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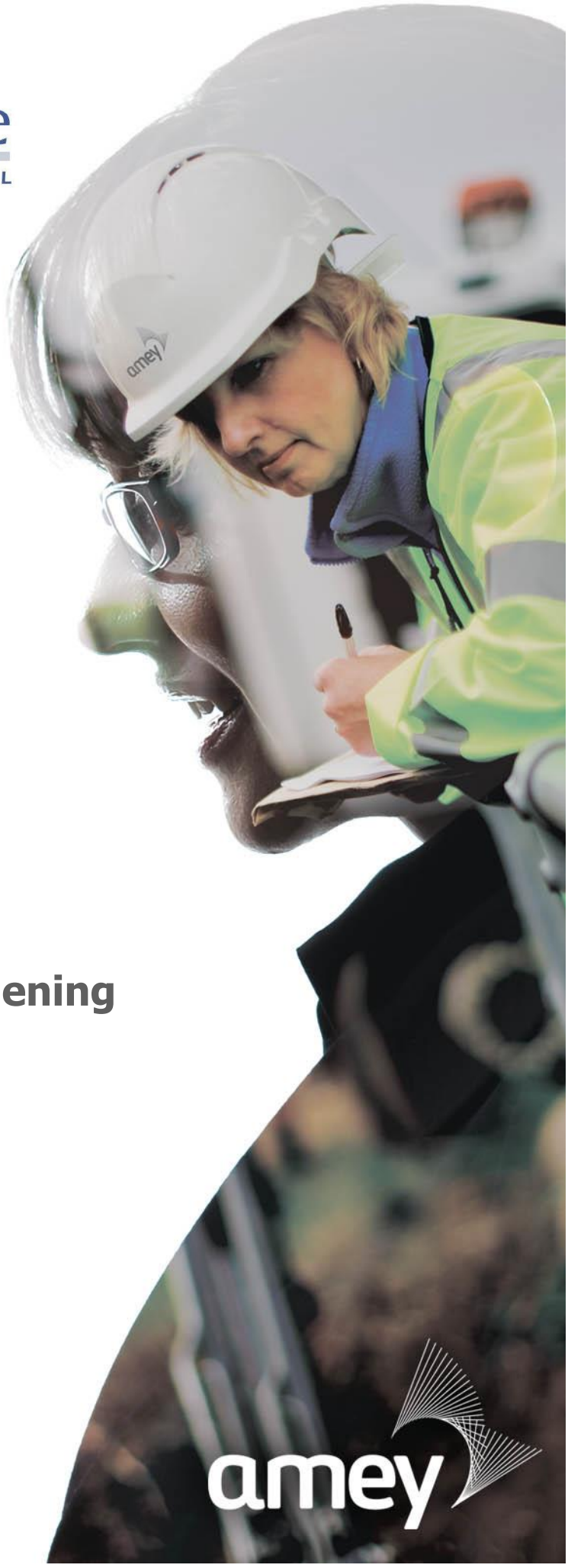

Model Validation - Technical Note

A430 Llanthony Road Widening Scheme

COGL43041066-TN 001 Revision 1

02 March 2017

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Document Control Sheet

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1 Introduction

1.1 Brief

Amey has been commissioned by Gloucestershire County Council to produce an S-Paramics microsimulation model of the A430 Llanthony Road and surrounding locale. The purpose of the model is to assess the traffic and economic impacts of various improvement options on the A430 between St Ann Way and Llanthony Road in Gloucester.

Congestion currently occurs on the A430 corridor into Gloucester during peak periods, particularly on the section between St Ann Way and Llanthony Road. The Gloucestershire Local Transport Plan 2015 – 2031 identified this section of the A430 as a congestion hotspot which is only expected to worsen in the future as new housing and employment comes online in this major local growth area. As a result, the A430 Llanthony Rd and St. Ann Way (Southwest bypass) Improvement scheme has been identified as a short term capital project (2015 – 2021) within the Local Transport Plan. The scheme will be funded through an application to GFirst LEP, and has been provisionally accepted by the Council as a priority for construction.

This technical note details the modelling methodology used to test the proposed improvement options at Llanthony Rd and St. Ann Way and provides a summary of the traffic and economic impacts of each of the options.

1.2 Site Description

1.2.1 General Layout

The A430 forms a P-shaped road around the centre of Gloucester and southwards, as illustrated in Figure 1.1. The central loop is the Gloucester Inner Ring Road, passing along St Ann Way, Trier Way, Black Dog Way, and Gouda Way, joining the A417 at St Oswald Road/Priory Road signalised junction. The north-south section of the A430 forms the Gloucester South Western Bypass, running from the A417 Westgate signalised junction in the north, to the signalised junction with the A38 Quedgeley bypass in the south. The road is a mixture of single and urban dual carriageways with no central reserve. The A430 has an annual average daily traffic flow of 25,000 vehicles per day and is subject to a 40mph speed limit at its northern and southern extents (Westgate to 85m north of the car park on Castle Meads Way, and Quedgeley bypass to Secunda Way Gyratory). From the car park on Castle Meads Way to Secunda Way Gyratory, the road is subject to a 30mph speed limit. With the exception of the gyratory on Secunda Way, all the primary junctions on the A430 are traffic signal controlled.

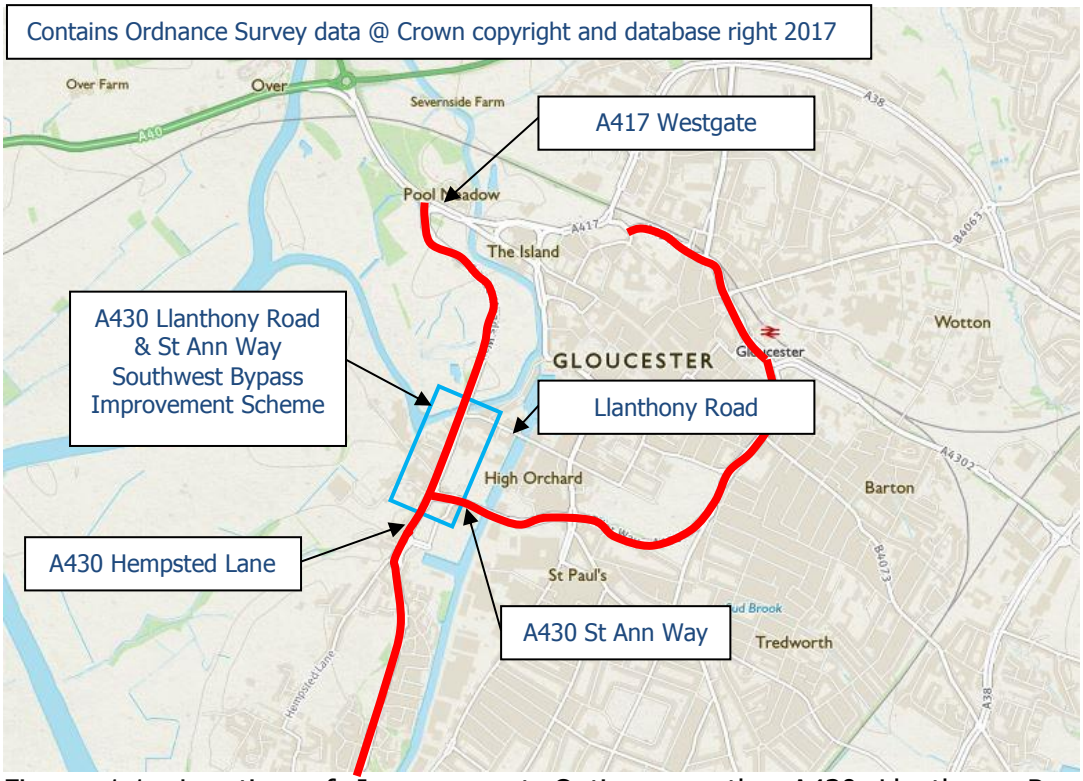


Figure 1.1: Location of Improvement Options on the A430 Llanthony Road in Gloucester

1.2.1 St Ann Way Signalised Junction

The junction of Hempsted Lane with St Ann Way/Spinnaker Road/Llanthony Road is a large signalised crossroads with staggered pedestrian crossings across the southern and eastern arms of the junction, (Hempsted Lane and St Ann Way). From Secunda Way Gyratory, the southern arm approaches the junction in three lanes with lane one designated as a straight ahead/left turn lane, lane two as straight ahead only, and lane three as a dedicated right turn lane. The two northbound through lanes quickly merge into a single lane on the north side of the junction.

Figure 1.2: Hempsted Lane - Southern arm
showing three lane approach and merge on exit from the junction.

On the eastern side of the junction, St Ann Way has two lanes on the approach to the signals, a left turn lane and a straight ahead/right turn lane. There are also two lanes on the exit from the junction, with lane 1 designated as a straight ahead/left turn lane and lane 2 designated as a right turn lane for the Sainsbury's signalised junction 50m downstream. Traffic turning left from Llanthony Road to St Ann Way has a left turn filter lane which becomes the eastbound lane 1 on St Ann Way. Right turning traffic from Hempsted Lane and straight ahead traffic from Spinnaker Road exit the junction in lane 2 on St Ann Way.

Figure 1.3: St Ann Way - Eastern arm
showing two lane approach and two lanes on exit and the Sainsbury's signalised junction 50m further east.

On the north side, Llanthony Road approaches the junction in a single lane, widening to two straight ahead lanes, a right turn lane and a left turn filter lane at the signals. The two southbound ahead lanes continue as two lanes on Hempsted Lane all the way to the gyratory.

Figure 1.4: Llanthony Road - Northern arm
showing left turn filter lane, two straight ahead lanes and a right turn lane

The western arm of the signalised junction is a single lane approach from and exit to the industrial area on Spinnaker Road.

1.2.2 Llanthony Road Signalised Junction

The junction of Llanthony Road with Castle Meads Way is a large signalised T junction with a staggered pedestrian crossing across the northern arm of the junction, (Castle Meads Way). The southern arm approaches the junction in two lanes, widening to three lanes north of the industrial estate. Lanes one and two are straight through lanes merging into a single lane on the exit. Lane 3 is a designated right turn lane. The stop line is set back approximately 120m from the centre of the side road, presumably to accommodate the swept path of larger vehicles turning left out of the side road.

Figure 1.6: Llanthony Road – Southern arm showing right turn filter lane and two straight ahead lanes.

Figure 1.5: Llanthony Road – southern arm exit showing two lane merge for northbound traffic exiting the junction and congestion in AM peak for southbound traffic

On the eastern side of the junction, Llanthony Road is a single lane carriageway, widening to two lanes, a left turn lane and a right turn lane, on the approach to the signals. Again, the stop line is set back approximately 20m from the mouth of the junction

Figure 1.7: Llanthony Road – Eastern arm showing set back stop line with two lane approach and single lane exit from the junction

On the north side, Castle Meads Way approaches and continues through the junction in a single lane. During peak periods, southbound traffic regularly queues back from the junction with St Ann Way, through the Llanthony Road junction all the way to the A417 at Westgate.

Figure 1.8: Castle Meads Way – Northern arm
showing southbound traffic queueing back from downstream signalised junction at St Ann Way during the AM peak.

1.3 Purpose of the Models

This project uses an S-Paramics microsimulation traffic model to assess the impacts of various options to improve the junction and network capacity of the A430 between St Ann Way and Llanthony Road in Gloucester. The aim of this scheme is to determine the optimum package of measure to accommodate existing and future traffic demands in this area.

To test whether the options deliver value for money, the economic impact of changes in vehicle journey times, vehicle operating costs and vehicle emissions are assessed using PEARS 15.1 (Program for the Economic Assessment of Road Schemes) software to monetise the outputs from the S-Paramics models.

2 Model Development

2.1 S-Paramics Version

This modelling was carried out using S-Paramics version 2014.1. The model extends from A417 Westgate in the north to the five arm gyratory at Secunda Way in the south. The signalised junctions at Llanthony Road, St Ann Way and the Sainsbury Junction (off St Ann Way) are replicated within the model. The uncontrolled priority junctions at the gyratory, Sudmeadow Road, Hemmingsdale Road, Gloucestershire College delivery access, Llanthony Industrial Estate, Castlemeads Car Park, and Severn Road (off Llanthony Road) are also included within the model. The road network in this area is a mix of urban single and dual carriageway. The extent of the model is shown in Figure 2.1.

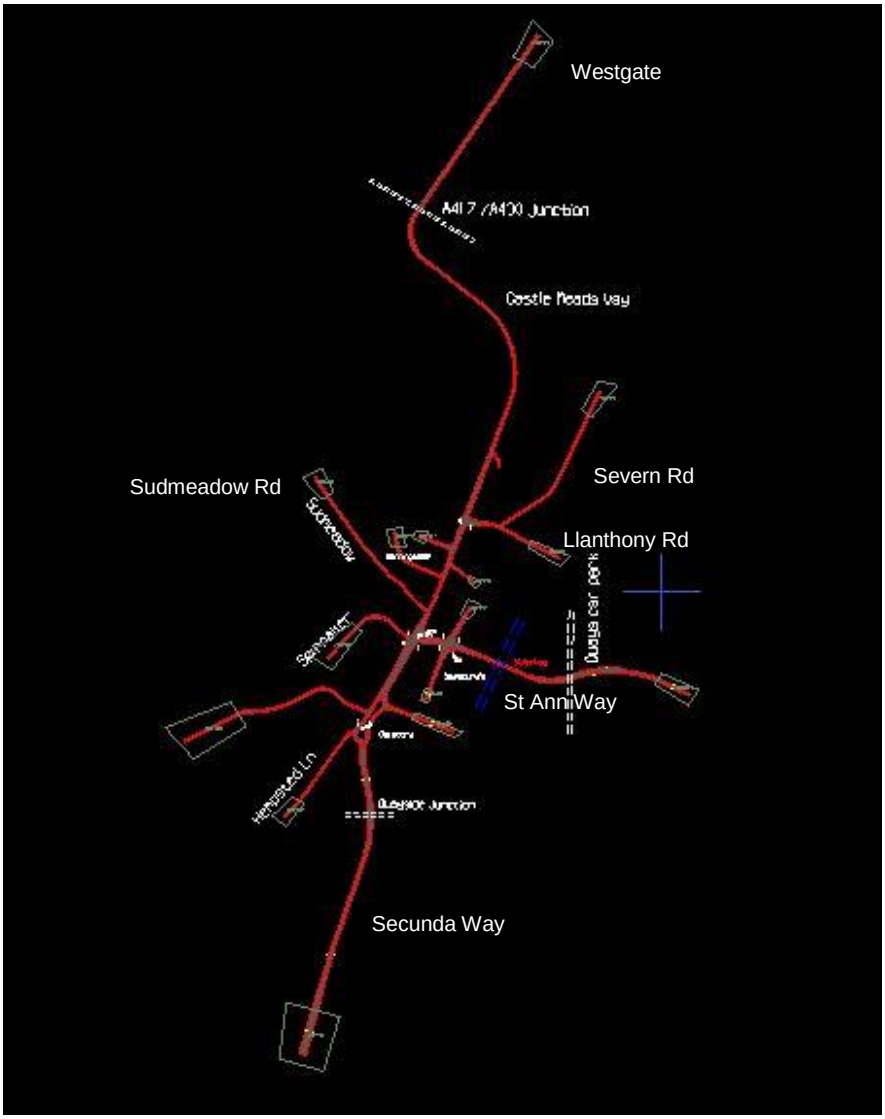


Figure 2.1: Screenshot showing the extents of the S-Paramics model.

2.2 Model Limitations

The modelling scope was to develop peak period (07:00 – 10:00 and 15:00 – 18:00) paramics microsimulation models primarily to test the impacts of improvement options on the A430 between St Ann Way and Llanthony Road in current and future years. 24-hour traffic survey data is not available and therefore Offpeak and Interpeak periods have not been considered in this appraisal. Traffic growth forecast were originally to be determined using an existing SATURN regional model of the Gloucester area, however, this model is currently in the process of being updated, and no future year forecasts are currently available. The TEMPRO growth factors show that there is no traffic growth from 2014 to 2016. Although there is a small amount of TEMPRO growth between 2016 and 2018 there aren't any LINSIG traffic signal data for 2018 traffic and therefore it is sensible to maintain the traffic at 2014/2016 levels in order to produce our 2018 opening year model. 2016 base traffic and 2031 traffic forecast are however available from the LINSIG traffic signal models provided, and equate to Tempro local growth factors. No growth factors were available beyond 2031; therefore the modelled periods in paramics are limited to the am and pm peaks in the 2014 base year, 2018 year of opening and 2031 future year. For this reason, this traffic and economic appraisal only considers the impacts of the improvement options during peak periods over a 15 year appraisal period.

The economic benefits of that scheme are a conservative estimate of the benefits likely to be incurred by the interventions as it does not consider any benefits that are likely to occur out-with peak periods as a result of the additional road space provided by these options.

The model extents do not include the A417/Castle Meads Way/Westgate signalised junction in the north, nor does it include the Gloucester Inner Ring Road beyond St Ann Way/Sainsbury signalised junction.

Additional traffic information and forecasts would be required if the model extents and periods were to be extended in the future.

2.3 Modelling Methodology

The base model has been developed using traffic data from surveys carried out in October 2014. No survey data was available for the gyratory at Secunda Way so the traffic flows at this junction were extracted from a Saturn model of the Gloucester area.

A review of TEMPRO in this area shows that there has been no significant growth in traffic on the A430 in Gloucester between 2014 and 2016 suggesting that current traffic conditions have not changed since 2014. Furthermore, TEMPRO v.7 does not predict any significant growth in traffic between 2014 and 2018 year of opening of the proposed scheme.. Table 2.1 shows the growth factors between the years 2014 to 2016 and 2014 to 2018.

Year	TEMPRO Area	TEMPRO growth	
		AM	PM
2014 to 2016	Gloucester 2,4,5,8,9	1.001	0.998
2014 to 2018	Gloucester 2,4,5,8,9	1.029	1.021

Table 2.1: TEMPRO Growth Factors

Given that there has been no increase in traffic since 2014, and that TEMPRO does not predict any significant increase in traffic by 2018, the 2014 base year model is assumed to be representative of traffic conditions in the 2018 year of opening.

The 2014 base year model has been successfully calibrated against the October 2014 surveyed junction turning count and ATC link flow data, and successfully validated against blue tooth journey time data from May 2015, and additional journey time and queue length surveys carried out during a site visit in December 2016. The model is well calibrated and validated, with GEH values of less than 5 in 100% of the hourly link flow comparisons, in 92% of all the hourly turncount comparisons, and 100% of all journey time comparisons. Details of the S-Paramics base model calibration & validation can be found in Appendix A.

For the purposes of the S-Paramics traffic assessment, a total of seven models have been developed for the core scenario during the AM and the PM peak periods. These are the 2018 year of opening for the Do-Nothing (no change to base model), Option 1 and Option 2, and the 2031 Do-Nothing, 2031 Do-Min (traffic signals optimised for forecast demands), 2031 Option 1 and 2031 Option 2.

Severn Road is currently used by drivers as a means of bypassing the lengthy queues and delays that occur on the A430 at Castle Meads Way during peak periods. The improvement options may significantly reduce congestion on the A430 in this area, making Castle Meads Way more attractive than Severn Road. It is expected that some traffic from Severn road will therefore re-route to Castle Meads Way under the improvement options. As the paramics model is not an assignment model, a sensitivity test has been carried out whereby all southbound trips on Severn Road have been manually re-assigned to Castle Meads Way under the improvement options. It is appreciated that not all traffic may re-route, however for the purpose of this assessment, a worst case scenario has been assumed, whereby under the improvement options, all southbound trips reassign to the A430 Castle Meads Way, increasing demands and reducing benefits on this section of the A430 mainline.

To address the uncertainty around routeing response to the improvement options, the methodology adopts the following Core Scenario and Sensitivity test:

- Core Scenario: Option 1 and Option 2 with proposed layout and optimised traffic signals.
- Sensitivity Scenario: Option 1 and Option 2 as above but with re-assigned trips from Severn Road to Castle Meads Way southbound.

A summary of each modelled scenarios including the network and demand assumptions can be found in Table 2.2 below.

Core Scenario	Model	Network	Summary
1	2018 Do Nothing	Do Nothing	Base model without the proposed scheme layout or any future development traffic
2	2018 Option 1	Do Something	Model to assess the Option 1 layout impact, adjusted signals to match Linsig model
3	2018 Option 2	Do Something	Model to assess the Option 2 layout impact, adjusted signals to match Linsig model
4	2031 Do Nothing	Do Nothing	Model of future baseline with future growth constrained to TEMPRO
5	2031 Do Min	Do Nothing	Model of future baseline with future growth constrained to TEMPRO and optimised traffic signals
6	2031 Option 1	Do Something	Model to assess the Option 1 layout impact with future growth(TEMPRO) adjusted signals to match Linsig model
7*	2031 Option 2	Do Something	Model to assess the Scenario 2 layout impact with future growth(TEMPRO) adjusted signals to match Linsig model
Sensitivity	**Model**	**Network**	**Summary**
8	2018 Option 1	Do Something	Model to assess the Option 1 layout impact with 2018 flows and re-assigned trips from Severn Road to Castle Meads Way
9	2018 Option 2	Do Something	Model to assess the Option 2 layout impact with 2018 flows and re-assigned trips from Severn Road to Castle Meads Way
10	2031 Option 1	Do Something	Model to assess the Option 1 layout impact with future growth(TEMPRO) and re-assigned trips from Severn Road to Castle Meads Way
11*	2031 Option 2	Do Something	Model to assess the Option 2 layout impact with future growth(TEMPRO) and re-assigned trips from Severn Road to Castle Meads Way

Table 2.2: Paramics model scenarios

*Note that in the 2031 Option 2 Core Scenario, (7), the provision of a pedestrian stage every cycle at the on Llanthony Road/Castle Meads Way signalised junction results in traffic gridlock and unreleased vehicles on the Castle Meads Way southbound link. To prevent this situation occurring, the modelling approach has been to restrict the pedestrian stage to once every third cycle time during the AM peak and once every second cycle time during the PM peak.

Similarly under 2031 Sensitivity Scenario for Option 2(11), the pedestrian stage on Llanthony Road/Castle Meads Way junction is only called every third cycle during both the AM and PM peak.

3 Option Model Development

3.1 Model Changes

Under the Do-Nothing Option, the existing road network will be maintained as it currently is; both in the 2018 year of opening and the 2031 future year models. The Do-Min Option retains the existing road layout; however the traffic signal timings are optimised in the future year to better manage increased traffic demands at the junctions. The Improvement Options are modelled by adjusting the Do-Min model to reflect the proposed changes in road layout and traffic signal timings as detailed in the Linsig models provided. The proposed options are as following:

Option 1

Option 1 involves widening on the A430 Llanthony Road from north of the Spinnaker Road Junction to Llanthony Industrial Estate. This option allows the two northbound lanes to be extended 240m further north, from the two lane merge at the junction at Spinnaker Road to the existing two lane merge north of the Llanthony Road Junction. It also extends the two southbound lanes 135m further north to the junction with Hemmingsdale Road. The westbound approach from St Ann Way is widened to three lanes to accommodate two right turn lanes into Llanthony Road, and new traffic signals at Sudmeadow Road improve access to and from the side road. To optimise the signals, the staggered pedestrian crossing has been relocated from the south arm of Spinnaker Road signalised junction to the south arm of the newly signalised Sudmeadow Road.

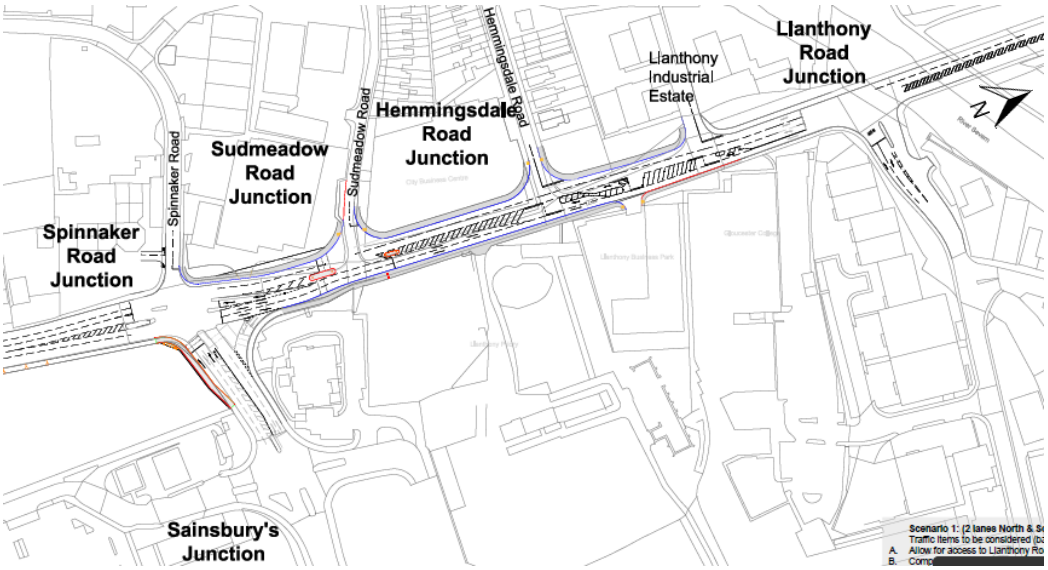


Figure 3.1: Proposed Layout under Option 1

Option 2

Option 2 also involves widening on the A430 Llanthony Road. This option provides two northbound lanes and two southbound lanes on the A430 from Spinnaker Road junction to north of Llanthony Road junction. In order to accommodate two through lanes in each direction, the staggered pedestrian crossing on the north side of Llanthony Road junction has been relocated to the south side of the junction, and the central island has been removed. This means that pedestrians will have to cross four 3.65m wide lanes in a single stage during an 'all-red' traffic phase, resulting in an increase in 'lost time' for vehicles at this junction. The existing northbound dedicated right turn lane (lane 3) on Llanthony Road junction has also been removed to accommodate two southbound lanes on the southern arm of the junction. As a result, right turning traffic from the southern arm of Llanthony Road junction will have to share lane 2 with straight ahead traffic. The northbound and southbound phases run together at this junction, and as such, it's likely that most northbound traffic on the mainline will use lane 1 to avoid being stuck behind stationary right turning traffic in lane 2.

As with Option 1, Option 2 includes the signalisation of Sudmeadow Road junction. St Ann Way is also widened to three lanes on its approach to Spinnaker Road signalised junction and the pedestrian crossing is relocated from the south side of the junction to the south side of Sudmeadow Road junction.

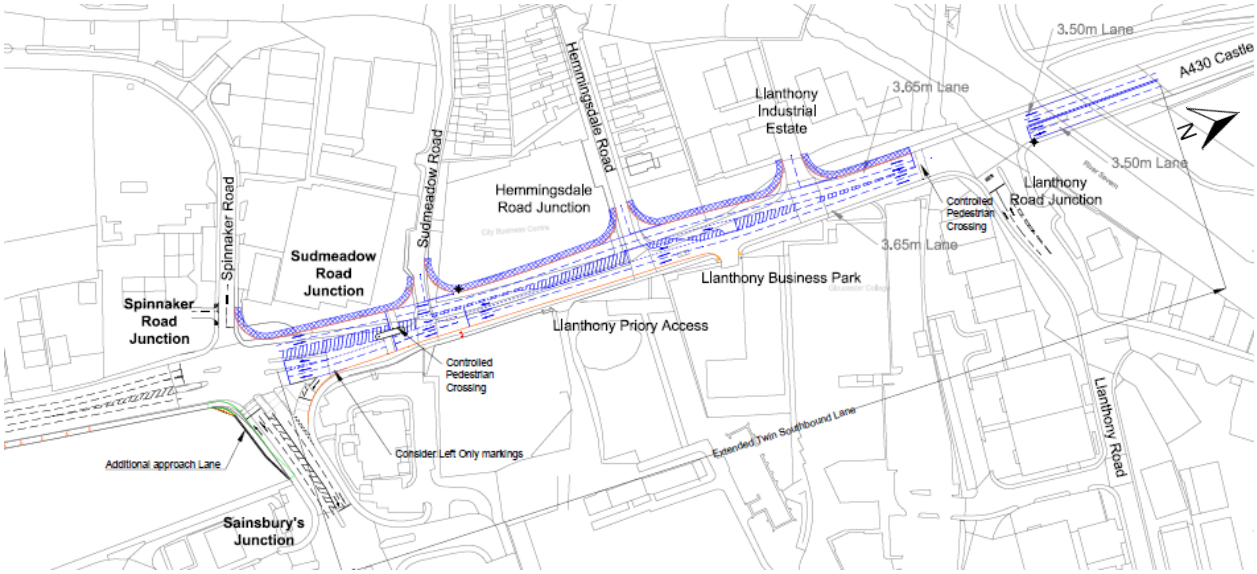


Figure 3.2: Proposed Layout under Option 2

3.2 Traffic Growth

Forecast year trip matrices have been developed by applying TEMPRO growth to the 2014 base year matrices. As TEMPRO predicts minimal growth between 2014 and 2018, the 2018 Do-Nothing matrices are assumed to be the same as the 2014 base year matrices. For the 2031 traffic levels the TEMPRO growth factors that were used are from 2014 to 2031 Table 3.1 shows the growth factors applied to create 2031 forecast year matrices.

Year	TEMPRO Area	TEMPRO growth	
		AM	PM
2014 to 2031	Gloucester 2,4,5,8,9	1.153	1.145

Table 3.1: TEMPRO Growth factors

4 Option Testing Results

4.1 Journey Times

The S-Paramics model has been used to measure average journey times along key paths through the network under various scenarios. Comparing the difference in journey times between the Do-Nothing and Improvement Options in 2018 and the Do-Min and Improvement options in 2031 provides an estimate of expected impact of the proposed improvements in the opening and future years. The journey times routes used in the comparison are illustrated in Appendix B.

Results for Options 1 and 2 under the Core Scenario are presented in Table 4.1 for 2018 and Table 4.2 for 2031. Results for the sensitivity test (where southbound trips are re-assigned from Severn Road to Castle Meads Way) are also shown in Appendix B.

Improvements of more than 60 seconds are highlighted in green. Improvements of more than 120 seconds are highlighted in dark green. Journey time increases of more than 30s are highlighted in orange.

Option 1 - Core Scenario

Overall, Option 1 offers significant journey time savings during the peak periods both in 2018 and 2031. The exception to this is two routes (paths 4 and 5) that experience negligible increases in journey time of less than 4 seconds. Southbound trips along the A430 experience the biggest journey time savings, with trips from Westgate to St Ann Way (paths 6 and 15) receiving journey time savings averaging between 4 to 5 minutes per vehicle during peak periods in 2018. Over two thirds of these southbound journey time savings are accrued on Castle Meads Way (path 7), as a result of the improved signal timings and increased capacity on the downstream link at Llanthony Road, where the southbound carriageway is widened to two lanes. This increased capacity resolves the existing problem of queues propagating back along the A430 from St Ann Way, through the Llanthony Road Junction to Westgate. By 2031, the journey time savings for vehicles travelling south along the A430 corridor are even greater, averaging over 6½ minutes per vehicle during the am peak and over 9 minutes per vehicle in the pm peak, with over 80% of the journey time savings being accrued on Castle Meads Way.

There are also significant journey time savings for vehicles travelling south on Severn Road to Llanthony Road (path 12). In 2018 they benefit from journey time savings of between 2 to 3 minutes, rising to around 7 minutes by 2031. As discussed in section 2.3 of this report, Severn Road may currently be used by drivers as an alternative route to bypass the congestion on Castle Mead Way. Option 1 generates significant journey time savings of up to 8 minutes by 2031 on Castle Mead Way, and as such drivers may re-route along the A430 southbound instead. This scenario was tested under the sensitivity test, the impacts of which are discussed later in this chapter.

Option 1 also generates some journey time savings for vehicles travelling northbound along the A430 corridor. Vehicles travelling from St Ann Way to Westgate (path 14) experience the largest benefits, saving over 4 minutes during the 2018 pm peak, and rising to nearly 6 minutes in the 2031 peak periods. Over 80% of these benefits are accrued on the westbound approach to the junction at St Ann Way (path 16), suggesting that the provision of an additional right turn lane at this junction offers substantial benefits.

Option 2 - Core Scenario

Option 2 offers similar, although generally reduced journey time savings compared to those generated under Option 1. Southbound trips along the A430 continue to experience the biggest journey time savings, with trips from Westgate to St Ann Way (paths 6 and 15) receiving journey time savings of 3 to 4 minutes per vehicle during the 2018 peak, (between 45 seconds and 60 seconds less than under Option 1). By the 2031 pm peak, Option 2 generates journey time savings of around 8 minutes on the A430 southbound. This is still almost 1½ minutes less than the journey time savings achieved under Option 1 for this route. The reason for the reduction in journey time savings under Option 2 is the alterations to the signal controlled junction at Llanthony Road. The relocation of the pedestrian crossing to the south side of the junction results in a significant amount of 'lost time' whilst drivers wait for pedestrians to cross the four lanes. This reduces the operational capacity of this junction, particularly on the southbound approach from Castle Mead Way, where there is less capacity on the upstream single carriageway link.

Northbound vehicles travelling from St Ann Way to Westgate (path 14) also incur a reduction in their journey time savings when compared to Option 1. Under Option 2, the journey time savings on this route are 30 seconds less in the 2018 am peak, rising to over 1½ minutes by the 2031 am peak. Again, these reductions in journey time benefits are associated with the changes to the signal controlled junction at Llanthony Road.

Option 2 does however appear to perform slightly better than Option 1 for westbound trips on St Ann Way (path 16) and southbound trips on Severn Road (paths 11 and 12) during the pm peaks. It is unclear why these trips should perform better under Option 2, however it may simply be associated with the optimised signal timings at the downstream junctions.

Sensitivity Test – Southbound Trips re-assigned from Severn Road to A430 Castle Mead Way

The sensitivity test for Options 1 and 2 generally follow the same pattern of results as under the Core Scenario. The increased volume of southbound traffic on the A430 Castle Mead Way, (re-assigned trips); result in a slight reduction in the magnitude of the journey time savings on this route. (See the results from the sensitivity tests in Appendix B).

4.2 Impacts on Journey Time Overall

From Tables 4.1 and 4.2 it can be seen that both options generate significant improvement in journey times throughout the modelled network. Overall, Option 1 performs better, delivering journey time savings up to 1½ minutes greater than under Option 2. Southbound trips along the A430 generally experience the biggest journey time savings, with journey time benefits of over 9 minutes per vehicle being generated by Option 1 in the 2031 in the pm peak.

Under Option 1, over two thirds of the southbound journey time savings are accrued on Castle Meads Way, as a result of the improved signal timings and increased capacity on the downstream link at Llanthony Road, where the southbound carriageway is widened to two lanes. This increased capacity resolves the existing problem of queues propagating back along the A430 from St Ann Way, through the Llanthony Road Junction to Westgate.

Under Option 2, the relocation of the pedestrian crossing to the south side of Llanthony Road junction results in a significant amount of 'lost time' whilst drivers wait for pedestrians to cross the four lanes. This reduces the operational capacity of this junction, particularly on the southbound approach from Castle Mead Way, where there is less capacity on the upstream single carriageway link. As a result, Option 2 delivers less journey time benefits than Option 1 (by up to 1 ½ minutes).

Journey time comparisons (2018 Core Scenario)													
		AM Peak (07:00-10:00)					PM Peak (15:00-18:00)					AM Peak	PM Peak
		Modelled average journey time (s)			Difference from base		Modelled average journey time (s)			Difference from base		Difference from Option 1	
	Path Name	2018 Base	2018 Option 1	2018 Option 2	2018 Option 1	2018 Option 2	2018 Base	2018 Option 1	2018 Option 2	2018 Option 1	2018 Option 2	2018 Option 2	2018 Option 2
1	"Quayside to Westgate"	00:03:01	00:02:46	00:03:15	-15	14	00:03:46	00:02:47	00:03:12	-59	-34	29	25
2	"Quayside to Hempsted"	00:00:31	00:00:23	00:00:23	-8	-8	00:00:30	00:00:17	00:00:17	-13	-13	0	0
3	"Gyratory to Hemmingsdale"	00:01:09	00:01:00	00:01:03	-9	-6	00:01:59	00:01:05	00:01:05	-54	-54	3	0
4	"Hemmingsdale to Llanthony"	00:00:19	00:00:18	00:00:44	-1	25	00:00:20	00:00:19	00:00:42	-1	22	26	23
5	"Llanthony to Westgate"	00:00:56	00:00:58	00:00:57	2	1	00:00:57	00:01:00	00:01:00	3	3	-1	0
6	"Westgate to Quayside"	00:06:48	00:02:50	00:03:33	-238	-195	00:07:29	00:02:50	00:03:48	-279	-221	43	58
7	"Westgate to Llanthony"	00:04:05	00:01:25	00:01:48	-160	-137	00:04:58	00:01:15	00:01:44	-223	-194	23	29
8	"Llanthony to Hemmingsdale"	00:00:45	00:00:10	00:00:11	-35	-34	00:00:38	00:00:12	00:00:12	-26	-26	1	0
9	"Hemmingsdale to Gyratory"	00:01:14	00:00:46	00:00:56	-28	-18	00:01:08	00:01:01	00:01:10	-7	2	10	9
10	"Hempsted to Quayside"	00:00:28	00:00:28	00:00:28	0	0	00:00:30	00:00:30	00:00:30	0	0	0	0
11	"Severn SB"	00:01:58	00:00:37	00:00:37	-81	-81	00:03:12	00:00:36	00:00:37	-156	-155	0	1
12	"Severn to Llanthony jct"	00:03:39	00:01:16	00:01:17	-143	-142	00:04:25	00:01:19	00:01:17	-186	-188	1	-2
13	"Llanthony to Severn"	00:00:54	00:00:46	00:00:46	-8	-8	00:00:54	00:00:43	00:00:45	-11	-9	0	2
14	"St Ann Way to Westgate"	00:04:46	00:03:56	00:04:26	-50	-20	00:07:52	00:03:24	00:03:30	-268	-262	30	6
15	"Westgate to St Ann Way"	00:06:39	00:02:36	00:03:21	-243	-198	00:07:16	00:02:21	00:03:19	-295	-237	45	58
16	"St Ann Way wb"	00:02:49	00:02:06	00:02:11	-43	-38	00:05:20	00:01:42	00:01:27	-218	-233	5	-15

Table 4.1: Journey time comparisons in 2018
(note that negative number represents an improvement (reduction) in journey time, while positive number represents a worsening (increase) of journey time.

Journey time comparison (2031 Core Scenario)												
		AM Peak (07:00-10:00)					PM Peak (15:00-18:00)					AM Peak	PM Peak
		Modelled average journey time (s)			Difference from Do-Min		Modelled average journey time (s)			Difference from Do-Min		Difference from Option 1	
	Path Name	2031 Do Min	2031 Option 1	2031 Option 2	2031 Option 1	2031 Option 2	2031 Do Min	2031 Option 1	2031 Option 2	2031 Option 1	2031 Option 2	2031 Option 2	2031 Option 2
1	"Quayside to Westgate"	00:03:32	00:02:54	00:03:07	-38	-25	00:06:08	00:02:54	00:03:13	-194	-175	13	19
2	"Quayside to Hempsted"	00:00:39	00:00:29	00:00:29	-10	-10	00:01:38	00:00:18	00:00:17	-80	-81	0	-1
3	"Gyratory to Hemmingsdale"	00:01:33	00:01:00	00:01:02	-33	-31	00:03:08	00:01:08	00:01:05	-120	-123	2	-3
4	"Hemmingsdale to Llanthony"	00:00:19	00:00:21	00:00:30	2	11	00:00:21	00:00:21	00:00:41	0	20	9	20
5	"Llanthony to Westgate"	00:00:56	00:00:59	00:00:57	3	1	00:00:57	00:01:00	00:00:59	3	2	-2	-1
6	"Westgate to Quayside"	00:09:38	00:02:59	00:03:26	-399	-372	00:12:10	00:03:01	00:04:13	-549	-477	27	72
7	"Westgate to Llanthony"	00:06:43	00:01:21	00:01:44	-322	-299	00:09:16	00:01:23	00:02:19	-473	-417	23	56
8	"Llanthony to Hemmingsdale"	00:00:55	00:00:10	00:00:11	-45	-44	00:00:53	00:00:13	00:00:13	-40	-40	1	0
9	"Hemmingsdale to Gyratory"	00:01:16	00:00:55	00:00:57	-21	-19	00:01:16	00:01:04	00:01:05	-12	-11	2	1
10	"Hempsted to Quayside"	00:00:28	00:00:28	00:00:28	0	0	00:00:30	00:00:30	00:00:30	0	0	0	0
11	"Severn sb"	00:06:25	00:00:37	00:00:37	-348	-348	00:07:31	00:01:31	00:00:59	-360	-392	0	-32
12	"Severn to Llanthony jct"	00:09:00	00:01:21	00:01:13	-459	-467	00:09:18	00:02:34	00:01:39	-404	-459	-8	-55
13	"Llanthony to Severn"	00:00:54	00:00:46	00:00:46	-8	-8	00:00:54	00:00:46	00:00:45	-8	-9	0	-1
14	"St Ann Way to Westgate"	00:09:15	00:04:13	00:05:45	-302	-210	00:09:28	00:03:32	00:03:54	-356	-334	92	22
15	"Westgate to St Ann Way"	00:09:30	00:02:44	00:03:13	-406	-377	00:11:59	00:02:23	00:03:48	-576	-491	29	85
16	"St Ann Way wb"	00:06:53	00:02:12	00:03:35	-281	-198	00:06:39	00:01:46	00:01:38	-293	-301	83	-8

Table 4.2: Journey time comparisons in 2031

4.3 Queue Lengths

Queue lengths from the Do-Min and Improvement Option models were compared to identify changes in network operation within the modelled area. A comparison of maximum queue lengths has been undertaken for the gyratory at Secunda Way, the St Ann Way (Spinnaker) junction, the Sainsbury's junction and the Llanthony Road junction during the 2018 and 2031 AM and PM peak periods. The queue lengths generated under the 2031 Do-Min and improvement options are shown in Figures 4.1 to 4.4.overleaf.

The introduction of two lanes northbound and two lanes southbound offers a significant improvement on queue lengths for both the mainline and side road traffic. On the A430 Llanthony road mainline, the delay caused by left or right turning vehicles in the Do-Min model is removed under Options 1 and 2 by the provision of two through lanes and right turn ghost islands which increase the mainline capacity in both directions. This is confirmed in the queue length graphs which show significantly different queueing profile with shorter queue lengths under the improvement options.

Option 1 – 2018 Core Scenario

Llanthony Road Junction

Under the 2018 Do-Nothing layout, average southbound queue lengths on Castle Meads Way are more than 480m long, with maximum queue lengths in excess of 1km, propagating back to the A417 Westgate Junction during the busiest periods. Under Option 1, the average southbound queue length is reduced to around 180m with a maximum queue length of 350m on this link. The combination of the optimised signals on Llanthony Road junction and the improved capacity on the Llanthony Road downstream link causes a dramatic decrease in southbound queue lengths on this section.

St Ann Way (Spinnaker) Junction

A similar reduction in queues occurs at the Spinnaker junction on Llanthony Road. Under Option 1, the southbound maximum queue length in the AM period is reduced from 360m to 76m and in the pm peak, from 360m to 126m. Under the Do-Min layout, vehicles turning left from Llanthony Road onto St Ann Way queue back from the left turn lane, blocking the southbound through movement from lane 1 of Llanthony Road. Option 1 optimise the traffic signals at the Spinnaker junction and provides two lanes for vehicles to turn right from St Ann Way and continue northbound in two lanes on the A430 exit. The increased capacity and optimised signal timings helps vehicles clear the junction, reducing the risk of vehicles blocking back and creating gridlock in this area.

Secunda Way Gyratory

Another significant reduction in queue lengths occurs at Secunda Way on the south arm of the gyratory. The maximum queue length in the PM peak reduces from 325m to 41m under Option 1. Again this is due to improvements in the downstream flow resulting from the optimised signals on the Spinnaker junction and the additional northbound lane on the exit to the Llanthony Road junction. For the same reason the queue length at Hempsted Lane northbound approach to the Spinnaker junction are reduced from an average of 225m in the PM peak to 100m under Option 1.

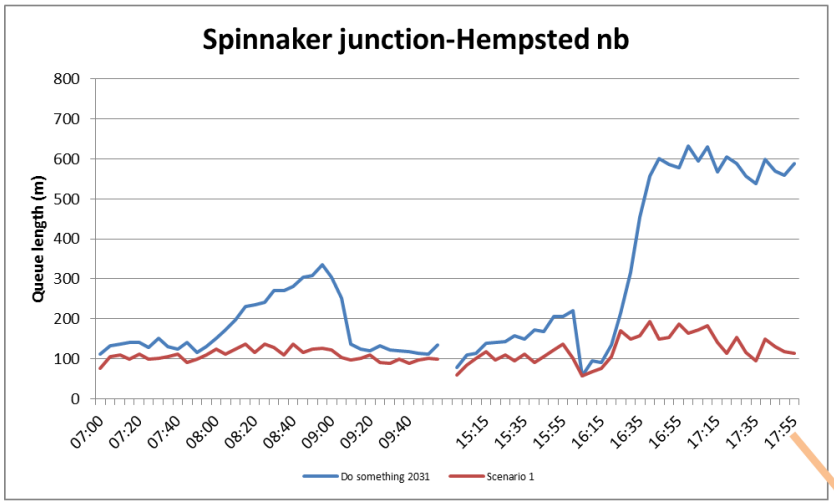
Sainsbury's Junction (St Ann Way Westbound)

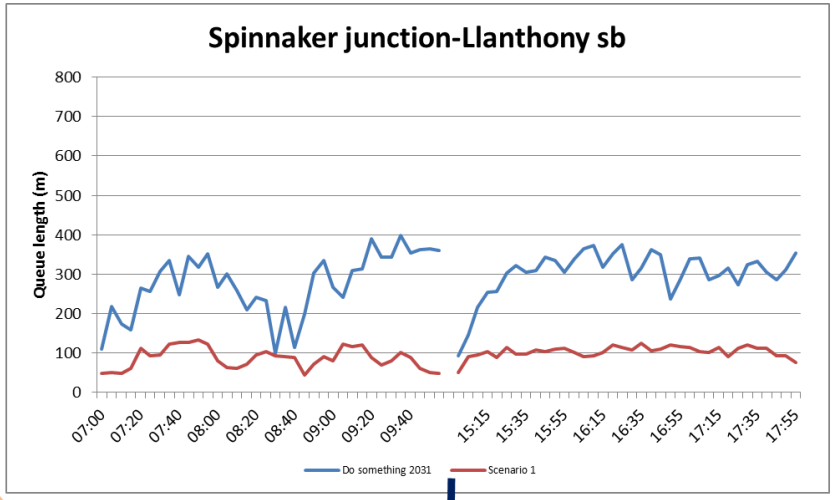
Queue length improvement also occur at Sainsbury's junction where the westbound traffic on the St Ann Way experience long delays and queues during the 2018 Do-Nothing PM peak. Average queues of 179m (maximum 364m); reduce to a maximum of 60m under Option 1.

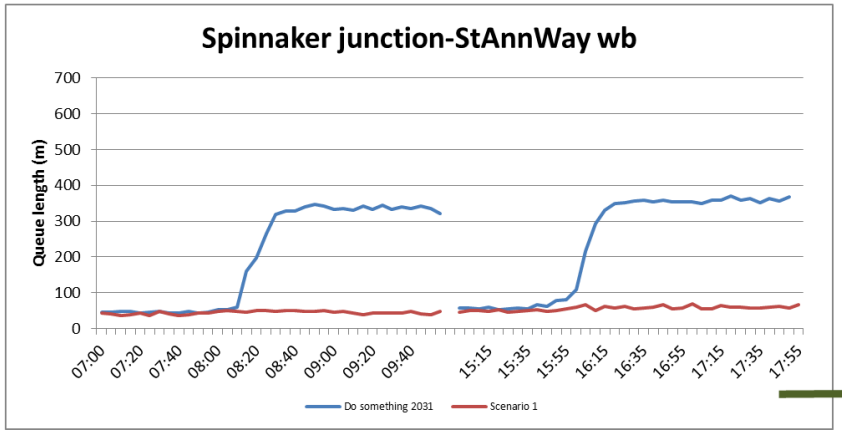
Option 1 – 2031 Core Scenario

Significant queue length improvements are also recorded in the 2031 future year models under Option1. Traffic grows by around 15% between 2018 and 2031. Applying this predicted growth to 2031 Do-Min model, results in long queues and delays on the modelled network. Under Option 1, average southbound queues on the Castle Meads Way at Llanthony Road junction reduced from 827m (maximum queues more than 1km) to 200m (maximum queues 300m). Castle Meads Way southbound queue length is highest in the PM period for both future models. Similar southbound reductions occur at the Spinnaker junction where average queue length reduced from 300m to 100m in 2031.

Option 1 also has a positive impact on queue lengths south of Spinnaker junction in 2031. The reduction in queues is a result of the network improvements on the A430 northbound and southbound between Spinnaker Junction and Llanthony Junction. Northbound queues on Hempsted Lane decreased from an average of 353m during PM period to 124m in 2031. As a result of this improvement, upstream queues on the Secunda Way south arm of the gyratory also decrease with average queues lengths reducing from 214m to 70m. Under option 1, the overall traffic conditions at Spinnaker junction improve with reduced queue lengths on all arms of the junction and their upstream links.







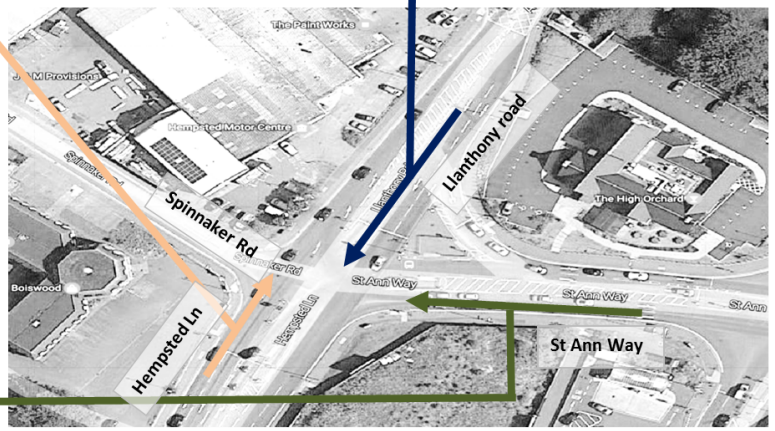


Figure 4.1: 2031 Queue length comparisons Option 1: Spinnaker junction and Sainsbury's junction.

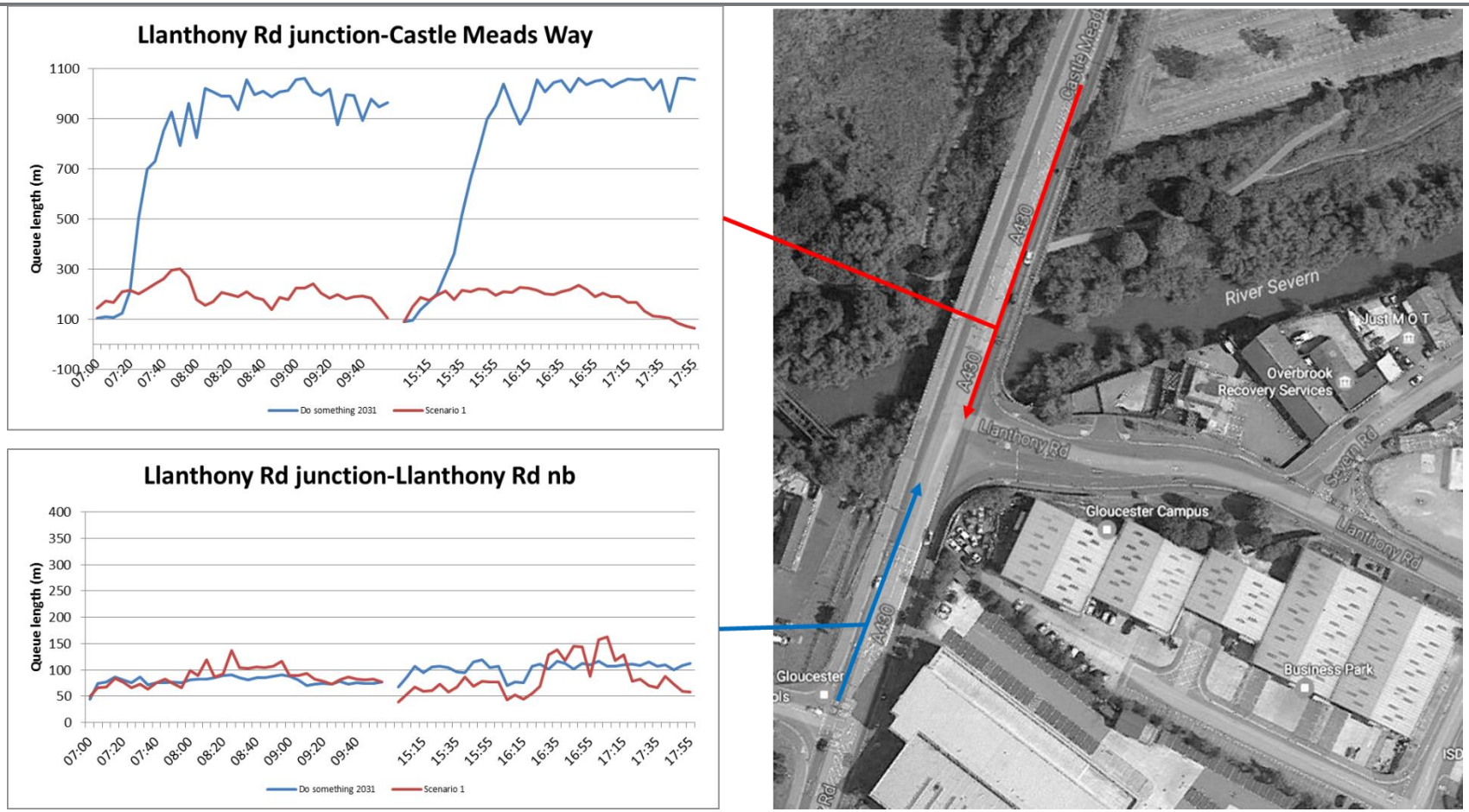


Figure 4.2: 2031 Queue length comparisons Option 1: Llanthony Rd junction

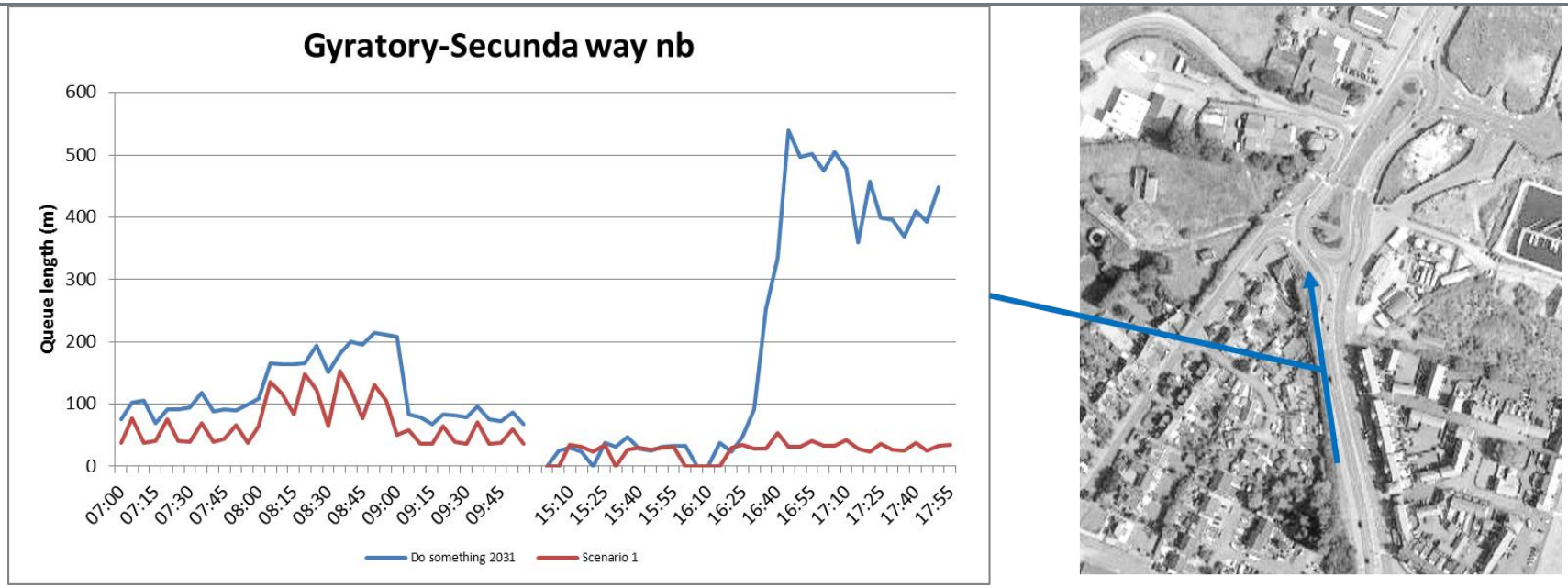


Figure 4.3: 2031 Queue length comparison Option 1: Secunda Way northbound

Option 2 – 2018 and 2031 Core Scenarios

Under Option 2 in the 2018 opening year, queue length improvements are quite similar to Option 1. However, in the 2031 future year, smaller queue length improvements occur when compared to the benefits from Option 1, and in fact generate a significant increase in queue lengths on the northbound approach to Llanthony Road Junction.

In order to accommodate two through lanes in each direction, under Option 2, the existing staggered pedestrian crossing on the north side of Llanthony Road junction has to be relocated to the south side of the junction as a single crossing. This requires the traffic signal staging to be amended to accommodate an 'all-red' stage for the pedestrians to cross 4 lanes at this relocated crossing. By 2031 the effects of this 'lost time' in conjunction with the removal of the dedicated northbound right turn lane and traffic growth in the area, cause the junction to gridlock with unreleased southbound vehicles on Castle Meads Way. To mitigate this situation, the pedestrian stage has to be restricted in the 2031 Option 2 model to once every 3rd cycle during the AM peak, and every 2nd cycle time during the PM peak. Even with these pedestrian restrictions in place in 2031, overall, Option 2 does not perform as well as Option 1, at any of the modelled junctions.

Even with the pedestrian stage called every 3rd cycle in 2031, the removal of the northbound dedicated right turn lane under Option 2 has a negative impact on northbound queues at Llanthony Road junction. Under the 2031 Do-Min arrangement the average queue length on this approach is 100m. This increases to an average of 145m under Option 2, with a maximum queue length of 275m. This increased queueing is evident throughout both AM and PM periods.

4.4 Impacts on Queue Lengths Overall

From Figures 4.1 to 4.3 it can be seem that Option 1 generates significant reductions in queue lengths on all of the approaches to the junctions within the modelled network. The exception to this is on the northbound approach to Llanthony Road Junction where, in 2031, northbound vehicles incur a slight increase in maximum queue lengths of approximately 50m under Option 1. Option 1 addresses the extensive queueing that occurs in the 2031 Do-Min model, bringing the queues down to acceptable levels, below 300m, particularly on the southbound approach to Llanthony Road Junction, Secunda Way northbound approach to the gyratory, Hempstead Lane northbound approach to Spinnaker Way Junction, and to a lesser degree, St Ann Way westbound approach.

From Figures 4.4 to 4.6, it can be seen that with increased traffic demands in 2031, Option 2 performs less favourably than Option 1, generating smaller reduction in queues lengths. Indeed, Option 2 actually generates an increase in queue lengths on the northbound approach to Llanthony Road Junction, compared to the 2031 Do-Min. The queues are consistently higher on this link throughout the 2031 peak periods; with an average increase in queue length of 45m and a maximum increase of 175m.

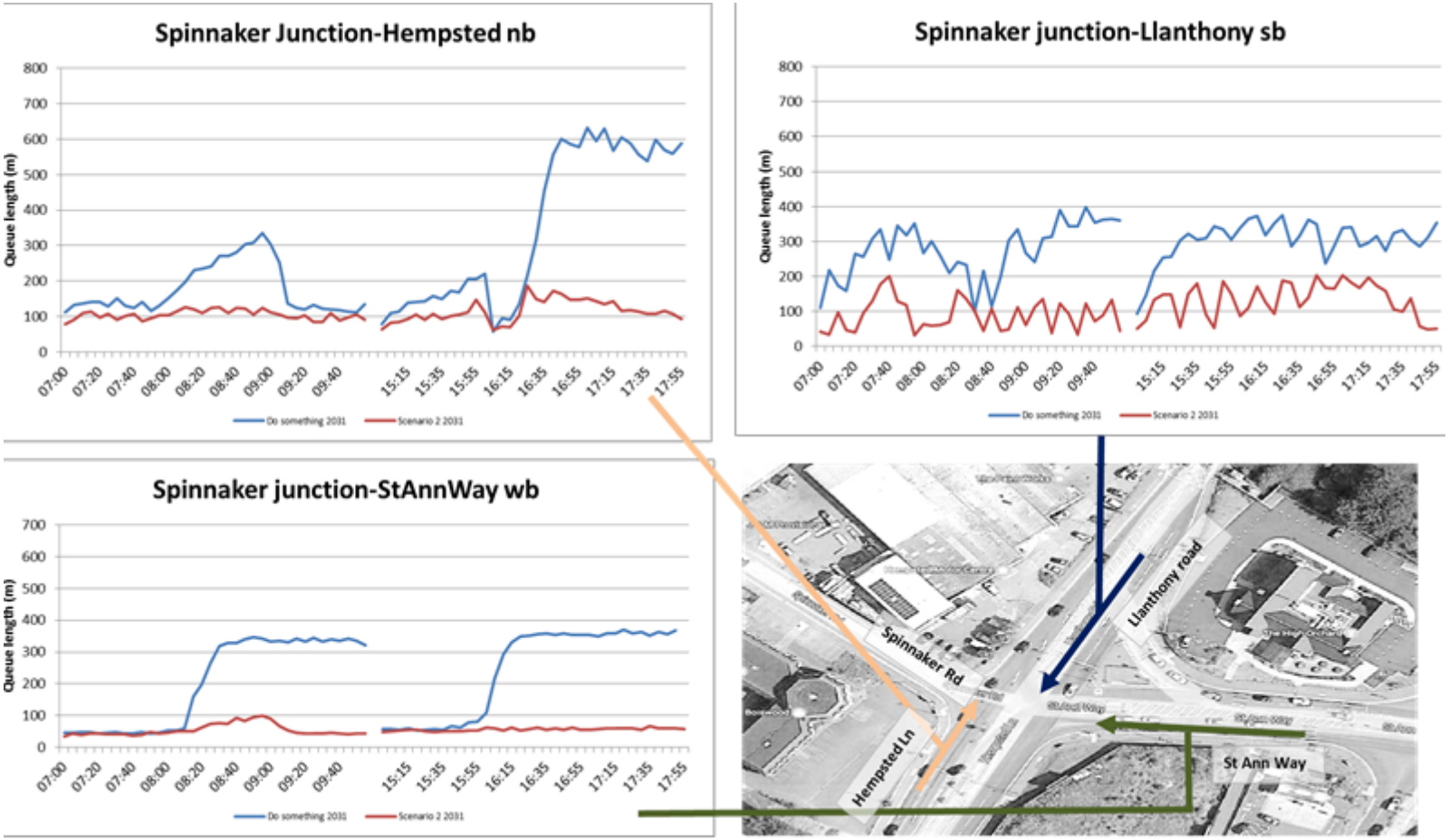


Figure 4.4: 2031 Queue length comparisons Option 2: Spinnaker Road junction

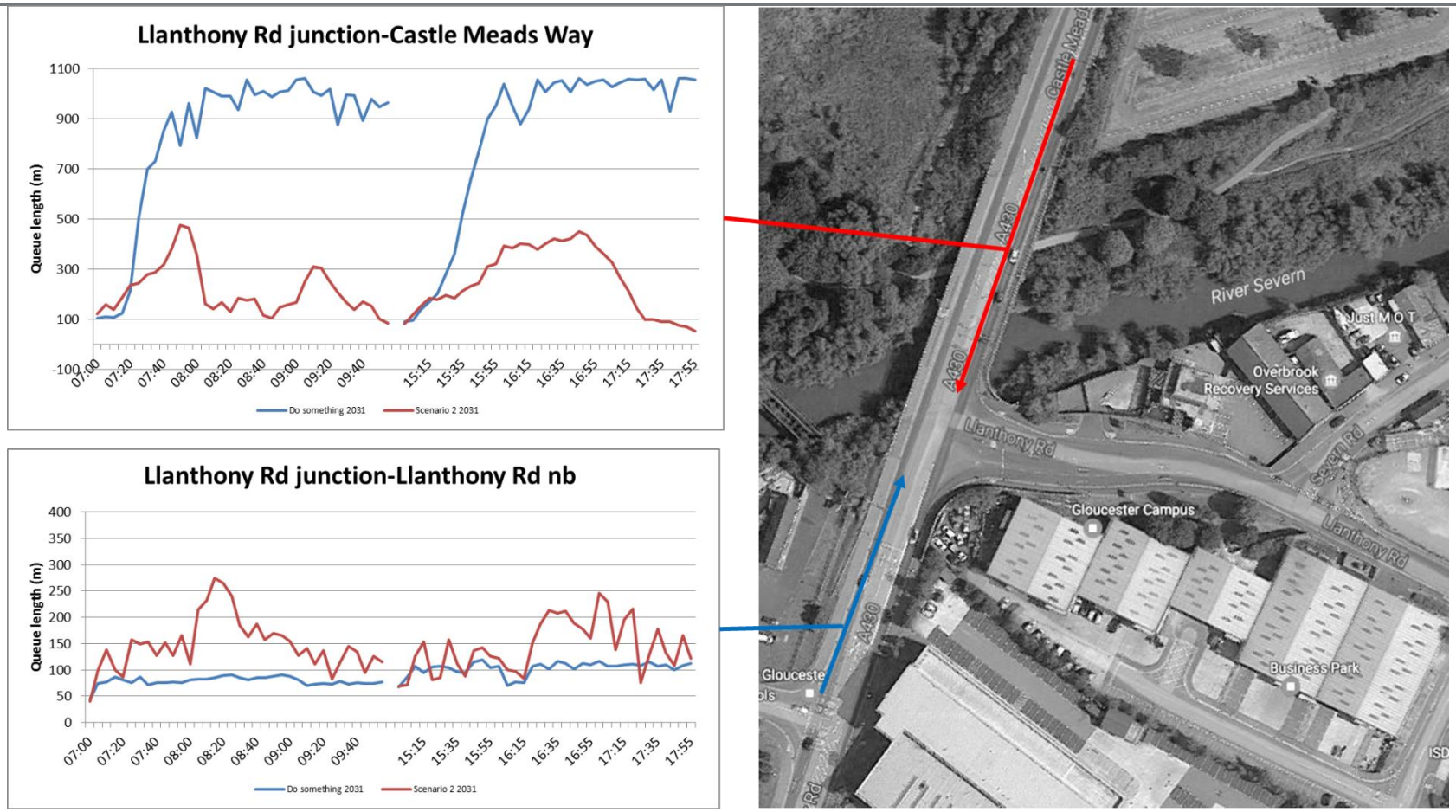


Figure 4.5: 2031 Queue length comparisons Option 2: Llanthony Rd junction

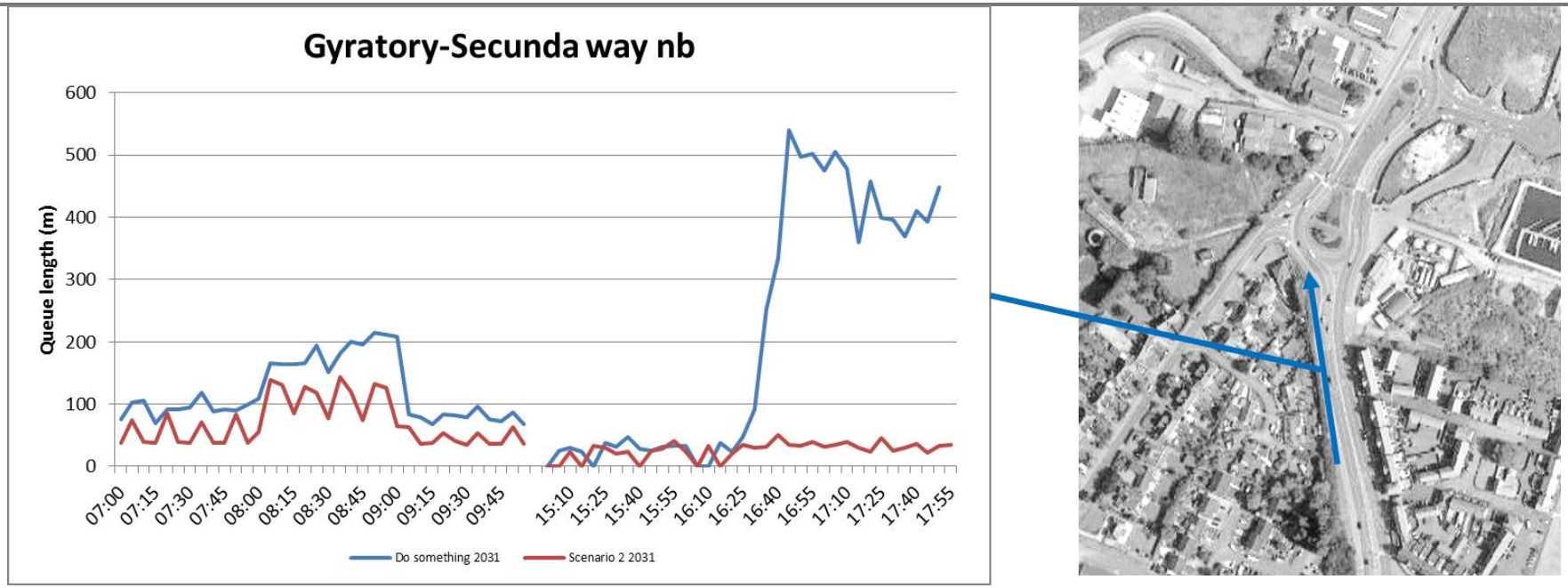


Figure 4.6: 2031 Queue length comparisons Option 2: Secunda Way northbound at Gyratory

4.5 Overall Combined Impacts of Options on Journey Time and Queue Length

Both options improve the overall capacity of the strategic road network in this area, generating significant journey time savings and reductions in queueing. The exception to this is at the Llanthony Road junction where, under Option 1 in 2031, northbound vehicles approaching the junction incur an additional delay of 3 seconds per vehicle. By comparison, under Option 2, northbound vehicles approaching the junction incur maximum additional delays of 25 seconds in 2018, and 20 seconds in 2031. (The delay reduces in 2031 as a result of the pedestrian stage being restricted under Option 2 to once every 2nd cycle in future years).

Not surprisingly, the impact of each option on vehicle journey times is reflected by comparable changes in queue lengths. Under Option 1 in 2031, the maximum queue length on the northbound approach to Llanthony Road junction increases from 100m in the Do-Min to 160m. Under Option 2, the northbound queue length increases to 300m in 2018, reducing slightly to 275m in 2031.

Conversely, on the north side of Llanthony Road junction, at Castle Meads Way, queue lengths and journey times are significantly improved. By 2031, Option 1 reduces the queues on this arm from over 1km to 300m, generating savings of nearly 8 minutes per vehicle during the pm peak. Option 2 delivers similar, although smaller improvements, reducing the queue length to 475m and saving nearly 7 minutes per vehicle during the pm peak.

Both options improve the performance of Spinnaker junction with Option 1 again outperforming Option 2. By 2031, Option 1 reduces the queues on the north arm (Llanthony Road S/B) from over 400m to 130m, on the east arm (St Ann Way W/B) from over 350m to less than 100m, and on the south arm (Hempsted Lane N/B) from over 600m to 200m.

On the northbound approach to the gyratory, Option 1 reduces the queues on Secunda Way from over 500m in the Do-Min to 50m in the 2031 pm peak. This results in journey time savings of nearly 1½ minutes per vehicle on this approach to the junction during the pm peak.

Overall, Option 1 consistently performs better than Option 2, delivering journey time savings up to 1½ minutes greater than under Option 2. Southbound trips along the A430 generally experience the biggest journey time savings, with journey time benefits of over 9 minutes per vehicle being generated by Option 1 in 2031 in the pm peak.

5 Economic Assessment

5.1 Overview

To test whether the options deliver value for money, the economic impact of changes in vehicle journey times, vehicle operating costs and vehicle emissions are quantified using PEARS 15.1 (Program for the Economic Assessment of Road Schemes) software to monetise the outputs from the S-Paramics models. The monetised benefits of each of the options are compared against the scheme costs to determine the Net Present Value (NPV) and Benefit Cost Ratio of the schemes.

As discussed in section 2.2 of this report, there are limitations with the modelling. As a result, this assessment only considers the economic impacts of the schemes during the AM and PM peak periods and the appraisal period is limited to 15 years. This approach will result in a conservative estimate of the traffic and economic benefits of the scheme, as it is unlikely that the schemes will generate disbenefits, outwith peak periods.

5.2 Scheme costs

The total scheme cost for Options 1 and 2 were provided in January 2017. The costs are estimated to be the same for both options at £4.74 million. This cost includes a risk allowance of £900,000 including Optimism Bias as shown in Table 5.1

All prices are adjusted to 2010 prices in PEARS (using the Consumer Prices Index (CPI)) and discounted to 2010 values for presentation in a common base year. In line with HM Treasure 'The Green Book' (ref. Table 6.1, The Green Book: Appraisal and Evaluation in Central Government), the discount rate is 3.5% for the first 30 years and 3.0% for the 30 years thereafter.

The scheme costs were calculated in January 2017. The CPI value for January 2017 is 101.4.

Scheme costs	
Site Works (land purchase, Stats, Highways)	£3,620,000
Risk Contingency (including optimism bias)	£900,000
Business Case, Detailed Design and Procurement	£220,000
Total excluding VAT (Jan 2017)	£4,740,000
Total excluding VAT (2010 prices and values)	£3.73M

Table 5.1: Scheme Cost

5.3 PEARS Economic Assessment

PEARS is an economic assessment package specifically designed for use with the output from traffic microsimulation models. Unlike TUBA which relies on a single travel time and vehicle operating cost for each link to represent the whole modelled period, PEARS carries out trip-based assessments of changes in travel time costs, vehicle operating costs, and carbon emission costs by aggregating the costs of each individually modelled vehicle on the network.

PEARS 15.1 reflects the updates to the TAG data book, dated November 2014. A new release of this software has not yet been issued to reflect the latest updates to the TAG data book which was issued in July 2016. The CPI reference table within the PEARS software has been manually updated to reflect the latest CPI values in the TAG data book of July 2016. The results of the PEARS analysis are shown in Table 5.2.

PEARS Results				
(Adjusted to 2010 prices, and discounted to 2010 values)	**Core Option 1**	**Core Option 2**	**Sensitivity 1**	**Sensitivity 2**
Non-Business Travel Time	+£33.83M	+£32.20M	+£33.39M	+£18.58M
Business Travel Time	+£33.70M	+£31.77M	+£33.09M	+£19.45M
Non-Business Vehicle Operating Costs	+£2.34M	+£2.22M	+£2.08M	+£1.06M
Business Vehicle Operating Costs	+£3.35M	+£3.10M	+£3.16M	+£1.69M
Private Sector Provider Impacts	+£0.07M	+£0.08M	+£0.08M	+£0.06M
Carbon	+£0.45	+£0.42	+£0.42	+£0.22M
Taxation	-£2.15	-£2.01	-£2.03	-£1.07M
TOTAL	**+£71.59M**	**+£67.78M**	**+£70.19M**	**+£39.97M**
TOTAL IMPACT (Present Value of Benefits)	**£71.59 M**	**£67.78 M**	**£70.19 M**	**£39.97 M**
Present Value of costs (PVC)	**£3.74 M**	**£3.74 M**	**£3.74 M**	**£3.74 M**
Net Present Value (NPV)	**£67.85 M**	**£64.04 M**	**£66.45 M**	**£36.23 M**
Overall Benefit to Cost Ratio	**+19.14**	**+18.13**	**+18.77**	**+10.69**

Table 5.2: Summary of Economic Impacts and TEE Table Results

Significant reductions in vehicle journey times within the modelled options, and their associated reductions in vehicle operating costs and vehicle emissions during the AM and PM peak period produce substantial economic benefits for road users.

The majority of the benefits are derived from reductions in travel times. In all scenarios, the level of benefits far exceeds the cost of the scheme resulting in high BCR values. Under the Core Scenario, Option 1 generates a NPV of £67.85M and a BCR of 19.14, whilst Option 2 is 5% less effective, delivering £3.8M fewer benefits to road users.

Under the sensitivity test, the southbound trips from Severn Road are reassigned to the A430 mainline as the journey time savings on the A430 may make this route more attractive. The increased flows on the mainline marginally reduce the effectiveness of Option 1, reducing the BCR by only 2%, with £1.4M fewer benefits over the appraisal period. Even under the sensitivity test, Option 1 performs better than the Core Scenario for Option 2, delivering a BCR of 18.77.

Although still delivering a positive BCR, Option 2 performs less well under the sensitivity test. From the journey time and queuing results in Appendix B it can be seen that by 2031, under the sensitivity test Option 2 delivers significantly less journey time savings and reductions in queue lengths on Castle Meads Way compared to the Core Scenario, (3½ mins v 7 mins & 800m v 475m). This suggests that under Option 2, the operational efficiency of Llanthony Road junction is less able to accommodate the increased traffic volumes associated with the sensitivity test.

The full TEE tables for the core assessment are presented in Tables 5.3 to 5.5 below for Option 1, and Tables 5.6 to 5.8 for Option 2. The TEE tables for the two sensitivity scenarios are included within Appendix C. All costs are presented in 2010 prices and are discounted to 2010 values.

Table 15A: Economic Efficiency of the Road System (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Ref.	Cal'n / Source	Total	Cars	LGVs	OGVs	Private Buses & Coaches	Service Buses
NON-BUSINESS USER BENEFITS								
Travel Time								
Commuting Travel Time	1		£14.37	£14.06	£0.20			£0.11
Other Travel Time	2		£19.46	£18.47	£0.65		£0.16	£0.18
Non-business Travel Time	**3**	**1+2**	**£33.83**					
Vehicle Operating Costs								
Commuter Fuel VOC	4		£1.13	£1.11	£0.02			
Commuter Non-fuel VOC	5		£0.01	£0.01	£0.00			
Other Fuel VOC	6		£1.19	£1.12	£0.08			
Other Non-fuel VOC	7		£0.01	£0.01	£0.00			
Non-business Vehicle Operating Costs	**8**	**4+5+6+7**	**£2.34**					
During Construction and Maintenance								
Commuting: During Construction and Maintenance (*)	*9*							
Other: During Construction and Maintenance (*)	*10*							
NET NON-BUSINESS BENEFITS: COMMUTING	**11**	**1+4+5+9**	**£15.51**					
NET NON-BUSINESS BENEFITS: OTHER	**12**	**2+6+7+10**	**£20.66**					
NET NON-BUSINESS BENEFITS - SUB TOTAL	**13**	**11+12**	**£36.17**					
BUSINESS USER BENEFITS								
User Benefits								
Business Travel Time	**14**		**£33.70**	£20.47	£10.12	£2.99	£0.03	£0.09
Fuel VOC	15		£1.68	£0.40	£0.70	£0.58		
Non-fuel VOC	16		£1.67	£0.80	£0.29	£0.58		
Business Vehicle Operating Costs	**17**	**15+16**	**£3.35**					
During Construction (*)	*18*							
During Maintenance (*)	*19*							
During Construction and Maintenance (*)	*20*	**18+19**						
Subtotal	**21**	**14+17+20**	**£37.05**					
Private Sector Provider Impacts								
Revenue (*)	*22*							
Fuel VOC	23		£0.04				£0.01	£0.03
Non-fuel VOC	24		£0.03				£0.01	£0.02
Private Sector Vehicle Operating Costs	**25**	**23+24**	**£0.07**					
Investment Costs (*)	26							
Grant / Subsidy (*)	27							
Subtotal	**28**	**22+25+26+27**	**£0.07**					
Other Business Impacts								
Developer & Other Contributions (*)	*29*							
NET BUSINESS IMPACT	**30**	**21+28+29**	**£37.12**					
TOTAL PRESENT VALUES OF TEE IMPACTS	**31**	**13+30**	**£73.29**					

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Sub-Totals / Impacts etc. as well as the NPV & BCR etc. in Table 15C.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table 5.3: Option 1 Core Scenario - Economic Efficiency of the Transport System (Market Prices)

Table 15B: Public Accounts

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'c / Source	Total
Local Government Funding			
Revenue (*)	32		
Investment Costs (*)	33		
Operating Costs (*)	34		
Maintenance Costs			
Non-Traffic (Group 1) (*)	35		
Traffic Related (Group 2) (*)	36		
Developer & Other Contributions (*)	37		
Grant Subsidy Payment (*)	*38*		
Net Impact	39	Sum(32 to 38)	
Central Government Funding: Transport			
Revenue (*)	40		
Investment Costs	41		£3.74
Operating Costs (*)	42		
Maintenance Costs			
Non-Traffic (Group 1) (*)	43		
Traffic Related (Group 2) (*)	44		
Developer & Other Contributions (*)	45		
Grant Subsidy Payment (*)	46		
Net Impact	47	Sum(40 to 46)	***£3.74***
Central Government Funding : Non-Transport			
Indirect Tax Revenues	48		£2.15
TOTALS			
Broad Transport Budget	49	39+47	**£3.74**
Wider Public Finances	50	48	**£2.15**

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Net Impacts / Totals etc. as well as the NPV & BCR etc. in Table 15C.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table 5.4: Option 1 Core Scenario – Public Accounts

Table 15C: Analysis of Monetised Costs and Benefits (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'n / Source	Total
TEE Impacts			
Noise (^)*	51		
Local Air Quality (^)*	52		
Greenhouse Gases (Emissions) (low)			£0.22
Greenhouse Gases (Emissions) (central)	53		**£0.45**
Greenhouse Gases (Emissions) (high)			£0.67
Journey Ambience (^)*	54		
Accident Benefits (*)	55		
Non-Business User Benefits: Commuting	56	11	£15.51
Non-Business User Benefits: Other	57	12	£20.66
Business User & Provider Benefits	58	30	£37.12
Wider Public Finance (Indirect Tax Revenue)	59	-50	£-2.15
Option Values (^)*	60		
Present Value of Benefits (PVB)	61	Sum(51 to 60)	**£71.59**
Broad Transport Budget	62	49	£3.74
Present Value of Costs (PVC)	63	62	**£3.74**
OVERALL IMPACTS			
Net Present Value (NPV)	64	61-63	**£67.85**
Benefit to Cost Ratio (BCR)	65	61/63	**19.14**

* Impact calculated external to PEARS & manually inputted by User. Any manual inputs will require the manual recalculation of the NPV & BCR etc.

^ Costs & benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect.

In addition to the costs & benefits outlined above, there may also be significant others, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does not provide a good measure of the value for money (VFM) and should not be used as the sole basis for decisions.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table 5.5: Option 1 Core Scenario – Monetised Costs and Benefits (Market Prices)

Table 15A: Economic Efficiency of the Road System (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Ref.	Cal'n / Source	Total	Cars	LGVs	OGVs	Private Buses & Coaches	Service Buses
NON-BUSINESS USER BENEFITS								
Travel Time								
Commuting Travel Time	1		£13.68	£13.39	£0.19			£0.10
Other Travel Time	2		£18.52	£17.55	£0.62		£0.18	£0.18
Non-business Travel Time	**3**	**1+2**	**£32.20**					
Vehicle Operating Costs								
Commuter Fuel VOC	4		£1.07	£1.05	£0.02			
Commuter Non-fuel VOC	5		£0.01	£0.01	£0.00			
Other Fuel VOC	6		£1.13	£1.06	£0.07			
Other Non-fuel VOC	7		£0.01	£0.01	£0.00			
Non-business Vehicle Operating Costs	**8**	**4+5+6+7**	**£2.22**					
During Construction and Maintenance								
Commuting: During Construction and Maintenance (*)	*9*							
Other: During Construction and Maintenance (*)	*10*							
NET NON-BUSINESS BENEFITS: COMMUTING	**11**	**1+4+5+9**	**£14.77**					
NET NON-BUSINESS BENEFITS: OTHER	**12**	**2+6+7+10**	**£19.66**					
NET NON-BUSINESS BENEFITS - SUB TOTAL	**13**	**11+12**	**£34.43**					
BUSINESS USER BENEFITS								
User Benefits								
Business Travel Time	**14**		**£31.77**	£19.34	£9.56	£2.75	£0.04	£0.09
Fuel VOC	15		£1.55	£0.38	£0.67	£0.50		
Non-fuel VOC	16		£1.55	£0.75	£0.27	£0.52		
Business Vehicle Operating Costs	**17**	**15+16**	**£3.10**					
During Construction (*)	*18*							
During Maintenance (*)	*19*							
During Construction and Maintenance (*)	*20*	**18+19**						
Subtotal	**21**	**14+17+20**	**£34.87**					
Private Sector Provider Impacts								
Revenue (*)	*22*							
Fuel VOC	23		£0.04				£0.02	£0.03
Non-fuel VOC	24		£0.04				£0.02	£0.02
Private Sector Vehicle Operating Costs	**25**	**23+24**	**£0.08**					
Investment Costs (*)	26							
Grant / Subsidy (*)	27							
Subtotal	**28**	**22+25+26+27**	**£0.08**					
Other Business Impacts								
Developer & Other Contributions (*)	*29*							
NET BUSINESS IMPACT	**30**	**21+28+29**	**£34.95**					
TOTAL PRESENT VALUES OF TEE IMPACTS	**31**	**13+30**	**£69.38**					

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Sub-Totals / Impacts etc. as well as the NPV & BCR etc. in Table 15C.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table 5.6: Option 2 Core Scenario - Economic Efficiency of the Transport System (Market Prices)

Table 15B: Public Accounts

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'c / Source	Total
Local Government Funding			
Revenue (*)	32		
Investment Costs (*)	33		
Operating Costs (*)	34		
Maintenance Costs			
Non-Traffic (Group 1) (*)	35		
Traffic Related (Group 2) (*)	36		
Developer & Other Contributions (*)	37		
Grant Subsidy Payment (*)	*38*		
Net Impact	39	Sum(32 to 38)	
Central Government Funding: Transport			
Revenue (*)	40		
Investment Costs	41		£3.74
Operating Costs (*)	42		
Maintenance Costs			
Non-Traffic (Group 1) (*)	43		
Traffic Related (Group 2) (*)	44		
Developer & Other Contributions (*)	45		
Grant Subsidy Payment (*)	46		
Net Impact	47	Sum(40 to 46)	***£3.74***
Central Government Funding : Non-Transport			
Indirect Tax Revenues	48		£2.01
TOTALS			
Broad Transport Budget	49	39+47	**£3.74**
Wider Public Finances	50	48	**£2.01**

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Net Impacts / Totals etc. as well as the NPV & BCR etc. in Table 15C.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table 5.7: Option 2 Core Scenario – Public Accounts

Table 15C: Analysis of Monetised Costs and Benefits (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'n / Source	Total
TEE Impacts			
Noise (^)*	51		
Local Air Quality (^)*	52		
Greenhouse Gases (Emissions) (low)			£0.21
Greenhouse Gases (Emissions) (central)	53		**£0.42**
Greenhouse Gases (Emissions) (high)			£0.62
Journey Ambience (^)*	54		
Accident Benefits (*)	55		
Non-Business User Benefits: Commuting	56	11	£14.77
Non-Business User Benefits: Other	57	12	£19.66
Business User & Provider Benefits	58	30	£34.95
Wider Public Finance (Indirect Tax Revenue)	59	-50	£-2.01
Option Values (^)*	60		
Present Value of Benefits (PVB)	61	Sum(51 to 60)	**£67.78**
Broad Transport Budget	62	49	£3.74
Present Value of Costs (PVC)	63	62	**£3.74**
OVERALL IMPACTS			
Net Present Value (NPV)	64	61-63	**£64.04**
Benefit to Cost Ratio (BCR)	65	61/63	**18.13**

* Impact calculated external to PEARS & manually inputted by User. Any manual inputs will require the manual recalculation of the NPV & BCR etc.

^ Costs & benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect.

In addition to the costs & benefits outlined above, there may also be significant others, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does not provide a good measure of the value for money (VFM) and should not be used as the sole basis for decisions.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table 5.8: Option 2 Core Scenario – Monetised Costs and Benefits (Market Prices)

6 Conclusions

6.1 Conclusions

The Traffic and Economic Assessment shows that both improvement options for the A430 between St Ann Way and Llanthony Road in Gloucester offer substantial improvements in operational performance, resulting in large benefits that deliver value for money.

Option 1 consistently performs better than Option 2, both in traffic and economic terms. Option 1 delivers journey time savings up to 1½ minutes greater than under Option 2. Southbound trips along the A430 generally experience the biggest journey time savings, with journey time benefits of over 9 minutes per vehicle being generated by Option 1 in 2031 in the pm peak.

Under the Core Scenario, Option 1 delivers a BCR of 19.14 whilst Option 2 has a slightly lower BCR of 18.13. However, when re-routeing is considered in the Sensitivity test, the BCR for Option 1, (18.77) is 75% greater than the BCR achieved by Option 2 (10.69).

Option 1 delivers the greatest benefits overall, particularly if re-routeing were to occur. It delivers the greatest improvement in the overall capacity of the strategic road network in this area, generating significant journey time savings and reductions in queueing. It also offers value for money, generating BCR values in excess of 18 in both scenarios. It is therefore recommended that Option 1 be taken forward to the next stage in the design/appraisal process.

Appendix A Model Development, Calibration & Validation Results

Model development

Network wide behaviour parameters

The following network-wide behaviour parameters have been assigned:

- Network-wide behaviour parameters.
- Aggression is set at its default value.
- Awareness is set at its default value.
- Mean headway is set at its defaults value of 1 s.
- Minimum gap is set at its default value of 2m.
- Overtaking is set at the defaults value of "Medium".
- Precise Release is selected.
- Seed value of zero is used.

Generalised Cost Equation

The generalised cost equation has been remained to the default values..

Hazard Overrides

There are no Hazard Overrides incorporated into the model

Traffic Data

Turning count surveys were not carried out for the present year but details of historic counts from the County Council are available. This data includes traffic turning counts for eight junctions. Additional data for the southern part of the model (gyratory) was extracted by a 2013 Saturn model.

Time periods

There are two periods in the model:

- 0700 to 1000 AM Peak (Weekday)
- 1500 to 1800 PM peak (Weekday)

Demand Profiles

Demand profiles were developed using Gloucester County's council historic counts to determine release profiles from each zone for each matrix level. These were then compared and similar profiles grouped together to reduce the number of profiles required in the model. A total of forty demand profiles were defined within the model.

Incidents

No "Incidents" have been included in the model.

Calibration

The S-Paramics model has been calibrated against the Gloucester County council's historic data. A good match between the obtained counter data and the observed flow swill ensure the model accurately represents present traffic behaviour on the network.

The level of accuracy required for calibration is detailed in the Design Manual for Roads and Bridges (DMRB) Volume 12, Section 2, Part 1.

- For flows that are less than 700vph, the model and survey flows should be within 100 vph;
- For flows that are between 700 and 2,700 vph, the model and survey flows should be within 15% in more than 85% of cases;
- For flows that are greater than 2,700 vph, the model and survey flows should be within 400 vph;

Another test of calibration is the GEH statistic. GEH is a Chi squared statistic; if M is the measured flow and C is the observed flow, then:

$$GEH = \sqrt{\frac{(M-C)^2}{\frac{1}{2}(M+C)}}$$

The value of the GEH statistic should be less than 5 in at least 85% of cases.

The calibration assessment has compared hourly values of link counts in the model against data from the traffic counters shown in Table A.2. These calibration calculations have been carried out for the AM peak and PM peak.

A total of 54 comparisons were undertaken for each hour between 0700-1000 and 1500-1800. The results showed that of the 324 hourly flow comparisons meet the above criteria. This indicated that the model compares very well against the observed data. GEH values were well within the calibration requirements of a GEH value of less than 5 in more than 85% of all cases. Table A.3 shows the percentage of comparisons which had a GEH value of <5 in each modelled hour. As an additional indicator, the percentage of GEH vales less than 3 has also been provided. This shows that at least 85% of all comparisons have a GEH value of less than 3, indicating that the model compares very well against the observed data as shown in Table A.1. In addition tables A.2 to A.5 details the survey differences at each junction by hour. In conclusion, the S-Paramics base model meets the DMRB criteria set in Volume 12, Section 2 Part 1 and is considered well-calibrated.

AM Peak	**07:00**		**08:00**		**09:00**		**07:00-10:00**	
GEH	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
Total with GEH less than 3	49	91%	53	98%	52	96%	54	100%
Total with GEH less than 5	54	100%	54	100%	54	100%	54	100%
Total with GEH greater than 5	0	0%	0	0%	0	0%	0	0%
Total number of comparisons	54		54		54		54	
PM Peak	**15:00**		**16:00**		**17:00**		**15:00-18:00**	
GEH	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
Total with GEH less than 3	52	98%	51	94%	50	93%	54	100%
Total with GEH less than 5	53	100%	54	100%	54	100%	54	100%
Total with GEH greater than 5	0	0%	0	0%	0	0%	0	0%
Total number of comparisons	53		54		54		54	

Table A.6.1: GEH calibration

Table A.2- AM - Turn count flow calibration																				
	07:00					08:00					09:00					07:00-10:00				
Movement	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH
Hempsted > Spinnaker	16	13	20%	3	0.69	20	24	-15%	-4	0.76	14	19	-25%	-5	1.15	50	56	-10%	-6	0.45
Hempsted > A430 Llanthony	862	924	-7%	-62	2.07	1137	1128	1%	9	0.26	800	774	3%	26	0.93	2799	2826	-1%	-27	0.29
Hempstead > StAnnWay	134	151	-11%	-17	1.44	221	234	-6%	-13	0.86	189	201	-6%	-12	0.84	544	586	-7%	-42	1.02
Spinnaker > A430 Llanthony	8	4	103%	4	1.67	10	15	-32%	-5	1.35	8	10	-25%	-3	0.85	26	29	-11%	-3	0.35
Spinnaker > StAnnWay	4	4	5%	0	0.10	7	5	30%	2	0.63	7	9	-20%	-2	0.63	18	18	-1%	0	0.01
Spinnaker > Hempsted Ln	6	7	-9%	-1	0.23	8	4	103%	4	1.67	5	10	-46%	-5	1.66	20	21	-5%	-1	0.14
Llanthony sb > StAnnWay	260	221	17%	39	2.48	282	312	-10%	-30	1.75	283	307	-8%	-24	1.42	824	840	-2%	-16	0.32
Llanthony sb > Hempsted	599	726	-17%	-127	4.93	640	568	13%	72	2.94	654	570	15%	84	3.41	1894	1864	2%	30	0.40
Llanthony sb > Spinnaker	15	22	-34%	-8	1.76	17	16	3%	1	0.12	18	16	9%	2	0.37	49	54	-10%	-6	0.44
StAnnWay > Hempsted	67	78	-15%	-12	1.35	81	84	-4%	-4	0.39	85	101	-16%	-16	1.68	232	263	-12%	-31	1.15
StAnnWay > Spinnaker	11	18	-40%	-7	1.90	13	11	18%	2	0.58	9	6	50%	3	1.10	33	35	-6%	-2	0.22
StAnnWay > A430 Llanthony	163	192	-15%	-29	2.20	261	281	-7%	-20	1.24	223	199	12%	24	1.63	646	672	-4%	-26	0.58
Sudmeadow > A430 Llanthony nb	8	9	-13%	-1	0.41	17	19	-8%	-2	0.38	25	27	-9%	-2	0.47	50	55	-9%	-5	0.41
Sudmeadow > A430 Llanthony sb	3	3	-7%	0	0.12	19	22	-15%	-3	0.73	30	32	-6%	-2	0.36	52	57	-10%	-6	0.43
A430 Llanthony sb > A430 Llanthony	876	964	-9%	-88	2.91	919	895	3%	24	0.81	923	845	9%	78	2.63	2718	2704	1%	14	0.16
A430 Llanthony sb > Sudmeadow	32	29	11%	3	0.60	35	32	9%	3	0.48	33	44	-24%	-11	1.72	100	105	-4%	-5	0.26
A430 Llanthony nb > Sudmeadow	38	46	-17%	-8	1.22	48	38	25%	10	1.47	36	42	-15%	-6	1.03	121	126	-4%	-5	0.24
A430 Llanthony nb > A430 Llanthony	995	1057	-6%	-62	1.94	1360	1383	-2%	-23	0.63	995	937	6%	58	1.86	3350	3377	-1%	-28	0.27
Hemmingsdale > A430 Llanthony northbound (left turn)	3	3	-7%	0	0.12	8	8	-4%	0	0.11	11	11	-5%	-1	0.15	21	22	-5%	-1	0.12
Hemmingsdale > A430 Llanthony northbound (right turn)	3	4	-18%	-1	0.37	4	4	-13%	-1	0.26	18	20	-9%	-2	0.41	25	28	-11%	-3	0.34
A430 nb > Hemmingsdale	8	1	670%	7	3.21	10	11	-9%	-1	0.31	7	15	-53%	-8	2.38	25	27	-8%	-2	0.25
A430 nb > A430 Llanthony	995	1061	-6%	-66	2.06	1367	1385	-1%	-18	0.47	1012	946	7%	66	2.12	3375	3392	-1%	-18	0.17
A430 sb > Hemmingsdale	7	1	580%	6	2.94	7	5	44%	2	0.89	6	13	-54%	-7	2.27	20	19	5%	1	0.13
A430 sb > A430 Llanthony	920	998	-8%	-78	2.53	947	928	2%	19	0.63	930	873	7%	57	1.90	2797	2799	0%	-2	0.02
Local Business > A430 sb (left turn)	2	3	-33%	-1	0.63	1	1	0%	0	0.00	2	3	-27%	-1	0.50	5	7	-26%	-2	0.42
Local Business > A430 nb (right turn)	1	1	0%	0	0.00	1	1	0%	0	0.00	1	1	10%	0	0.10	3	3	3%	0	0.03
A430 nb > A430 Llanthony	994	1068	-7%	-74	2.31	1370	1383	-1%	-13	0.35	1020	943	8%	77	2.44	3383	3394	0%	-11	0.11
A430 nb > Local Business	4	2	90%	2	1.06	5	8	-39%	-3	1.22	3	4	-18%	-1	0.37	12	14	-14%	-2	0.32
A430 sb > Local Business	0	2	-100%	-2	2.00	0	1	-100%	-1	1.41	0	4	-100%	-4	2.83	0	7	-100%	-7	2.16
A430 sb > A430	931	1021	-9%	-90	2.89	953	934	2%	19	0.61	930	890	4%	40	1.33	2814	2845	-1%	-32	0.34
chipsaway > A430 nb	2	2	-10%	0	0.15	6	6	3%	0	0.08	7	7	0%	0	0.00	15	15	0%	0	0.00
chipsaway > A430 sb	1	1	11%	0	0.11	4	5	-22%	-1	0.52	4	5	-18%	-1	0.42	9	11	-17%	-2	0.34
A430 nb > chipsaway	9	10	-7%	-1	0.23	13	14	-10%	-1	0.38	10	13	-25%	-3	0.95	32	37	-14%	-5	0.52
A430 nb > A430 Llanthony	986	1055	-7%	-70	2.18	1358	1373	-1%	-15	0.40	1011	936	8%	75	2.40	3355	3364	0%	-9	0.09
A430 sb > A430 Llanthony	937	1015	-8%	-78	2.50	950	940	1%	10	0.32	924	887	4%	37	1.21	2810	2842	-1%	-32	0.35
A430 sb > chipsaway	7	9	-20%	-2	0.63	7	5	46%	2	0.93	6	6	7%	0	0.16	21	20	4%	1	0.11
Llanthony nb > Castle Meads Way	886	960	-8%	-74	2.45	1167	1146	2%	21	0.63	884	809	9%	75	2.59	2937	2915	1%	22	0.24
Llanthony nb > Llanthony A430	98	87	13%	11	1.16	196	227	-14%	-31	2.14	134	133	1%	1	0.10	428	447	-4%	-19	0.52
Castle Meads Way> Llanthony sb	821	867	-5%	-46	1.60	731	681	7%	50	1.88	719	692	4%	27	1.03	2271	2240	1%	31	0.38
Castle Meads Way > Llanthony eb	64	33	95%	31	4.50	59	59	-1%	-1	0.07	57	40	43%	17	2.48	180	132	37%	48	2.23
Llanthony east arm > A430 Llanthony sb	129	147	-12%	-18	1.51	232	256	-9%	-24	1.54	200	206	-3%	-6	0.40	561	609	-8%	-48	1.14
Llanthony east arm > Castle Meads Way	19	6	213%	13	3.63	33	45	-26%	-12	1.87	29	33	-13%	-4	0.79	81	84	-4%	-3	0.21

Table A.2- AM - Turn count flow calibration																				
	07:00					08:00					09:00					07:00-10:00				
Movement	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH
Severn road > Llanthony Rd (right turn)	139	148	-6%	-9	0.78	216	246	-12%	-30	1.99	161	155	4%	6	0.44	515	549	-6%	-34	0.85
Severn road > Llanthony Rd (left turn)	47	51	-7%	-4	0.54	105	120	-12%	-15	1.39	40	33	21%	7	1.16	193	204	-6%	-12	0.47
LlanthonyRd > Severn Rd	78	66	18%	12	1.43	92	97	-6%	-5	0.56	76	82	-7%	-6	0.63	246	245	0%	1	0.04
LlanthonyRd > Business Park	85	46	84%	39	4.77	163	185	-12%	-22	1.70	115	85	36%	30	3.02	362	316	15%	46	1.45
Business Park > LlanthonyRd	10	11	-10%	-1	0.34	61	71	-14%	-10	1.19	57	65	-12%	-8	1.00	128	147	-13%	-19	0.92
Business Park > Severn Rd	3	3	-3%	0	0.06	30	31	-3%	-1	0.18	35	35	-1%	0	0.03	68	69	-2%	-1	0.09
Sainsburys arm > St Ann Way wb	47	68	-32%	-22	2.84	72	48	49%	24	3.04	59	59	0%	0	0.03	177	175	1%	2	0.08
Sainsburys arm > St Ann Way eb	79	77	2%	2	0.22	185	183	1%	2	0.13	121	116	4%	5	0.43	384	376	2%	8	0.25
St Ann way eastbound	344	329	5%	15	0.83	445	492	-10%	-47	2.19	420	430	-2%	-10	0.49	1209	1251	-3%	-42	0.69
St Ann way eb > Sainsbury's	50	48	4%	2	0.29	64	50	29%	14	1.90	59	82	-28%	-23	2.71	174	180	-4%	-6	0.28
StAnnWay westbound	194	217	-10%	-23	1.58	288	329	-12%	-41	2.32	252	254	-1%	-2	0.12	735	800	-8%	-65	1.36
StAnnWay wb > Sainsbury's	42	40	6%	2	0.37	101	100	1%	1	0.13	126	121	4%	5	0.41	269	261	3%	8	0.29

Table A.6.2: Turn count flow calibration AM peak

DMRB criteria (Volume 12, Section 2 Part 1)	07:00			08:00			09:00			07:00-10:00		
	Total	Number OK	% OK	Total	Number OK	% OK	Total	Number OK	% OK	Total	Number OK	% OK
1. 700-2700 vehicles must be within 15% in more than 85% of all cases	12	11	92%	10	10	100%	10	10	100%	6	6	100%
2. <700 vehicles must be within 100 vehicles in more than 85% of all cases*	42	42	100%	44	44	100%	44	44	100%	61	61	100%
3. >2700 vehicles must be within 400 vehicles in more than 85% of all cases										11	11	100%

Table A.6.3: Flow calibration summary – AM peak

Table A.4- PM - Turn count flow calibration																				
	15:00					16:00					17:00					15:00-18:00				
Movement	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH
Hempsted > Spinnaker	7	14	-51%	-7	2.20	8	12	-36%	-4	1.37	9	2	370%	7	3.10	24	28	-14%	-4	0.45
Hempsted > A430 Llanthony	776	795	-2%	-19	0.69	864	916	-6%	-52	1.74	1105	997	11%	108	3.33	2745	2708	1%	37	0.41
Hempstead > StAnnWay	145	170	-15%	-25	2.00	127	141	-10%	-14	1.24	185	186	-1%	-1	0.09	456	497	-8%	-41	1.08
Spinnaker > A430 Llanthony	17	21	-20%	-4	0.94	20	24	-15%	-4	0.79	22	19	18%	3	0.75	60	64	-7%	-4	0.32
Spinnaker > StAnnWay	12	13	-6%	-1	0.23	12	14	-14%	-2	0.53	15	15	2%	0	0.08	40	42	-6%	-2	0.22
Spinnaker > Hempsted Ln	11	12	-5%	-1	0.18	14	21	-33%	-7	1.67	17	16	9%	1	0.34	43	49	-13%	-6	0.53
Llanthony sb > StAnnWay	228	261	-13%	-33	2.14	270	253	7%	17	1.07	255	270	-6%	-15	0.95	753	784	-4%	-32	0.66
Llanthony sb > Hempsted	667	716	-7%	-49	1.86	788	779	1%	9	0.31	730	790	-8%	-60	2.18	2185	2285	-4%	-100	1.22
Llanthony sb > Spinnaker	5	11	-58%	-6	2.29	6	5	14%	1	0.30	6	1	470%	5	2.57	16	17	-6%	-1	0.14
StAnnWay > Hempsted	145	169	-14%	-24	1.88	201	242	-17%	-41	2.74	219	257	-15%	-38	2.44	566	668	-15%	-102	2.37
StAnnWay > Spinnaker	2	9	-73%	-7	2.76	3	3	-17%	-1	0.30	4	0	0%	4	2.72	9	12	-28%	-3	0.61
StAnnWay > A430	268	305	-12%	-	2.19	318	342	-7%	-24	1.31	307	315	-3%	-8	0.46	893	962	-7%	-69	1.31

Table A.4- PM - Turn count flow calibration

	15:00					16:00					17:00					15:00-18:00				
Movement	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH
Llanthony				37																
																0	0	0%	0	
Sudmeadow > A430 Llanthony nb	27	26	3%	1	0.14	26	29	-10%	-3	0.55	22	24	-8%	-2	0.40	75	79	-5%	-4	0.27
Sudmeadow > A430 Llanthony sb	38	43	-11%	-5	0.77	45	52	-13%	-7	0.99	38	42	-11%	-5	0.71	121	137	-12%	-16	0.83
A430 Llanthony sb > A430 Llanthony	868	934	-7%	-66	2.21	1023	990	3%	33	1.04	944	1033	-9%	-89	2.83	2835	2957	-4%	-123	1.31
A430 Llanthony sb > Sudmeadow	15	23	-36%	-8	1.91	17	18	-4%	-1	0.19	16	8	99%	8	2.29	48	49	-2%	-1	0.10
A430 Llanthony nb > Sudmeadow	23	40	-43%	-17	3.09	25	25	2%	0	0.08	29	15	92%	14	2.95	77	80	-4%	-3	0.20
A430 Llanthony nb > A430 Llanthony	1032	1072	-4%	-40	1.23	1178	1243	-5%	-65	1.86	1408	1309	8%	99	2.69	3618	3624	0%	-6	0.05
																0	0	0%	0	
Hemmingsdale > A430 Llanthony northbound (left turn)	13	13	-2%	0	0.06	10	10	-2%	0	0.06	5	5	8%	0	0.18	28	28	0%	0	0.00
Hemmingsdale > A430 Llanthony northbound (right turn)	10	11	-9%	-1	0.31	9	9	-6%	-1	0.17	6	6	-8%	-1	0.21	24	26	-8%	-2	0.23
A430 nb > Hemmingsdale	6	11	-43%	-5	1.60	8	13	-39%	-5	1.58	10	2	375%	8	3.13	24	26	-9%	-2	0.27
A430 nb > A430 Llanthony	1047	1104	-5%	-57	1.73	1196	1273	-6%	-77	2.20	1426	1343	6%	83	2.24	3669	3720	-1%	-51	0.48
A430 sb > Hemmingsdale	6	12	-53%	-6	2.16	7	5	46%	2	0.93	6	2	195%	4	1.96	19	19	-1%	0	0.03
A430 sb > A430 Llanthony	883	942	-6%	-59	1.96	1036	983	5%	53	1.66	942	1035	-9%	-93	2.95	2861	2960	-3%	-99	1.06
																0	0	0%	0	
Local Business > A430 sb (left turn)	5	5	-10%	-1	0.23	4	5	-12%	-1	0.28	5	5	2%	0	0.04	14	15	-7%	-1	0.15
Local Business > A430 nb (right turn)	0	0	0%	0		1	1	0%	0	0.00	2	2	0%	0	0.00	3	3	0%	0	0.00
A430 nb > A430 Llanthony	1056	1124	-6%	-68	2.06	1205	1281	-6%	-76	2.17	1432	1360	5%	72	1.92	3692	3765	-2%	-73	0.69
A430 nb > Local Business	2	4	-63%	-3	1.51	2	2	-25%	-1	0.38	2	1	100%	1	0.82	5	7	-29%	-2	0.47
A430 sb > Local Business	0	2	-100%	-2	2.00	0	4	-100%	-4	2.83	0	1	-100%	-1	1.41	0	7	-100%	-7	2.16
A430 sb > A430	887	957	-7%	-70	2.29	1040	988	5%	52	1.65	939	1021	-8%	-82	2.63	2867	2966	-3%	-99	1.06
																0	0	0%	0	
chipsaway > A430 nb	15	15	2%	0	0.08	12	12	3%	0	0.09	10	11	-5%	-1	0.18	38	38	0%	0	0.00
chipsaway > A430 sb	7	8	-9%	-1	0.25	4	4	-13%	-1	0.26	10	12	-15%	-2	0.54	21	24	-13%	-3	0.37
A430 nb > chipsaway	4	6	-27%	-2	0.70	5	6	-22%	-1	0.56	5	6	-25%	-2	0.65	14	18	-24%	-4	0.64
A430 nb > A430 Llanthony	1049	1116	-6%	-68	2.05	1202	1277	-6%	-75	2.13	1431	1352	6%	79	2.12	3682	3745	-2%	-63	0.60
A430 sb > A430 Llanthony	886	952	-7%	-66	2.19	1040	989	5%	51	1.60	927	1013	-9%	-86	2.77	2852	2954	-3%	-102	1.09
A430 sb > chipsaway	3	5	-44%	-2	1.11	3	5	-34%	-2	0.83	3	1	190%	2	1.36	9	11	-18%	-2	0.37
																0	0	0%	0	
Llanthony nb > Castle Meads Way	977	1020	-4%	-43	1.36	1130	1176	-4%	-46	1.37	1344	1271	6%	73	2.01	3450	3467	0%	-17	0.16
Llanthony nb > Llanthony	73	99	-26%	-	2.78	90	94	-4%	-4	0.42	101	89	13%	12	1.20	264	282	-6%	-18	0.63

Table A.4- PM - Turn count flow calibration																				
	15:00					16:00					17:00					15:00-18:00				
Movement	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH	Modelled	Observed	% Difference	Difference	GEH
A430				26																
Castle Meads Way> Llanthony sb	658	688	-4%	-30	1.16	730	616	18%	114	4.38	547	624	-12%	-77	3.18	1935	1928	0%	7	0.09
Castle Meads Way > Llanthony eb	30	16	86%	14	2.88	33	24	36%	9	1.63	25	22	11%	3	0.52	87	62	40%	25	1.67
Llanthony east arm > A430 Llanthony sb	238	272	-13%	-34	2.14	315	377	-16%	-62	3.32	376	398	-6%	-22	1.13	929	1047	-11%	-118	2.17
Llanthony east arm > Castle Meads Way	45	46	-3%	-1	0.18	59	66	-11%	-7	0.94	65	69	-6%	-4	0.50	168	181	-7%	-13	0.55
																0	0	0%	0	
Severn road > Llanthony Rd (right turn)	216	237	-9%	-21	1.40	284	328	-14%	-45	2.54	313	323	-3%	-10	0.54	813	888	-8%	-75	1.49
Severn road > Llanthony Rd (left turn)	14	14	0%	0	0.00	45	49	-8%	-4	0.57	48	49	-1%	-1	0.09	108	112	-4%	-5	0.25
LlanthonyRd >	51	68	-24%	-17	2.15	59	50	19%	9	1.26	68	66	3%	2	0.22	179	184	-3%	-6	0.24
LlanthonyRd > Business Park	52	60	-14%	-8	1.12	63	60	5%	3	0.37	58	47	23%	11	1.51	172	167	3%	5	0.24
Business Park > LlanthonyRd	70	77	-9%	-7	0.80	99	113	-12%	-14	1.34	117	135	-13%	-18	1.61	286	325	-12%	-39	1.28
Business Park >	18	21	-14%	-3	0.66	35	42	-16%	-7	1.06	28	34	-17%	-6	1.06	82	97	-16%	-15	0.94
																0	0	0%	0	
Sainsburys arm > St Ann Way wb	69	83	-17%	-14	1.63	89	78	14%	11	1.24	91	78	16%	13	1.38	249	239	4%	10	0.36
Sainsburys arm > St Ann Way eb	134	134	0%	0	0.03	126	122	4%	4	0.39	150	146	3%	4	0.33	410	402	2%	8	0.23
St Ann way eastbound	317	364	-13%	-47	2.56	346	341	1%	5	0.26	380	391	-3%	-12	0.59	1042	1096	-5%	-54	0.95
St Ann way eb > Sainsbury's	63	69	-8%	-6	0.71	68	67	1%	1	0.07	75	74	1%	1	0.07	205	210	-2%	-5	0.18
StAnnWay westbound	359	395	-9%	-36	1.86	428	499	-14%	-71	3.28	452	479	-6%	-27	1.23	1240	1373	-10%	-133	2.13
StAnnWay wb > Sainsbury's	146	146	0%	0	0.02	168	176	-5%	-8	0.61	217	230	-5%	-13	0.84	532	552	-4%	-20	0.51

Table A.6.4: Turn count flow calibration – PM peak

DMRB criteria (Volume 12, Section 2 Part 1)	15:00			16:00			17:00			15:00-18:00		
	Total	Number OK	% OK	Total	Number OK	% OK	Total	Number OK	% OK	Total	Number OK	% OK
1. 700-2700 vehicles must be within 15% in more than 85% of all cases	11	11	100%	11	11	100%	11	11	100%	10	10	100%
2. <700 vehicles must be within 100 vehicles in more than 85% of all cases*	43	43	100%	43	42	98%	43	43	100%	61	61	100%
3. >2700 vehicles must be within 400 vehicles in more than 85% of all cases	0	0		0	0		0	0	#DIV/0!	10	10	100%

Table A.6.5: Flow calibration summary - PM peak

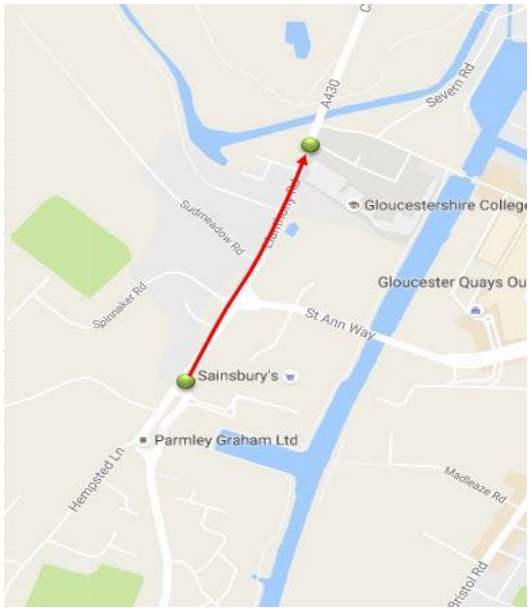
Validation

Validation of the model required a comparison of modelled against observed survey values using an independent set of data to that used in the calibration of the model. Two data sets were used to validate the model; journey time surveys and maximum queue length surveys.

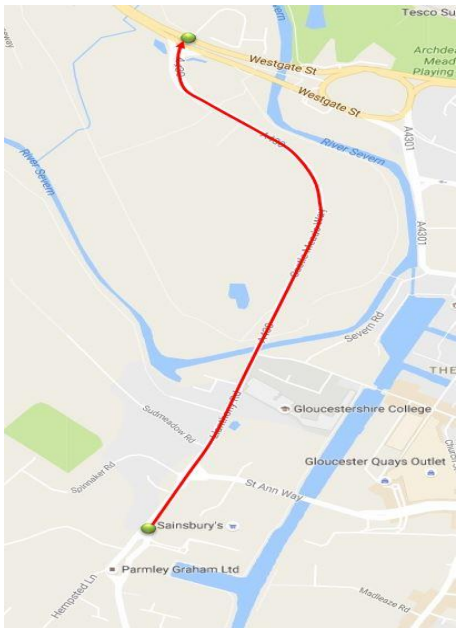
Journey time validation

Surveys were undertaken between 12 and 14 December 2016 using the moving observer method, where the driver of each survey car attempts to match the speed of the surrounding traffic. This produces realistic estimates of the journey times on key paths through the modelled network.

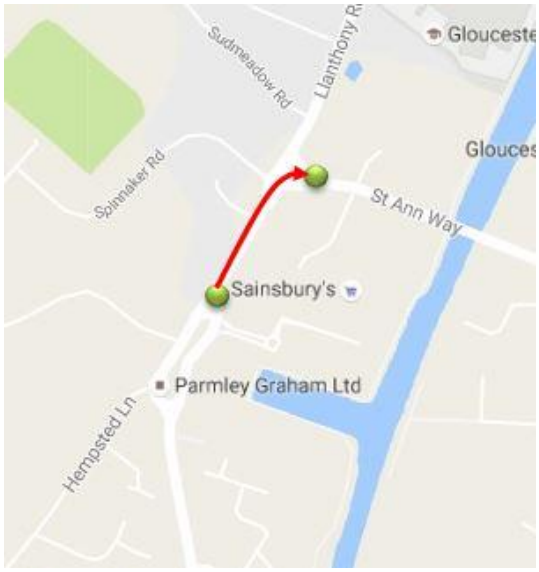
One survey car was used to measure journey times on Secunda Way, Hempsted Lane, Llanthony Road and St Ann Way during AM and PM peak. This survey provided a good measure of journey times along the mainline; however, no sample of journeys to and from the side roads was collected at this time. To improve the level of data collection Gloucester county council's historic data provides Bluetooth journey time surveys for the year 2015 and the month of May-June. The survey routes are illustrated in Table A.6



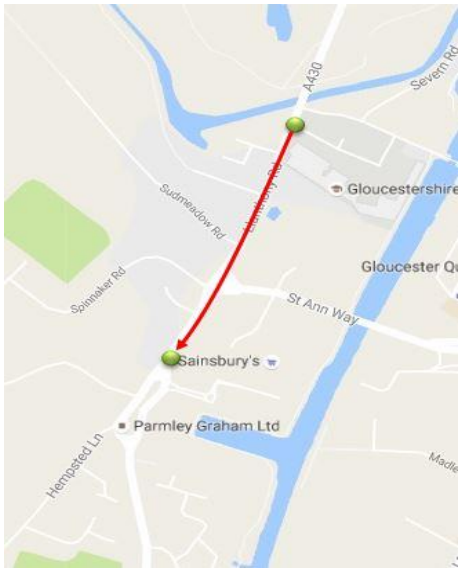
Hempsted Ln to Llanthony jct(BT25-26)



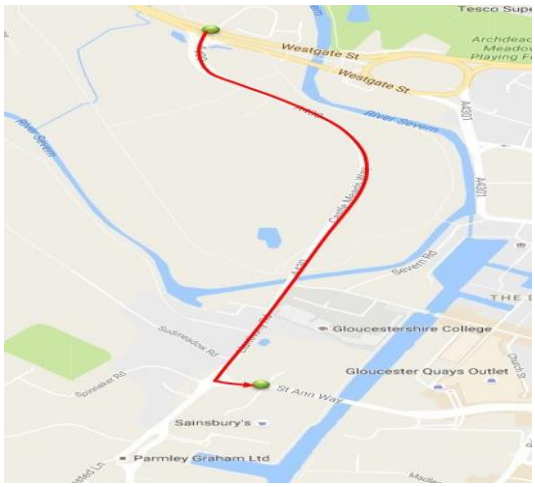
Hempsted Ln to A417 jct (BT25-BT29)



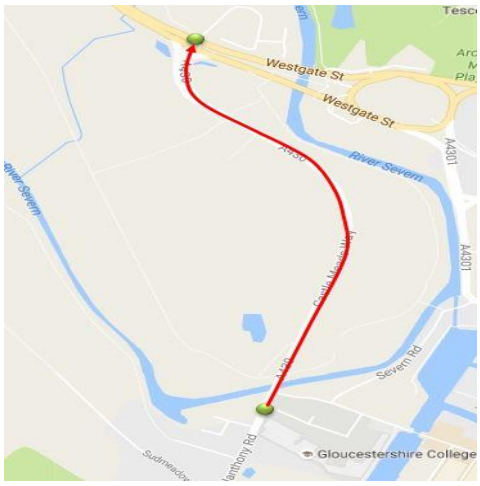
Hempsted to Spinnaker (BT25-BT24)



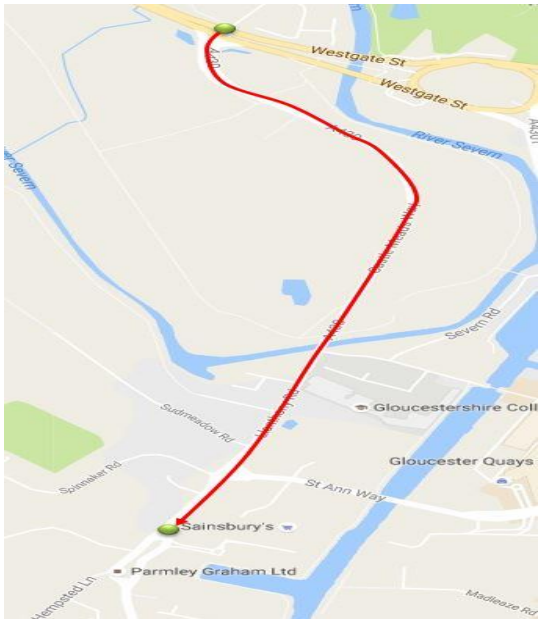
Llanthony jct to Hempsted (BT26-BT25)



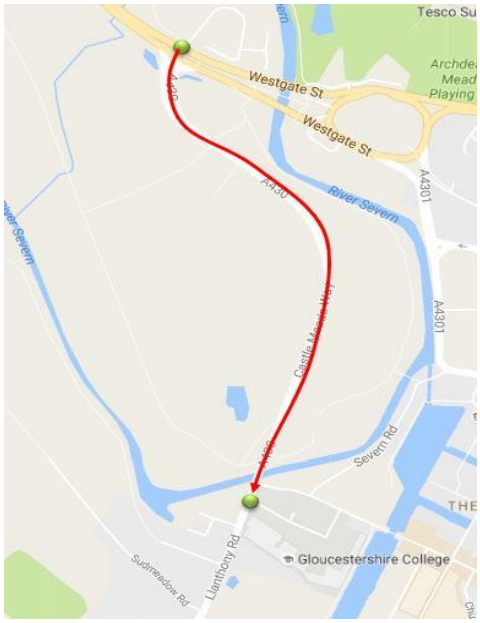
Llanthony jct to St Ann Way (BT26-BT24)



Llanthony jct to A417 jct (BT26-BT29)



A417 jct to gyratory (BT29-BT25)



A417 to Llanthony jct (BT29-BT26)

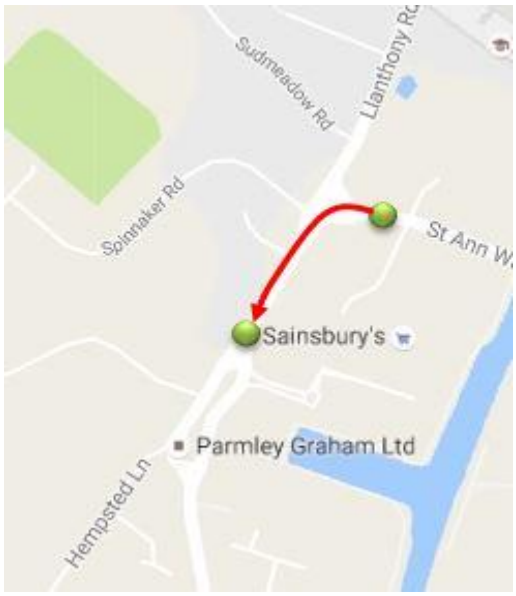
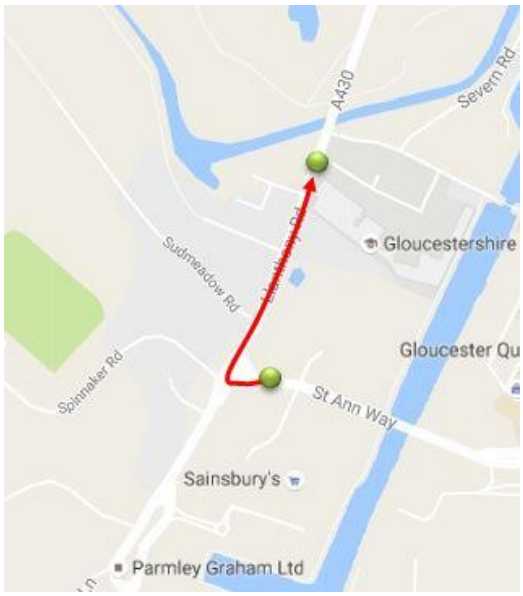
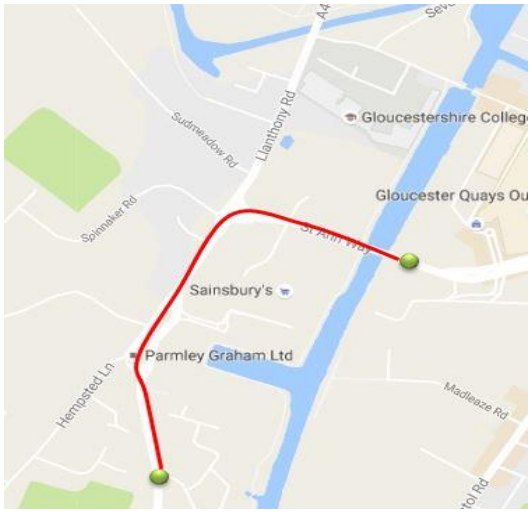
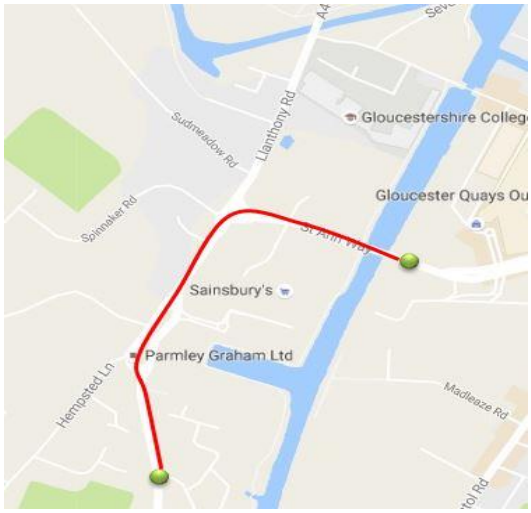
	
Spinnaker jct to Gyratory (BT24-BT25)	Spinnaker to Llanthony jct (BT 24-BT26)
	
Quayside to Bridge NB	Quayside to Bridge SB

Table A.6.6: Journey time survey routes

Comparing journey times in the model and on the on the road network is one of the primary methods of validation, and DMRB Section 12 sets a validation standard that recommends that modelled and observed journey times should be within 15% (or 1 minute if higher) for >85% of routes. Comparisons between the average journey times produced by from 10 runs of the S-Paramics Base model and the average journey times produced by the journey time surveys are shown in Table A.7 to A.8. These results show that the model meets DMRB requirements with 100% of all comparisons falling within 15% of the observed values and 100% of all journey times being within one minute of the observed value.

The DMRB criteria for comparison of modelled journey times versus observed journey time is defined as;

Journey time validation against DMRB criteria (AM peak period)							
AM Peak (07:00 to 10:00)		Modelled Results		Observed Data	Comparison		
	Path Name	Path Length (km)	Average Journey Time	Average Journey Time	Difference	Percentage Difference	Validation Successful?
1	Hempsted to Llanthony junction (BT25-26)	0.6	73	40	33	83	YES
2	Hempsted to Castle Meads Way (BT25-BT29)	1.6	129	106	23	22	YES
3	Hempsted to StAnnWay(BT25-BT24)	0.3	88	100	-12	12	YES
4	Castle Meads Way to Hempsted (BT26-BT25)	0.6	122	103	19	18	YES
5	Castle Meads Way to StAnnWay(BT26-BT24)	0.4	105	68	37	54	YES
6	Castle Meads Way to A417 (BT26-BT29)	1.1	62	76	-14	18	YES
7	A417 to Hempsted (BT29-BT25)	1.6	378	419	-41	10	YES
8	A417 to Castle Meads Way (BT29-BT26)	1.1	260	310	-50	16	YES
9	StAnnWay to Hempsted (BT24-BT25)	0.2	50	75	-25	33	YES
10	StAnnWay to Castle Meads Way (BT24-BT26)	0.4	73	106	-33	31	YES
11	"Quayside to Bridge"	0.9	156	149	7	5	YES
12	"Bridge to Quayside"	0.9	134	152	-18	12	YES

Table A.6.7: Journey time validation – AM peak

Journey time validation against DMRB criteria (AM peak period)							
PM Peak (15:00 to 18:00)		Modelled Results		Observed Data	Comparison		
	Path Name	Path Length (km)	Average Journey Time	Average Journey Time	Difference	Percentage Difference	Validation Successful?
1	Hempsted to Llanthony junction (BT25-26)	0.6	114	79	35	44	YES
2	Hempsted to Castle Meads Way (BT25-BT29)	1.6	176	177	-1	1	YES
3	Hempsted to StAnnWay(BT25-BT24)	0.3	98	132	-34	26	YES
4	Castle Meads Way to Hempsted (BT26-BT25)	0.6	122	134	-12	9	YES
5	Castle Meads Way to StAnnWay(BT26-BT24)	0.4	116	91	25	28	YES
6	Castle Meads Way to A417 (BT26-BT29)	1.1	65	94	-29	31	YES
7	A417 to Hempsted (BT29-BT25)	1.6	397	429	-32	8	YES
8	A417 to Castle Meads Way (BT29-BT26)	1.1	280	280	0	0	YES
9	StAnnWay to Hempsted (BT24-BT25)	0.2	43	90	-47	52	YES
10	StAnnWay to Castle Meads Way (BT24-BT26)	0.4	74	110	-36	33	YES
11	"Quayside to Bridge"	0.9	176	128	48	38	YES
12	"Bridge to Quayside"	0.9	219	208	11	5	YES

Table A.6.8: Journey time validation – PM peak

Queues

An additional validation check can be to compare the maximum queue length in metres. While not typically used as a measure of validation, comparison of model queue lengths offer a further measure of the appropriateness of the traffic behaviour within the model, particularly where journey times can be variable.

Maximum queue length surveys undertaken as a part of the data collection exercise in December 2016 provided a baseline from which queues could be compared within the model. Maximum queue lengths were observed during AM peak (0800-1000) and PM peak (1600-1800) periods.

Gyratory roundabout

Maximum queue lengths were observed on the Secunda way northbound arm only at the Gyratory roundabout. Queues form on the Secunda Way when traffic is travelling northbound due to the queue on Hempsted Ln northbound at Spinnaker junction. Queues extend back to Quayside/Secunda Way junction. Queues on Secunda Way could only be measured for up to 210 metres but notes were taken when the queue extend beyond that point. Maximum queue lengths on Secunda Way observed during the PM peak between 16:45 and 17:25. Vehicles tends to use lane 1 only on the Secunda Way without utilise the lane two. Figure A.1 below illustrate the comparison of modelled versus observed queue lengths on Secunda Way at Gyratory roundabout.

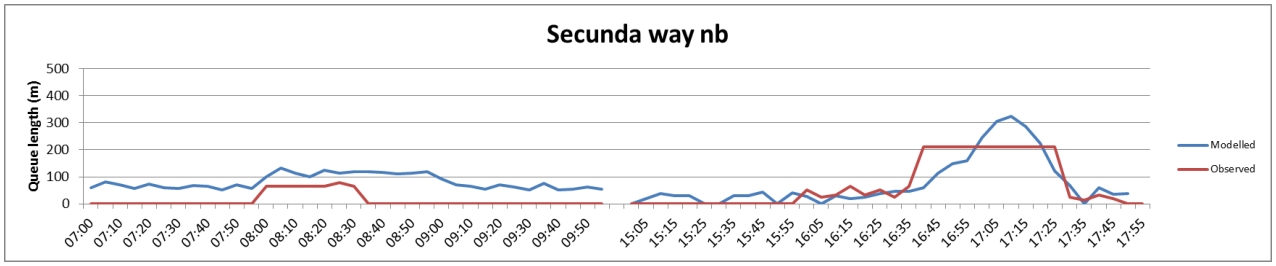


Figure A.1: max queue lengths – Secunda Way wb - Gyratory

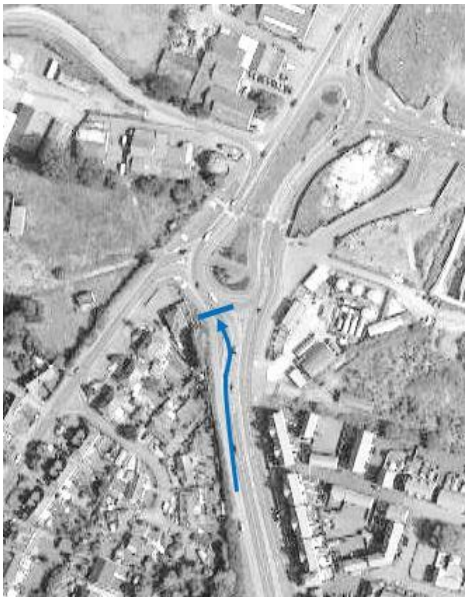


Figure A.2: Secunda Way wb location

Spinnaker junction & Sainsbury's junction

Maximum queue lengths were observed on Hempsted Lane northbound and on Llanthony Road southbound at Spinnaker junction. In addition queue lengths were observed on St Ann Way westbound at Sainsbury's junction. Queues form on Llanthony Road southbound when left turning vehicles travelling eastbound block the straight ahead traffic to Hempsted lane southbound.

Observations on St Ann Way westbound were made only during PM peak. On the St Ann Way, poor signal optimisation between Spinnaker and Sainsbury's traffic lights contributes to increased queueing particularly during PM peak period. Queues on St Ann Way extend back and beyond Peel car park junction.

Figure A.3 below illustrate the comparison of modelled versus observed queue lengths at the Spinnaker and Sainsbury's junction. These show that the modelled queueing compares well against the observed queueing throughout the survey period.

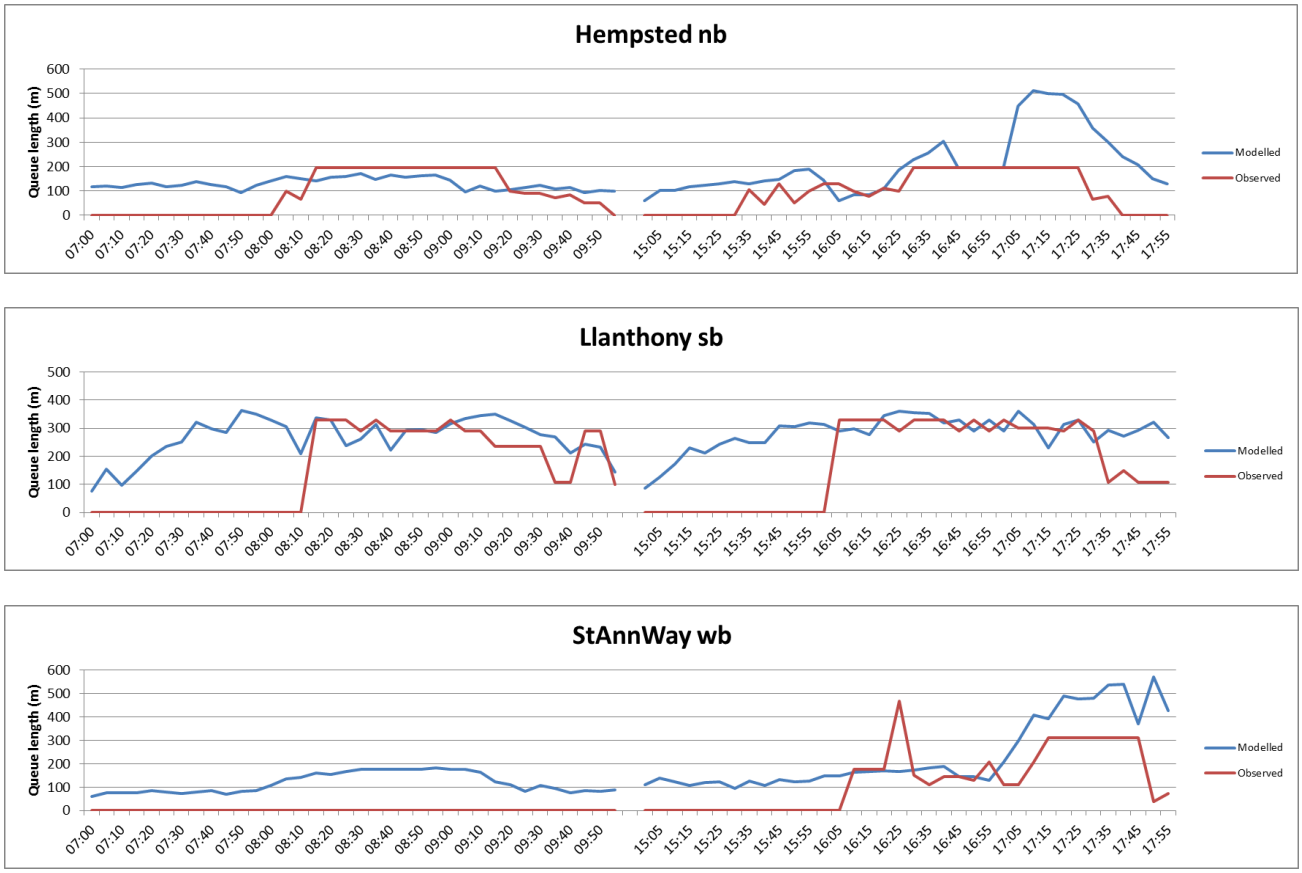


Figure A.3: Maximum queue – Spinnaker junction

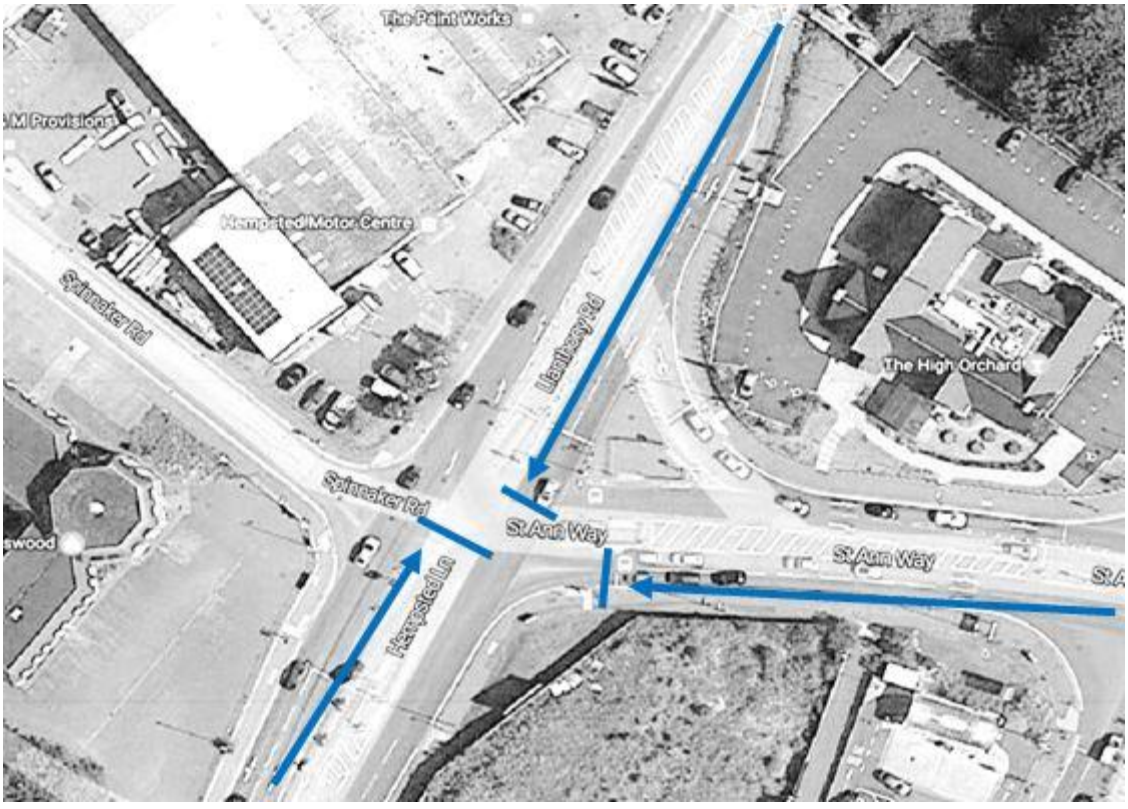


Figure A.4: Spinnaker junction location

Llanthony Road junction

Maximum queue lengths were observed on the A430 Llanthony northbound and the side road Llanthony Road (east arm). Queue lengths on the Castle Meads Way were collected in the form of notes as this arm has a length of 1km. The queueing behaviour observed in the model is consistent with on-site observations. Queues form on Castle Meads Way southbound traffic and extend back the A417 Westgate several times during the AM peak after 7:45 and during the PM peak. Significant queue found on Llanthony east arm extend back to Severn road/A4301 junction especially during the PM peak. Due to lack of resources, queues on that arm could only be measured for up 100 metres. Comparison of the observed queue lengths to the extent and duration of slow traffic is sown below in Figure A.4

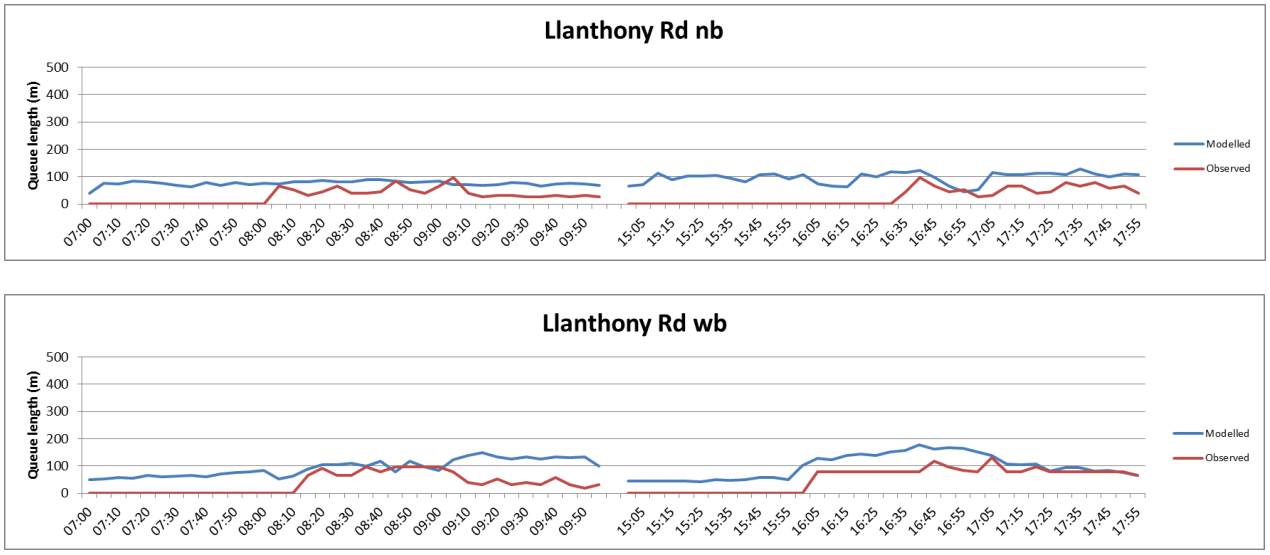
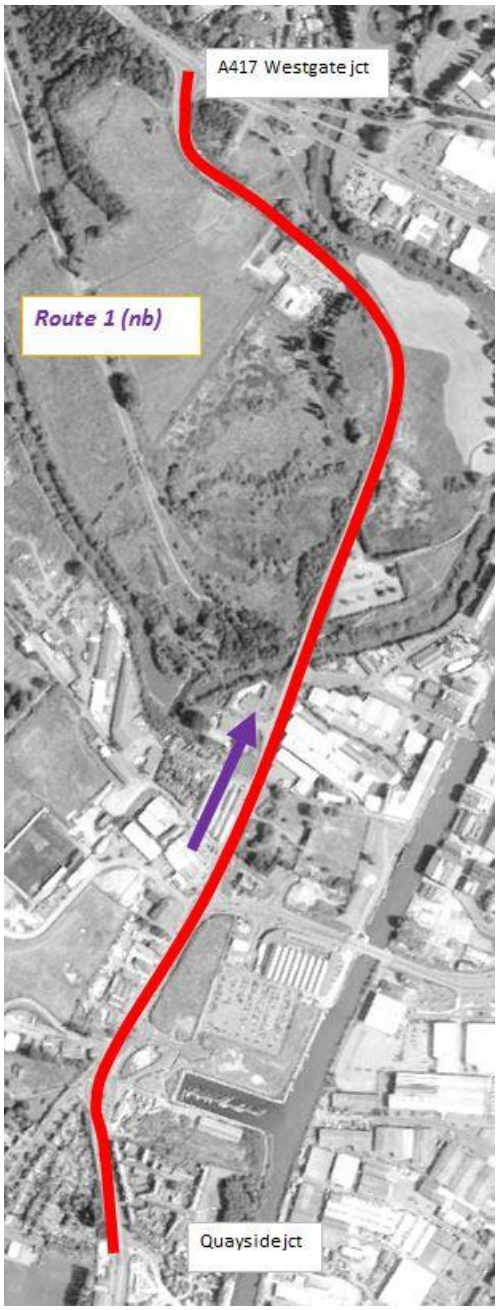
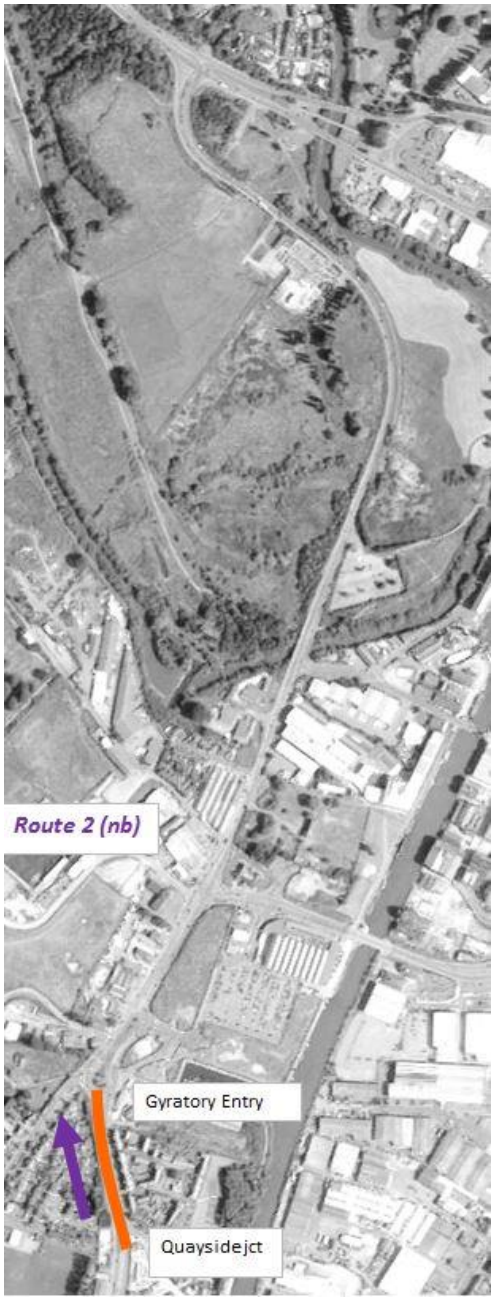


Figure A.5: Maximum queue lengths – Llanthony road junction.

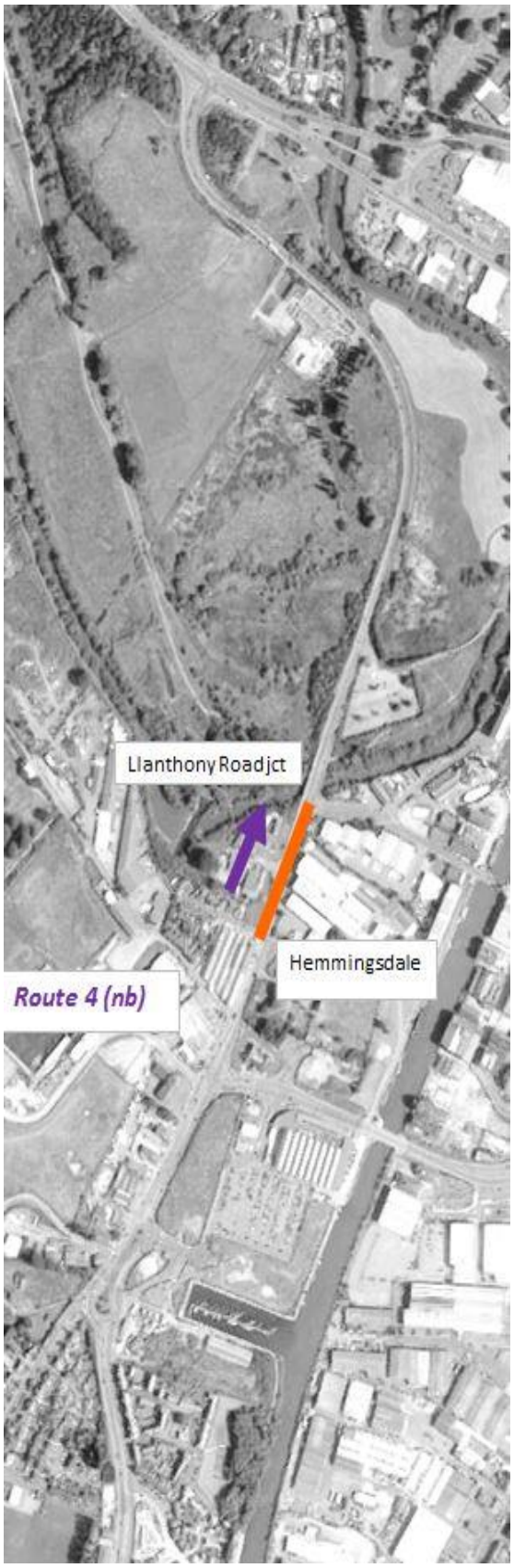
Figure A.6: Spinnaker junction location

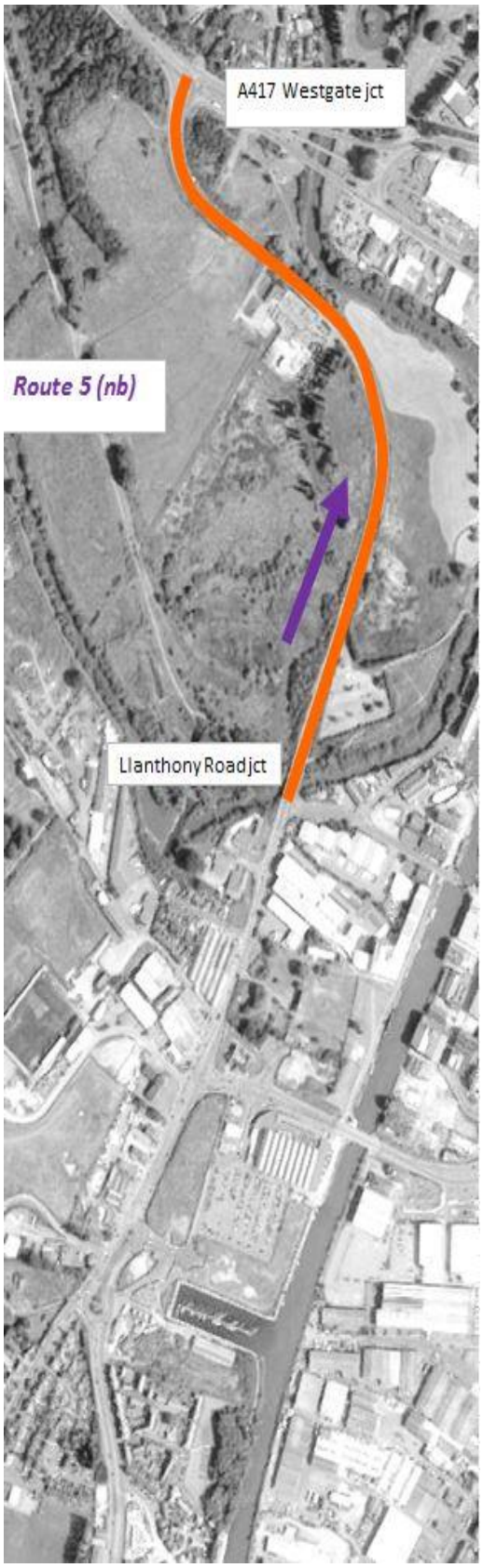
Appendix B Journey time comparison routes and Sensitivity test results (Journey times and queue lengths)

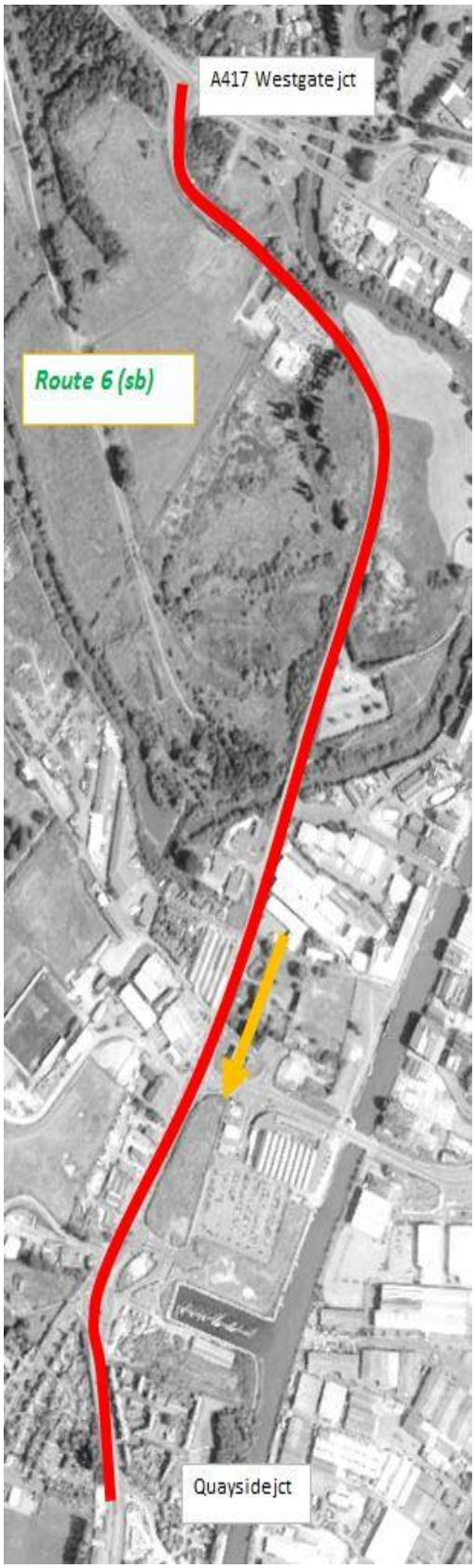

A417 Westgate jct
Route 1 (nb)
Quaysidejct


Route 2 (nb)
Gyratory Entry
Quaysidejct

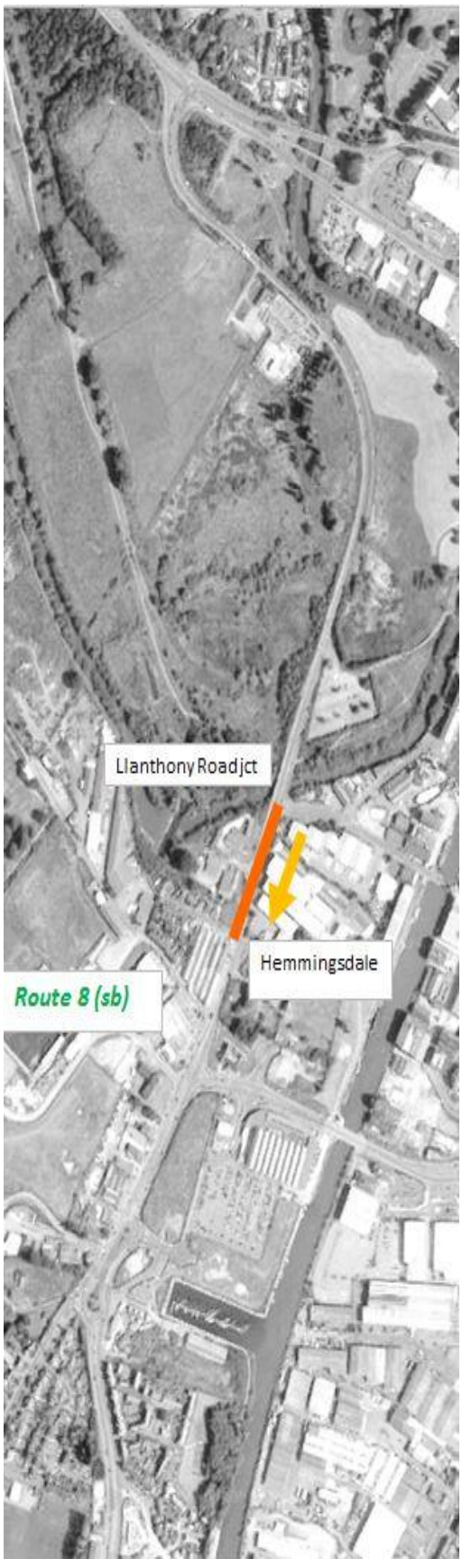

Hemmingsdale
Route 3 (nb)
Gyratory Entry

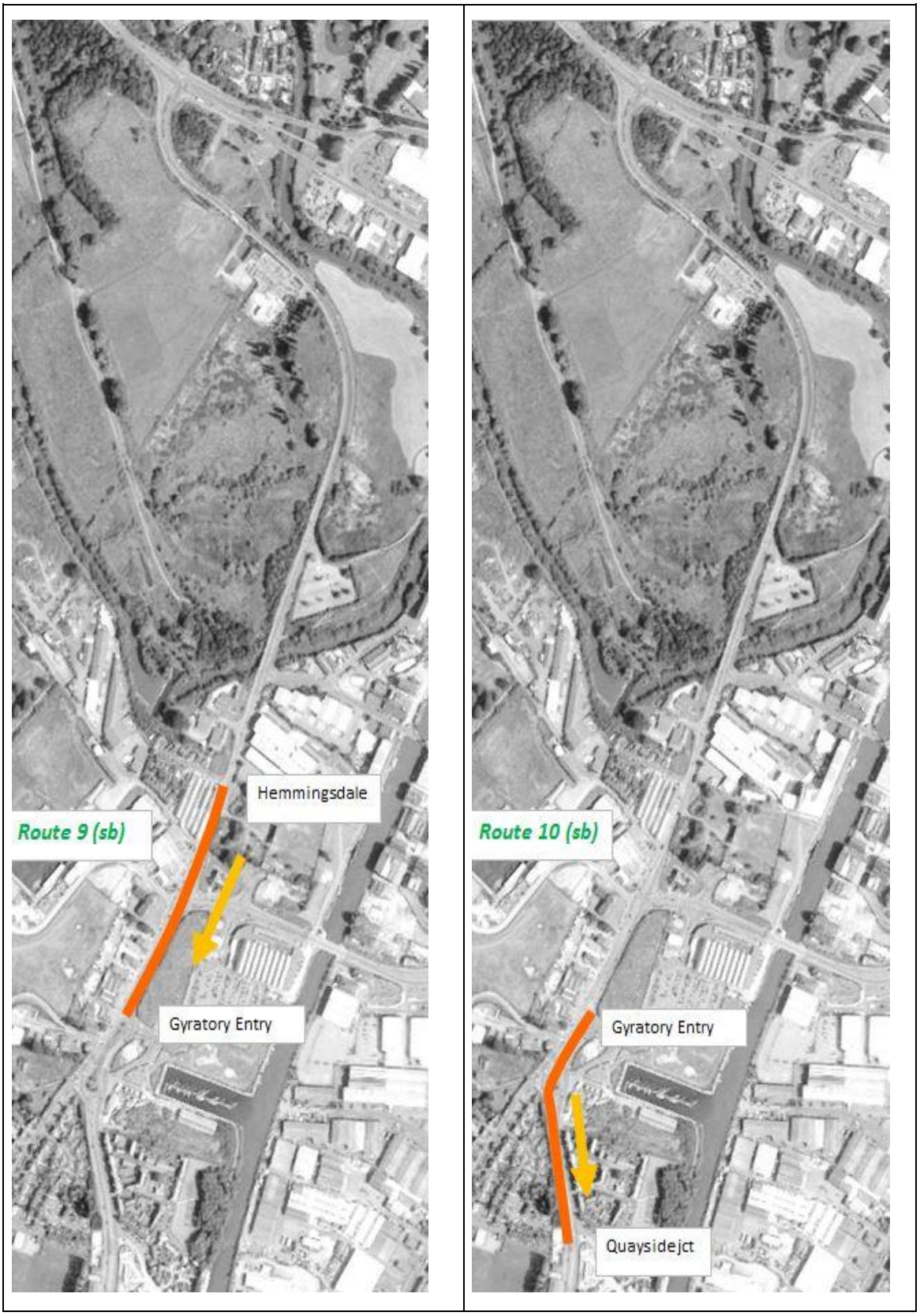

Llanthony Road jct
Hemmingsdale
Route 4 (nb)


A417 Westgate jct
Route 5 (nb)
Llanthony Road jct

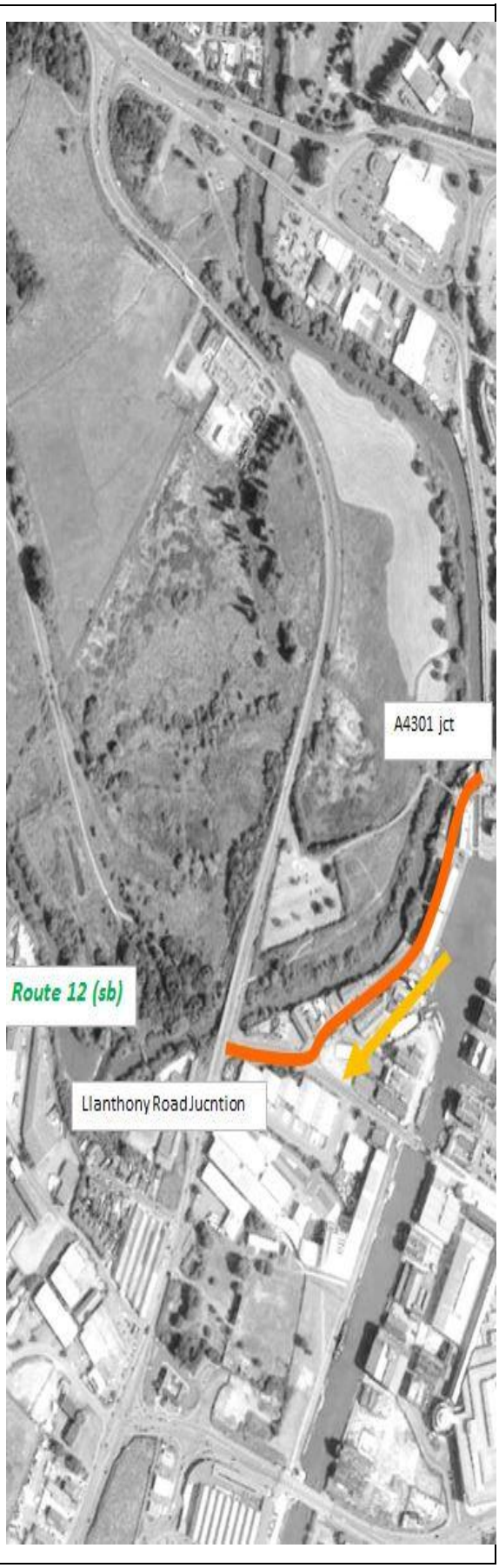

A417 Westgate jct
Route 6 (sb)
Quayside jct

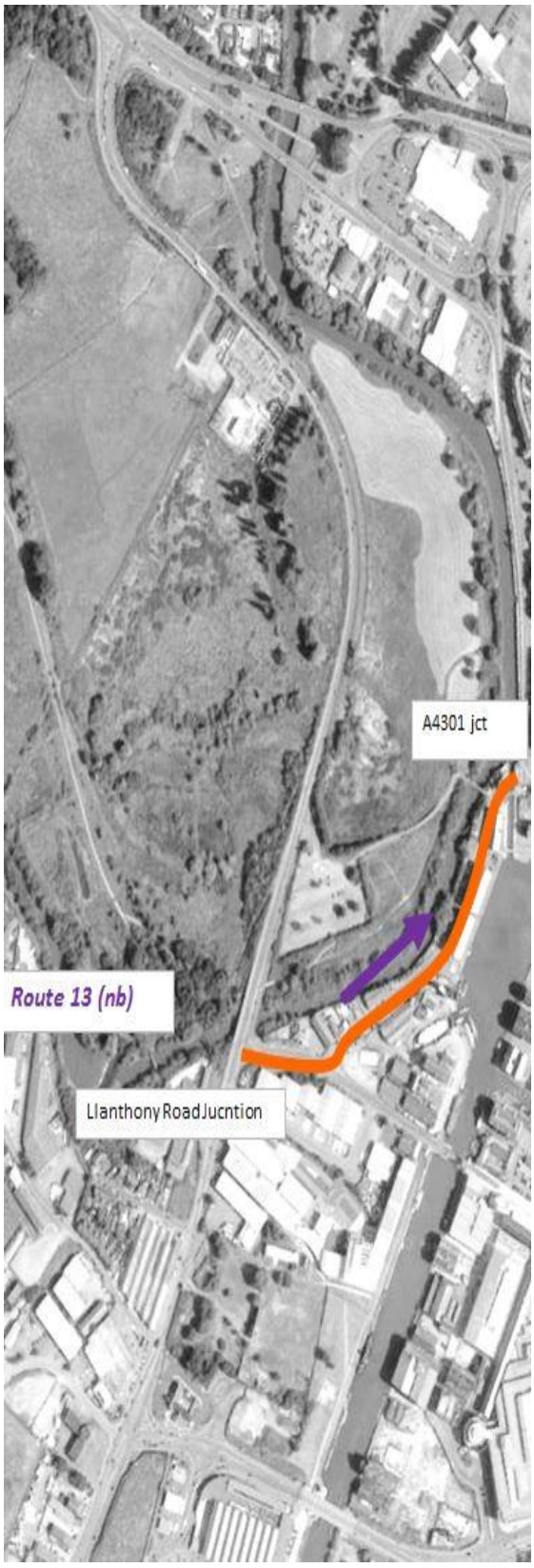

A417 Westgate jct
Route 7 (sb)
Llanthony Road jct


Llanthony Road jct
Hemmingsdale
Route 8 (sb)


Route 9 (sb)
Hemmingsdale
Gyratory Entry
Route 10 (sb)
Gyratory Entry
Quaysidejct


A4301 jct
Route 11 (sb)
Severn road


A4301 jct
Route 12 (sb)
Llanthony Road Jucntion


A4301 jct
Route 13 (nb)
Llanthony Road Jucntion

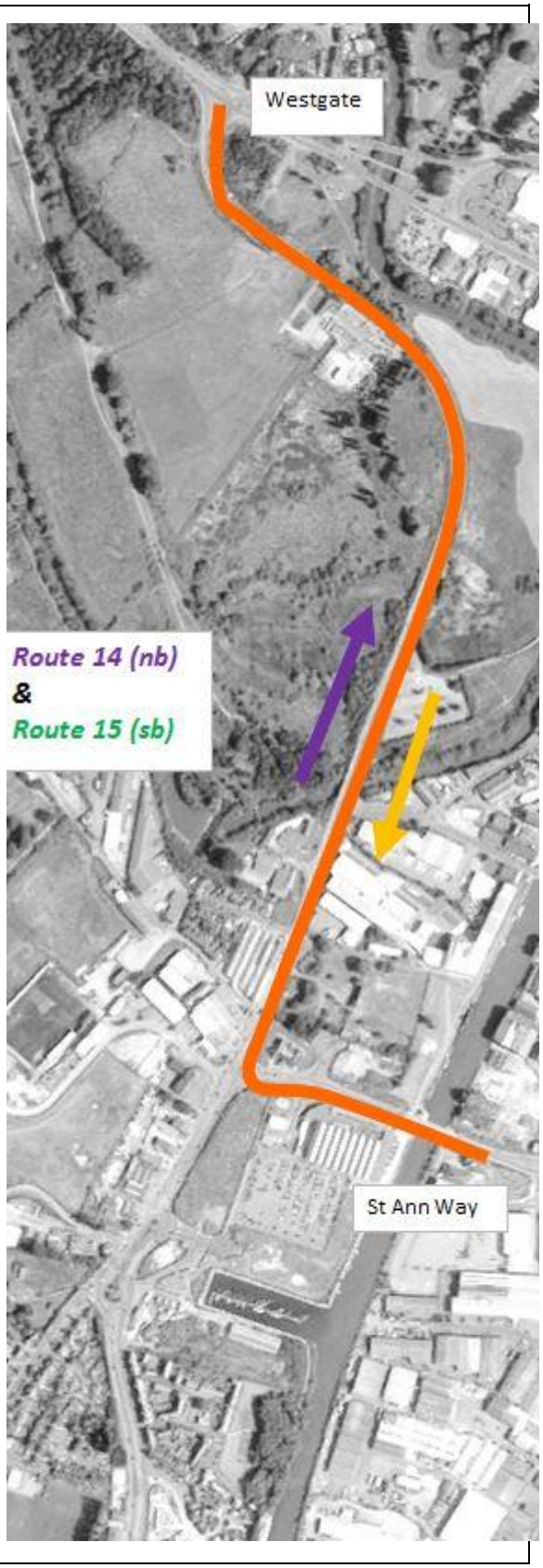

Westgate
Route 14 (nb)
&
Route 15 (sb)
St Ann Way

Figure B.1: journey time comparison routes

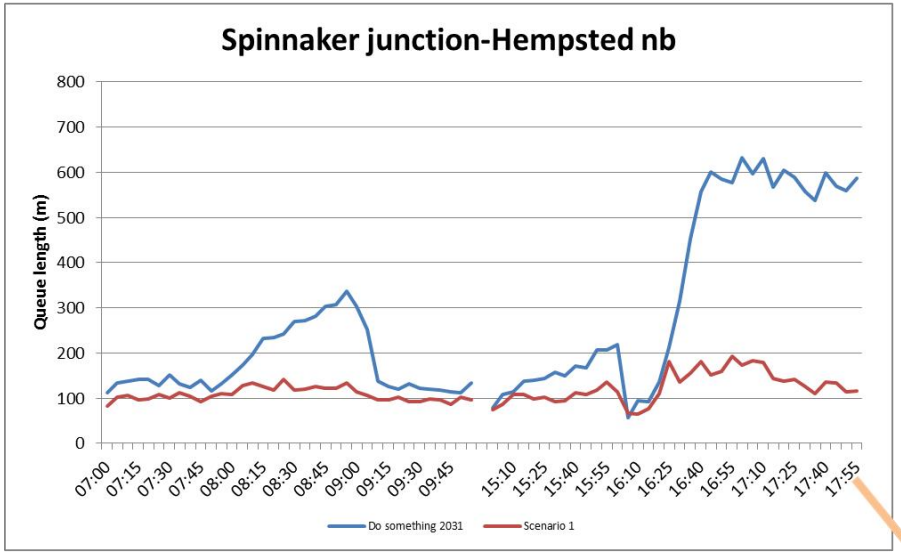
Sensitivity Test Journey time results

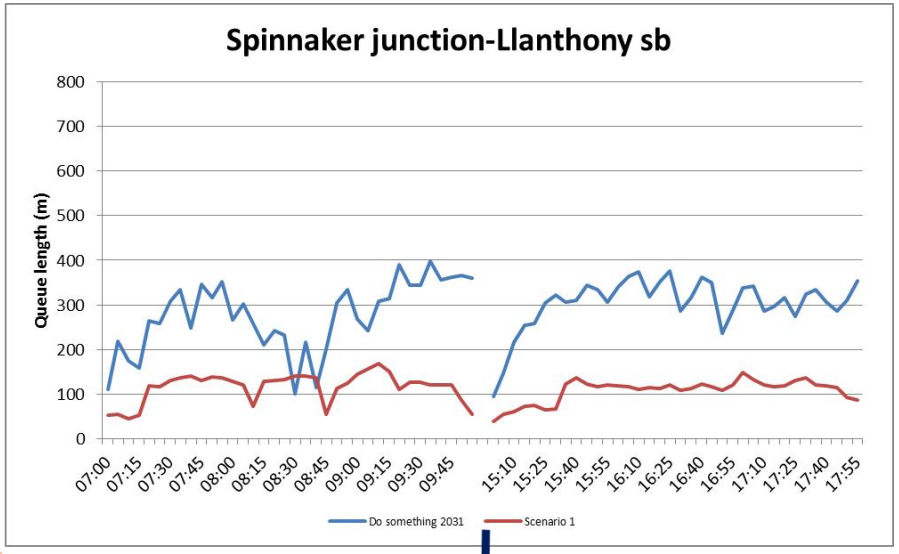
Table B1 - Journey time comparisons (2018 Sensitivity Test)											
		AM Peak (07:00-10:00)					PM Peak (15:00-18:00)				
		Modelled average journey time (s)			Difference from base		Modelled average journey time (s)			Difference from base	
	Path Name	2018 Base	2018 Option 1	2018 Option 2	2018 Option 1	2018 Option 2	2018 Base	2018 Option 1	2018 Option 2	2018 Option 1	2018 Option 2
1	"Quayside to Westgate"	00:03:01	00:02:47	00:03:13	-14	12	00:03:46	00:02:51	00:03:10	-55	-36
2	"Quayside to Hempsted"	00:00:31	00:00:23	00:00:23	-8	-8	00:00:30	00:00:17	00:00:17	-13	-13
3	"Gyratory to Hemmingsdale"	00:01:09	00:00:59	00:01:05	-10	-4	00:01:59	00:01:04	00:01:06	-55	-53
4	"Hemmingsdale to Llanthony"	00:00:19	00:00:20	00:00:41	1	22	00:00:20	00:00:23	00:00:42	3	22
5	"Llanthony to Westgate"	00:00:56	00:00:59	00:00:57	3	1	00:00:57	00:01:00	00:00:59	3	2
6	"Westgate to Quayside"	00:06:48	00:02:54	00:03:19	-234	-209	00:07:29	00:02:51	00:06:38	-278	-51
7	"Westgate to Llanthony"	00:04:05	00:01:25	00:01:40	-160	-145	00:04:58	00:01:21	00:04:49	-217	-9
8	"Llanthony to Hemmingsdale"	00:00:45	00:00:10	00:00:10	-35	-35	00:00:38	00:00:13	00:00:12	-25	-26
9	"Hemmingsdale to Gyratory"	00:01:14	00:00:44	00:00:53	-30	-21	00:01:08	00:00:47	00:01:10	-21	2
10	"Hempsted to Quayside"	00:00:28	00:00:28	00:00:29	0	1	00:00:30	00:00:30	00:00:30	0	0
11	"Severn SB"	00:01:58	00:00:37	00:00:37	-81	-81	00:03:12	00:00:33	00:00:30	-159	-162
12	"Severn to Llanthony jct"	00:03:39	00:01:36	00:01:32	-123	-127	00:04:25	00:01:52	00:01:35	-153	-170
13	"Llanthony to Severn"	00:00:54	00:00:46	00:00:46	-8	-8	00:00:54	00:00:46	00:00:46	-8	-8
14	"StAnnWay to Westgate"	00:04:46	00:03:59	00:04:34	-47	-12	00:07:52	00:03:30	00:03:16	-262	-276
15	"Westgate to StAnnWay"	00:06:39	00:02:39	00:03:07	-240	-212	00:07:16	00:02:35	00:06:06	-281	-70
16	"St Ann Way wb"	00:02:49	00:02:06	00:02:21	-43	-28	00:05:20	00:01:44	00:01:28	-216	-232

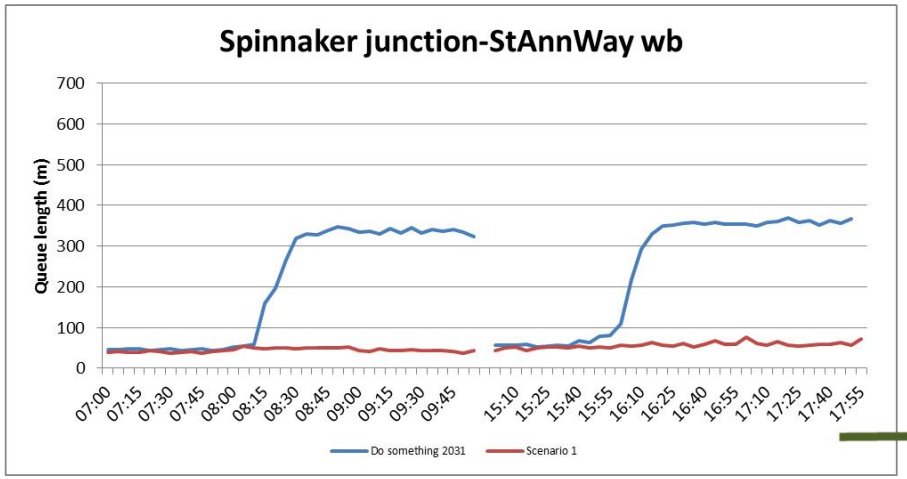
Table B2 - Journey time comparisons (2031 Sensitivity Test)											
		AM Peak (07:00-10:00)					PM Peak (15:00-18:00)				
		Modelled average journey time (s)			Difference from base		Modelled average journey time (s)			Difference from base	
	Path Name	2031 Base	2031 Option 1	2031 Option 2	2031 Option 1	2031 Option 2	2031 Base	2031 Option 1	2031 Option 2	2031 Option 1	2031 Option 2
1	"Quayside to Westgate"	00:03:32	00:02:55	00:03:35	-37	3	00:06:08	00:02:58	00:03:26	-190	-162
2	"Quayside to Hempsted"	00:00:39	00:00:29	00:00:29	-10	-10	00:01:38	00:00:18	00:00:18	-80	-80
3	"Gyratory to Hemmingsdale"	00:01:33	00:01:00	00:01:17	-33	-16	00:03:08	00:01:09	00:01:19	-119	-109
4	"Hemmingsdale to Llanthony"	00:00:19	00:00:24	00:00:45	5	26	00:00:21	00:00:26	00:00:54	5	33
5	"Llanthony to Westgate"	00:00:56	00:00:59	00:00:57	3	1	00:00:57	00:01:00	00:00:59	3	2
6	"Westgate to Quayside"	00:09:38	00:03:18	00:03:41	-380	-357	00:12:10	00:03:22	00:08:44	-528	-206
7	"Westgate to Llanthony"	00:06:43	00:01:32	00:01:49	-311	-294	00:09:16	00:01:17	00:05:52	-479	-204
8	"Llanthony to Hemmingsdale"	00:00:55	00:00:10	00:00:12	-45	-43	00:00:53	00:00:13	00:00:29	-40	-24
9	"Hemmingsdale to Gyratory"	00:01:16	00:01:01	00:01:06	-15	-10	00:01:16	00:01:09	00:01:42	-7	26
10	"Hempsted to Quayside"	00:00:28	00:00:28	00:00:28	0	0	00:00:30	00:00:30	00:00:31	0	1
11	"Severn SB"	00:06:25	00:00:37	00:00:37	-348	-348	00:07:31	00:00:41	00:00:35	-410	-416
12	"Severn to Llanthony jct"	00:09:00	00:01:44	00:01:35	-436	-445	00:09:18	00:02:23	00:02:07	-415	-431
13	"Llanthony to Severn"	00:00:54	00:00:46	00:00:46	-8	-8	00:00:54	00:00:47	00:00:46	-7	-8
14	"StAnnWay to Westgate"	00:09:15	00:04:19	00:04:47	-296	-268	00:09:28	00:03:43	00:04:17	-345	-311
15	"Westgate to StAnnWay"	00:09:30	00:03:04	00:03:28	-386	-362	00:11:59	00:03:03	00:09:09	-536	-170
16	"St Ann Way wb"	00:06:53	00:02:13	00:02:20	-280	-273	00:06:39	00:01:47	00:01:37	-292	-302

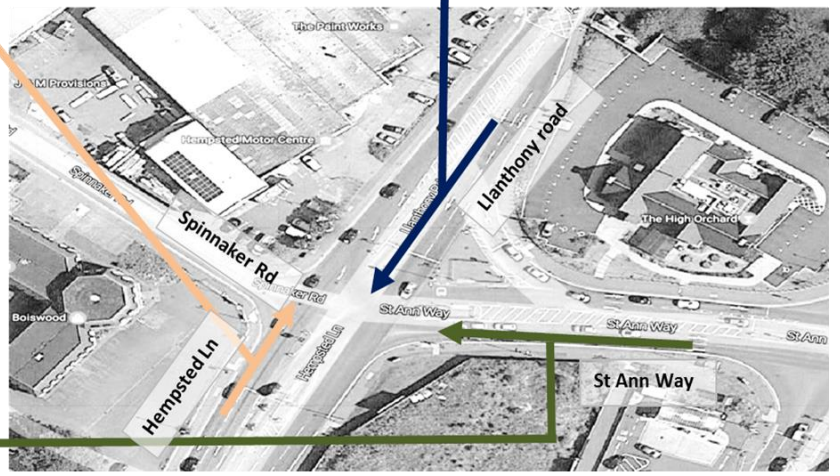
Sensitivity test queue length graphs (2031)

Spinnaker junction – Sensitivity Test – 2031 Option 1

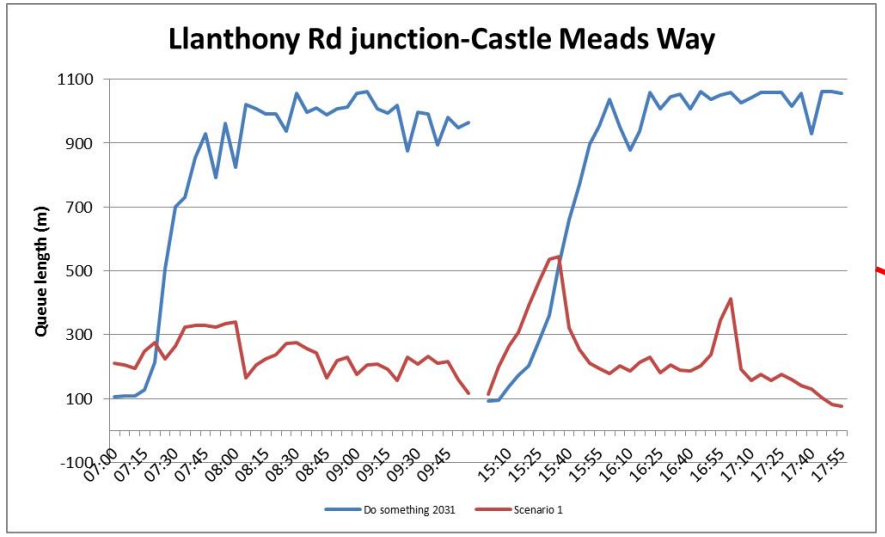


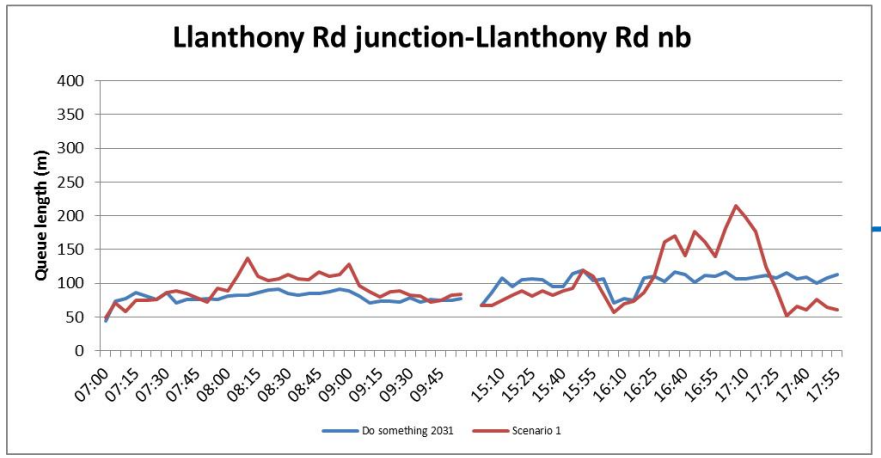


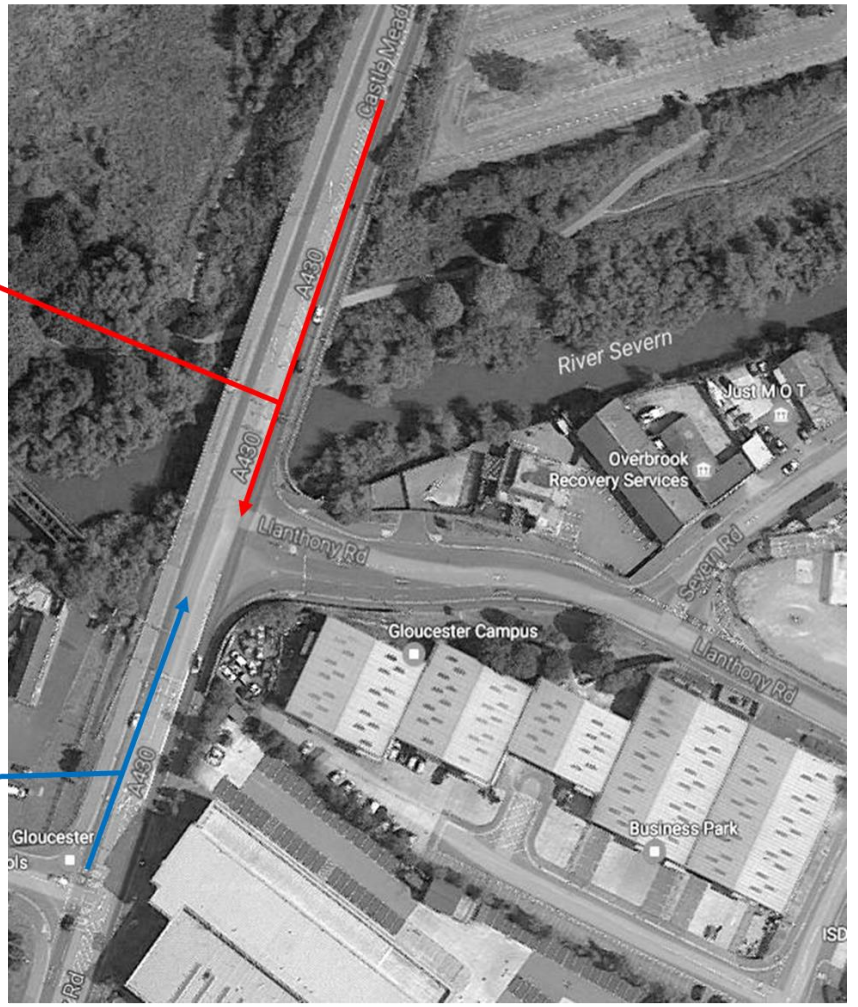




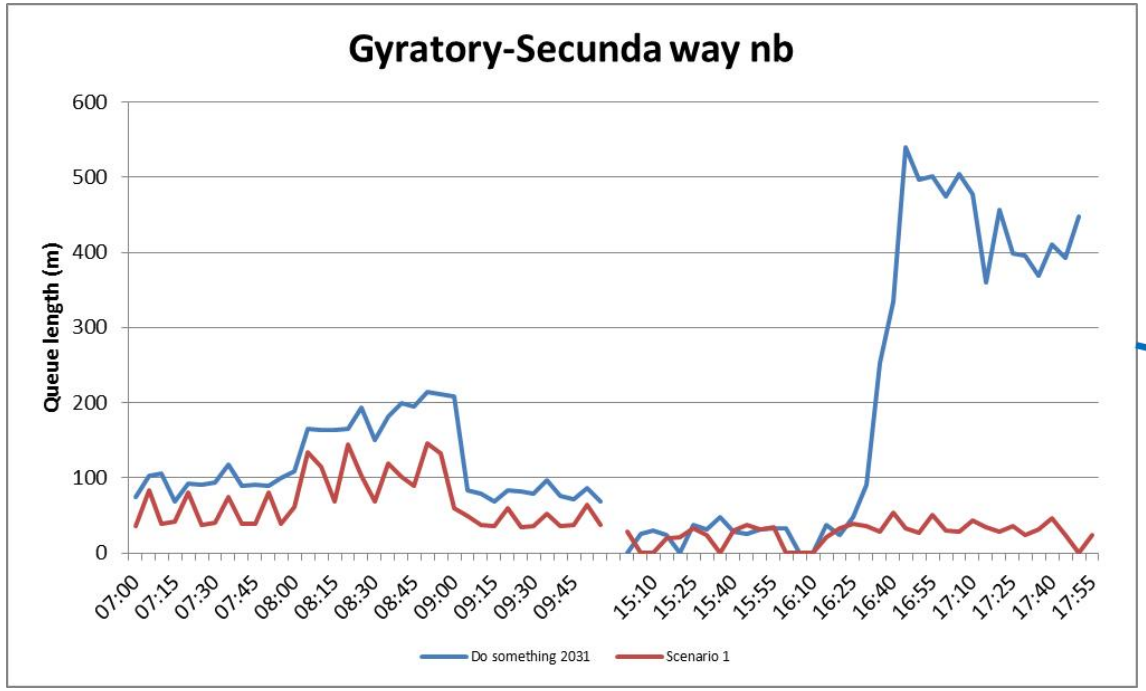
Llanthony Road Junction– Sensitivity Test – 2031 Option 1

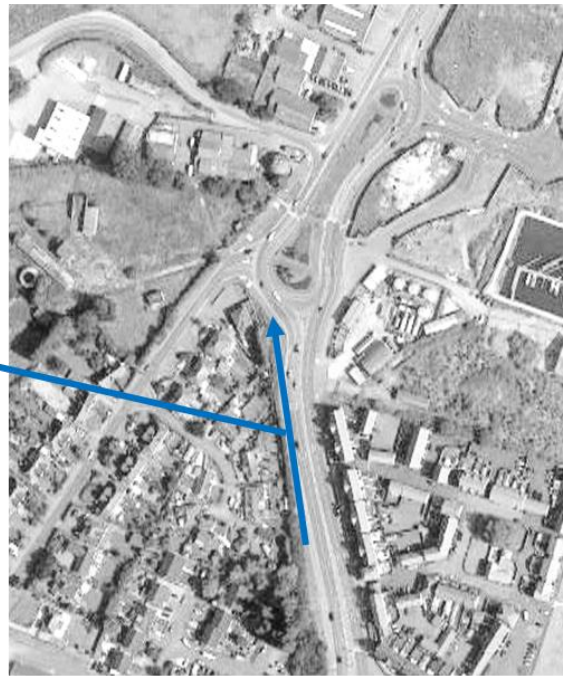




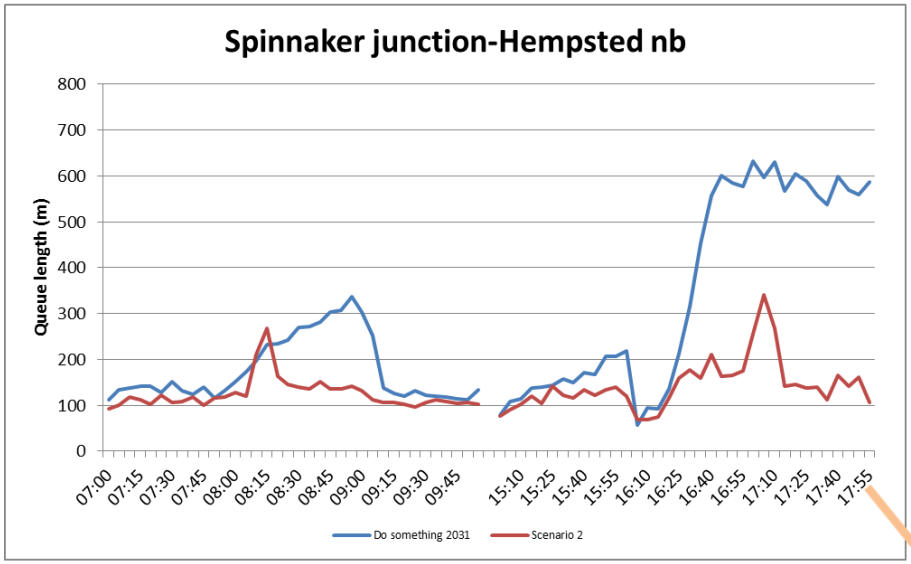


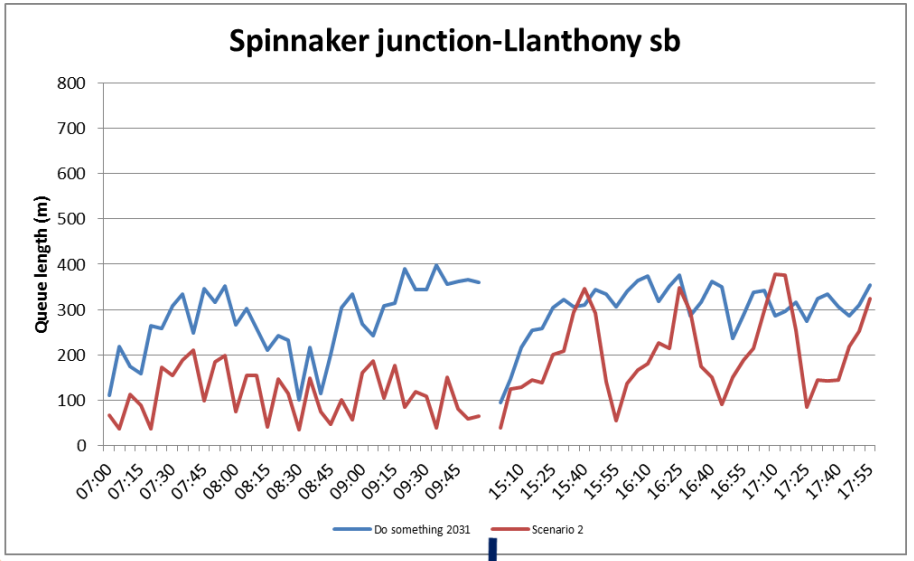
Gyratory– Sensitivity Test – 2031 Option 1

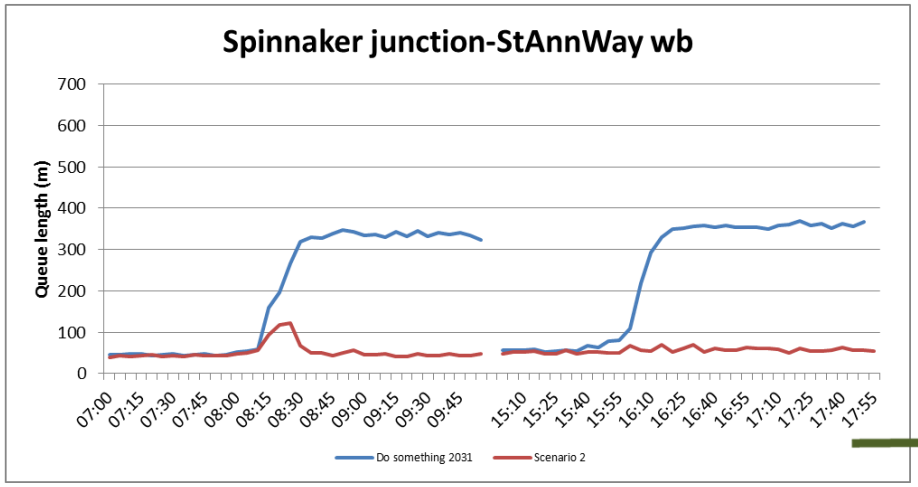




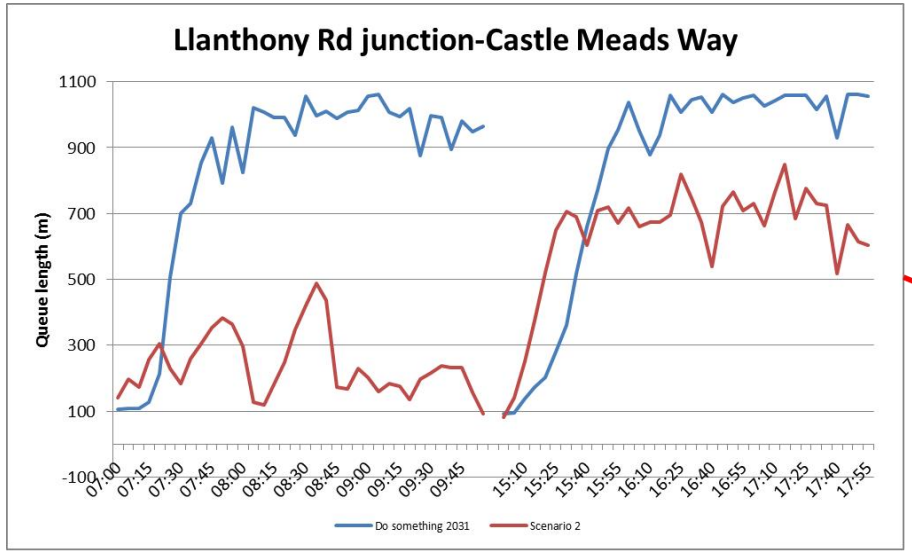
Spinnaker junction – Sensitivity Test – Option 2

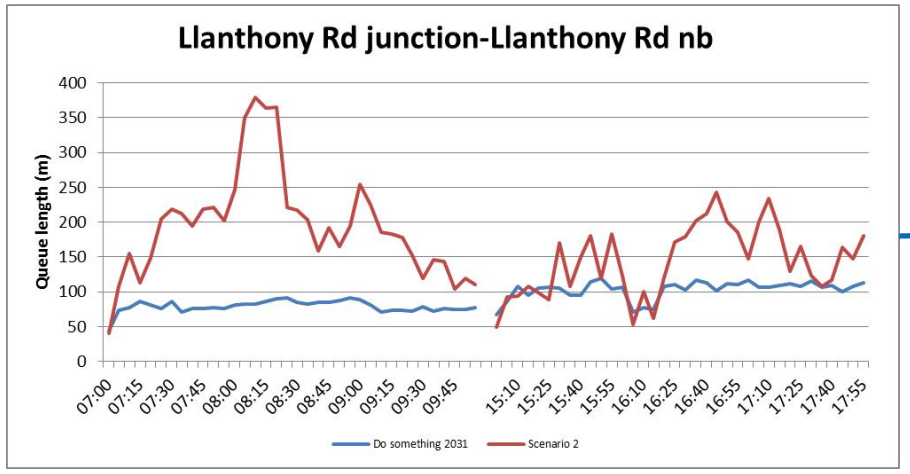


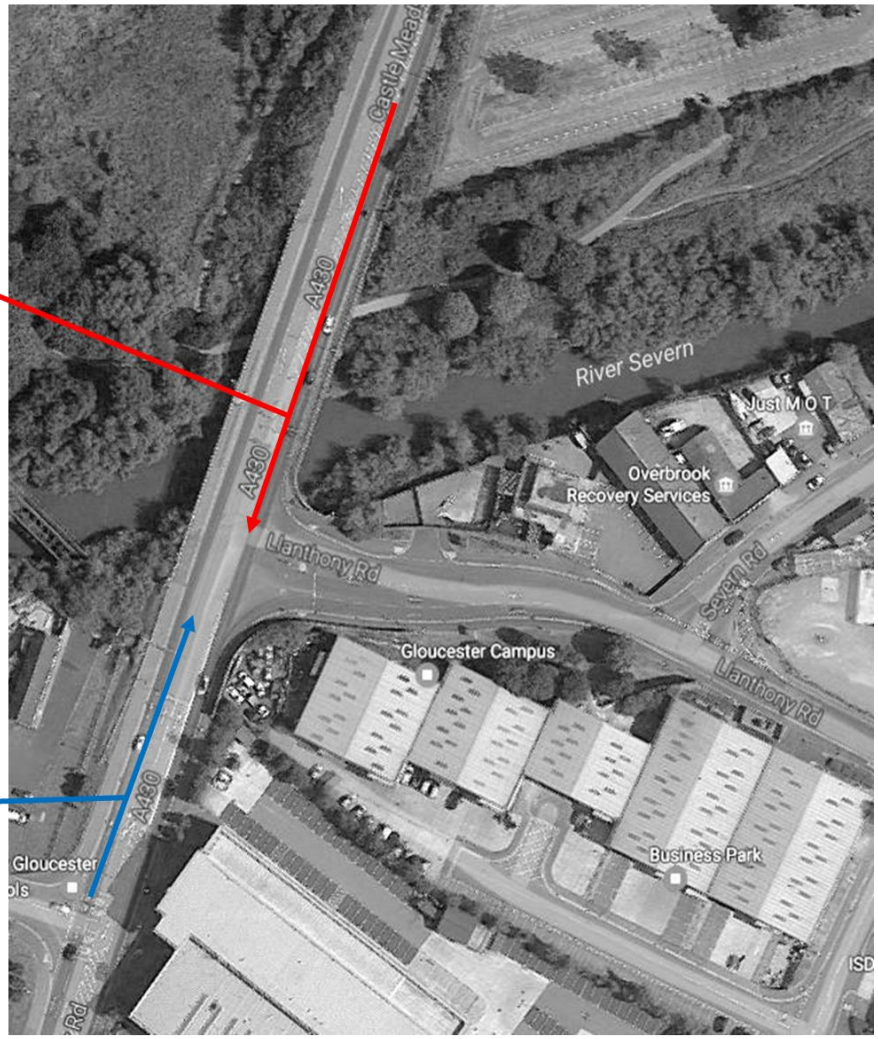




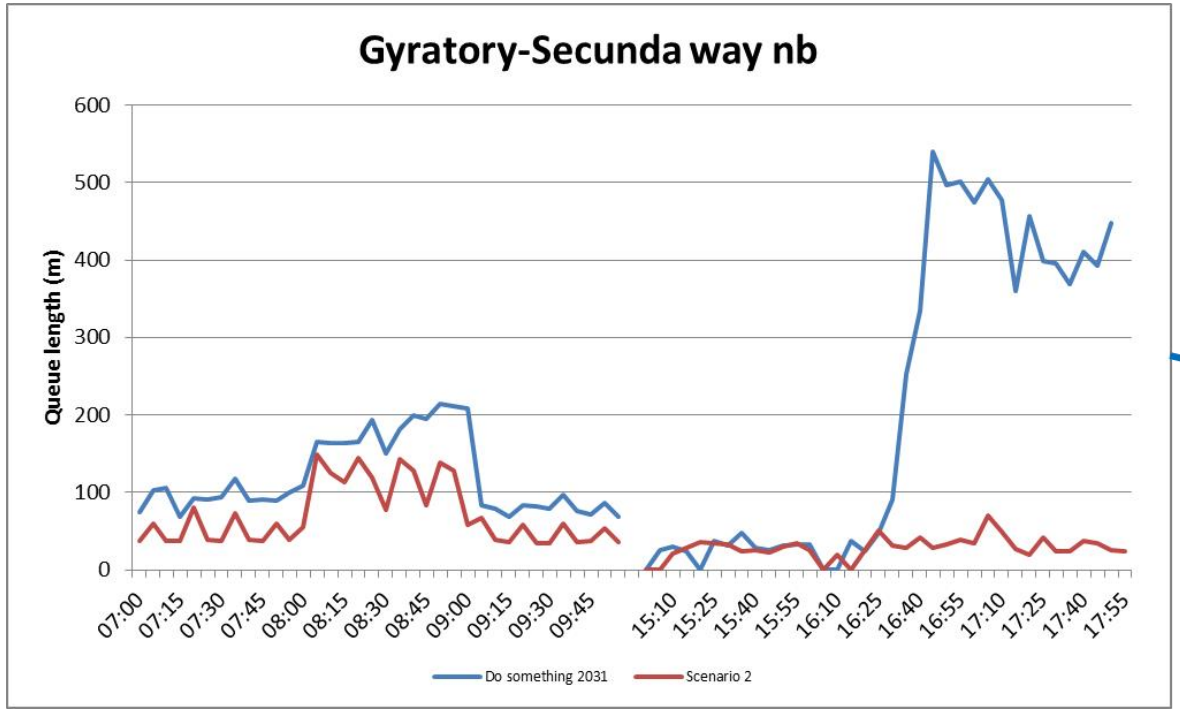
Llanthony Road Junction– Sensitivity Test – 2031 Option 2

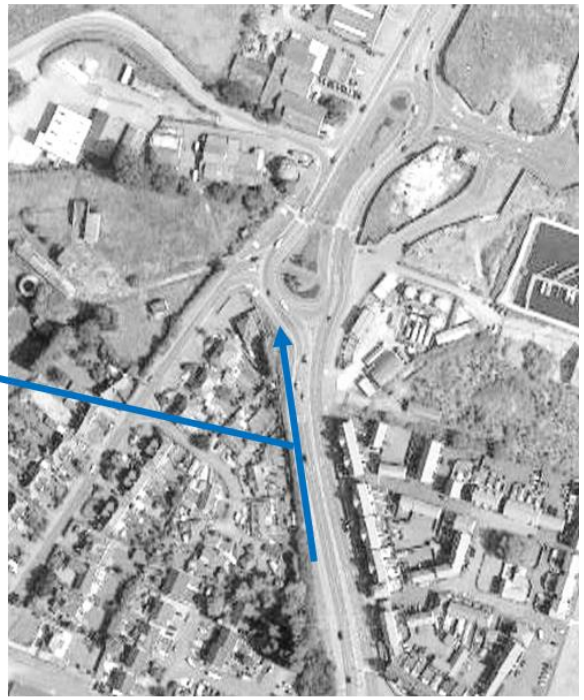






Gyratory– Sensitivity Test – 2031 Option 2





Appendix C TEE tables -Economic Results Sensitivity Test

Table 15A: Economic Efficiency of the Road System (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Ref.	Cal'n / Source	Total	Cars	LGVs	OGVs	Private Buses & Coaches	Service Buses
NON-BUSINESS USER BENEFITS								
Travel Time								
Commuting Travel Time	1		£14.25	£13.94	£0.20			£0.11
Other Travel Time	2		£19.14	£18.15	£0.64		£0.17	£0.18
Non-business Travel Time	**3**	**1+2**	**£33.39**					
Vehicle Operating Costs								
Commuter Fuel VOC	4		£1.08	£1.06	£0.02			
Commuter Non-fuel VOC	5		£-0.04	£-0.04	£0.00			
Other Fuel VOC	6		£1.11	£1.03	£0.07			
Other Non-fuel VOC	7		£-0.06	£-0.06	£0.00			
Non-business Vehicle Operating Costs	**8**	**4+5+6+7**	**£2.08**					
During Construction and Maintenance								
Commuting: During Construction and Maintenance (*)	*9*							
Other: During Construction and Maintenance (*)	*10*							
NET NON-BUSINESS BENEFITS: COMMUTING	**11**	**1+4+5+9**	**£15.28**					
NET NON-BUSINESS BENEFITS: OTHER	**12**	**2+6+7+10**	**£20.19**					
NET NON-BUSINESS BENEFITS - SUB TOTAL	**13**	**11+12**	**£35.47**					
BUSINESS USER BENEFITS								
User Benefits								
Business Travel Time	**14**		**£33.09**	£20.08	£9.96	£2.93	£0.03	£0.09
Fuel VOC	15		£1.59	£0.37	£0.67	£0.55		
Non-fuel VOC	16		£1.56	£0.76	£0.25	£0.56		
Business Vehicle Operating Costs	**17**	**15+16**	**£3.16**					
During Construction (*)	*18*							
During Maintenance (*)	*19*							
During Construction and Maintenance (*)	*20*	**18+19**						
Subtotal	**21**	**14+17+20**	**£36.25**					
Private Sector Provider Impacts								
Revenue (*)	*22*							
Fuel VOC	23		£0.04				£0.01	£0.03
Non-fuel VOC	24		£0.04				£0.01	£0.02
Private Sector Vehicle Operating Costs	**25**	**23+24**	**£0.08**					
Investment Costs (*)	26							
Grant / Subsidy (*)	27							
Subtotal	**28**	**22+25+26+27**	**£0.08**					
Other Business Impacts								
Developer & Other Contributions (*)	*29*							
NET BUSINESS IMPACT	**30**	**21+28+29**	**£36.33**					
TOTAL PRESENT VALUES OF TEE IMPACTS	**31**	**13+30**	**£71.80**					

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Sub-Totals / Impacts etc. as well as the NPV & BCR etc. in Table 15C.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table C.1: Option 1 (Sensitivity Test)

Table 15B: Public Accounts

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'c / Source	Total
Local Government Funding			
Revenue (*)	32		
Investment Costs (*)	33		
Operating Costs (*)	34		
Maintenance Costs			
Non-Traffic (Group 1) (*)	35		
Traffic Related (Group 2) (*)	36		
Developer & Other Contributions (*)	37		
Grant Subsidy Payment (*)	*38*		
Net Impact	39	Sum(32 to 38)	
Central Government Funding: Transport			
Revenue (*)	40		
Investment Costs	41		£3.74
Operating Costs (*)	42		
Maintenance Costs			
Non-Traffic (Group 1) (*)	43		
Traffic Related (Group 2) (*)	44		
Developer & Other Contributions (*)	45		
Grant Subsidy Payment (*)	46		
Net Impact	47	Sum(40 to 46)	***£3.74***
Central Government Funding : Non-Transport			
Indirect Tax Revenues	48		£2.03
TOTALS			
Broad Transport Budget	49	39+47	**£3.74**
Wider Public Finances	50	48	**£2.03**

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Net Impacts / Totals etc. as well as the NPV & BCR etc. in Table 15C.

Table C.2: Option 1 (Sensitivity Test)

Table 15C: Analysis of Monetised Costs and Benefits (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'n / Source	Total
TEE Impacts			
Noise (^)*	51		
Local Air Quality (^)*	52		
Greenhouse Gases (Emissions) (low)			£0.21
Greenhouse Gases (Emissions) (central)	53		**£0.42**
Greenhouse Gases (Emissions) (high)			£0.63
Journey Ambience (^)*	54		
Accident Benefits (*)	55		
Non-Business User Benefits: Commuting	56	11	£15.28
Non-Business User Benefits: Other	57	12	£20.19
Business User & Provider Benefits	58	30	£36.33
Wider Public Finance (Indirect Tax Revenue)	59	-50	£-2.03
Option Values (^)*	60		
Present Value of Benefits (PVB)	61	Sum(51 to 60)	**£70.19**
Broad Transport Budget	62	49	£3.74
Present Value of Costs (PVC)	63	62	**£3.74**
OVERALL IMPACTS			
Net Present Value (NPV)	64	61-63	**£66.45**
Benefit to Cost Ratio (BCR)	65	61/63	**18.77**

* Impact calculated external to PEARS & manually inputted by User. Any manual inputs will require the manual recalculation of the NPV & BCR etc.

^ Costs & benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect.

In addition to the costs & benefits outlined above, there may also be significant others, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does not provide a good measure of the value for money (VFM) and should not be used as the sole basis for decisions.

This analysis is based on TEMPRO traffic growth.
Benefits appear as positive numbers, while costs appear as negative numbers.

Table C.3: Option 1 (Sensitivity Test)

Table 15A: Economic Efficiency of the Road System (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Ref.	Cal'n / Source	Total	Cars	LGVs	OGVs	Private Buses & Coaches	Service Buses
NON-BUSINESS USER BENEFITS								
Travel Time								
Commuting Travel Time	1		£8.80	£8.59	£0.11			£0.10
Other Travel Time	2		£9.78	£9.16	£0.36		£0.08	£0.18
Non-business Travel Time	**3**	**1+2**	**£18.58**					
Vehicle Operating Costs								
Commuter Fuel VOC	4		£0.63	£0.62	£0.01			
Commuter Non-fuel VOC	5		£-0.04	£-0.04	£0.00			
Other Fuel VOC	6		£0.53	£0.49	£0.04			
Other Non-fuel VOC	7		£-0.06	£-0.05	£0.00			
Non-business Vehicle Operating Costs	**8**	**4+5+6+7**	**£1.06**					
During Construction and Maintenance								
Commuting: During Construction and Maintenance (*)	*9*							
Other: During Construction and Maintenance (*)	*10*							
NET NON-BUSINESS BENEFITS: COMMUTING	**11**	**1+4+5+9**	**£9.39**					
NET NON-BUSINESS BENEFITS: OTHER	**12**	**2+6+7+10**	**£10.24**					
NET NON-BUSINESS BENEFITS - SUB TOTAL	**13**	**11+12**	**£19.64**					
BUSINESS USER BENEFITS								
User Benefits								
Business Travel Time	**14**		**£19.45**	£12.21	£5.53	£1.61	£0.02	£0.09
Fuel VOC	15		£0.84	£0.21	£0.36	£0.28		
Non-fuel VOC	16		£0.84	£0.44	£0.11	£0.30		
Business Vehicle Operating Costs	**17**	**15+16**	**£1.69**					
During Construction (*)	*18*							
During Maintenance (*)	*19*							
During Construction and Maintenance (*)	*20*	**18+19**						
Subtotal	**21**	**14+17+20**	**£21.14**					
Private Sector Provider Impacts								
Revenue (*)	*22*							
Fuel VOC	23		£0.03				£0.01	£0.03
Non-fuel VOC	24		£0.03				£0.00	£0.02
Private Sector Vehicle Operating Costs	**25**	**23+24**	**£0.06**					
Investment Costs (*)	26							
Grant / Subsidy (*)	27							
Subtotal	**28**	**22+25+26+27**	**£0.06**					
Other Business Impacts								
Developer & Other Contributions (*)	*29*							
NET BUSINESS IMPACT	**30**	**21+28+29**	**£21.19**					
TOTAL PRESENT VALUES OF TEE IMPACTS	**31**	**13+30**	**£40.83**					

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Sub-Totals / Impacts etc. as well as the NPV & BCR etc. in Table 15C.

Table C.4: Option 2 (Sensitivity Test)

Table 15B: Public Accounts

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'c / Source	Total
Local Government Funding			
Revenue (*)	32		
Investment Costs (*)	33		
Operating Costs (*)	34		
Maintenance Costs			
Non-Traffic (Group 1) (*)	35		
Traffic Related (Group 2) (*)	36		
Developer & Other Contributions (*)	37		
Grant Subsidy Payment (*)	*38*		
Net Impact	39	Sum(32 to 38)	
Central Government Funding: Transport			
Revenue (*)	40		
Investment Costs	41		£3.74
Operating Costs (*)	42		
Maintenance Costs			
Non-Traffic (Group 1) (*)	43		
Traffic Related (Group 2) (*)	44		
Developer & Other Contributions (*)	45		
Grant Subsidy Payment (*)	46		
Net Impact	47	Sum(40 to 46)	***£3.74***
Central Government Funding : Non-Transport			
Indirect Tax Revenues	48		£1.07
TOTALS			
Broad Transport Budget	49	39+47	**£3.74**
Wider Public Finances	50	48	**£1.07**

* Impact calculated external to PEARS & manually input by User. Any manual inputs will require the manual recalculation of the Net Impacts / Totals etc. as well as the NPV & BCR etc. in Table 15C.

Table C.5: Option 2 (Sensitivity Test)

Table 15C: Analysis of Monetised Costs and Benefits (Market Prices)

Scheme Title A430 Llanthony Road widening scheme - Economic Appraisal

IMPACT	Reference	Cal'n / Source	Total
TEE Impacts			
Noise (^)*	51		
Local Air Quality (^)*	52		
Greenhouse Gases (Emissions) (low)			£0.11
Greenhouse Gases (Emissions) (central)	53		**£0.22**
Greenhouse Gases (Emissions) (high)			£0.33
Journey Ambience (^)*	54		
Accident Benefits (*)	55		
Non-Business User Benefits: Commuting	56	11	£9.39
Non-Business User Benefits: Other	57	12	£10.24
Business User & Provider Benefits	58	30	£21.19
Wider Public Finance (Indirect Tax Revenue)	59	-50	£-1.07
Option Values (^)*	60		
Present Value of Benefits (PVB)	61	Sum(51 to 60)	**£39.97**
Broad Transport Budget	62	49	£3.74
Present Value of Costs (PVC)	63	62	**£3.74**
OVERALL IMPACTS			
Net Present Value (NPV)	64	61-63	**£36.23**
Benefit to Cost Ratio (BCR)	65	61/63	**10.69**

* Impact calculated external to PEARS & manually inputted by User. Any manual inputs will require the manual recalculation of the NPV & BCR etc.

^ Costs & benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect.

In addition to the costs & benefits outlined above, there may also be significant others, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does not provide a good measure of the value for money (VFM) and should not be used as the sole basis for decisions.

Table C.6: Option 2 (Sensitivity Test)