

Appendix 2

Cardiff West Option Modelling Report

Castle Street Option Modelling Summary Note

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Quality information

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1. Introduction

Purpose of Modelling

- 1.1 Cardiff Council are considering two options for the future layout of Castle Street: a permanent version of the existing pop-up cycle scheme which maintains access for all traffic, or a permanent version of the existing pop-up cycle scheme which introduces a bus gate on Castle Street, limiting motorised access to buses and taxis.
- 1.2 This report summarises the Vissim modelling undertaken to assess the options, with consideration to the impact on, or of, further schemes in the wider network.
- 1.3 Vissim is a multimodal traffic simulation software which allows the local impact of a proposed scheme to be assessed, providing detailed visualisation and statistical outputs for individual modes of transport.
- 1.4 In the context of the Castle Street scheme, Vissim was particularly required to obtain the local impacts on buses using the city centre.

Study Area

Figure 1-1 – Cardiff City Centre West Network Extent



- 1.5 The Vissim model covers the extent shown in red in **Figure 1-1**. The results obtained from the model show the impacts of the scheme within this extent and cannot show further impacts on the wider network.

SEWTM / Ricardo Context

- 1.6 Cardiff Council (CC) separately commissioned Ricardo to undertake an Air Quality (AQ) Assessment of the Castle Street scheme, where AQ is the driver for the scheme due to the Air Quality Management Area (AQMA) covering Castle Street.
- 1.7 The AQ assessment uses traffic data from the South East Wales Transport Model (SEWTM). The SEWTM model is a strategic model covering the whole of Cardiff and beyond, and re-routes traffic under the proposed scheme.
- 1.8 Data was fed between the Vissim model and SEWTM model to ensure as much consistency as possible, and to provide the Vissim model with an estimate for volumes of traffic in the scenario where Castle Street is closed to general motorised traffic (Option 2).

Scenarios / Schemes

- 1.9 Descriptions of each modelled scenario are provided below. Further information about the methodology, particularly in relation to the traffic changes and relationship to the SEWTM model, is held in **Appendix A**.

Base Description

- 1.10 A Base Vissim model was developed to replicate the on-street conditions during the traffic surveys conducted on 3rd and 5th March 2022.
- 1.11 As detailed in the Existing Conditions Report (ECR), the modelled period based on analysis of traffic data (flows, queue lengths, and journey times) is as follows:
- AM: 07:30-09:30 with a peak hour of 08:00-09:00
 - PM: 16:00-18:00 with a peak hour of 16:30-17:30
 - SAT: 13:00-15:00 with a peak hour of 13:30-14:30
- 1.12 The model period allows for a half hour warm-up and cool-down period either side of the peak hour. The warm-up allows for pre-load of vehicles, so the peak hour network conditions are representative of on-street conditions. The cool-down allows all vehicles to complete their desired journey.
- 1.13 The highway network was coded using OS Mapping to define the length, width, and number of lanes for each modelled link. On site observations during the survey period and Google Maps were used to assist in checking the highway, lane allocation, and to check that link distances were accurate. Along Castle Street a new bidirectional cycle lane was implemented on-street. The designs from these schemes were also used in the development of this model.
- 1.14 The Base model aims to replicate current on-street conditions. However, Cardiff City Centre is constantly evolving, therefore, it was decided that a Reference Case model should be developed to capture recent developments.

Reference Case Description

- 1.15 The Cardiff City Centre road network is currently undergoing a number of changes. It was necessary to code some of these changes into a Reference Case model so that the Option modelling could be compared to the network with committed schemes in place. The committed schemes are:
- Tudor Street and Wood Street / Central Square cycle scheme, includes rerouting of traffic using Dispenser Street in the Base model – including all bus routes;
 - Castle Street westbound bus lane extension;
 - Cathedral Road / Cowbridge Road E signal changes; and,
 - Opening of Cardiff Bus Interchange (and associated bus rerouting).

Option 1 Description

- 1.16 The Option 1 model was built upon the Reference Case model and is a permanent version of the existing popup cycle scheme. A design drawing was provided to aid in the coding of the Option 1 model. This design involves the following changes from the Reference Case:
- Castle Street popup cycle scheme made permanent;
 - Castle Street / Westgate Street design alterations to accommodate cycle movements between Westgate Street and Castle Street, and associated signal changes;
 - North Road / Boulevard de Nantes scheme including pedestrian crossings & associated signal changes; and,
 - Signal timing changes to accommodate new scheme.

Option 2 Description

1.17 Option 2 built upon the Option 1 model. A design drawing was provided to aid in the coding of the Option 2 model. This design involves the following changes from the Option 1 model:

- Bus gate on Castle Street, east of Westgate Street – reduces westbound to one lane;
- Castle Street / Westgate Street signal timing changes;
- New pedestrian crossing on Castle Street;
- North Road / Boulevard de Nantes signal timing changes;
- Traffic demand changes; and,
- Signal timing changes to accommodate new traffic patterns (Cowbridge Rd E / Cathedral Road, Tudor St/Clare St).

2. High-level Results

2.1 Graphs depicting the bus journey time impacts are in **Appendix B**.

Reference Case

Bus Travel Times

2.2 Generally, bus journey times in the Reference Case are similar to those in the Base model, however, there are two routes with changes.

- Bus journey times decrease northbound on Clare Road. This is caused by the completion of the Clare Road / Tudor Street junction roadworks in the Reference Case, and reopening Tudor Street to eastbound traffic. Buses are no longer required to divert north onto Clare Street and along Despenser Street. A shorter journey results in a decrease in journey time. The completed junction also results in shorter queues on the Clare Road northbound arm, further improving bus journey times.
- Bus journey times decrease on the West Loop route, on which buses enter on Neville St, Despenser Street, and Fitzhamon Embankment; and then exit northbound along Westgate Street, Castle Street and Cowbridge Road E in a westbound direction. Journey times increase on the inbound section of this route as buses are diverted from Despenser Street onto Clare Street and Tudor Street with increased queuing southbound into the Clare Road / Tudor Street junction. However, the journey time of exiting buses decreases along Castle Street and Cowbridge Road E due to the new westbound bus lane on Castle Street and signal improvements at the Cathedral Road / Cowbridge Road E junction. The combination of these two impacts results in an overall improvement to bus journey times on the West Loop.

General Traffic Travel Times

2.3 Compared to the Base model, general traffic journey times decrease westbound between Boulevard de Nantes and Cowbridge Road E. This is a direct result of signal improvements at the Cathedral Road / Cowbridge Road E junction.

2.4 General traffic journey times northbound between Corporation Road and Cathedral Road decrease. This is in part, due to the completion of the Clare Road / Tudor Street junction roadworks, and signal improvements at the Cathedral Road / Cowbridge Road E junction.

Option 1

Bus Travel Times

- 2.5 Option 1 bus journey times are similar to the Reference Case, except for an increase in northbound bus travel times on Westgate Street, eastbound on Castle Street and northbound on North Road. The increases in journey time of up to 3 minutes is caused by:
- Changes made to the Castle Street / Westgate Street junction to incorporate the new cycle crossing causing a slight increase in queueing on Westgate Street.
 - Changes to the North Road / Boulevard De Nantes junction to incorporate new pedestrian crossings, increasing northbound queueing and impacting buses where general traffic queues exceeded the length of the bus lane.
- 2.6 Whilst no results have been extracted for buses entering the network southbound on North Road, this reverse route would experience delays for the same reasons.
- 2.7 Elsewhere in the network, Option 1 results in bus journey times similar to the Reference Case, which are either similar to or improved over the Base journey times.

General Traffic Travel Times

- 2.8 General traffic journey times increase on all approaches to the North Road / Boulevard De Nantes junction due to the implementation of pedestrian crossings reducing the available 'green time' for traffic stages at the traffic signals.

Option 2

Bus Travel Times

- 2.9 Westbound bus journey times on Tudor Street increase by 5 minutes in the AM peak and 2 minutes in the Saturday peak. The reassignment of traffic under Option 2 results in a significant increase in congestion on the westbound approach to the Clare Road / Tudor Street junction.
- 2.10 In the AM peak, the northbound ahead and right-turn from Corporation Road experiences an increase in demand which leads to an increase in queue lengths on Corporation Road. This causes bus journey times to increase by 1 minute compared to the Reference Case; the journey time is nevertheless 1 minute shorter than the Base model result. However, in the PM, demand and queueing reduces resulting in reductions in bus journey times of 4 minutes.
- 2.11 Elsewhere in the network, Option 2 results in bus journey times similar to the Reference Case, which are either similar to or improved over the Base journey times. The congestion seen in Option 1 at the North Road / Boulevard de Nantes junction is not present due to the reduction in traffic volume due to the bus gate.

General Traffic Travel Times

- 2.12 Overall, the Option 2 model experiences increased congestion southbound on Clare Street and westbound on Tudor Street.
- 2.13 The Clare Street queue regularly stretched from the Clare Road / Tudor Street junction to Lower Cathedral Road and Neville Street in the AM and Saturday peaks – in the AM peak the queue occasionally reaches the Cathedral Road / Cowbridge Road E junction.
- 2.14 The westbound Tudor Street queue stretched back to Fitzhamon Embankment in both the AM and Saturday peaks.

3. Wider Network Considerations

Callaghan Square

- 3.1 The Option 2 Castle Street bus gate scheme would have wider implications for the routing of general motorised traffic in Cardiff City Centre, and likely displace traffic onto nearby routes. This section considers the Callaghan Square scheme currently under development, to review the Castle Street scheme in the context of the capacity and accessibility of the city centre network.
- 3.2 AECOM recently undertook a Vissim modelling exercise for the proposed scheme to introduce a Metro Rail link between Cardiff Central and Cardiff Bay, which has secured Levelling Up Funding from UK Government. The rail link route would pass through Callaghan Square, which is the nearest available east-west route, south of Castle Street, and the only other through the city centre.
- 3.3 The concept design for Callaghan Square is currently in early stages of development and the first round of modelling will be used to further develop the scheme, which may include increasing the network capacity from that provided in the concept scheme.
- 3.4 Nevertheless, the initial indication is that weekday peak hour motorised traffic volumes would need to decrease through the Callaghan Square area by approximately 50%. The result therefore would be an increased stress on alternative east-west routes through Cardiff city centre.
- 3.5 Castle Street Option 1 allows general motorised traffic on Castle Street, maintaining the existing east-west corridor access and providing resilience to the city centre road network should the Callaghan Square scheme come forward.
- 3.6 The Callaghan Square Vissim modelling exercise does not consider mode shift or traffic re-routing. However, as the Castle Street corridor is the nearest available east-west corridor and the only other route within the city centre, it is reasonable to assume a proportion of the displaced traffic may wish to travel through the Castle Street corridor. There is a risk therefore that should the Callaghan Square scheme come forward, there would be increased demand on Castle Street, which could impact on the AQ in the area. This would need to be managed through wider network management strategies considered alongside the Callaghan Square proposals.
- 3.7 It is expected that should motorised traffic demand on Castle Street increase, a wider network management plan be implemented to control the volume of motorised traffic accessing Castle Street. For example, a traffic signal network management plan.

4. Summary

- 4.1 Option 1 modelling indicates the scheme would result in increased congestion at the North Road / Boulevard De Nantes junction. This could impact on northbound and southbound buses in addition to the general motorised traffic. Further design considerations, such as extending the southbound bus lane on North Road, would ensure bus priority is provided. Furthermore, if the design was refined, for example to retain the underpass instead of providing pedestrian crossings, this may help relieve the congestion issues shown in the model.
- 4.2 Elsewhere in the network, Option 1 results in bus journey times similar to the Reference Case, which are either similar to or improved over the Base journey times.
- 4.3 Option 2 shows increased congestion on the network around Clare Street / Tudor Street. Buses travelling southbound on Clare Street could be protected by continuing to use Despenser Street, however the models indicate buses travelling westbound on Tudor Street would have longer journey times under Option 2.
- 4.4 Elsewhere in the network, Option 2 results in bus journey times similar to the Reference Case, which are either similar to or improved over the Base journey times.
- 4.5 General traffic experiences delays in similar locations to the buses.

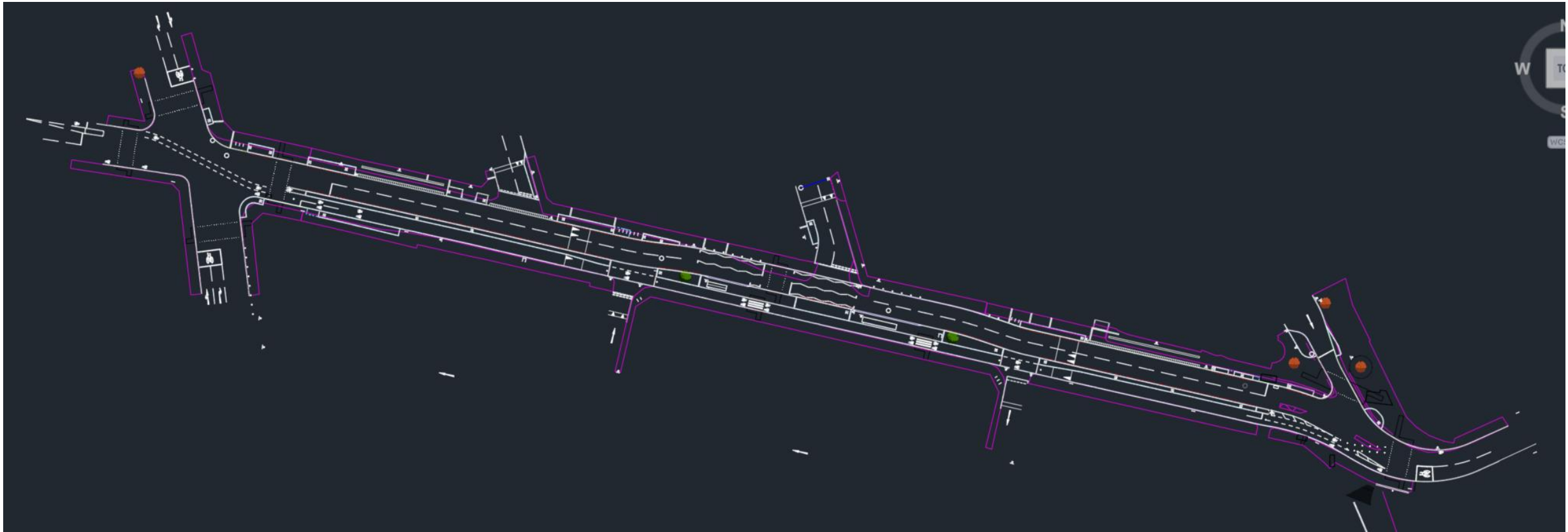
- 4.6 Either Option 1 or Option 2 could be implemented. Each have different locations where delay is predicted under the scheme, but further design or network considerations could help ease the delay to buses.
- 4.7 However, when considering the east-west cross city movements and the proposed scheme at Callaghan Square, Option 1 would provide greater resilience in the city centre network.
- 4.8 There is a risk the Callaghan Square scheme could increase traffic demand on the Castle Street corridor; this would require management through a wider network management plan.

Appendix A – Limitations & Methodology

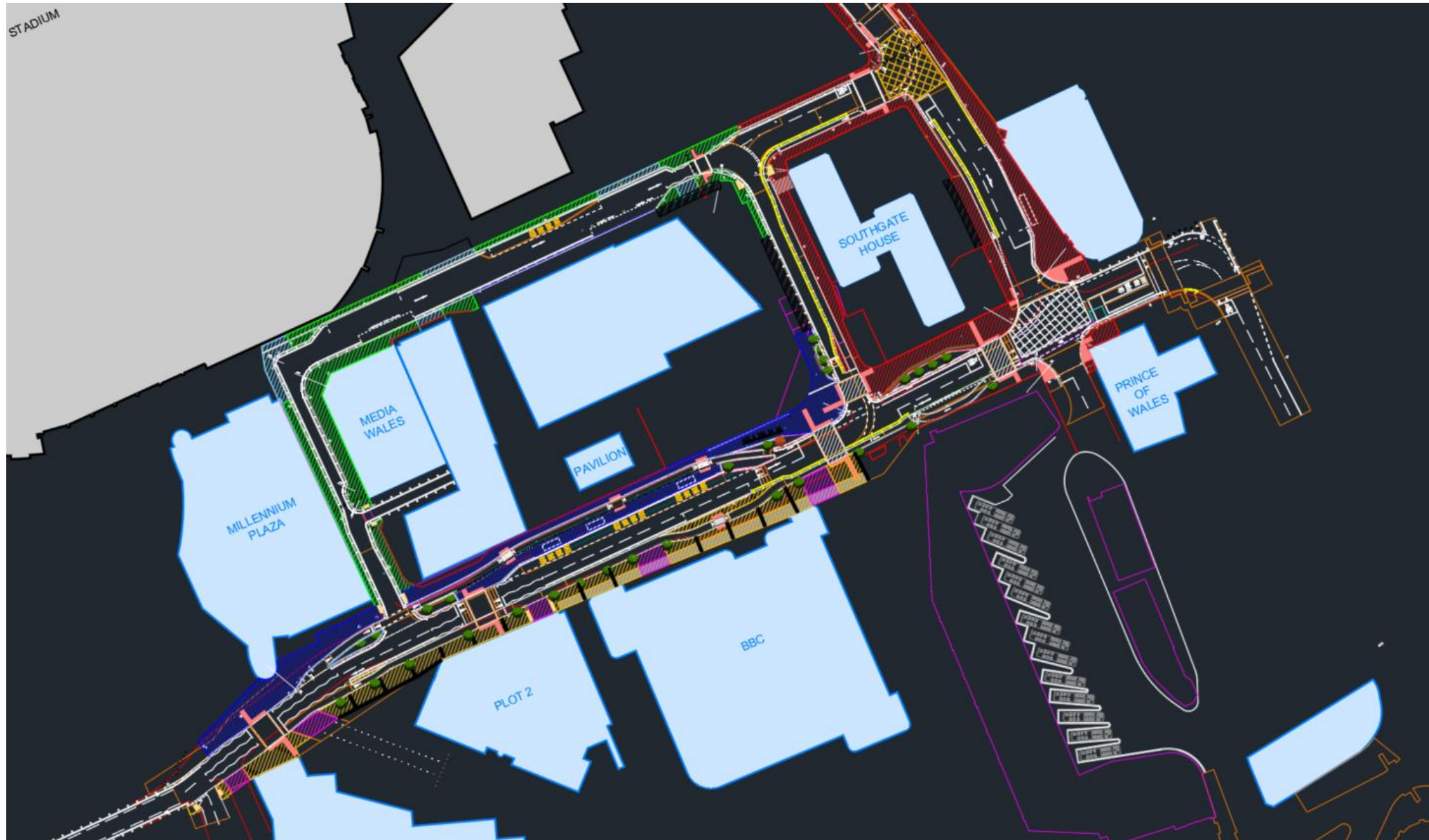
Modelled Options

- **2022 Base Model corresponding to SEWTM 2022 Base**
 - Based on traffic surveys undertaken on Thursday 3rd & Saturday 5th March 2022
- **Reference Case corresponding to SEWTM Do Minimum**
 - Introduction of Westbound bus lane on Castle Street, west of Westgate Street
 - Signal changes at Cowbridge Rd E / Cathedral Rd junction
 - Completion of Tudor Street / Wood St roadworks and opening of permanent scheme
- **Option 1 does not correspond to a SEWTM model**
 - Popup cycle scheme made permanent
 - Signal changes at North Rd / Boulevard de Nantes junction
 - Introduction of pedestrian crossings
- **Option 2 corresponding to SEWTM Do Something 1**
 - Option 1 changes, plus:
 - Bus gate on Castle Street between Westgate St and Queen St – all general traffic (excluding taxis) removed / reassigned

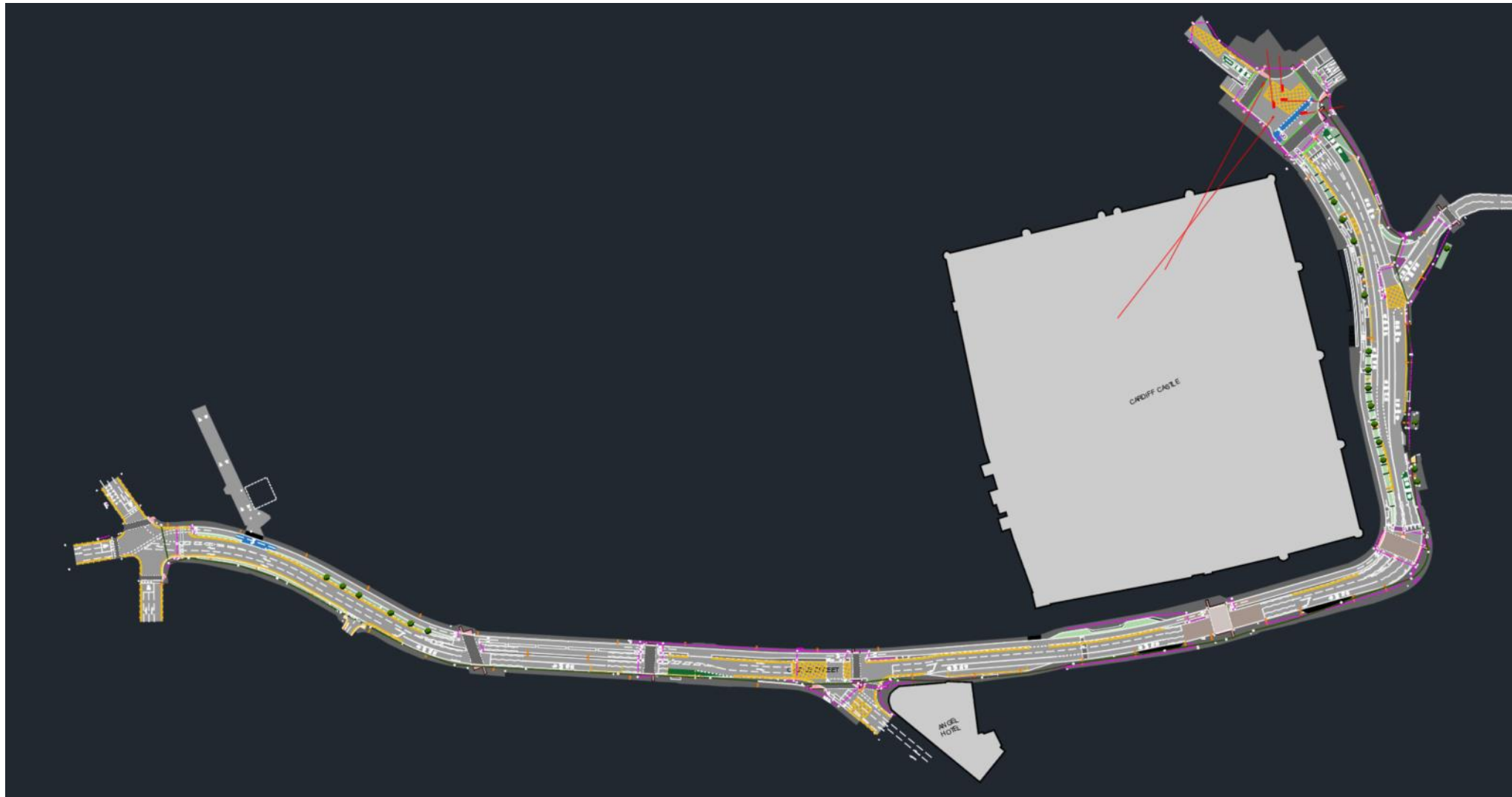
Modelled Options – Reference Case Design (Tudor Street)



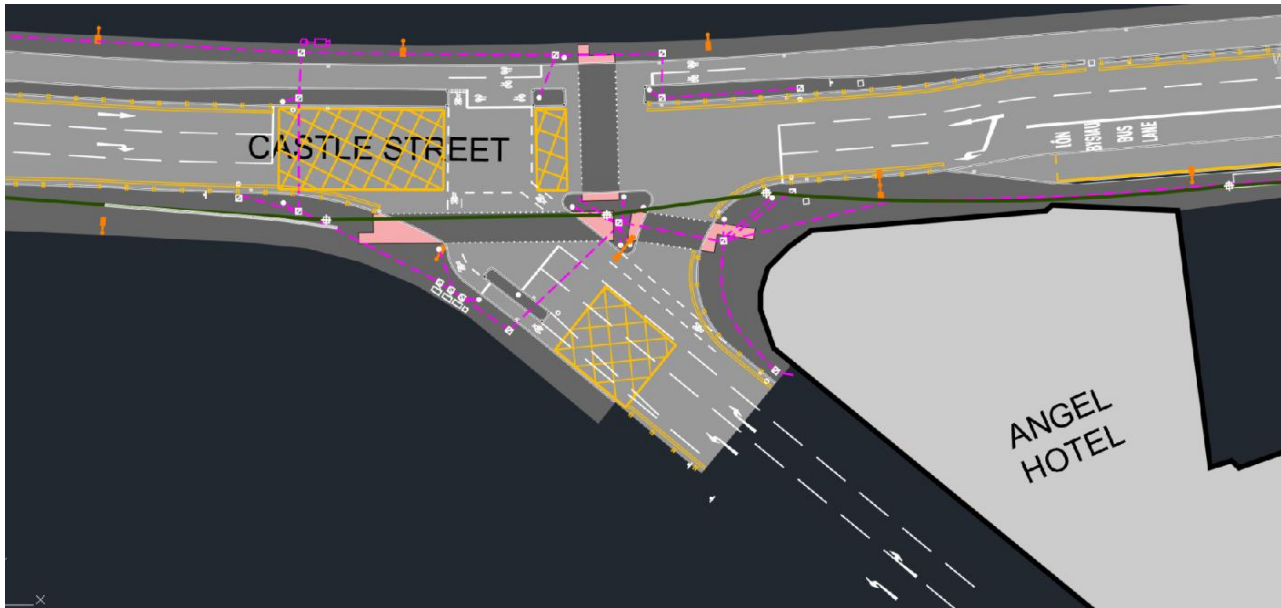
Modelled Options – Reference Case Design (Wood Street)



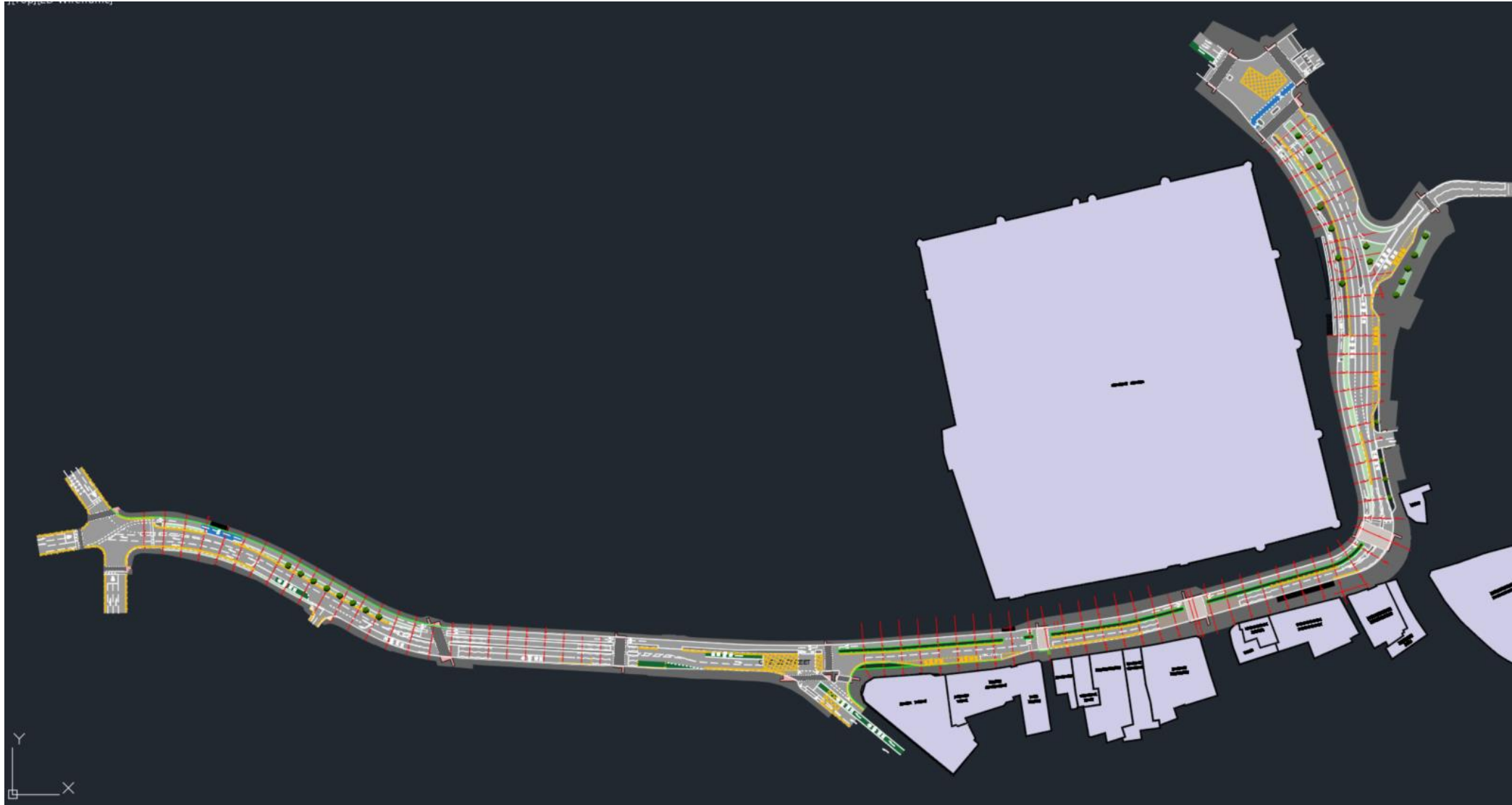
Modelled Options – Option 1 Design



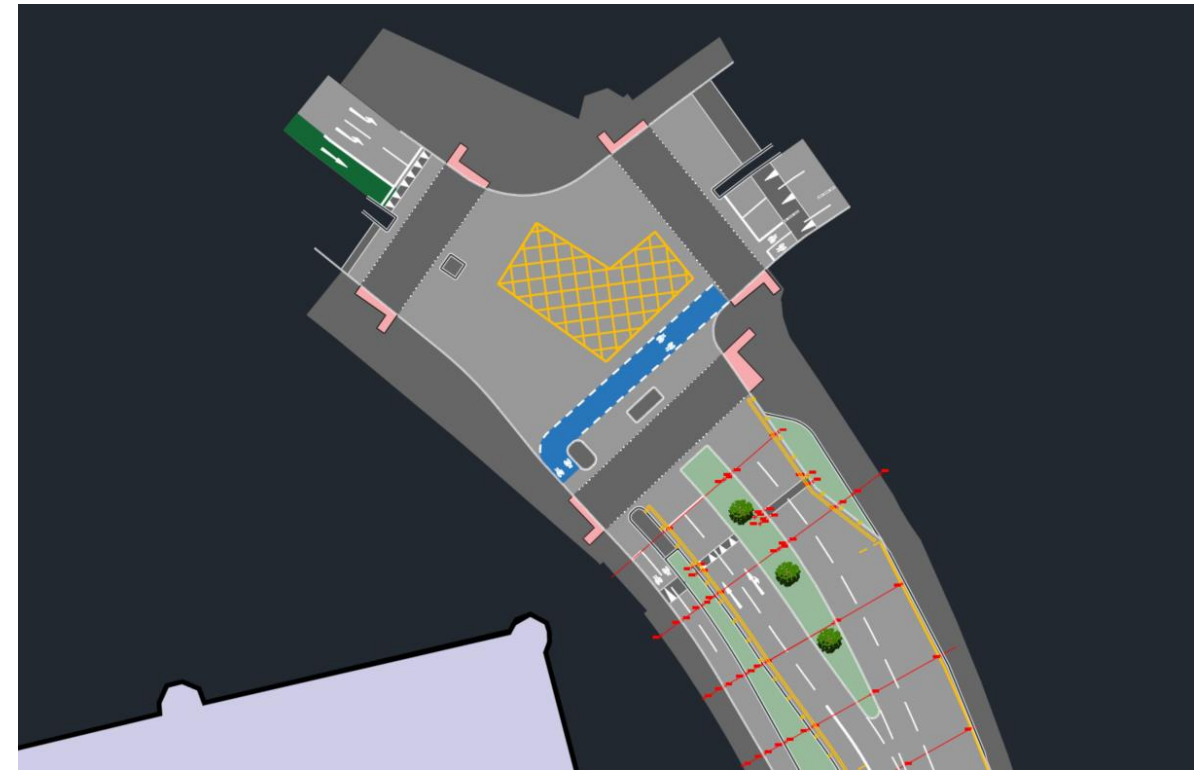
Modelled Options – Option 1 Design



Modelled Options – Option 2 Design



Modelled Options – Option 2 Design



Changes in Traffic Volumes

– Base to Reference Case

- Tudor St eastbound reopened with vehicles rerouted from Despenser St / Fitzhamon Embankment
 - 68 vehicles in the AM peak
 - 46 vehicles in the PM peak
 - 41 vehicles in the SAT peak

– Reference Case to Option 1

- *No changes in demand*

– Reference Case to Option 2

- Bus gate on Castle St between Westgate St and Queen St
- Significant decrease in Castle St motorised traffic
 - adjacent tables indicate a 60-70% reduction in traffic
- Re-routing informed by option SEWTM models (AM & PM peak only)

Castle Street Traffic Volumes

		Ref Case	Option 2	Difference	% Difference
Eastbound	AM	647	297	-350	-54%
	PM	584	235	-349	-60%
	SAT	499	209	-290	-58%

		Ref Case	Option 2	Difference	% Difference
Westbound	AM	568	127	-441	-78%
	PM	599	244	-355	-59%
	SAT	475	116	-359	-76%

		Ref Case	Option 2	Difference	% Difference
Two-way Combined	AM	1215	424	-791	-65%
	PM	1183	479	-704	-60%
	SAT	974	325	-649	-67%

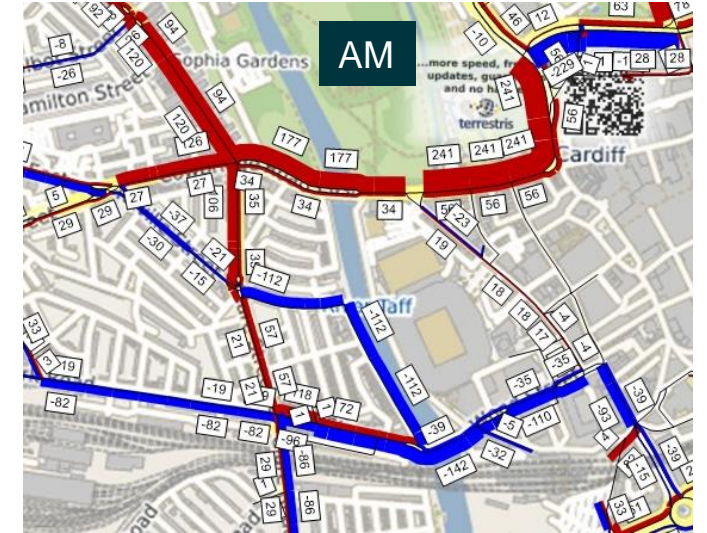
Limitations – Option 2 Traffic Re-routing Methodology

SEWTM (*strategic model*) traffic volume changes were analysed to create the Option 2 AM & PM weekday Vissim matrices. SEWTM does not have a Saturday scenario and therefore the Option 2 Saturday methodology differs.

Reference Case traffic flows were applied within the Vissim model directly, and does not consider changes predicted between the SEWTM Base and Reference case scenarios

- For example, SEWTM predicts an increase in northbound demand on Clare Street between the Base and Ref Case in both the AM and PM peaks. This is at-least in part due to SEWTM representing an increase in capacity at the Cathedral Road / Cowbridge Road E junction. However, Vissim models showed the Tudor Street / Clare Road junction did not have the capacity to accept this increase in demand. Therefore, the Vissim model maintained the Base demands in the Ref Case modelling.
- SEWTM also predicts an increase in demand on Castle Street EB between the Base and Do Min (Ref Case) which is not represented in Vissim.

SEWTM Do Min -
Base Flow Plots



Limitations – Option 2 Traffic Re-routing Methodology (cont.)

SEWTM traffic flow matrices were used to create difference matrices showing how demands changed between the Do Min (Ref Case) and Option 2.

This difference matrix was applied directly to the Vissim Ref Case matrices. The resulting matrices were then furnished to 15-minute matrices to create the Vissim Option 2 matrices.

Due to differences in demand between the Strategic and Vissim models, some Origin-Destination trips could not be removed (where the strategic modelling suggested a reduction in flow greater than the initial Vissim demand).

In general, the patterns of demand increases/decreases is consistent between the Strategic and Vissim models.

- One exception is Clare Road: SEWTM suggests a overall reduction in demand on Clare Road Northbound and Southbound (AM & PM).
- The Vissim model has an increase in demand Southbound in the AM peak hour. Due to SEWTM removing more trips from some movements than existed in the Vissim model matrices.

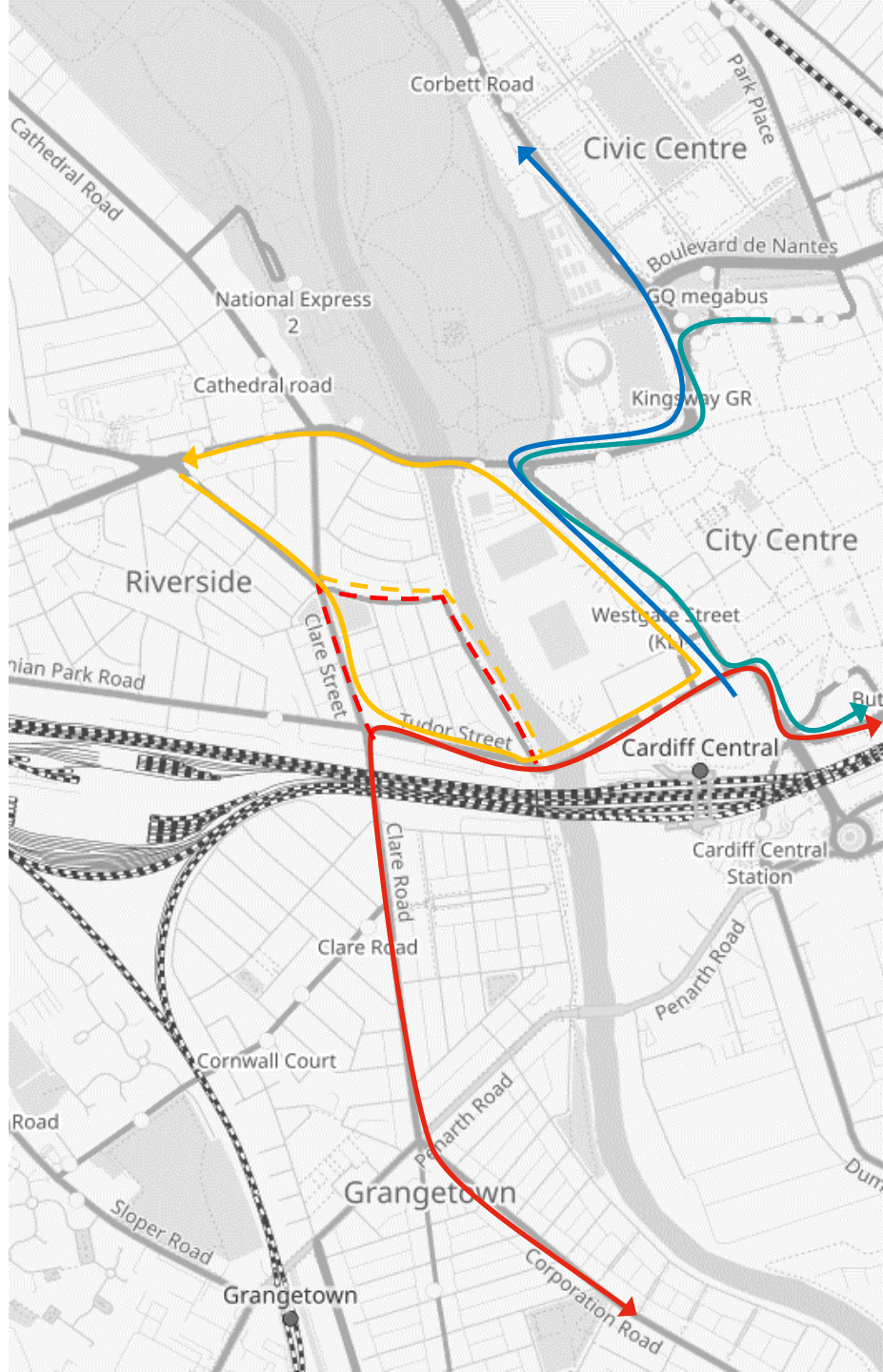
Limitations – Option 2 Traffic Re-routing Methodology (cont.)

There is not a strategic model for the Saturday peak. Therefore, the Option 2 Saturday matrices were generated using a set of assumptions which allows for traffic using Castle St to be diverted:

- Eastbound
 - Trips from south of the railway line (south of Tudor Street) will use Penarth Road
 - Trips from Tudor Street will use Wood Street
 - Trips from Clare Street side turnings will use Wood Street
 - Trips from Wellington St, Cowbridge Road E, and Cathedral Road will be split, 50% using Wood Street and 50% being removed from the matrices (assuming they would reroute outside of our network)
- Westbound
 - Trips to south of the railway line (south of Tudor Street) will enter from Penarth Road
 - Trips to Tudor Street will enter from Wood Street
 - Trips to Clare Street side turnings will enter from Wood Street
 - Trips to Wellington St, Cowbridge Road E, and Cathedral Road will be split, 50% using Wood Street and 50% being removed from the matrices (assuming they would reroute outside of our network)

A difference matrix (Option 2 - Ref Case) was calculated for each peak hour. With these, the Saturday matrices were checked against the AM and PM. Overall, the shift of traffic showed a similar pattern.

Appendix B – Bus Journey Time Graphs



Bus Journey Time Routes

Clare Road NB/SB

Bus Box

West Loop

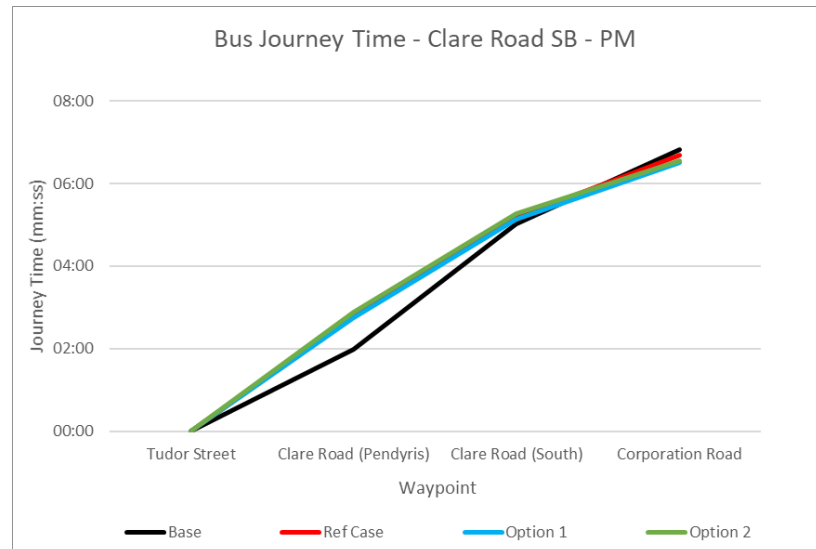
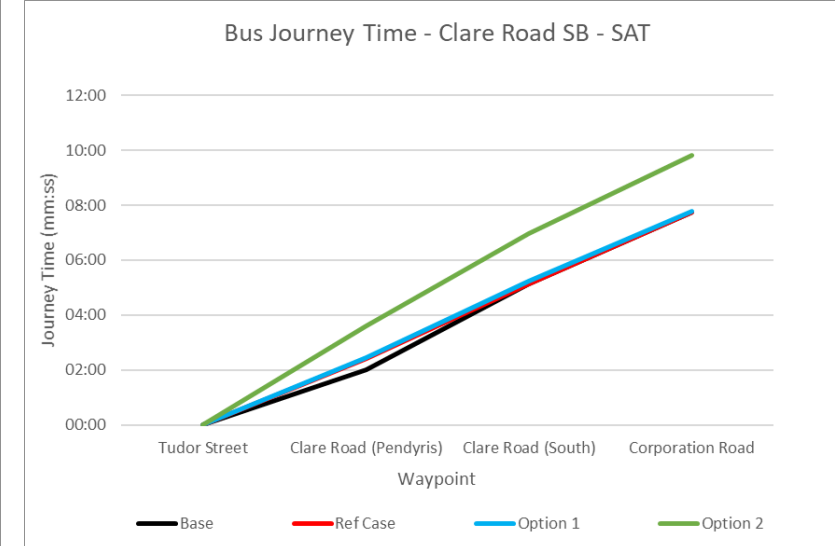
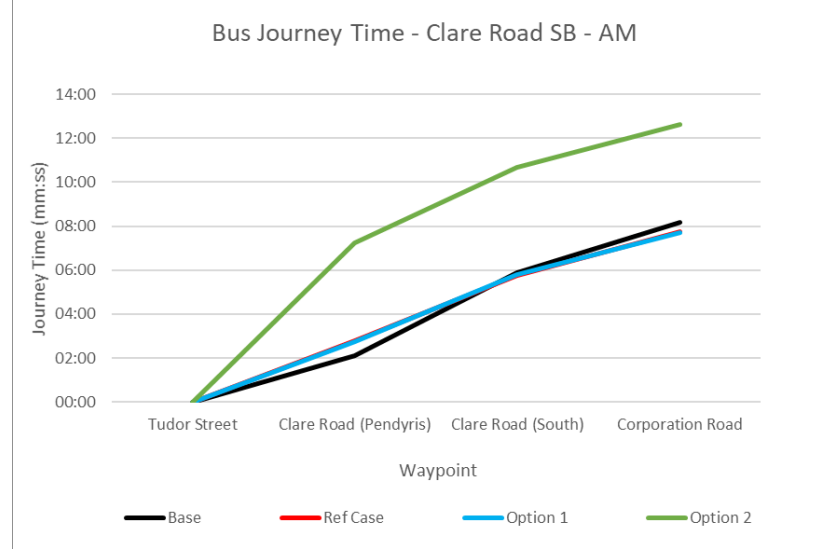
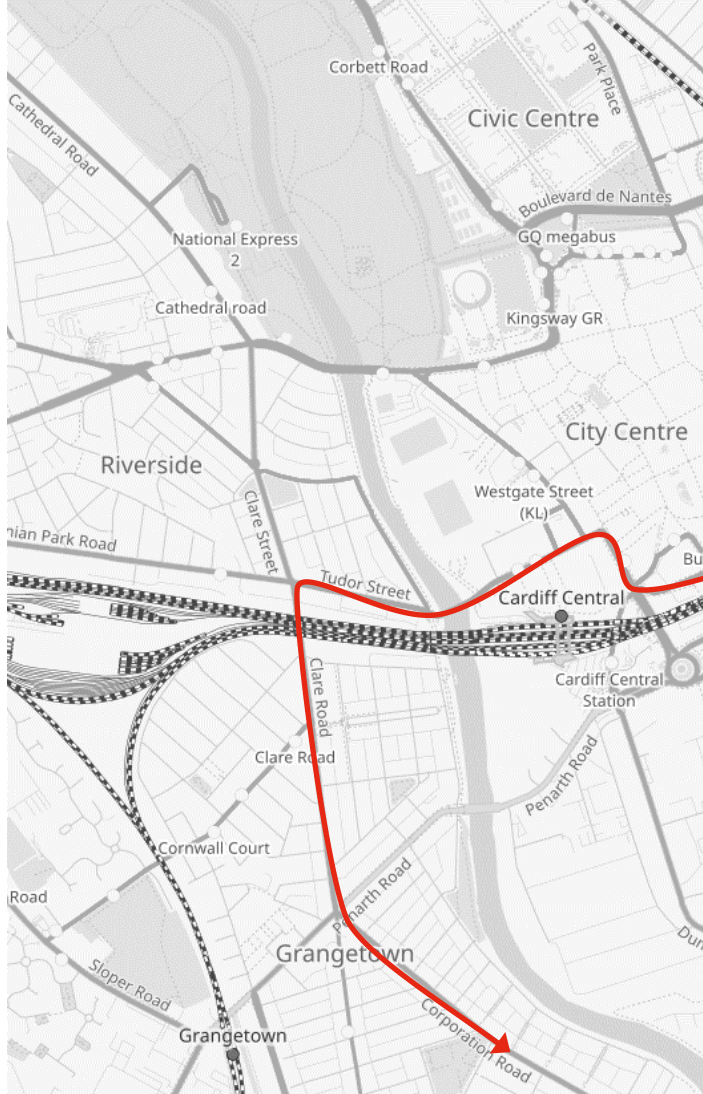
Castle St EB

Note – dashed lines signify the base model eastbound route using Despensers St due to Tudor St roadworks

Bus Journey Times – Clare Road SB

Clare Rd SB	Base	Ref Case	Option 1	Option 2
AM	08:10	07:44	07:42 (-00:02)	12:39 (+04:55)
PM	06:50	06:41	06:31 (-00:10)	06:33 (-00:08)
SAT	07:45	07:46	07:47 (+00:01)	09:48 (+02:02)

Option 1 & 2 journey time compared to Ref Case



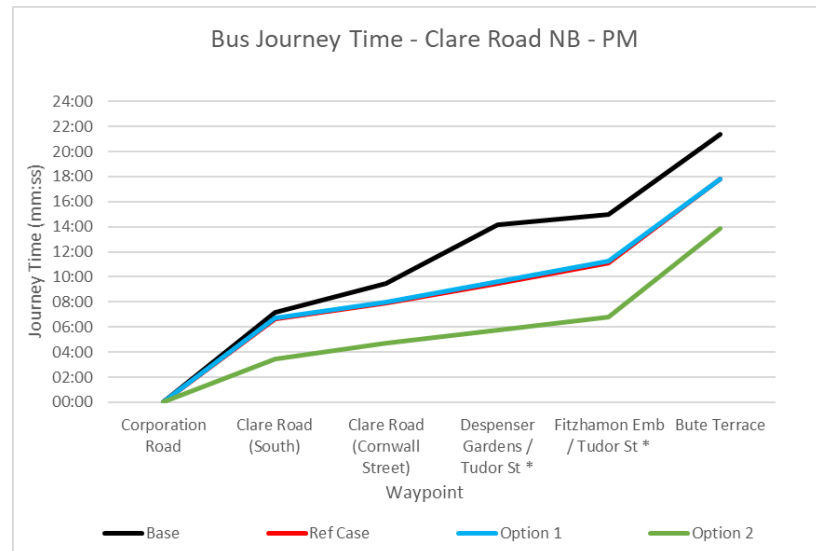
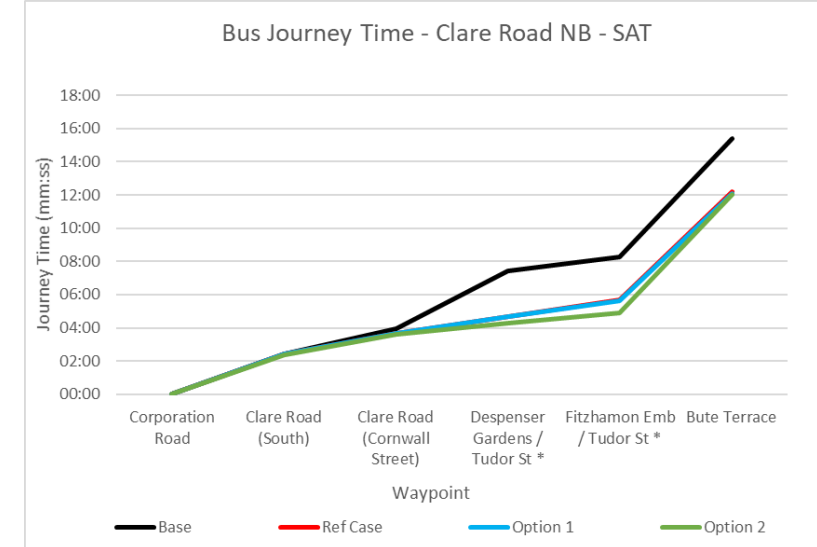
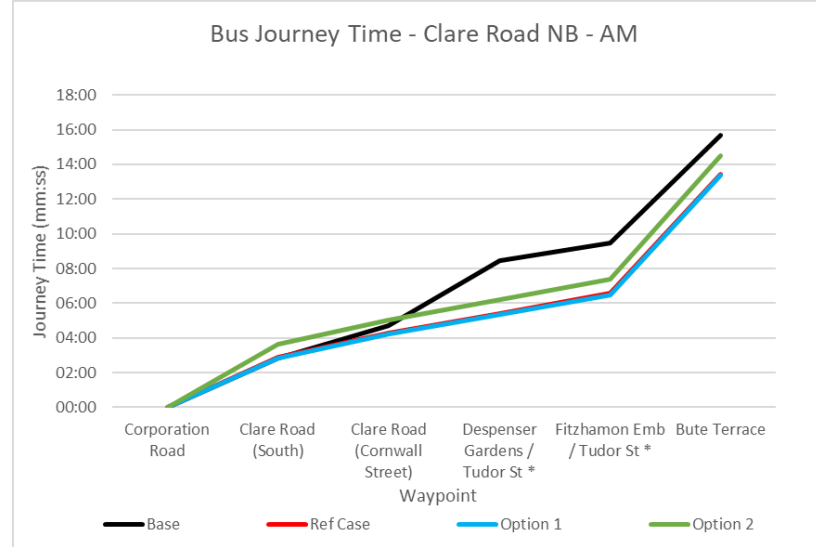
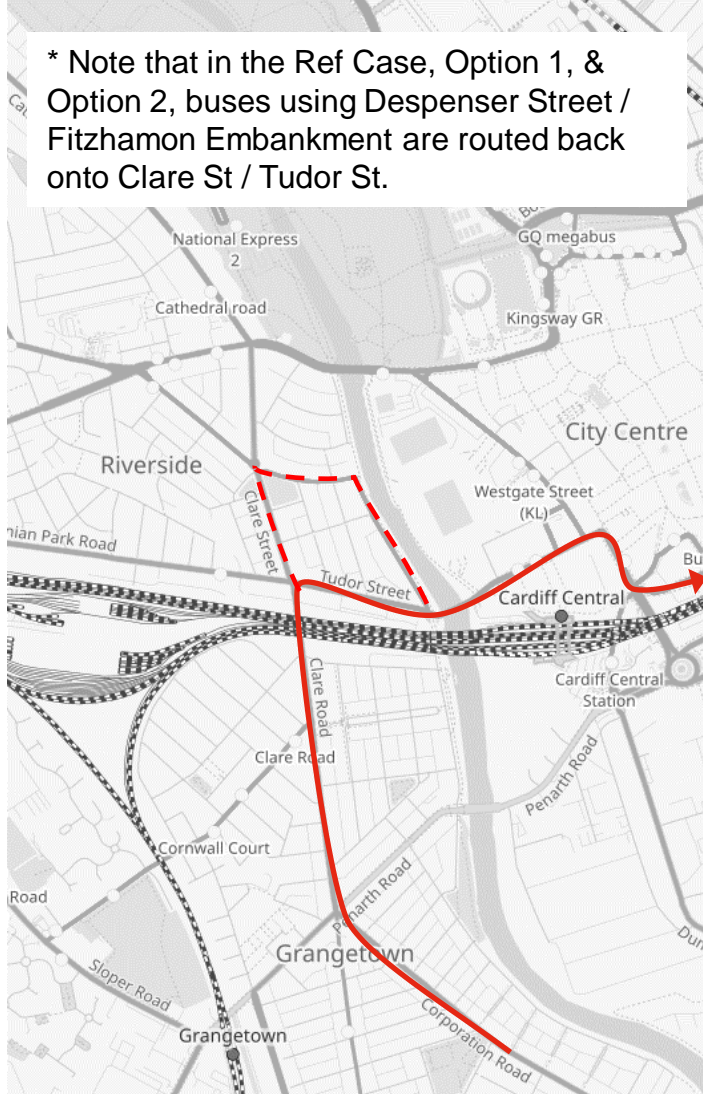
- Westbound delay on Tudor Street in Option 2 AM peak: Caused by reallocation of green times at the Tudor St signalised junction to account for increased southbound traffic on Clare Street
- Increased delay on Tudor St in Option 2 Saturday peak: due to increased traffic volumes on Tudor Street

Bus Journey Times – Clare Road NB

Clare Rd NB	Base	Ref Case	Option 1	Option 2
AM	15:40	13:25	13:24 (-00:01)	14:29 (+01:04)
PM	21:22	17:49	17:47 (-00:02)	13:51 (-03:58)
SAT	15:25	12:12	12:07 (-00:05)	12:01 (-00:11)

Option 1 & 2 journey time compared to Ref Case

* Note that in the Ref Case, Option 1, & Option 2, buses using Despenser Street / Fitzhamon Embankment are routed back onto Clare St / Tudor St.

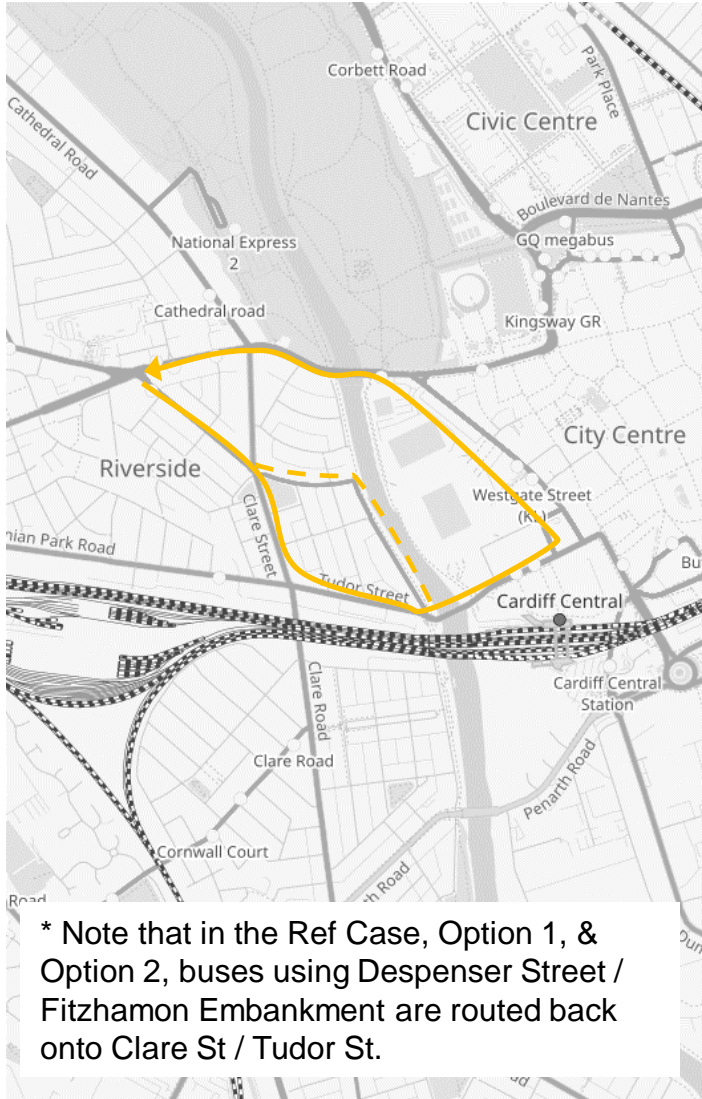


- Faster eastbound travel times in the Ref Case & Option models: mainly due to the reopening of Tudor Street Eastbound and reduced distance travelled.

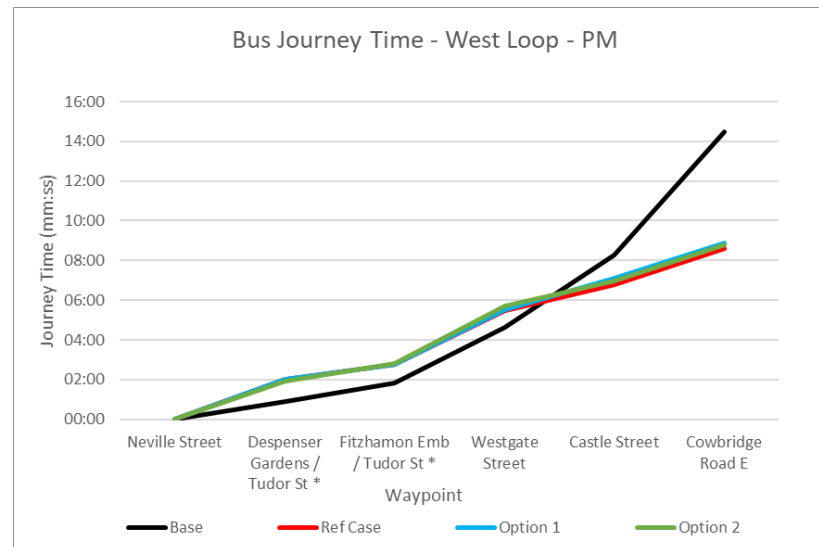
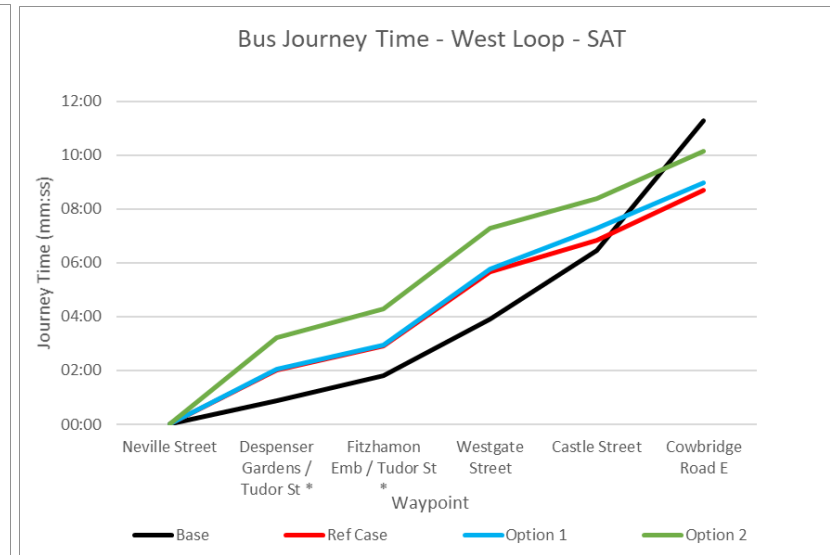
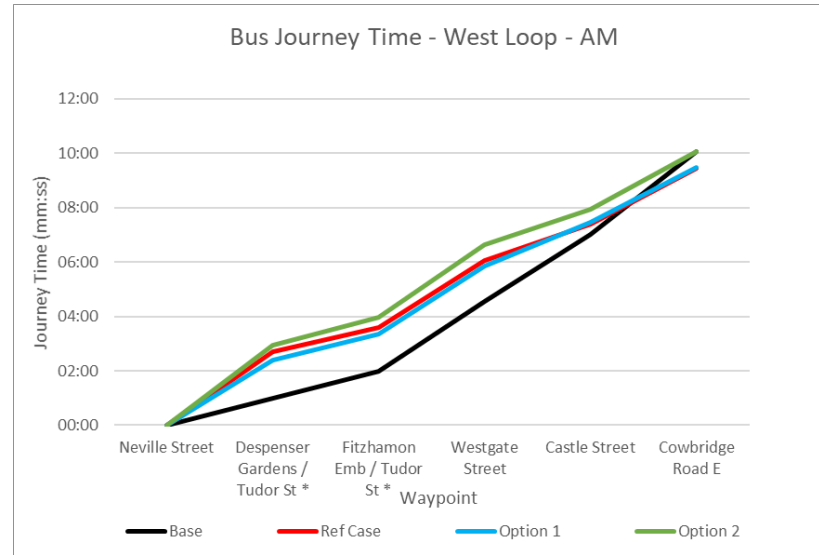
Bus Journey Times – West Loop

West Loop	Base	Ref Case	Option 1	Option 2
AM	10:04	09:27	09:28 (+00:01)	10:04 (+00:36)
PM	14:29	08:36	08:54 (+00:18)	08:48 (+00:13)
SAT	11:16	08:42	08:58 (+00:16)	10:09 (+01:26)

Option 1 & 2 journey time compared to Ref Case



* Note that in the Ref Case, Option 1, & Option 2, buses using Despenser Street / Fitzhamon Embankment are routed back onto Clare St / Tudor St.

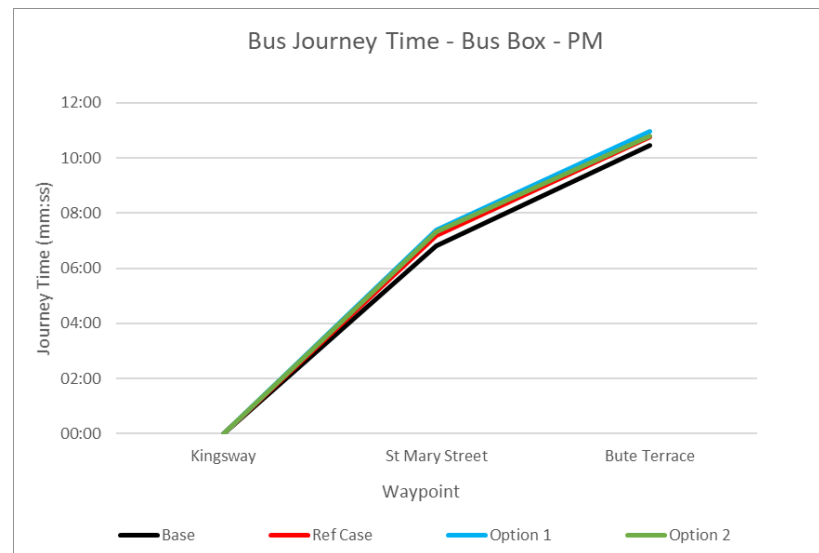
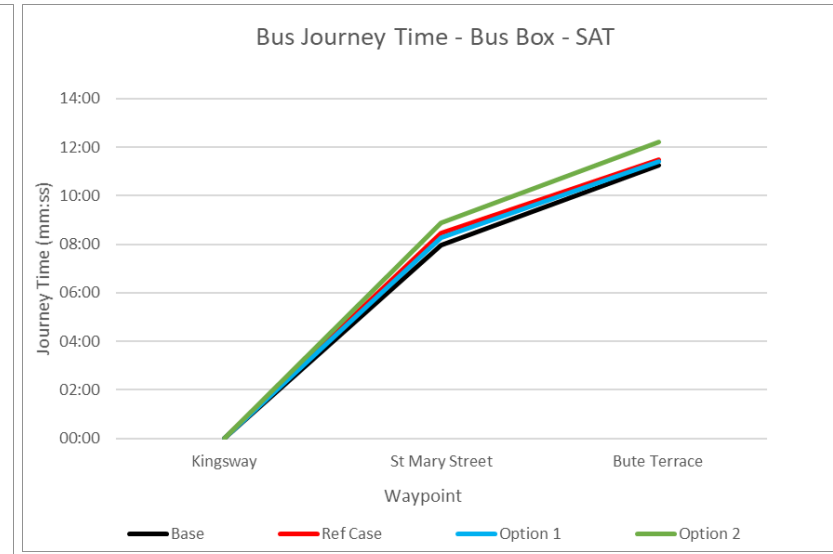
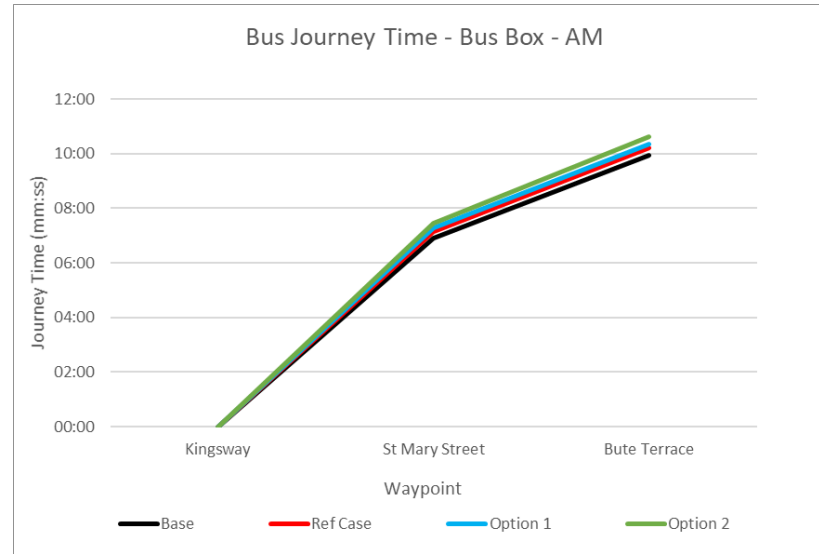
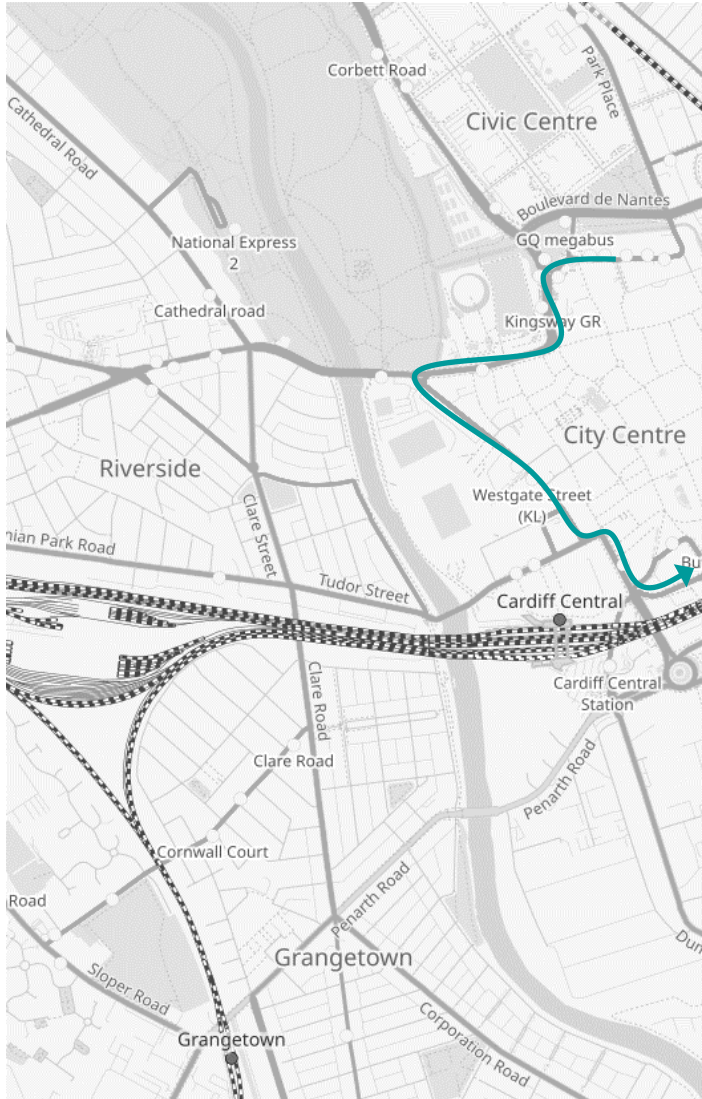


- Additional southbound delay on Clare Road: due to re-routing of buses through Clare St / Tudor St junction – option to maintain bus routes on Despenser Street?
- Improved/comparable westbound travel time on Castle Street in Ref Case & Options: due to provision of westbound bus lane on Castle Street & adjusted signal staging at Cathedral Road junction.

Bus Journey Times – Bus Box

Bus Box	Base	Ref Case	Option 1	Option 2
AM	09:57	10:12	10:21 (+00:09)	10:37 (+00:25)
PM	10:27	10:46	10:57 (+00:11)	10:47 (+00:01)
SAT	11:14	11:30	11:25 (-00:05)	12:13 (+00:43)

Option 1 & 2 journey time compared to Ref Case

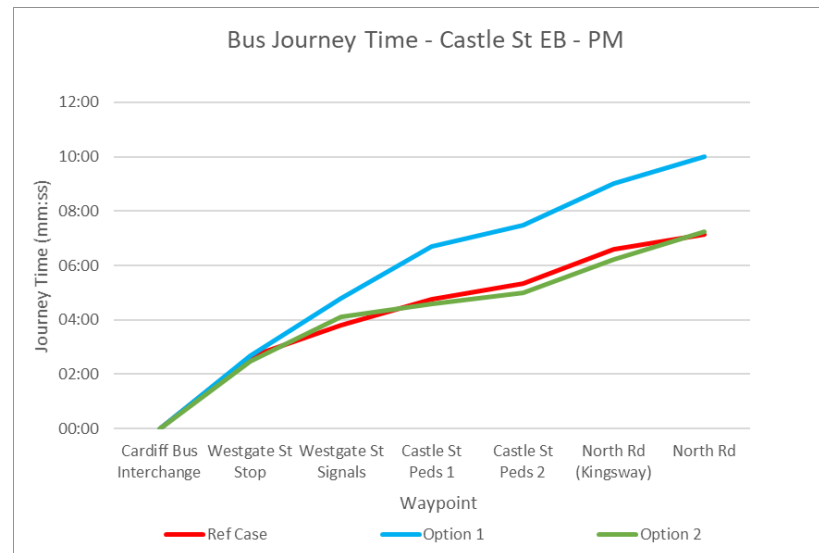
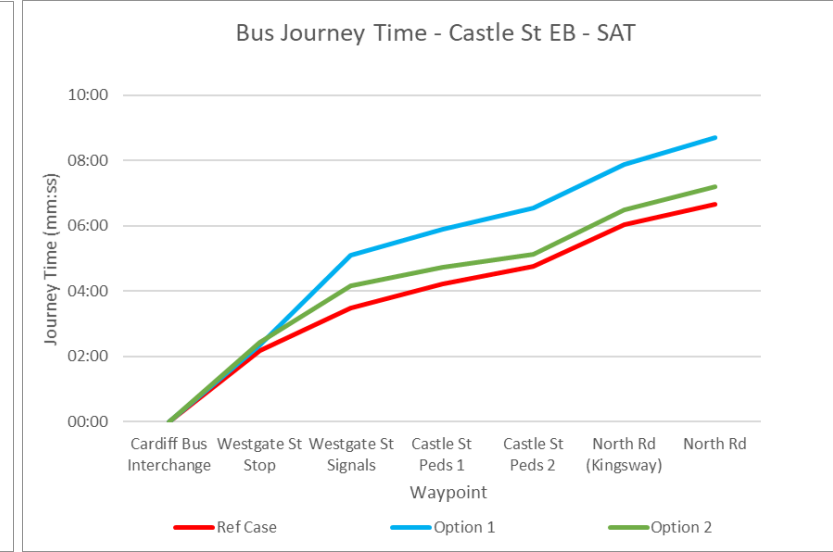
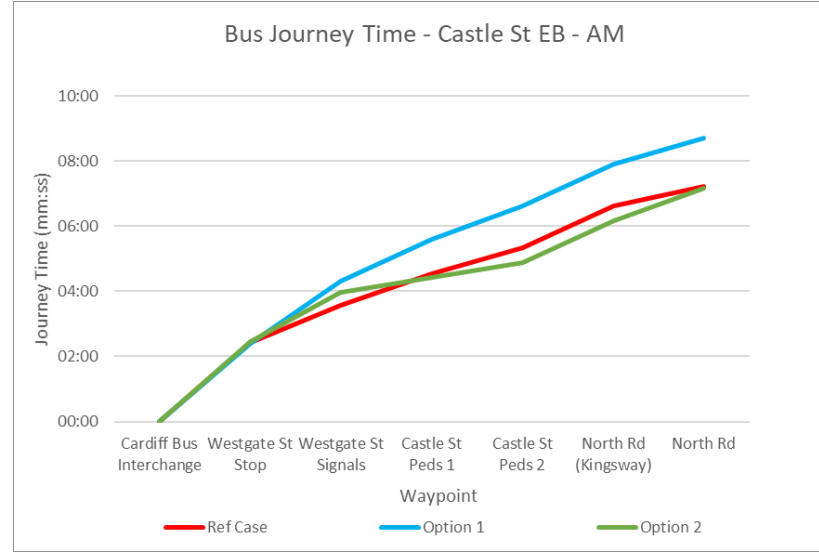
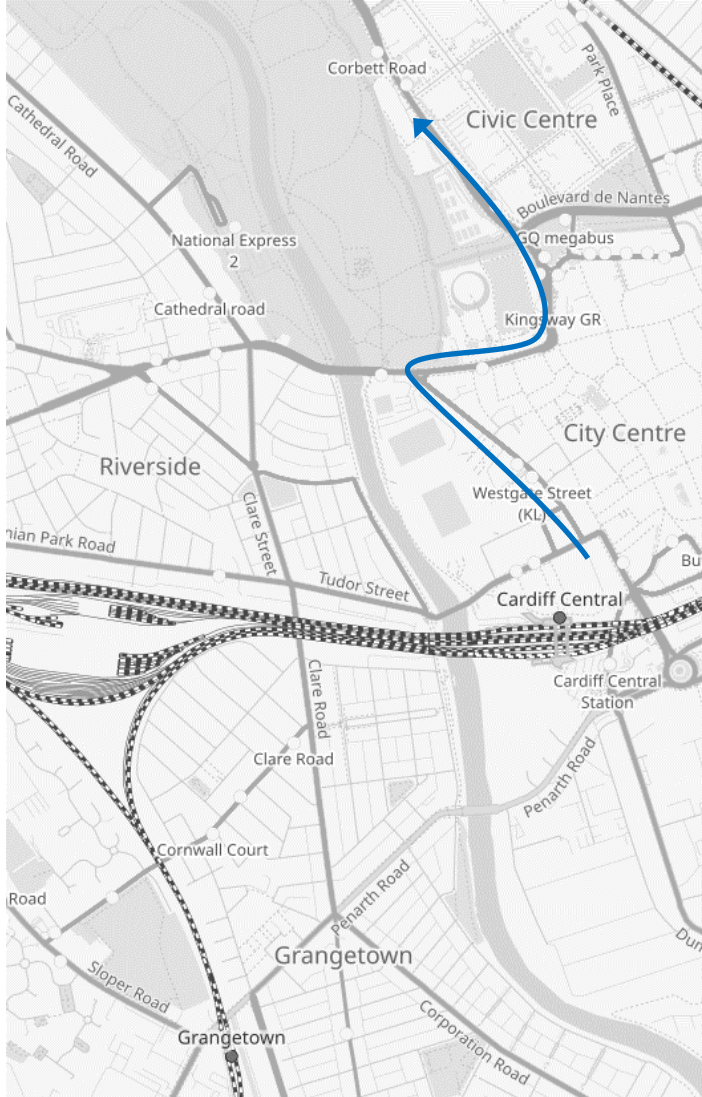


- Consistent travel times in all options: buses are protected on this route through bus lanes and/or bus gate

Bus Journey Times – Castle St EB

Castle St EB	Base	Ref Case	Option 1	Option 2
AM	-	07:14	08:43 (+01:29)	07:10 (-00:04)
PM	-	07:09	10:00 (+02:51)	07:15 (+00:07)
SAT	-	06:40	08:42 (+02:02)	07:12 (+00:32)

Option 1 & 2 journey time compared to Ref Case



- No Base model results as Bus Interchange not in operation.
- Increased travel times in Option 1: due to impacts of proposed design at North Road / Boulevard De Nantes junction.
- No delays in Option 2: as the bus gate on Castle Street, and lower traffic volumes, mitigate the impact to the North Road junction.

