QLENMAX	QSTOPS	QLEN	QLENMAX	QSTOPS	QLEN	QLENMAX	QSTOPS	QLEN	QLENMAX	QSTOPS	QLEN	QLENMAX	QSTOPS
A803 e/b to Mill Rd	88	243	727	111	278	854	32	176	453	48	205	682	18	120	399
Mill Rd s/b to A803	250	432	909	240	435	1053	120	289	719	43	177	590	18	95	331
A803 w/b to Mill Rd (R/t)	41	205	497	22	168	295	25	199	353	11	125	237	14	144	269
A803 w/b to Mill Rd	41	206	496	22	168	292	26	199	352	11	125	233	14	144	265
Mill Road n/b to A803	142	202	623	148	206	589	145	201	608	141	206	1295	151	213	1398
A803 e/b to Sainsburys	104	282	748	153	332	1090	83	307	788	84	319	936	60	287	736
Sainsbury	6	35	48	5	30	45	3	28	49	4	31	61	4	26	56
A803 w/b to Sainsburys	22	130	288	29	148	321	22	141	297	7	72	102	10	94	131
Lidl	6	26	52	4	22	39	3	19	42	3	21	45	2	25	46
A803 e/b to E Mill Rd	55	162	482	62	162	567	49	162	531	39	163	471	32	162	392
E Mill Rd	4	27	90	4	21	92	4	26	94	4	21	96	4	27	92
Retail Park	2	10	28	3	16	28	2	10	27	2	16	32	3	16	31
A803 w/b to E Mill Rd	27	149	357	47	210	475	29	151	392	17	110	287	19	117	323
A803 e/b to A706	85	318	630	74	336	726	30	225	523	122	470	1579	34	237	836
A803 w/b to A706	86	174	343	55	144	378	44	94	361	53	177	885	55	226	977
A706	173	244	290	152	221	221	146	219	248	179	273	519	163	268	500
A706 s/b Signal at Railway	15	70	130	14	73	143	6	70	130	4	45	144	4	51	156
A706 n/b Signal at Railway	136	378	460	149	327	379	113	263	378	62	197	410	45	196	356
Preston Rd	49	161	174	45	190	243	11	122	205	8	88	284	14	129	339
A706 St Ninian's Rd LT	137	442	366	38	166	158	7	97	91	4	41	100	4	56	85
A706 St Ninian's Rd RT	137	442	353	39	166	158	8	97	93	4	41	99	5	56	92
St John's Ave LT	1	8	9	0	10	12	0	8	10	0	6	9	0	7	9
St John's Ave RT	17	82	58	15	65	57	3	42	53	2	26	65	2	32	64
A803 e/b	223	469	2847	107	411	1245	44	260	633	38	309	865	14	201	492
Blackness Rd	258	509	1585	185	478	1655	67	337	727	45	386	802	17	172	470
High Port	26	138	376	33	153	411	16	126	363	7	78	321	11	100	387
High Port	76	156	578	70	158	491	55	158	433	53	157	517	43	157	439
Back Stn Rd w/b	44	151	216	38	117	152	20	109	150	150	284	788	136	248	761
Back Stn Rd e/b	251	420	1179	343	465	1618	342	480	1685	417	506	2128	292	482	1673
A803 e/b	0	41	8	0	18	6	0	12	5	0	15	5	0	9	6
A803 w/b	46	209	200	27	88	125	7	88	122	1	31	125	1	38	133
Springfield Rd	16	56	190	5	40	162	3	41	164	2	49	183	2	45	184
A706 e/b	19	67	174	19	62	160	19	62	179	2	29	144	1	27	137
B8029 s/b	10	98	102	9	74	79	5	76	91	1	46	87	1	55	99
A706 e/b	74	223	169	95	262	241	86	299	273	4	134	86	4	112	98
Kettl'ston Mains	17	53	113	18	52	84	19	54	94	2	38	99	2	44	107

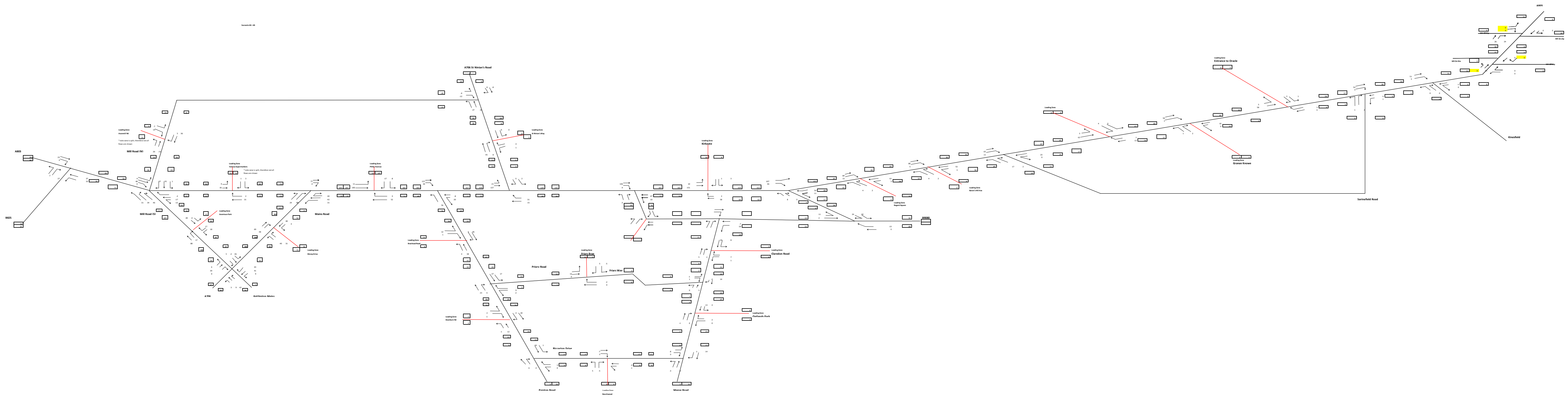
Appendix C – Network Flow Change


Scenario 6b - 6a
A706 St Ninian's Road
Loading Zone
Avonmill Rd
* note zone is split, therefore not all flows are shown
Mill Road (N)
A803
B825
Loading Zone
Various Supermarkets
* note zone is split, therefore not all flows are shown
Loading Zone
Philip Avenue
Loading Zone
St Ninian's Way
Mill Road (S)
Loading Zone
Avontoun Park
Mains Road
Loading Zone
Moray Drive
A706
Kettleston Mains
Loading Zone
Braehead Road
Priory Road
Loading Zone
Friars Brae
Friars Way
Loading Zone
Deanburn Rd
Riccarton Drive
Preston Road
Loading Zone
Beechwood
Manse Road
Loading Zone
Kirkgate
Loading Zone
Claredon Road
Loading Zone
Oatlands Park
Loading Zone
Regent Square
Loading Zone
Baron's Hill Ave
B9080
Loading Zone
Entrance to Oracle
Loading Zone
Grange Knowe
Springfield Road
Kingsfield
A803
M9 On slip
M9 Off slip

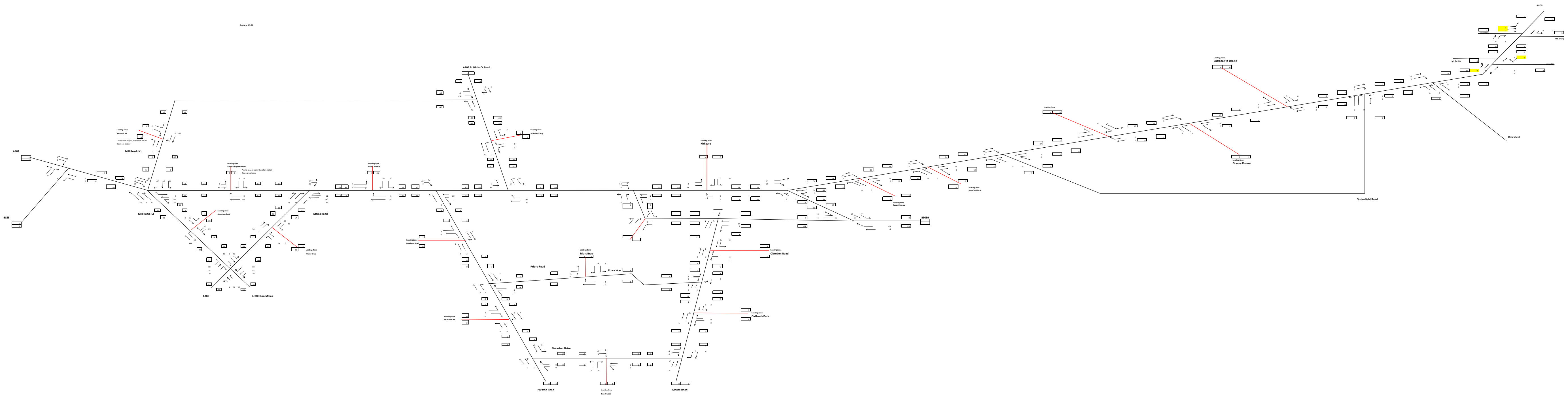
Scenario 6C - 6B



Scenario 6D - 6B



Scenario 6E - 6C



Appendix Two: Transport Assessment of Sites Submitted During Consultation on the *West Lothian Local Development Plan Main Issues Report*

Transport Assessment of Submissions for Residential Use Received During Consultation on the West Lothian LDP Main Issues Report

Preferred   Not Preferred

Ref	Site	Town	Access to local services	Bus service provision	Access to rail services	Walking and cycling access	Impact on school transport	Impact on station parking	Impact on local road network	Impact on strategic road network	Impact on town centre parking	Total score
MIRQ 0044	Croftfoot Farm	Fauldhouse	4	1	3	2	3	5	5	5	5	**33**
MIRQ 0053	Pond Industrial Estate	Bathgate	3	1	3	2	1	3	3	4	3	**23**
MIRQ 0159	Niddry Mains House	Winchburgh	2	4	0	2	2	4	5	5	4	**28**
MIRQ 0172	Eastoun Farm	Bathgate	4	1	3	0	3	5	4	5	4	**29**
MIRQ 0162	Land south of Willowdean	Bridgend	1	4	2	0	2	4	5	5	4	**27**
MIRQ 0134	Mavisbank/ Drumcross	Bathgate	4	1	3	0	2	3	3	5	3	**24**
EOI Brotherton	Brotherton Farm	Livingston	3	4	3	2	2	2	2	3	2	**23**
MIRQ 0125	Hopetoun Estate	South Queensferry	1	0	2	0	2	4	4	5	4	**22**
MIRQ 0046	Blackburn House	Blackburn	3	4	3	0	1	2	2	4	2	**21**
MIRQ 0038(1)	Hunter Road	Livingston	4	3	3	2	3	4	4	5	5	**33**
MIRQ 0038(2)	Murieston Valley	Livingston	4	2	5	2	3	5	5	5	5	**36**
MIRQ 0041	Burnhouse East	Dechmont	1	4	4	2	2	4	3	5	4	**37**
MIRQ 0163	Land at Cousland Farm, south of A705	Livingston	3	4	3	2	2	3	1	4	5	**27**
MIRQ LATE2	West Calder High School, Limefield	Polbeth	4	2	3	0	3	4	5	5	4	**30**