Thickthorn Interchange Improvements

Concept Scheme Options
Traffic Assessment

June 2013

Norfolk County Council

Mott MacDonald

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Contents

Executive Summary

Following the analysis of future flows through the Norwich Area Transport Strategy (NATS) Model Thickthorn Interchange was identified as one of a number of major junctions that would see a significant increase in traffic demand. In its current form the junction would be unable to accommodate an increase in traffic and therefore improvements would be required to cater for additional traffic arising from planned growth in the Norwich area as set out in the adopted Joint Core Strategy (JCS).

Mott MacDonald as Norfolk County Council's Strategic Partner has been commissioned to review all studies that have considered upgrades at the interchange and to appraise a short list of viable options with a view to arriving at a preferred option or options. This is the first stage of this work and this interim report considers the traffic aspects of proposed improvement schemes and the geometric aspects of proposed solutions.

The principal objective of the scheme is to enable the Thickthorn Junction to accommodate additional traffic arising from planned growth in the Norwich area. Furthermore, any proposed scheme will also have to enhance bus priority at the interchange to meet the aspirations of local bus operators and also to promote sustainable transport.

This report considered all options that have been previously identified in previous studies and included additional options that arose as part of this study. Through due consideration the study arrived at a short list of viable Do-minimum and Do-something options.

In total, 21 options have been reviewed in this report namely:-

- Option 1 - Left-in to the park and ride from the A11 (west);
- Option 2 - Closure of 'old' Newmarket road arm, with alternative re-provision off A11 (east);
- Option 3 - Closure of Cantley Lane South egress on A47 south off-slip;
- Option 4 - Closing B1172 park and ride arm and re-providing access to the west of the park and ride site by a new junction with the A11 (west);
- Option 5 – Grade separation for the A11 right turn movements;
- Option 6 – Grade separation for the A11 straight-ahead movements;
- Option 7 – New Grade Separated Junction with an Increased Inscribed Circle Diameter;
- Option 8 – Hamburger Roundabout;
- Option 9 – Cantley Lane Improvements;
- Option 10 – Exit slip road to park and ride extension;
- Option 11 – Bus lane on the roundabout;
- Option 12 – Bus only Link Road over the A47;
- Option 13 – An A11 east to west bypass;
- Option 14 – A free-flow lane from the A47 (North) off slip to the A11 (East);
- Option 15 – Widening the A47 (East) on-slip to a three-lane exit from the roundabout;
- Option 16 – A bus gate on the B1172 (West) on the entry to the roundabout;
- Option 17 – An additional flared lane on the A47 (East) off-slip, on the entry to the roundabout;
- Option 18 – A11 (West) park and ride access/egress with left-turn egress on the B1172;
- Option 19 – A free flow lane from the A11 (East) to the A47 (South);
- Option 20 – A11 East 'Teardrop' option (partial closure of the circulatory carriageway); and
- Option 21 – A11 East 'Teardrop' option (partial closure of the circulatory carriageway) with an extension to the circulatory carriageway.

Option Sifting Exercise

A high level option sifting exercise was undertaken in Section 6.1 which reduced the number of options (at that stage) to be progressed further down to 15 options.

Option 1 and Option 10 were very similar and provide a new access to the park and ride site from the A11 (West), therefore these options have been consolidated into one option. Options 5, 6, 7 and 8 were discounted at that stage due to their viability in terms of operational benefit, cost and constructability.

Options were then categorised into types of scheme namely Minor, Bus Priority, Slip Road and Major whereby Major schemes were treated as Do-something options and the other schemes treated as the Do-minimum options. The basis for this was that only the major schemes were capable of accommodating the growth in traffic and the Do-minimum options could complement the Do-something options.

Do-minimum Options

Do-minimum options that did not compliment the Do-something options (i.e. they became redundant or required removal) to allow the Do-something options to be implemented were discounted at this stage. The Do minimum options that were progressed at that stage included:-

- Option 1 Left in access to the park and ride site from the A11 (West) and/or Option 18 A left turn link from the A11 (West) to the B1172 via a new park and ride link;
- Option 15 Widening the A47 (South) on-slip to a three-lane exit from the roundabout;
- Option 16 A bus gate on the B1172 (West) on the entry to the roundabout;
- Option 17 An additional flared lane on the A47 (South) off-slip, on the entry to the roundabouts; and
- Option 19 A Free Flow Lane from the A11 (East) to the A47 (South).

Whilst option 14 did not compromise the viability of the Do-something options, the traffic flows on this movement (i.e. north to east) only negligibly increase during the assessment years and the approach is operating satisfactorily therefore it is considered that this option would not improve the capacity of the interchange as a whole. However, this option may be required as an add-on to the Do-something options to maintain capacity on this approach.

Do-something Options

Option 13, 20 and 21 were promoted as Do-Something options.

Traffic Modelling

Following this option sifting exercise the aforementioned Do-minimum and Do-something options were modelled to determine their operational effectiveness.

Do Minimum

Option 15 and Option 17 offer moderate improvements to the operational capacity of the junction in their locality. Whilst Option 15 does offer a moderate improvement on the A47 (south) on-slip it is likely to

achieve a low VFM score due to the necessary widening works on the on-slip and therefore only Option 17 should be progressed as a Do minimum option. Options 16 and 18 would only provide a minor improvement to the operational capacity of the junction and therefore it is considered that they too would achieve a low VFM score and should not be progressed further.

Option 11 significantly reduces the operational capacity of Thickthorn interchange because it removes a general traffic lane and re-allocates it to bus only. Whilst this would achieve a low VFM score it would achieve the Promoter's aspiration to promote bus priority at the interchange. This option could only be implemented if surplus capacity was created on the circulatory of the interchange (i.e. implemented with a DO-something option).

Do-Something

The option that performs best in traffic terms is option 13 the (bypass option). Option 21 does accommodate the 2032 traffic flows but a number of approaches experience over saturation and queuing. Option 20 does not operate effectively because it requires significant improvements to Round House Way Roundabout.

The do-something models are adversely affected by the bus lane provision on the circulatory carriageway because this removes a general traffic lane. If this were removed all options would perform better operationally, but would not meet the Promoter's aspirations for bus priority provision.

Option Appraisal

Option 13 (Bypass Option) performs best overall when considered against the DfT's appraisal criteria. Whilst there are some adverse impacts on adjacent residential dwellings it is considered that with appropriate mitigation that these impacts could be reduced to acceptable levels.

1 Introduction

1.1 Introduction

Following the analysis of future flows through the Norwich Area Transport Strategy (NATS) Model Thickthorn Interchange was identified as one of a number of major junctions that would see a significant increase in traffic demand. In its current form the junction would be unable to accommodate an increase in traffic and therefore improvements would be required to cater for additional traffic arising from planned growth in the Norwich area as set out in the adopted Joint Core Strategy (JCS).

1.2 Study Remit

Mott MacDonald as Norfolk County Council's Strategic Partner has been commissioned to review all studies that have considered upgrades at the interchange and to appraise a short list of viable options with a view to arriving at a preferred option or options. This is the first stage of this work and this interim report considers the traffic aspects of proposed improvement schemes and the geometric aspects of proposed solutions.

The principal objective of the scheme is to enable the Thickthorn Junction to accommodate additional traffic arising from planned growth in the Norwich area. Furthermore, any proposed scheme will also have to enhance bus priority at the interchange to meet the aspirations of local bus operators and also to promote sustainable transport.

There have been a number of previous studies and workshops considering different options and this document will constitute a consolidated options selection report which is intended to provide the evidence, rationale and context for how the preferred improvement scheme or schemes were reached.

1.3 Background

In November 2008 Mott MacDonald reported on an initial capacity assessment of three of the A47's Norwich Southern Bypass Junctions which included the A47/A11 Thickthorn Interchange. As part of this assessment three low cost options, and three major re-alignment options were proposed. Following a study workshop where the aforementioned options were discussed a seventh (radical) option was also developed.

In November 2010 AECOM were instructed by the Highways Agency to prepare some indicative options for the A47/A11 Thickthorn Interchange as potential do-minimum schemes. This study identified five different options which were traffic capacity assessed and were considered in different combinations with each other to create a number of implementation scenarios.

This report will consider all options that have been previously identified, include any additional options that arise as part of this study and through due consideration arrive at a short list of viable options. The short list of options will then be appraised using webtag criteria to take a holistic view of the short listed options.

1.4 Report Structure

Following this introduction there are a further nine sections which are as follows:-

- **Context and Constraints** – This section provides an overview of the scheme milieu including physical constraints and a chronology of previous studies that have been undertaken;

- **A47 Southern Bypass Junctions** – Capacity Assessment Report – This section examines each option considered in this study, including an option specific description, key considerations, a table of advantages and disadvantages and summary of the options' viability;
- **Review of Options for A47/A11 Thickthorn Interchange** – This section examines each option considered in this study, including an option specific description, key considerations, a table of advantages and disadvantages and summary of the options' viability;
- **Pre-Commission Workshop** – This section examines each option considered in this study, including an option specific description, key considerations, a table of advantages and disadvantages and summary of the options' viability;
- **Short List of Options** – This section presents a short list of options considered appropriate to develop further along with the rationale for options to be discounted or progressed;
- **Traffic Assessment** – This section reviews the operational capacity of those options that have not been previously assessed in traffic terms;
- **Appraisal Framework** – This section explains the methodology used to assess all options explained in the context of the New Approach to Transport Appraisal guidance and additional criteria used;
- **Appraisal of Short List of Options** – This section examines the short list of options in greater detail and appraises them against the criteria as detailed in the Appraisal Framework section; and
- **Conclusion** – This section summarises the findings of this study along with salient points and conclusions to improve the A47/A11 Thickthorn Interchange.

2 Context and Constraints

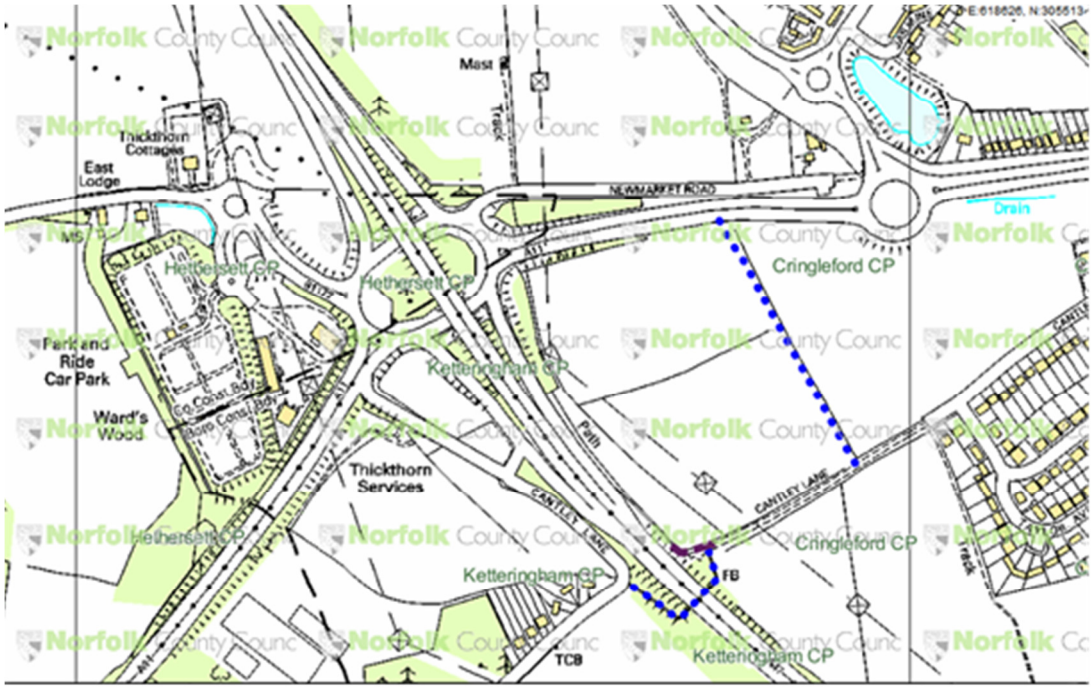
2.1 Overview

Due to the significant growth anticipated to occur in the South East region (at the time of the initial studies), Broadland, Norwich City and South Norfolk Councils were working together to produce a Joint Core Strategy (JCS) for their area. The function of the JCS could be likened to an overarching Local Development Framework (LDF) for all of the areas.

The main aim of the JCS was to focus on delivering this anticipated significant level of growth, which also involved the identification of and high level assessment of any infrastructure improvements that would be required as the result of the growth scenarios.

The A47/A11 Thickthorn interchange along with other junctions was identified as being unable to cope with the traffic demand from the planned growth of developments in the surrounding areas and was therefore investigated to consider opportunities to upgrade the interchange.

2.2 Site Description



The A47/A11 Thickthorn Interchange is a 6-arm signal controlled, grade separated roundabout where the A11 travels from southwest to east underneath the A47. The A47 is a D2M type carriageway which runs northwest-southeast at the interchange and provides a link to Swaffham to the north, and to Great Yarmouth to the southeast. The A11 is a D2AP type carriageway, and from Thickthorn Interchange the A11 continues northeasterly towards Norwich and southwesterly towards Thetford and Attleborough.

From the East in clockwise direction, the roundabout's approach roads are:

- A11 Newmarket Road (East) flares to three lanes approximately 70 metres prior to the stop line, and there are four lanes at the stop line;
- The A47 (South) off slip road joins the roundabout from the south-easterly direction. The slip road gradually flares to provide three lanes at the stop line. The nearside lane is marked with a left arrow, the middle lane with left and straight ahead arrows, whilst the outside lane is marked with a straight ahead arrow;
- The A11 (Southwest) approach widens from two lanes to four lanes approximately 130 metres from the stop line;
- The B1172 approach road is located to the northwest of the roundabout and is not signalised. The road connects the roundabout to the B1172 Norwich Road. Most of the length of the nearside lane is marked as bus lane. The bus lane stops approximately 27 metres prior to the roundabout.
- The A47 (North) off slip road is located to the northwest of the roundabout. The slip road widens to three lanes approximately 40 metres from the roundabout.
- Newmarket Road is a track that runs parallel with the A11 Newmarket Road. The road serves as a private access to agricultural land and private properties along its north side. The approach road is not included in the existing traffic signal arrangement.

Circulatory Carriageway

The north-half of the circulatory carriageway (i.e. between the A11 (West) approach and Newmarket Road approach), is wider than the south-half. The north part of the roundabout has four lanes, whilst there are only three lanes provided on the south part.

Over the years Thickthorn Interchange has been upgraded with various improvements resulting in the conversion of all but one entry arm to be signal controlled

Surrounding Areas

The land in the northeast and southeast quadrants is predominantly agricultural land, and the land in the southwest quadrant is mainly fields. The land in the northwest quadrant accommodates Thickthorn Park and Ride (P&R), Thickthorn Services; a motel, an electricity sub station and a petrol filling station.

2.3 Non-Motorised Users

Pegasus crossings are provided on the A47 (South) slip roads in the immediate vicinity of the circulatory carriageway. Similarly, Toucan crossings are provided on the A47 (North) slip roads in the immediate vicinity of the circulatory carriageway.

Footpaths are provided adjacent to the circulatory carriageway at the interchange which permit east to west movements, however there is no formal provision to allow vulnerable road users to cross the A11 carriageway when wishing to travel in a north to south direction.

2.4 Modelling Outputs

2.4.1 Delay

From previous modelling exercises it was found that during the morning peak period, the B1172 Norwich Road approach road was predicted to have the highest delays of 137 seconds, or 2.28 minutes per vehicle. This is likely due to the significant increase of traffic flows on the rest of the roundabout approaches and on the circulatory carriageway between the A11 (West) and the B1172 Norwich Road. Long delays were also identified on the A47 (N) off slip road with 136 seconds and on the circulatory carriageway between the A11 (W) off slip road and B1172 Norwich Road approach.

From previous modelling exercises it was found that during the evening peak period, long delays were predicted on the A47 (North) off slip with delays of 89 seconds. Delays are also expected on the A47 (S) off slip, and on the circulatory carriageway between the A11 (West) and the B1172 Norwich Road.

2.4.2 Queue Lengths

During the morning peak period, long queues of 44 PCUs (in total) were expected on the circulatory carriageway between the A11 (West) and the B1172 Norwich Road. Assuming that one PCU is approximately six metres and the queue lengths are divided equally with the number of lanes, the queue lengths equate to 66 metres per lane, which would block the B1172 Norwich Road exit and the A11 (W) approach. Total queues of 16 vehicles, or 24 metres per lane, are also expected on the circulatory

carriageway between the A47 (N) on slip road and the B1172 Norwich Road, and queue lengths of six vehicles per lane, or 36 metres per lane, are expected on the A47 (N) off slip approach.

During the evening peak period, queues are identified on the A47 (South) and the A47 (North) off slip roads, on the circulatory carriageway between the A11 (West) and the B1172 and on the circulatory carriageway between the A11 (East) and the A47 (South) on slip road. However, these queues are expected not to block the successive exits or approach roads.

2.5 Chronology of Previous Investigations

The section briefly describes previous studies that have been undertaken to investigate improvements at the Thickthorn Interchange.

2.5.1 A47 Southern Bypass Junctions – Capacity Assessment Report

Mott MacDonald undertook an initial capacity assessment of three junctions situated on the A47 Norwich southern bypass in November 2009, one of which was the Thickthorn Interchange. The purpose of this study was to:-

- Assess the capacity of the A47 southern bypass junctions for the future scenario of Joint Core Strategy (JCS) developments plus Northern Distributor Road (NDR);
- Identify capacity problems; and
- To propose potential solutions to address these problems.

It should be noted that the scope of the study did not include investigation of sustainable transport measures such as bus rapid transit because they may have had an adverse affect on delays to general traffic without major interventions. Furthermore, improvements to pedestrian and cycle facilities were not considered either.

The study considered seven options which were as follows:-

- Option 1 - Left-in to the park and ride from the A11 (west);
- Option 2 - Closure of 'old' Newmarket road arm, with alternative re-provision off A11 (east);
- Option 3 - Closure of Cantley Lane South egress on A47 south off-slip;
- Option 4 - Closing B1172 park and ride arm and re-providing access to the west of the park and ride site by a new junction with the A11 (west);
- Option 5 – Grade separation for the A11 right turn movements;
- Option 6 – Grade separation for the A11 straight-ahead movements; and
- Option 7 – New Grade Separated Junction with an Increased Inscribed Circle Diameter.

2.5.2 Review of Options for A47/A11 Thickthorn Interchange

Following on from the A47 Southern Junctions – Capacity Assessment study, AECOM were instructed by the Highways Agency (H.A.) to prepare some indicative options for possible mitigation schemes. This included the consideration of the feasibility of free-flow slips, additional side road bridges, link roads, earthworks and additional signals and other major highway structures. These features were intended to accommodate a Do-Minimum scheme infrastructure change to the local road network at the interchange which would allow the identification of small scale options for traffic capacity testing. Special provisions for public transport including extension of the existing bus facilities at the junction were also included in the proposals.

The study considered the following options:-

- Option 8 - Hamburger Roundabout;
- Option 9 - Cantley Lane Improvements;
- Option 10 - Exit Slip Road to Park and Ride Extension;
- Option 11 - Bus Lane on the Roundabout; and
- Option 12 - Bus only Link Road over/under the A47.

The investigation also considered combinations of the above options.

2.5.3 Pre commission Workshop December 2011

A workshop was held on Thursday 22nd December 2011 and was attended by Officers from Norfolk County Council and Consultants from Mott MacDonald. The purpose of the workshop was to consider the options presented to date and to scope potential longer term solutions for improving the Thickthorn Interchange. Furthermore the outcome of the workshop would shape the development of this interchange.

In addition to considering the aforementioned options identified during previous studies, the workshop considered a 'bypass' option with a number of minor variants. The bypass option included a new roundabout on the A11 (West) on the approach to the Thickthorn Interchange which also provided access and egress to the existing park and ride site. The bypass link could travel up and over, or under the A47 near to the merge/diverge noses of the A47 (South) southern slip roads before tying into the existing roundabout where the A11 (East) meets Round House Way.

Following this workshop a 'teardrop' option was conceived which involved closing the circulatory carriageway on the interchange opposite the A11 (East) approach. Thus routing all east to south traffic via the Round House Way roundabout on the A11, and leaving the A11 (East) entry to Thickthorn interchange unopposed.

3 A47 Southern Bypass Junctions – Capacity Assessment Report

This section provides a summary of the options that were considered in the A47 Southern Bypass Junctions – Capacity Assessment Report which was undertaken by Mott MacDonald in November 2008. Six junction improvement options were identified as part of the investigation and a seventh (more radical) option was discussed during a workshop held as part of the A47 Southern Bypass Junctions study. At the time, options one to six were allocated into two categories namely low cost and major realignment.

For the purpose of this appraisal all options have been considered on their own merit, but for reference options one to three below were low cost options and options four to seven fall into the major realignment category. Each option is described below along with a commentary on their relative advantages and disadvantages.

The options were as follows:-

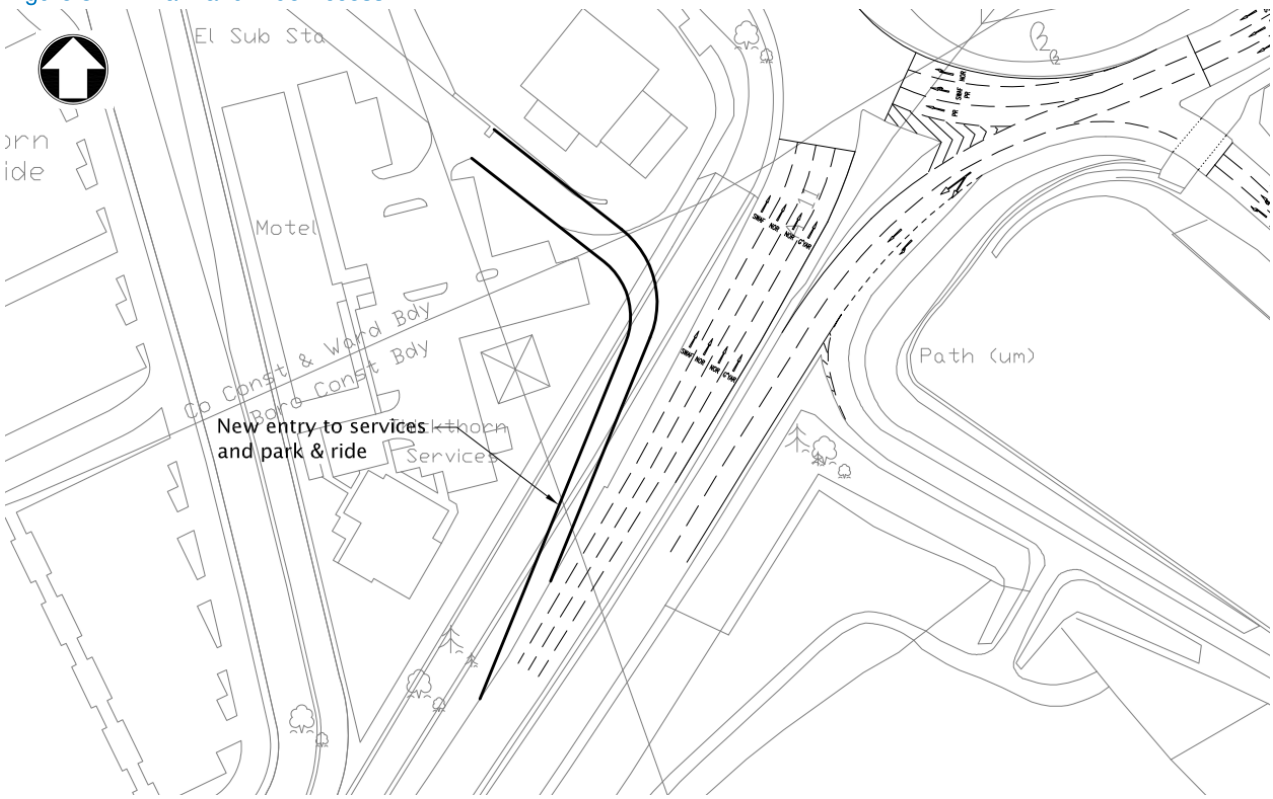
- Option 1 - Left-in to the park and ride from the A11 (west);
- Option 2 - Closure of 'old' Newmarket Road arm, with alternative re-provision off A11 (east);
- Option 3 - Closure of Cantley Lane South egress on A47 south off-slip;
- Option 4 - Closing B1172 park and ride arm and re-providing access to the west of the park and ride site by a new junction with the A11 (west);
- Option 5 – Grade Separation for the A11 Right-Turn Movements;
- Option 6 – Grade separation for the A11 straight-ahead movement; and
- Option 7 – New Grade separated junction with a large oblong ICD.

The estimated capital costs for construction of options were reported in the A47 Southern Bypass Junctions – Capacity Assessment Report at the first quarter 2008. They did not include VAT, land costs, statutory undertaker works, design development surveys or accommodation works. These cost estimates have been used to form a judgement on which category the option falls into (I.e. low, moderate or high).

3.1 Option 1 - Left-in to the Park and Ride from the A11 (West)

A new entry to the Norwich (Thickthorn) Park Ride and Services from the A11 was considered. This included a new access link from the A11 northeastbound carriageway which tied into the existing Services loop road. An egress link was discounted at this location due to the short weave length for right-turning traffic between the Services' Loop Road and the roundabout entry which was considered unsafe and not possible during congested periods.

Figure 3.1: Park and Ride Access



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.1.1 Key Considerations

This is a low cost option that improves access to Norwich (Thickthorn) Park and Ride Site and Services, reducing the number of left turning vehicles on the A11 northeast bound approach.

In the order of 110 vehicles in the morning peak period and 47 vehicles in the evening peak period turn left at the Thickthorn Interchange from the A11 (West) to the B1172 in the 2012 Origin – Destination matrix.

Table 3.1: Option 1 Review

Category	Advantages	Disadvantages
Operational	Negligible operational improvement to the A11 (West) approach in the morning peak period and similar improvement to the roundabout of the B1172 with the existing park and ride access road following the reduction in traffic.	
Safety	Negligible benefit, there are potentially less collisions at the circulatory carriageway because there are less conflicting movements.	
Indicative cost	**Low cost**	
Constructability		Level differences to overcome between the A11 (West) and the Services' Loop Road which may require a retaining structure adjacent to the A11 carriageway.
Environmental		Some tree loss and potential habitat loss in the verge (for the length of the proposed off-slip).
Modal shift	Negligibly makes travel by buses more appealing, since it bypasses minor queues on the A11 (West) approach.	
Promoter's Objectives	Improves access to the park and ride site. Increases visibility of the park and ride site.	Does not increase the operational capacity of the roundabout and therefore would not accommodate any additional traffic.

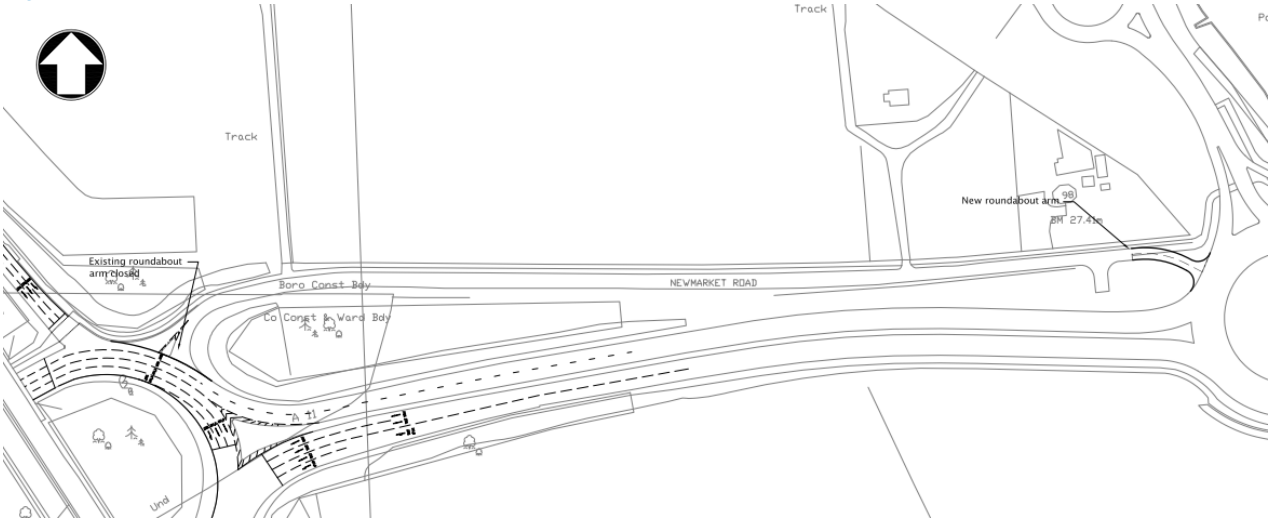
3.1.2 Summary

This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers negligible operational improvements to the interchange. It is considered that this low cost option is best suited to be implemented with other measures to best meet the Promoters' objectives.

3.2 Option 2 - Closure of 'Old' Newmarket Road Arm, with Alternative Re-provision off A11 (East)

This option involves a point closure of 'Old' Newmarket Road at Thickthorn Interchange which would rationalise the number of approaches to the junction and allow greater management of the queues on the circulatory carriageway because this approach is priority controlled. To retain access to 'Old' Newmarket Road, a new approach would be created on the existing roundabout of the A11 with Road House Way.

Figure 3.2: Park and Ride Access



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.2.1 Key Considerations

The proposed new approach on the existing roundabout with Round House Way would not work without significant and costly enlargement of the roundabout since there is insufficient space to accommodate another arm as shown in the figure above.

Table 3.2: Option 2 Review

Category	Advantages	Disadvantages
Operational		Adds traffic (albeit only minor flows) to the existing roundabout with Round House Way and the A11 (East).
Safety		Vehicles could not safely enter or exit the A11 roundabout to or from the 'Old' Newmarket Road which is likely to create a collision problem in the layout shown in Figure 3.2.
Indicative cost		This scheme would be **low cost** to implement, however this approach arm could not be tied into the existing roundabout layout without significant geometry changes to the inscribed circle diameter and therefore it is considered as moderate to high cost.
Constructability	Relatively straight forward construction. The majority of construction involved in this option is undertaken adjacent to the carriageway and therefore its impact on general traffic could be managed and mitigated.	
Environmental		Only likely to affect a small number of vehicles, but it is a more convoluted route to follow (i.e. increasing journey distances and times) and in turn increasing petrol consumption and vehicle emissions.
Modal shift		No benefit for buses.
Promoter's Objectives		No real benefit when considered on its own, this is more likely to be an element that complements other options.

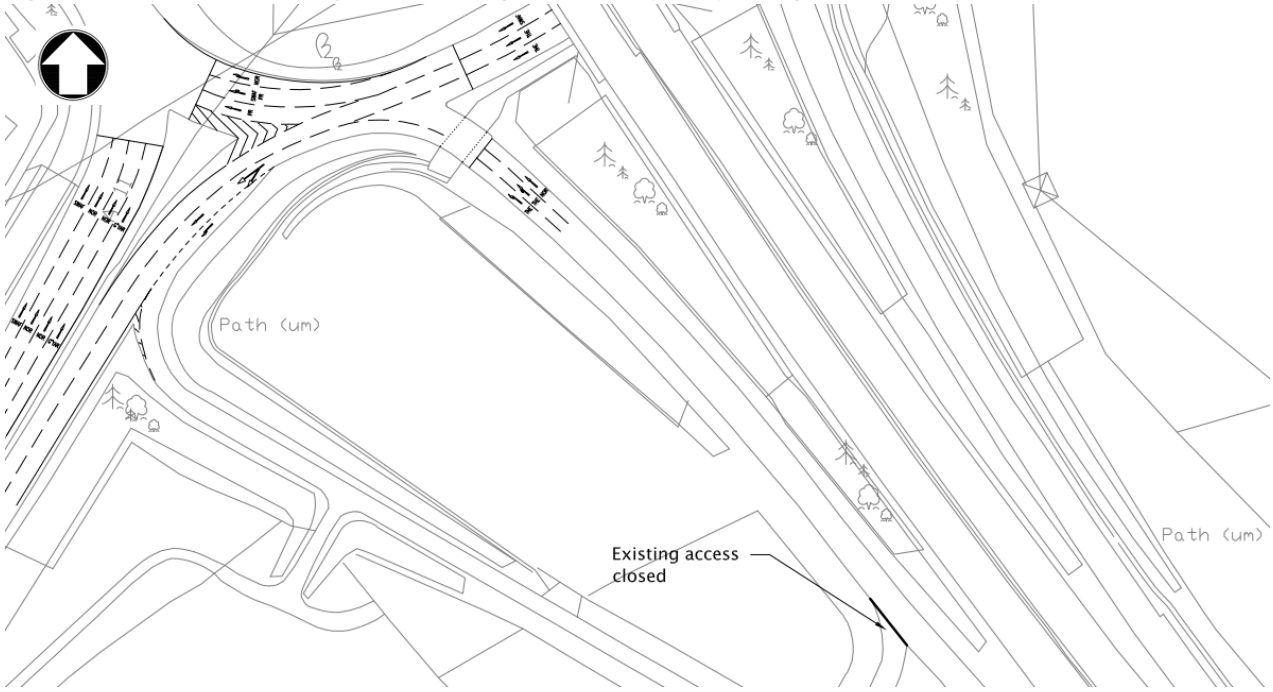
3.2.2 Summary

This option, if implemented on its own it will not meet or contribute towards the aspirations of neither the Promoters nor the bus operators. It is considered that this low cost option is a requirement for other options to be implemented since it does not offer benefits of its own.

3.3 Option 3 - Closure of Cantley Lane South Egress on A47 (South) Off-slip

This option involves the closure of the vehicular egress on the A47 (South) off-slip to rationalise the number of accesses leading up to the Thickthorn Interchange. As a consequence vehicles from Cantley Lane South would re-route via the A11 (West) approximately 2km southwest of the Thickthorn Interchange.

Figure 3.3: Closure of Cantley Lane South Egress on A47 (South) Off-slip



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.3.1 Key Considerations

This option is only a low cost solution and best suited to complement other options rather than a treatment in its own right.

The option simply transfers a small volume of traffic from one approach to another, which does not have a real benefit to the operational capacity of the interchange.

Vehicles travelling from Cantley Lane South would be significantly inconvenienced without other measures to provide alternative means of access. Vehicles would have to join the A11 (West) at Station Lane some two kilometres away from the A47 (South) off-slip, equating to an additional four kilometres or five minutes to people's journeys (during off peak periods). **[Post investigation comment: The gap in the central reserve on the A11 has since been closed, and therefore the aforementioned convoluted route is more onerous thus making the option unfeasible].**

Table 3.3: Option 3 Review

Category	Advantages	Disadvantages
Operational	Slight reduction in the number of vehicles arriving at the junction on the A47 (South).	Slight increase in the number of vehicles arriving at the junction on the A11 (West).
Safety	Potentially reduces the number of conflicts between vehicles entering the A47 (South) off-slip from Cantley Lane South.	Potentially increases the number of conflicts between vehicles where Station Lane meets the A11 (West). Vehicles would be required to cross a high speed dual carriageway.
Indicative cost	**Low cost**	
Constructability	Relatively straight forward construction.	
Environmental		Only likely to affect a small number of vehicles, but it is a more convoluted route (in the order of 4km) to follow (i.e. increasing journey distances and times) and in turn increasing petrol consumption and vehicle emissions.
Modal shift		No benefit for buses.
Promoter's Objectives		No real benefit when considered on its own, this is more likely to be an element that complements other options.

3.3.2 Summary

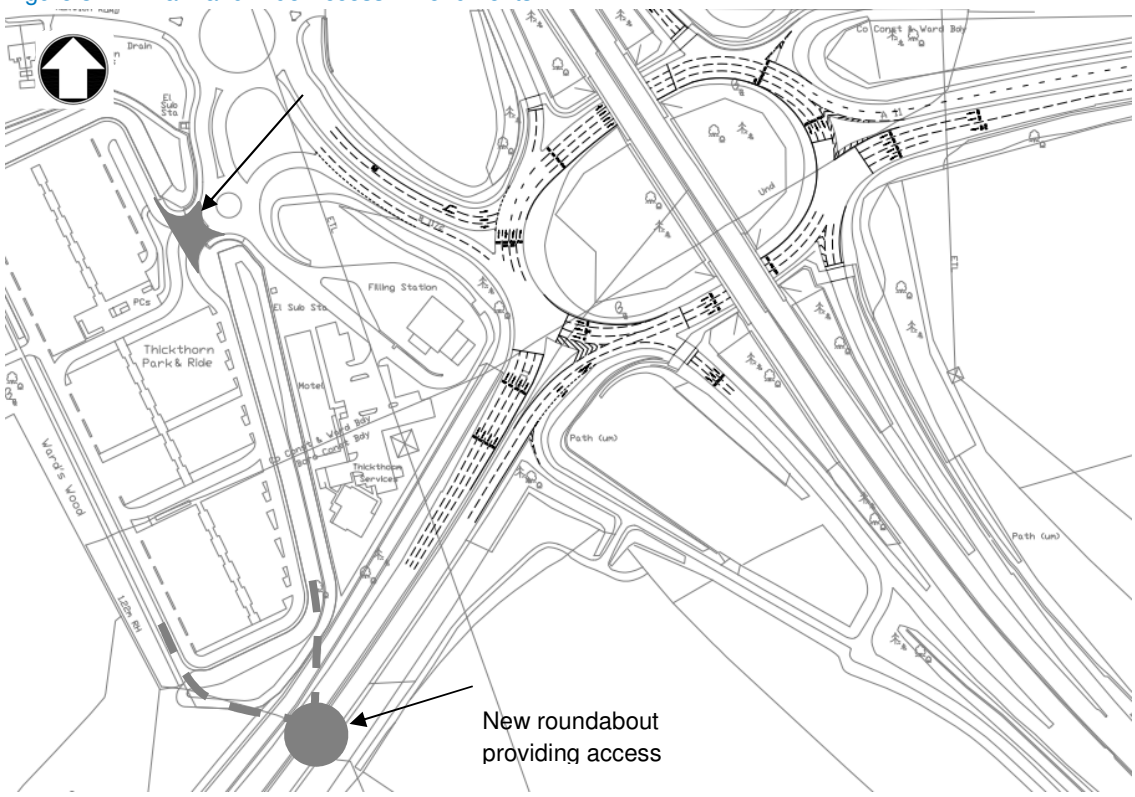
This option, if implemented on its own it will not meet or contribute towards the aspirations of neither the Promoters nor the bus operators. It is considered that this low cost option is a requirement for other options to be implemented since it does not offer benefits of its own.

3.4 Option 4 - Closing B1172 Park and Ride arm and re-providing access to the west of the Park and Ride site by a new junction with the A11 (West)

This option considered the closure of Norwich (Thickthorn) Park and Ride access from the B1172 Norwich Road, with the roundabout retaining access to the Services. In turn this would require a new roundabout to be constructed on the A11 (West) on the approach to the Thickthorn Interchange to provide access to the park and ride site.

This option effectively routes all traffic leaving the Thickthorn Interchange travelling towards the park and ride site via the A11 (West) instead of the B1172. Therefore there is less traffic opposing the A11 (West) entry at the Thickthorn Interchange potentially allowing more green time to be given to the A11 (West) entry.

Figure 3.4: Park and Ride Access Amendments



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.4.1 Key Considerations

At present the demand from the park and ride site doesn't generate a significant volume of traffic and therefore re-routing this traffic may not achieve a significant improvement. However, when the park and ride site is expanded and fully utilised, this option would achieve a slight to moderate benefit.

Table 3.4: Option 4 Review

Category	Advantages	Disadvantages
Operational	Thickthorn Interchange entry flow from the A11 (West) is reduced since park and ride traffic from this route has already exited the link at the proposed roundabout. The heavy flows from A11 (West) benefit from less opposed traffic on the circulatory carriageway at Thickthorn Interchange and would therefore could benefit from additional green time, because less traffic is held on the adjacent circulatory carriageway.	It may lead to queues extending back from the proposed roundabout on the A11 (West), northeast to the Thickthorn Interchange affecting the progression of vehicles on the circulatory carriageway. It may lead to queues extending back from the Thickthorn Interchange on the A11 (West), southwest to the proposed roundabout affecting the progression of vehicles on the circulatory carriageway. Traffic arriving at the Thickthorn Interchange on the B1172 would have to travel via a convoluted route to the park and ride site. However it is likely that the number of vehicles travelling on the B1172 to the park and ride site is low.
Safety		
Indicative cost		This option would be of **moderate cost** but is only considered to provide a slight to moderate improvement to the operational capacity of the interchange.
Constructability		Mostly on-line construction which would significantly disrupt general traffic on the A11 (West).
Environmental		Some tree loss and potential habitat loss at the location of the new roundabout.
Modal shift	This option increases the visibility of the park and ride site which may encourage people to consider using the facility. The new access simplifies and reduces the route that westbound buses travel through the park and ride site. This offers a small journey time saving to buses.	
Promoter's Objectives	Slight to moderate improvement in the operational capacity of the junction.	

3.4.2 Summary

This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers slight to moderate operational improvements to the A11 (West). It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

3.5 Option 5 - Grade Separation for the A11 Right-Turn Movements

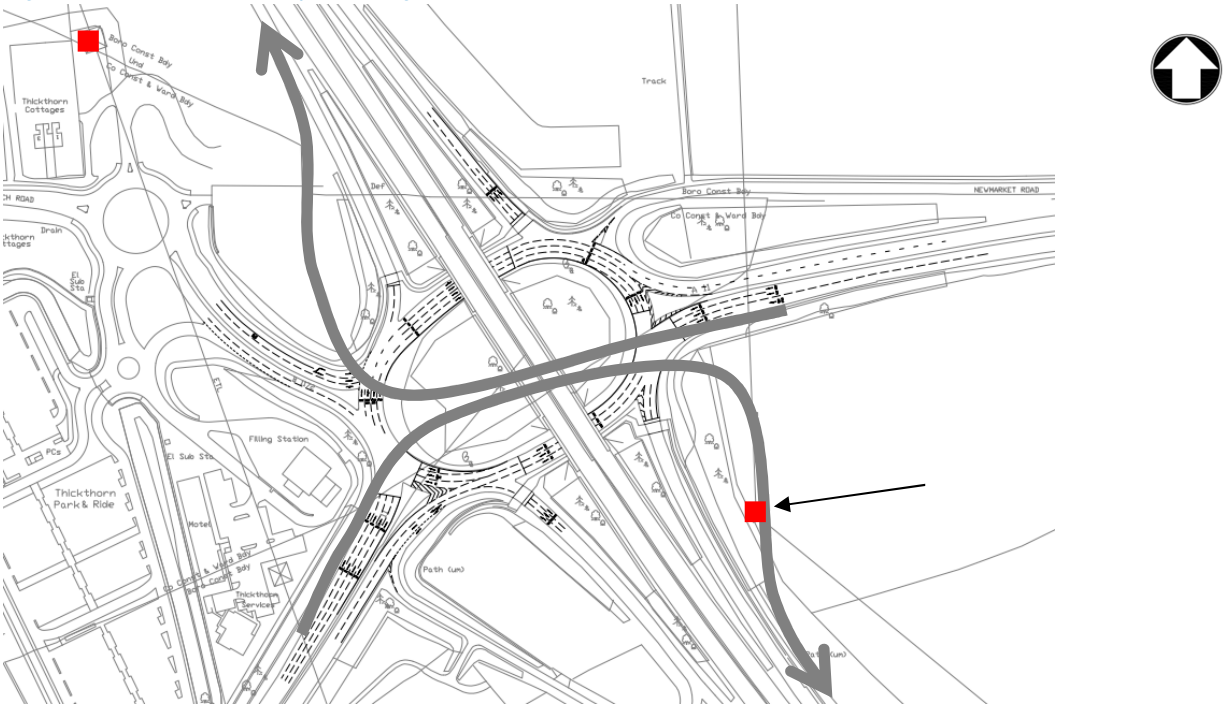
This option provided grade separation for the A11 right turn movements from the A11 to the A47 via new bridges over the A47. This would allow unimpeded progression of the A11 right turn manoeuvres through the junction albeit slowing on the diverge and merge noses. Furthermore this would significantly reduce the flows on the circulatory carriageway of the Thickthorn Interchange, and in turn improve the operational capacity of the interchange.

In 2012 traffic flows, this would remove in the order of 1053 vehicles (884 travelling south and 169 travelling north) in the morning peak period, and 1178 vehicles (917 travelling south and 261 travelling north) in the evening peak period.

In the 2017 traffic flows, this would remove in the order of 1221 vehicles (1025 travelling south and 196 travelling north) in the morning peak period, and 1234 vehicles (961 travelling south and 273 travelling north) in the evening peak period.

In the 2032 traffic flows, this would remove in the order of 1400 vehicles (1176 travelling south and 224 travelling north) in the morning peak period, and 1599 vehicles (1245 travelling south and 354 travelling north) in the evening peak period.

Figure 3.5: A11 Grade Separated right turns



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.5.1 Key considerations

This option is likely to require a large amount of land take to accommodate the horizontal alignment (with a design speed of 120kmph), and the vertical alignment to raise the carriageway up and over the A47.

Pylons are located in land adjacent to the interchange which may pose a constraint to the proposed grade separated carriageways due to their relative positions and also when the alignments are dropping back down to ground level to maintain a sufficient clearance underneath the overhead electricity lines.

The pedestrian footbridge over the A47 in line with Cantley Lane South may constrain the position where the southbound merge ties into the A47, which may necessitate the need to provide a new footbridge.

Table 3.5: Option 5 Review

Category	Advantages	Disadvantages
Operational	Significantly reduces the traffic on the immediate approaches to the roundabout and on the circulatory carriageway.	
Safety	Potentially safer on the approaches to the interchange because there are less conflicts between vehicles.	Drivers may become hesitant when approaching the elevated carriageway due to the route choice decisions which could lead to shunt type collisions.
Indicative cost		**High cost.**
Constructability		Diversion of pylons situated in the field to the southeast of the junction to accommodate on-slip road. May require re-provision of the existing Cantley Lane footbridge over the A47 southern slip roads. Would require full closure of the A47 during the lift of the over bridge deck structure. There may not be sufficient room for the southbound merge to tie-in before the railway line. Likely to be constrained on the A11 (West) approach due to the close proximity to the Services. Most of the construction occurs on-line and therefore there is likely to be significant disruption to general traffic during construction.
Environmental	Less queuing of traffic with less start/stop driving characteristics therefore improving air quality.	Large embankments required to overcome level differences and design speed of the carriageway. Significant adverse visual impact on the landscape. Potential habitat loss. Likely to require mitigation to reduce noise nuisance generated from the elevated carriageway.
Modal shift		The option would reduce congestion at the interchange therefore making public transport less attractive.
Promoter's Objectives	Increases the capacity of the interchange to accommodate an increase in traffic flows particularly the right turn hooking movements from the A11 and then in the absence this traffic on the circulatory.	

3.5.2 Summary

This option, if implemented on its own is likely to contribute towards the aspirations of the Promoters since it would increase the operational capacity of the interchange. In its current form this option goes towards improving bus journey times and reliability since it removes traffic from the circulatory carriageway, but this benefit may be lost over time as congestion on the circulatory increases. It is considered that other measures in addition to this option would be required to maintain the benefit to buses achieved by the removal of right turning traffic from the circulatory.

3.6 Option 6 - Grade Separation for the A11 Straight-Ahead Movement

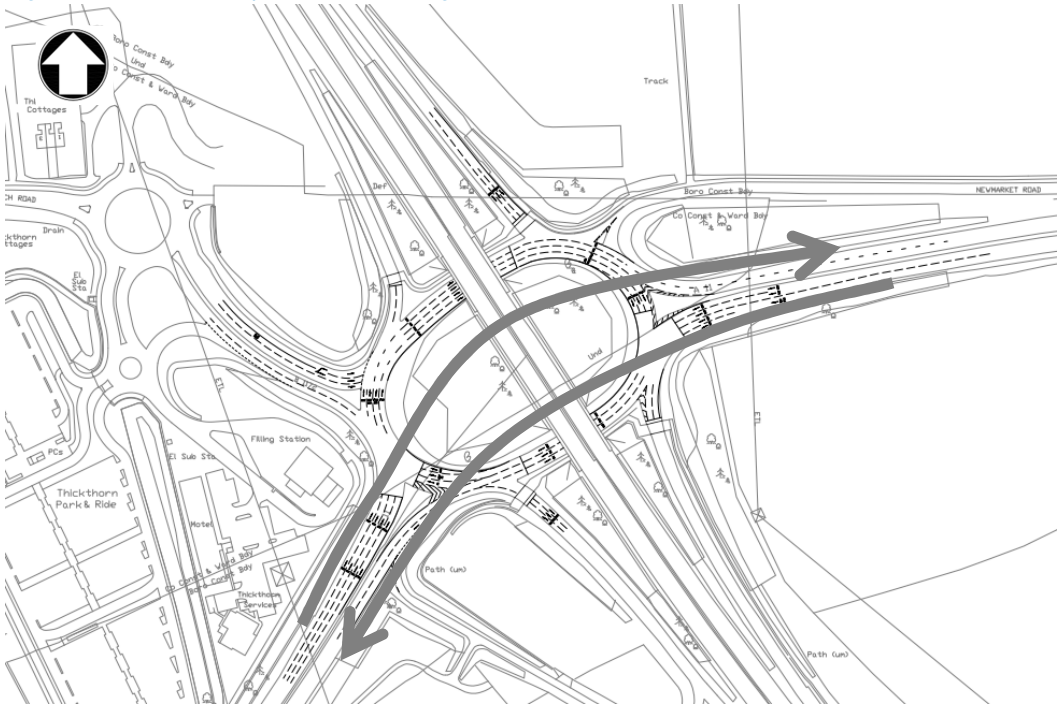
This option considered the grade separation of the A11 straight ahead movements via over-bridges above the A47. This would allow unimpeded progression of the A11 ahead manoeuvres through the junction albeit slowing on the diverge and merge noses. Furthermore this would significantly reduce the flows on the circulatory carriageway of the Thickthorn Interchange, and in turn improve the operational capacity of the interchange.

In 2012 traffic flows, this would remove in the order of 1960 vehicles (1217 travelling east and 743 travelling west) in the morning peak period, and 1530 vehicles (642 travelling east and 888 travelling west) in the evening peak period.

In the 2017 traffic flows, this would remove in the order of 2272 vehicles (1411 travelling east and 861 travelling west) in the morning peak period, and 1604 vehicles (673 travelling east and 931 travelling west) in the evening peak period.

In the 2032 traffic flows, this would remove in the order of 2606 vehicles (1618 travelling east and 988 travelling west) in the morning peak period, and 2078 vehicles (872 travelling east and 1206 travelling west) in the evening peak period.

Figure 3.6: Grade Separated A11 Straight Ahead Movements



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.6.1 Key Considerations

The proposed alignment would have to travel over the grade separated A47 carriageway that currently travels over the A11, therefore the proposed alignment would create a large elevated structure.

The merges and diverges on the proposed alignment may be difficult to tie-in to the existing carriageways due to the roads and services adjacent to the A11.

Table 3.6: Option 6 Review

Category	Advantages	Disadvantages
Operational	Significantly reduces the traffic on the immediate approaches to the roundabout and on the circulatory carriageway.	
Safety		Drivers may become hesitant when approaching the elevated carriageway due to the route choice decisions which could lead to shunt type collisions.
Indicative cost		Considerably long embankments and elevated structures which are likely to be expensive. **High cost.**
Constructability		Likely to be constrained on the A11 (West) approach due to the close proximity to the Services. Would require full closure of the A47 during the lift of the over bridge deck structure. All construction occurs on-line and therefore there is likely to be significant disruption for a relatively long period of time to general traffic during construction.
Environmental	Less queuing of traffic with less start/stop driving characteristics therefore improving air quality.	Large embankments required to overcome level differences. Significant adverse visual impact on the landscape. Likely to require mitigation to reduce noise nuisance generated from the elevated carriageway.
Modal shift		No direct improvement for public transport. The option would reduce congestion at the interchange therefore making public transport less attractive.
Promoter's Objectives	Significantly improves the operational capacity of the A11 approaches to the interchange and	

3.6.2 Summary

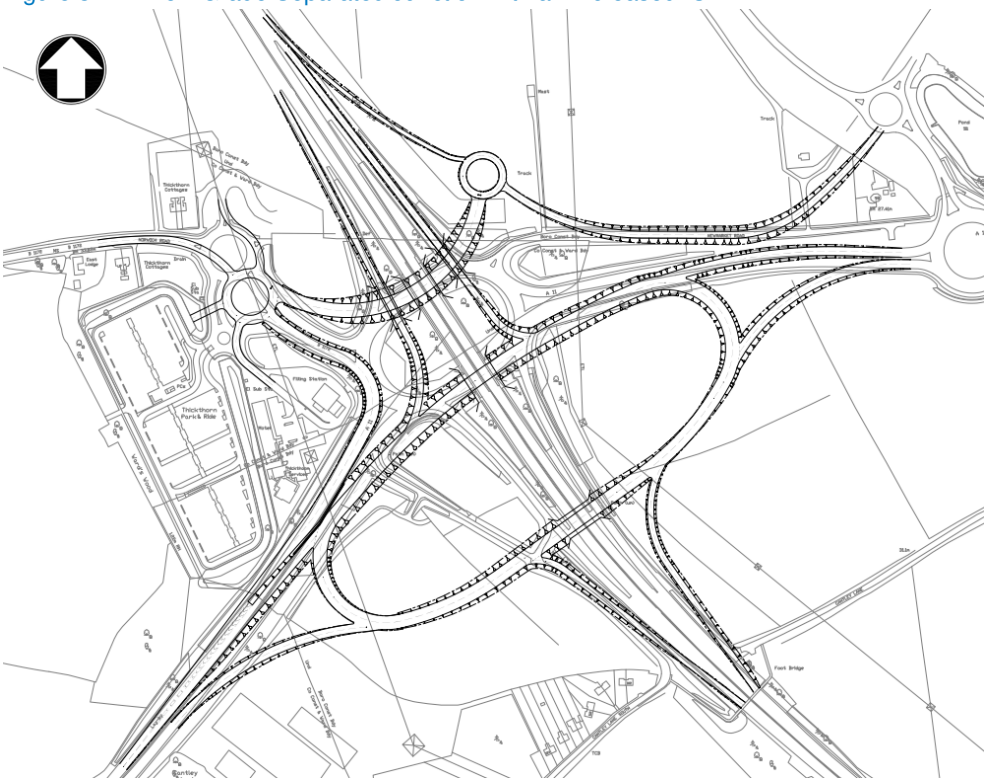
This option, if implemented on its own is likely to contribute towards the aspirations of the Promoters since it would increase the operational capacity of the interchange. In its current form this option goes towards improving bus journey times and reliability since it removes traffic from the circulatory carriageway, but this benefit may be lost over time as congestion on the circulatory increases. It is considered that other measures in addition to this option would be required to maintain the benefit to buses achieved by the removal of right turning traffic from the circulatory.

3.7 Option 7 – New Grade Separated Junction with an Increased Inscribed Circle Diameter

A workshop was held with key stakeholders to present and discuss options 1 to 6. An outcome from the workshop was the development of another solution which involved a new grade separated roundabout with significantly increased inscribed circle diameter provided to the south of the existing roundabout.

This option was considered as a radical solution to meet the aspirations of both the bus operators and the Promoters of the scheme. It proposed a new grade separated roundabout with a significantly increased inscribed circle diameter, located to the south of the existing roundabout and used the existing southern underbridge and a new overbridge. The B1172 and access to the park and ride site is effectively segregated from other traffic at the interchange.

Figure 3.7: New Grade Separated Junction with an Increased ICD



Source: A47 Southern Bypass Junctions – Capacity Assessment Report

3.7.1 Key Considerations

The proposed alignment would have to travel over the grade separated A47 carriageway that currently travels over the A11, therefore the proposed alignment would create large elevated structures.

The topography of the land in the vicinity of the interchange and the proposed highway creates significant vertical differences (in the order of 12m) that would be difficult to overcome especially the proposed alignment of the circulatory carriageway which travels both under and over the A47 and the new approach roads to the interchange.

The existing footbridge from Cantley Lane over the A47 may affect the tie-ins of the new scheme to the existing A47 (South).

Table 3.7: Option 7 Review

Category	Advantages	Disadvantages
Operational	Significantly increases the operational capacity of the junction and would accommodate a large increase in new traffic. Offers relative segregation from congestion for buses in both directions through the interchange. Improves the progression of vehicles travelling to/from the B1172 though the interchange.	Short distance between the proposed roundabout and the existing roundabout with Round House Way which may lead to queues extending back through the junctions onto both circulatory carriageways and in turn gridlocked the interchange.
Safety		Potentially substandard length slip roads on the A47 (South) of interchange which could lead to; vehicles failing to give-way at the roundabout entry, shunt type collisions at the back of a queue, or vehicles entering the A47 mainline carriageway at inappropriate speeds and in turn leading to shunt-type collisions. Unusual diverge arrangement on the A47 (North) off-slip where the slip road splits into two. This proposed arrangement is likely to create a variety of collisions (shunt-type, lane change and loss of control). The proposed circulatory carriageway of the interchange is somewhat elongated which forms an oblong arrangement and is likely to allow vehicles to travel at inappropriate speeds which could lead to loss of control collisions.
Indicative cost	**High cost**, however it is considered that this option would achieve better value for money (VFM) than other options since it is one of a few options that creates a substantial traffic capacity improvement and bus priority segregation through the interchange.	
Constructability		Most construction occurs on-line which would create significant disruption to the interchange over a long period of time because major works are proposed. All routes through the interchange would be affected at some point during construction. May require the removal of the existing footbridge over the A47 at
Environmental		Increased journey lengths for bus journeys and vehicles travelling to/from the B1172 and therefore an increase in petrol consumption and vehicle emissions. A number of large embankments required to overcome level differences. Significant visual impact on the landscape. Likely to require mitigation to reduce noise nuisance generated from the elevated carriageways. Some tree loss and potential habitat loss on the central island of the roundabout.
Modal shift	Significant improvement to bus journey times and reliability in both directions through the interchange that would not be affected as the	The new route for buses could be considered as somewhat more convoluted than the current route that could see them penalised until the roundabout

Category	Advantages	Disadvantages
	adjacent roundabout becomes congested (overtime) by general traffic.	becomes congested over a considerable amount of time.
Promoter's Objectives	Fully meets the objectives of the Promoters and the bus operators.	

3.7.2 Summary

This option, if implemented on its own is likely to meet the aspirations of the Promoters and the bus operators since it significantly improves the operational capacity of the interchange whilst providing relatively segregated bus priority improvements to the park and ride site through the interchange in both directions.

However, it is acknowledged that this option is likely to be very expensive, and significantly disrupt general traffic for long periods at the interchange during construction since most construction takes place online. Furthermore, whilst this option is likely to have adverse environmental impacts, it is considered that these could be removed with amendments to the design or mitigated through the development of this option.

4 Review of Options for A47/A11 Thickthorn Interchange

This section provides a summary of the options that were considered in the Review of Options for the A47/A11 Thickthorn Interchange Technical Note which was undertaken by AECOM in November 2010. The purpose of the investigation was to prepare some indicative options for a do-minimum scheme to improve the local road network at the interchange on a phased delivery.

Options 8 and 9 (below) were identified to improve the situation for general traffic, and Options 10 to 12 was identified to improve the provision for buses.

For the purpose of this appraisal the options have been considered on their own merit. Each option is described below along with a commentary on their relative advantaged and disadvantages.

The options were as follows:-

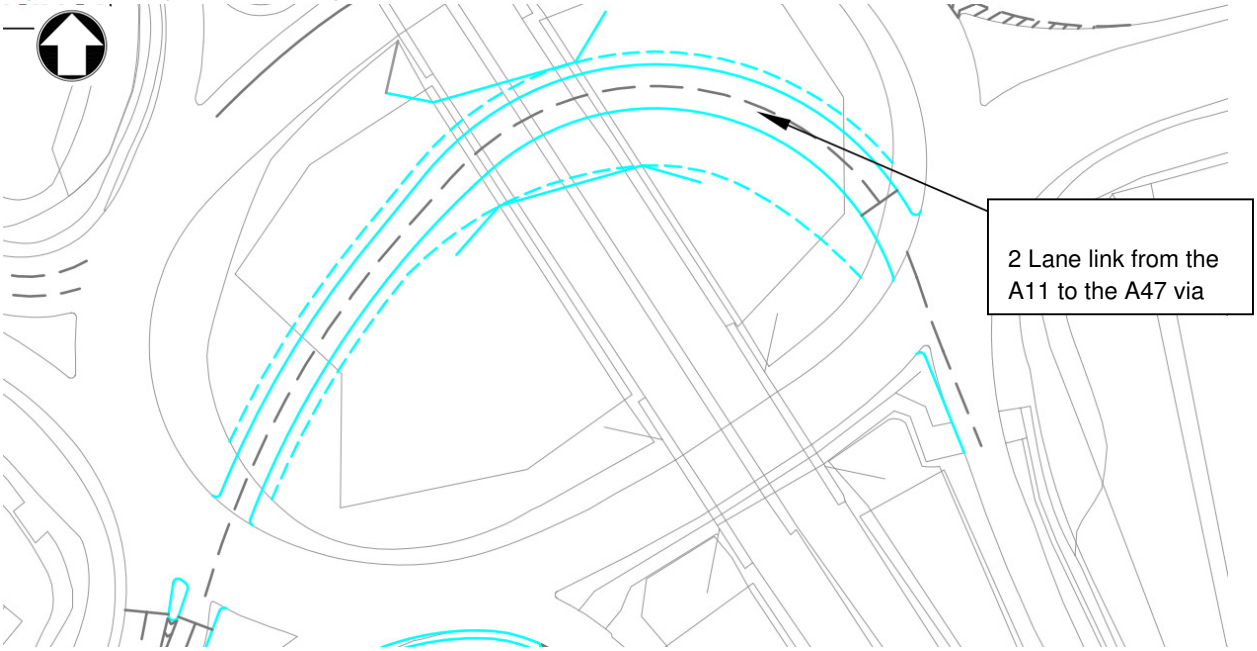
- Option 8 – Hamburger Roundabout;
- Option 9 – Cantley Lane Improvements;
- Option 10 – Exit slip road to park and ride extension;
- Option 11 – Bus lane on the roundabout; and
- Option 12 – Bus only Link Road over/under the A47.

The estimated capital costs for construction of options were reported in the Review of Options for the A47/A11 Thickthorn Interchange. They did not include VAT, land costs, statutory undertaker works, or optimism bias. These cost estimates have been used to form a judgement on which category the option falls into (I.e. low, moderate or high).

4.1 Option 8 Hamburger Roundabout

This option aimed to address the heavy right turn movement from the A11 (West) on to the A47 (South) by taking it through the centre of the roundabout at grade. By removing this traffic from the circulating carriageway adjacent to the B1172 approach, it should in principle be possible to improve conditions for buses emerging from the B1172 and from the Park & Ride site. This option involves a 2 lane link from A11 (West) to A47 (South) via an underpass. The A11 (West) approach would be widened to 4 lanes with 2 lanes allocated to A47 (South) by realignment of the central reserve and introduction of a new splitter island.

Figure 4.1: Option 8 Hamburger Roundabout



Source: AECOM Techincal Note Greater Norwich Joint Core Stategy - November 2010

4.1.1 Key Considerations

Significant earthworks would be required for the construction of the underpass, the existing support embankment needing excavation to accommodate the proposed structure.

Table 4.1: Option 8 Review

Category	Advantages	Disadvantages
Operational	Removes the heavy right turn movement from the A11 (West) to the A47 (South) from the circulatory carriageway allowing more green time to be given the B1172.	The new link would require another traffic stage to be added to accommodate the conflict of this new approach with the circulatory carriageway and the A11 (East), therefore reducing the operational capacity of the interchange.
Safety		none
Indicative cost		**High cost** due to the large volume of earthworks involved and new structure required under the A47.
Constructability		Either a cheaper option of a single span bridge or a more expensive option of a jacked box underbridge.
Environmental		Some tree loss and potential habitat loss on the central island of the roundabout. Would generate significant volume cutting material than would need tipping off site, however some material could be used for landscaping of the roundabout.
Modal shift	Provides more green time to the B1172 approach therefore potentially improving the journey time and reliability for public transport.	
Promoter's Objectives		Overall, it does not improve the operational capacity of the interchange; whilst the option potentially improves the situation for the B1172 thus benefiting public transport it requires an additional traffic stage therefore increasing the amount of lost time within the operation of the interchange.

4.1.2 Summary

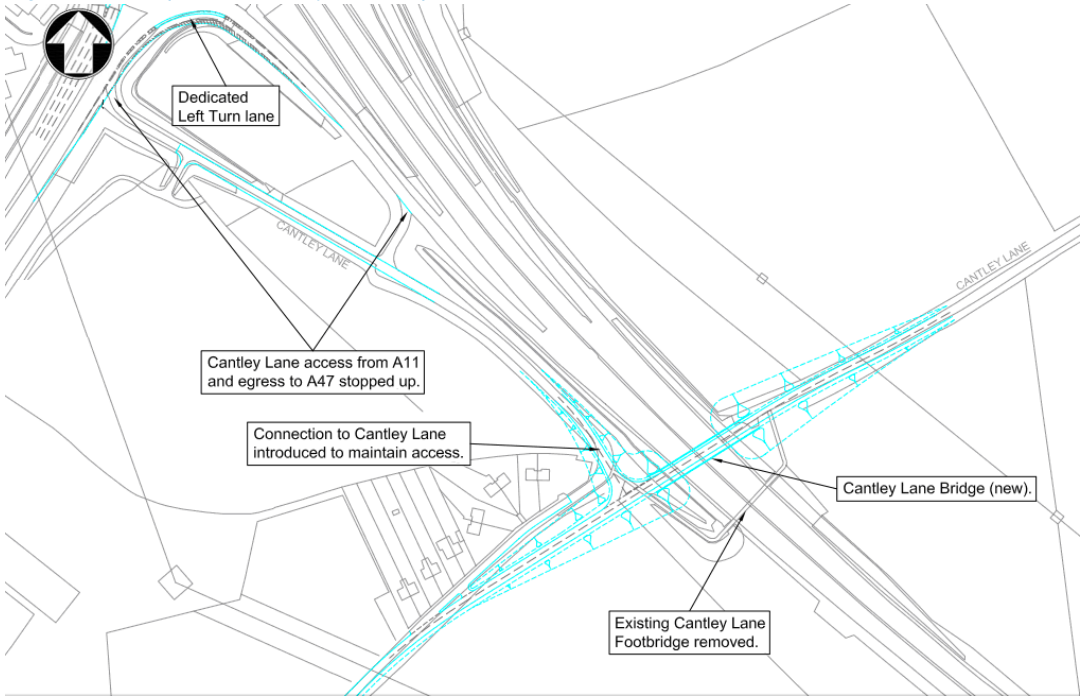
This option, if implemented on its own is unlikely to meet the aspirations of the Promoters but might go towards meeting the aspirations of the bus operators since relieves congestion on the northern half of the circulatory allowing eastbound buses to progress through the interchange relatively unimpeded. However, this benefit to buses may be lost as congestion on the circulatory returns over time.

Whilst the option reduces congestion from the northern half of the circulatory at the interchange, it simply transfers the congestion to the south-eastern quadrant of the circulatory because this newly created link requires a new stage to be added to the cycle of the signals at the approach with the A11 (east). As a consequence westbound travelling buses are impeded when progressing through the interchange.

4.2 Option 9 Cantley Lane Improvements

This option aimed to address the heavy left turning movement from the A47 (South) to the A11 (West) with the provision of a free-flow left turn lane. This is only possible with the closure of the existing Cantley Lane South egress on the A47 northbound off-slip, and closure of the Cantley Lane South access on the A11 soutwestbound carriageway. Therefore, to maintain access to properties on Cantley Lane South, a new vehicular bridge could be constructed over the A47 re-linking Cantley Lane South with Cantley Lane (i.e. a former route) that was severed by the construction of the A47.

Figure 4.2: Option 9 Cantley Lane Improvements



Source: AECOM Techincal Note: Greater Norwich Joint Core Strategy 9th November 2010

4.2.1 Key Considerations

This option requires the removal of the existing footbridge over the A47; therefore a footway or footways would need to be provided on the new over bridge.

There is an informal path that is routed between Cantley Lane and Cantley Lane South that runs parallel to the A47 and along a footpath adjacent to the circulatory carriageway at Thickthorn interchange. In the event of widening to accommodate the left-turn free-flow lane, this footpath would need relocating.

There are signal controlled Pegasus crossings on the A47 southern slip roads that would increase the amount of widening here to accommodate a staggered traffic island.

Table 4.2: Option 9 Review

Category	Advantages	Disadvantages
Operational	Moderate improvement to the operational capacity the A47 (South) off-slip by allowing vehicles to bypass the interchange and also transferring local traffic elsewhere.	May transfer traffic to the A11 (East) approach which is more congested than this approach.
Safety	Potentially reduces conflicts from vehicles emerging from the egress on to the A47 off slip in unacceptable gaps in traffic.	
Indicative cost		**Moderate cost** with only a moderate improvement to the operation of the junction.
Constructability		Major earthworks would be required for the new Cantley Lane bridge consisting of supporting embankments either side to carry the side road approaches. Would require full closure of the A47 during the lift of the over bridge deck structure. Require the removal of the existing footbridge over the A47. A Pegasus crossing is provided on the A47 south off-slip. If a segregated free-flow lane is to be provided an island large enough to safely store horses would need to be provided between the free-flow lane and ahead lanes, thus increasing the widening required on the entry radius.
Environmental		Large embankments required to overcome level differences. Significant visual impact on the landscape, especially immediately in front of the residential properties on Cantley Lane South.
Modal shift		None
Promoter's Objectives	Moderate improvement to the capacity of the A47 (South) off-slip.	Does not improve public transport journey times or reliability.

4.2.2 Summary

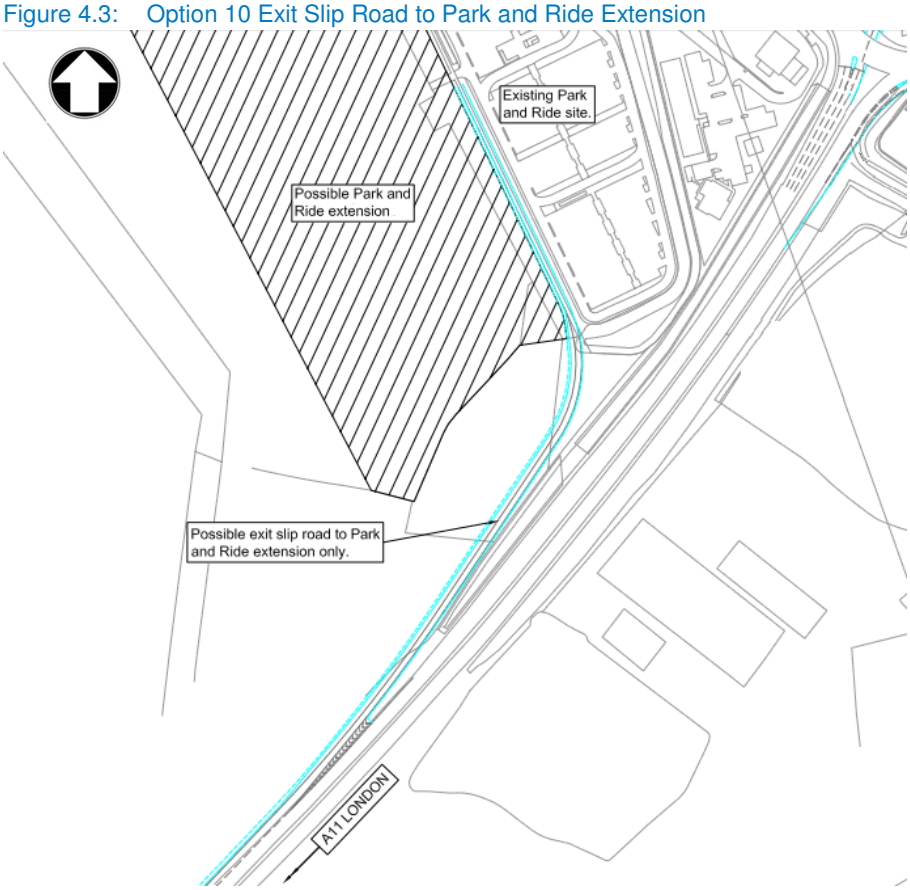
This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers slight to moderate operational improvements to the A47 (South) off-slip. It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

It is noted that this option would achieve low VFM due to the proposed structure and approach embankments relative to the achieved benefits from the free-flow left turn lane on the A47 (South) off-slip.

4.3 Option 10 Exit Slip Road to Park and Ride Extension

Similar to Option 1, this option aimed to encourage the use of the park and ride facility by providing a direct access road into the site for traffic approaching from the A11 (West). The only difference between the two options was the positioning of the diverge tapers on the slip roads and where the slip roads tied into the existing Park and Ride internal roads.

Figure 4.3: Option 10 Exit Slip Road to Park and Ride Extension



Source: AECOM Techincal Note Greater Norwich Joint Core Stategy - November 2010

4.3.1 Key Considerations

This is a low cost option that improves access to Norwich (Thickthorn) Park and Ride Site and Services, reducing the number of left turning vehicles on the A11 northeastbound approach.

In the order of 110 vehicles in the morning peak period and 47 vehicles in the evening peak period turn left at the Thickthorn Interchange from the A11 (West) to the B1172 in the 2012 Origin – Destination matrix.

Table 4.3: Option 10 Review

Category	Advantages	Disadvantages
Operational	Negligible operational improvement to the A11 (West) approach in the morning peak period due to the low number of vehicles turning in to the park and ride site. Equally, a similar improvement to the operational capacity of the roundabout on the B1172 with the existing park and ride access road because vehicles from the A11 (West) no longer travel via this route. This could also form an access to any future Park and Ride extension.	
Safety	Negligible benefit, there are potentially less conflicts at the circulatory carriageway because left turning vehicles are removed.	
Indicative cost	**Low cost**.	
Constructability	Relatively straight forward construction taking place off-line.	Level differences to overcome between the A11 (West) and the Services' Loop Road which may require a retaining structure adjacent to the A11 carriageway.
Environmental		Some tree loss in the verge (for the length of the proposed off-slip).
Modal shift	Negligibly makes travel by buses more appealing, because the scheme only bypasses minor queuing on the A11 (West) approach.	
Promoter's Objectives	Improves access to the park and ride site. Increases visibility of the park and ride site.	Does not increase the operational capacity of the roundabout and therefore would not accommodate any additional traffic.

4.3.2 Summary

Similar to Option 1, this option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers negligible operational improvements to the interchange. It is considered that this low cost option is best suited to be implemented with other measures to best meet the Promoters' objectives.

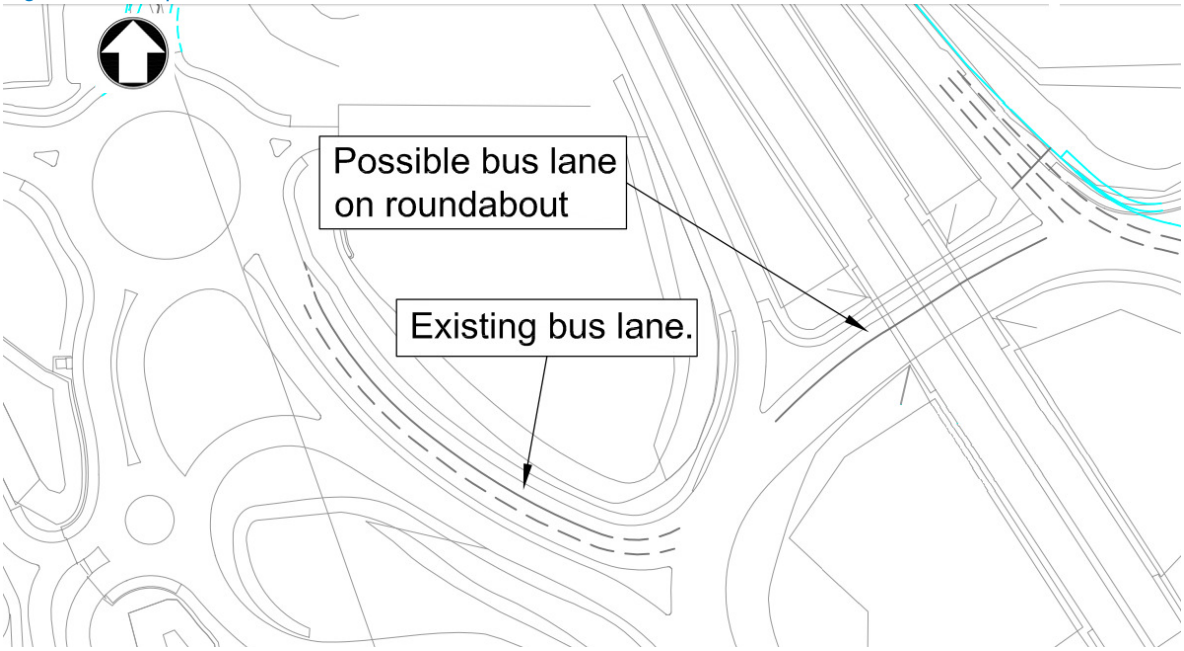
It is acknowledged though that if the park and ride provision is extended this would help meet the increased vehicular demand.

4.4 Option 11 Bus Lane on the Roundabout

This option aimed to benefit inbound buses by re-allocating road space on the circulatory carriageway at the expense of general traffic.

This option would necessitate the conversion of Lane 1 on the Norwich-bound portion of the circulatory carriageway to a bus-only lane. The remaining three lanes would be reallocated as Lane 2 and 3 to Norwich, and Lane 4 to Great Yarmouth.

Figure 4.4: Option 11 Bus Lane on the Roundabout



Source: AECOM Techincal Note Greater Norwich Joint Core Stategy - November 2010

4.4.1 Key Considerations

This option would complement Option 8, in which the amount of general traffic using the circulatory carriageway on this side of the roundabout would be reduced by the provision of a Hamburger-type layout. Without the Hamburger, this option would have the potential to adversely affect general traffic by increasing congestion on the circulating carriageway of the roundabout.

Table 4.4: Option 11 Review

Category	Advantages	Disadvantages
Operational		This option would significantly delay general traffic, since a general traffic lane on the circulatory is reallocated to a bus lane. Furthermore, queues would have to be managed on the approaches to the interchange to ensure that the circulatory did not become gridlocked.
Safety		This option is likely to increase queuing on the approaches to the interchange and therefore is likely to increase the likelihood of shunt type collisions.
Indicative cost	Very **low cost,** but may require an enforcement regime which would slightly increase this cost.	
Constructability	Very simple, only requires new road markings and signing to implement. As mentioned above, the scheme may require bus lane enforcement cameras but again these are relatively straight forward to implement.	
Environmental	May encourage modal shift since buses would benefit from priority through the interchange.	The scheme may increase congestion and queuing at the interchange and in turn this may increase noise and air pollution as a consequence of the start/stop characteristics of vehicles queuing.
Modal shift	May encourage modal shift since buses would benefit from priority through the interchange.	
Promoter's Objectives	May encourage modal shift since buses would benefit from priority through the interchange.	This scheme is likely to have an adverse affect on the operational capacity of the junction; therefore no additional traffic could be accommodated at the interchange.

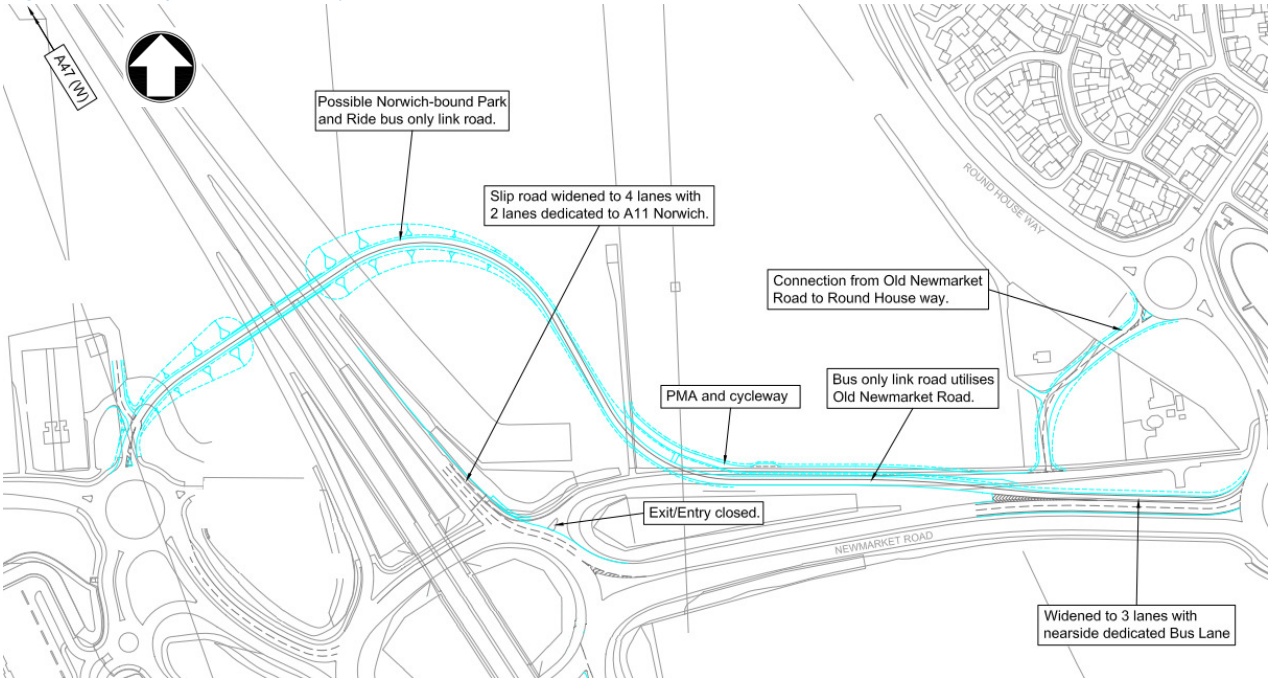
4.4.2 Summary

If this option was implemented on its own it would not meet the aspirations of neither the Promoters nor the bus operators since it is unlikely to work without other interventions to address the congestion that would occur with the loss of a general traffic lane. It is considered that this low cost option is best suited to be implemented with other measures to best meet the Promoters' objectives.

4.5 Option 12 Bus only Link Road over/under the A47

This option aimed to benefit inbound buses by removing them from the Thickthorn Interchange altogether and taking them straight to a priority lane on the A11 approach to Round House Way. Although primarily aimed at buses, this Option would have some potential to benefit general traffic by freeing up the road space on the circulatory carriageway occupied by the buses that currently use it. This option involves a new single link road for Norwich-bound park and ride buses. The link would go over/under the A47 to the north of the interchange, and then it would be join the Old Newmarket Road. The A11 would then be divided into three lanes at the roundabout approach with a nearside dedicated bus lane, and a connection would be provided from Old Newmarket Road to Round House Way. Private means of access and a cycleway can be incorporated into the design as shown on the drawing. To facilitate this option, the existing entry/exit from the interchange to Old Newmarket Road would need to be closed. A47 eastbound slip road could be widened to 4 lanes with 2 lanes dedicated to A11 Norwich. Major earthworks would be required to construct embankments or cuttings for the bridge/underpass on either side of the A47. Significant land purchase would be required on the eastern side of the trunk road.

Figure 4.5: Option 12 Bus only Link Road over the A47



Source: AECOM Techincal Note Greater Norwich Joint Core Stategy - November 2010

4.5.1 Key Considerations

The current layout shown on the A11 eastbound approach to the roundabout would not work practically since left turning vehicles entering the circulatory would conflict with buses. Additionally, the circulatory carriageway is not wide enough to accommodate three lanes of traffic; therefore this is also a safety issue.

This option would require a bus gate on the approach to the roundabout to allow buses and vehicle to safely merge.

There could be an option of making this two-way for buses by linking the new bus link to the Roundhouse Way roundabout.

Table 4.5: Option 12 Review

Category	Advantages	Disadvantages
Operational	This option would only marginally improve the operational capacity of the interchange since it removes eastbound buses travelling through the interchange. Eastbound buses could bypass the interchange, hence avoiding queuing and delays.	Requires the point closure of 'Old' Newmarket Road rerouting local traffic via a convoluted route. However this issue could be overcome with the new link provided to Round House Way.
Safety		Conflicts between eastbound buses and left turners at the roundabout on the A11 to Roundhouse Way. Insufficient circulatory carriageway width on the A11 roundabout to accommodate 3 lanes on the approach.
Indicative cost		**Moderate cost.**
Constructability	Mostly off-line construction that could be implemented without significant disruption to general traffic.	Would require full closure of the A47 during the lift of the over bridge deck structure. Major earthworks would be required for the new bus only link bridge consisting of supporting embankments either side to carry the side road approaches.
Environmental	Would encourage modal shift since buses would bypass the congested interchange.	Major earthworks would be required for the new bus only link bridge/underpass consisting of supporting embankments either side to carry the side road approaches. Significant visual impact on the landscape.
Modal shift	Significant improvement for eastbound bus journey times and reliability through Thickthorn Interchange, thus encouraging modal shift.	Does not cater for westbound travelling buses.
Promoter's Objectives	This option would meet the aspirations of the local bus operators.	Would only negligibly improve the operational capacity of the interchange since it removes eastbound travelling buses from the interchange, therefore no significant improvement to accommodate additional traffic.

4.5.2 Summary

This option if implemented on its own is unlikely to meet the aspirations of the Promoters but might go towards meeting the aspirations of the bus operators since it provides bus priority to allow eastbound buses to bypass the interchange unimpeded.

The are safety issues inherent in this design with regard to the three eastbound lanes on the approach to the existing roundabout with Round House Way which only has two lanes on the circulatory carriageway. However it is considered that this could be resolved with a bus gate provided on the approach to the roundabout.

5 Pre-Commission Workshop

This section provides a description of a 'bypass' option which was discussed during the pre-commission workshop, including a number of variants. The workshop was held on Thursday 22nd December 2011, and was attended by Officers from Norfolk County Council and members of Mott MacDonald Staff. This section also describes two further options that have been developed during this report exercise which form 'teardrop' option.

The bypass option and its variants discussed during the workshop were as follows:-

- Option 13 – An A11 east to west bypass;
- Option 14 – A free-flow lane from the A47 eastbound off slip to the A11 (East);
- Option 15 – Widening the A47 (East) on-slip to a three-lane exit from the roundabout;
- Option 16 – A bus gate on the B1172 (West) on the entry to the roundabout;
- Option 17 – An additional flared lane on the A47 (East) off-slip, on the entry to the roundabout;
- Option 18 – A11 (West) park and ride access/egress with left-turn egress on the B1172;
- Option 19 – A free flow lane from the A11 (East) to the A47 (South);
- Option 20 – A11 East 'Teardrop' option (partial closure of the circulatory carriageway); and
- Option 21 – A11 East 'Teardrop' option (partial closure of the circulatory carriageway) with an extension to the circulatory carriageway.

5.1 Option 13 A11 East to West Bypass

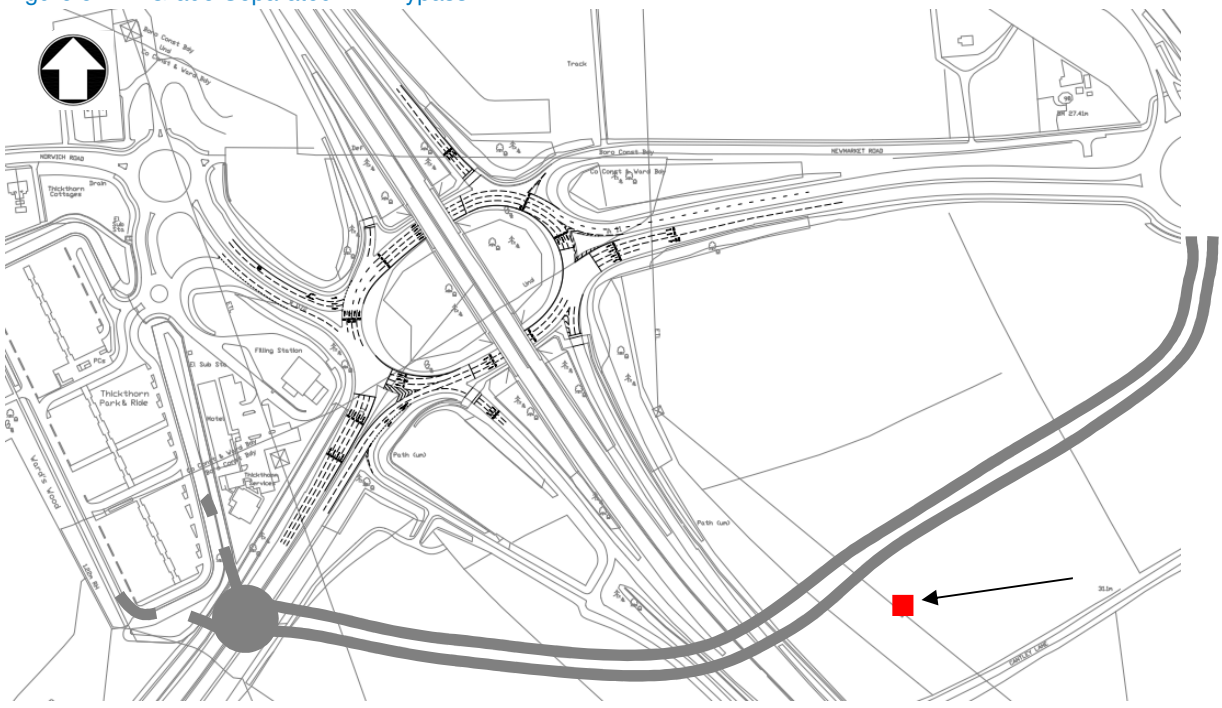
This option provides an east to west bypass of the junction from the A11 (West) to the A11 (East) via a new dual carriageway under the A47 at the merge/diverge noses of its southern slip roads to the southeast of the Thickthorn Interchange. It requires a new roundabout to be provided on the A11 (West) to allow vehicles to join the new bypass on the approach to the Thickthorn Interchange. The new roundabout could serve as either an additional access/egress to the park and ride site or it could replace the exiting provision on the B1172. The bypass would tie-in to the A11 (East) via the existing roundabout with Round House Way.

In 2012 traffic flows, this would remove in the order of 1960 vehicles (1217 travelling east and 743 travelling west) in the morning peak period, and 1530 vehicles (642 travelling east and 888 travelling west) in the evening peak period.

In the 2017 traffic flows, this would remove in the order of 2272 vehicles (1411 travelling east and 861 travelling west) in the morning peak period, and 1604 vehicles (673 travelling east and 931 travelling west) in the evening peak period.

In the 2032 traffic flows, this would remove in the order of 2606 vehicles (1618 travelling east and 988 travelling west) in the morning peak period, and 2078 vehicles (872 travelling east and 1206 travelling west) in the evening peak period.

Figure 5.1: Grade Separated A11 Bypass



Source: Mott MacDonald

5.1.1 Key Considerations

Need to retain access to Cantley Lane South, either via a new over bridge or by other means.

Pylons are located in the fields adjacent to the proposed highway link, whilst they can be avoided by the alignment they are considered as a constraint.

There is the option for the new highway link to travel underneath the A47 (South) which would reduce the conflict with the pylon in the adjacent field.

Table 5.1: Option 13 Review

Category	Advantages	Disadvantages
Operational	Significantly reduces the traffic on the immediate approaches to Thickthorn Interchange and on the circulatory carriageway.	May require widening on the A11 (west) arm on the approach to the roundabout so that queues do not extend back to the circulatory carriageway of Thickthorn Interchange.
Safety		
Indicative cost	**High cost**	
Constructability	Most of the construction occurs off-line. Minimal online construction which can be managed to maintain traffic flows. The new carriageway would follow an alignment that reduces the height of the elevated carriageway over the A47. The new carriageway would follow an alignment that avoids the need to divert pylons and their overhead wires.	Would require full closure of the A47 during the lift of the over bridge deck structure.
Environmental		Major earthworks would be required for the new over bridge consisting of supporting embankments either side to carry the side road approaches. Visual impact on the landscape. Potential habitat loss.
Modal shift		The option would reduce congestion at the interchange therefore making public transport less attractive.
Promoter's Objectives	Increases the capacity of the interchange to accommodate an increase in traffic flows.	

5.1.2 Summary

This option, if implemented on its own is likely to contribute towards the aspirations of the Promoters since it would significantly increase the operational capacity of the interchange. In its current form this option goes towards improving bus journey times and reliability since it removes traffic from the circulatory carriageway, but this benefit may be lost over time as congestion on the circulatory increases. It is considered that other measures in addition to this option would be required to maintain the benefit to buses achieved by the removal of east to west bound traffic on the A11 from the circulatory.

5.2 Option 14 free-flow lane from the A47 (North) off slip to the A11 (East)

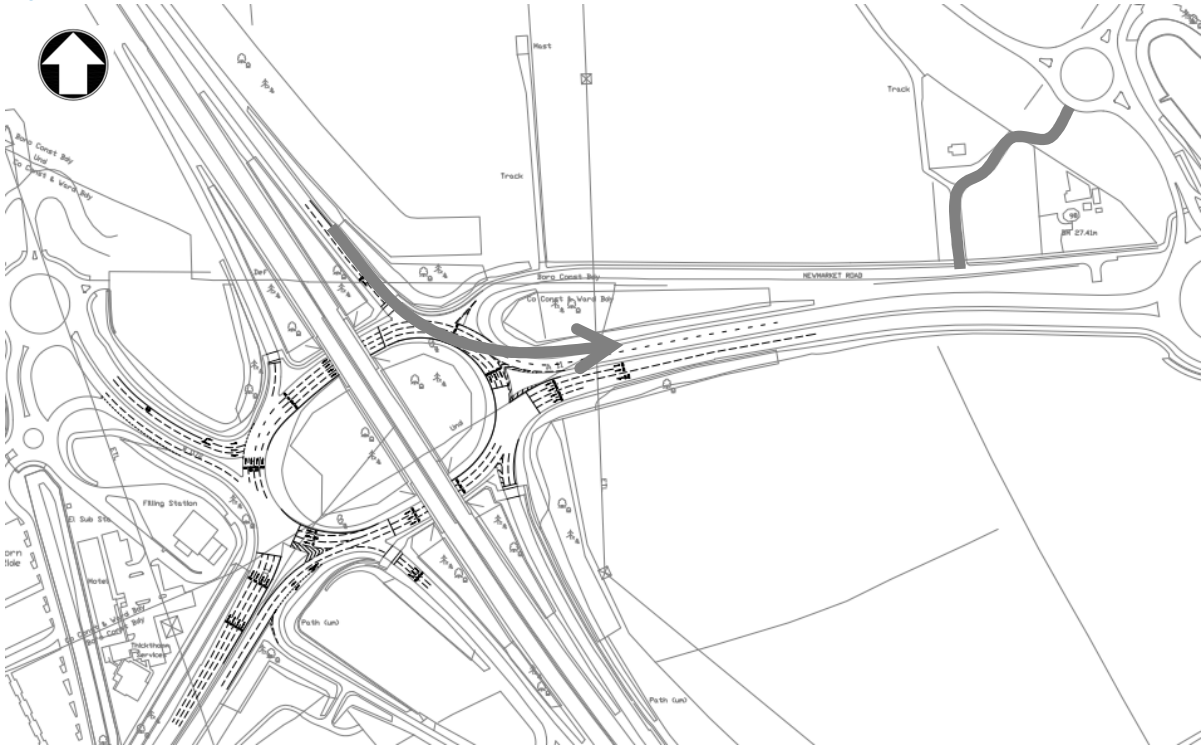
This option provides a free-flow left turn lane from the A47 (North) off slip to the A11 (East) which would require widening on both of these carriageways. It would also require a point closure of 'Old' Newmarket Road at the Thickthorn Interchange, with access maintained via a new link road tying into the existing roundabout on Round House Way with Dragonfly Lane. The free-flow lane would merge with the two lanes on the A11 (East).

In 2012 traffic flows, this would allow in the order of 386 vehicles to bypass Thickthorn Interchange in the morning peak period, and 158 vehicles in the evening peak period.

In 2017 traffic flows, this would allow in the order of 448 vehicles to bypass Thickthorn Interchange in the morning peak period, and 166 vehicles in the evening peak period.

In 2032 traffic flows, this would allow in the order of 513 vehicles to bypass Thickthorn Interchange in the morning peak period, and 215 vehicles in the evening peak period.

Figure 5.2: A47 Free-Flow Left-turn Lane



Source: Mott MacDonald

5.2.1 Key Considerations

The presence of Toucan crossings on the A47 (North) slip roads would necessitate the need for further widening to accommodate a staggered crossing between the ahead movements and the segregated free-flow, left turn lane to overcome 'see-through' issues relating to the green man aspects.

Table 5.2: Option 14 Review

Category	Advantages	Disadvantages
Operational	This would remove approximately 250 vehicles from the A47 (North) off slip during the peak periods and therefore this approach would require less green time. Subsequently freeing up more green time for the circulatory carriageway.	Requires the point closure of 'Old' Newmarket Road rerouting local traffic via a convoluted route. However this issue could be overcome with the new link provided to Round House Way.
Safety	Reduce potential conflicts between vehicles entering the Thickthorn circulatory and those travelling on the circulatory since left turning vehicles are no longer opposed by other vehicles. May reduce shunt-type collisions on the A47 (North) off-slip since queuing on this slip road is likely to be reduced.	
Indicative cost		**Low cost**
Constructability	Most of the construction occurs off-line. Minimal online construction which can be managed to maintain traffic flows.	A Toucan crossing is provided on the A47 north off-slip. If a segregated free-flow lane was provided here an island large enough to safely store cyclists would need to be provided between the free-flow lane and the ahead lanes, thus increasing the widening required on the entry radius. In turn this widening would encounter existing earth bunds and embankments present adjacent to the A47 and A11, which could involve retaining structures or re-grading.
Environmental	Less queuing of traffic with less start/stop driving characteristics therefore improving air quality.	Visual impact on the landscape. Potential habitat loss.
Modal shift		The option would reduce congestion at the interchange therefore making public transport less attractive.
Promoter's Objectives	Marginally increases the capacity of the interchange to accommodate an increase in traffic flows.	

5.2.2 Summary

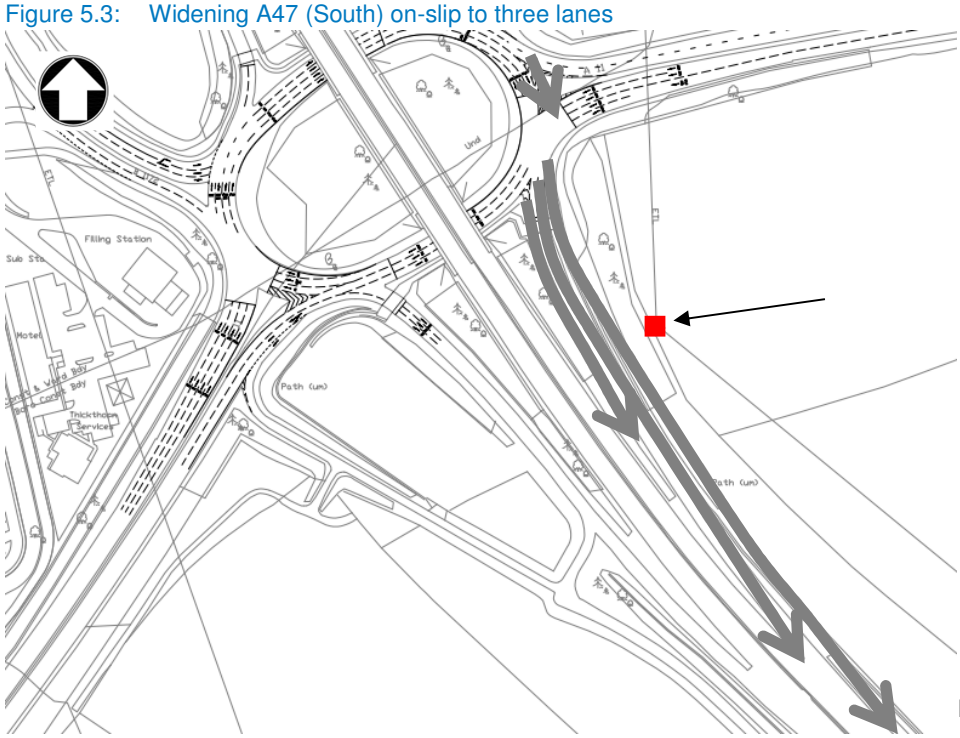
This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers slight to moderate operational improvements to the A47 (North) off-slip. It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

5.3 Option 15 Widening the A47 (South) on-slip to a three-lane exit from the roundabout

This option provides an additional lane on the exit of the roundabout on the A47 (South) on-slip and widens the circulatory carriageway from three lanes to four (on the north-eastern quadrant). This would increase the storage capacity on the circulatory carriageway in the order of two to three vehicles per cycle of the signals therefore increasing the associated stop line saturation flow, in turn marginally increasing the operational capacity of the roundabout.

Currently this slip road is marked as a two lane exit which merges into one lane on the approach to the merge taper with the A47 main line carriageway. This option would involve widening along the length of the slip road to accommodate another lane creating a ghost island merge with the A47 mainline carriageway.

Figure 5.3: Widening A47 (South) on-slip to three lanes



Footbridge located at the

Source: Mott MacDonald

1.1.1 Key Considerations

The footbridge over the A47 at the end of the slip roads may constrain widening at this location.

Table 5.3: Option 15 Review

Category	Advantages	Disadvantages
Operational	This would increase the storage capacity of the stop line on the circulatory by at least three vehicles per cycle (approximately in the order of 180 vehicles per hour). This could allow more green time to be given to the A11 (East). It would also increase the merge capacity of the slip road joining the A47 (South).	
Safety		Unconventional road layout that may confuse motorists and in turn lead to side-swipe or shunt type collisions.
Indicative cost	**Low cost.**	
Constructability	Most of the construction occurs immediately adjacent to the carriageway which can be managed to maintain traffic flows. Construction to widen the circulatory carriageway would only create minimal disruption to general traffic over a relatively short period of time. Cantley Lane footbridge bridge constrains widening at the slip road taper.	
Environmental		Tree and potential habitat loss on the slip road.
Modal shift		Does not improve public transport facilities. The option would reduce congestion at the interchange which could make public transport less attractive.
Promoter's Objectives	Increases the capacity of the interchange to accommodate an increase in traffic flows.	

5.3.1 Summary

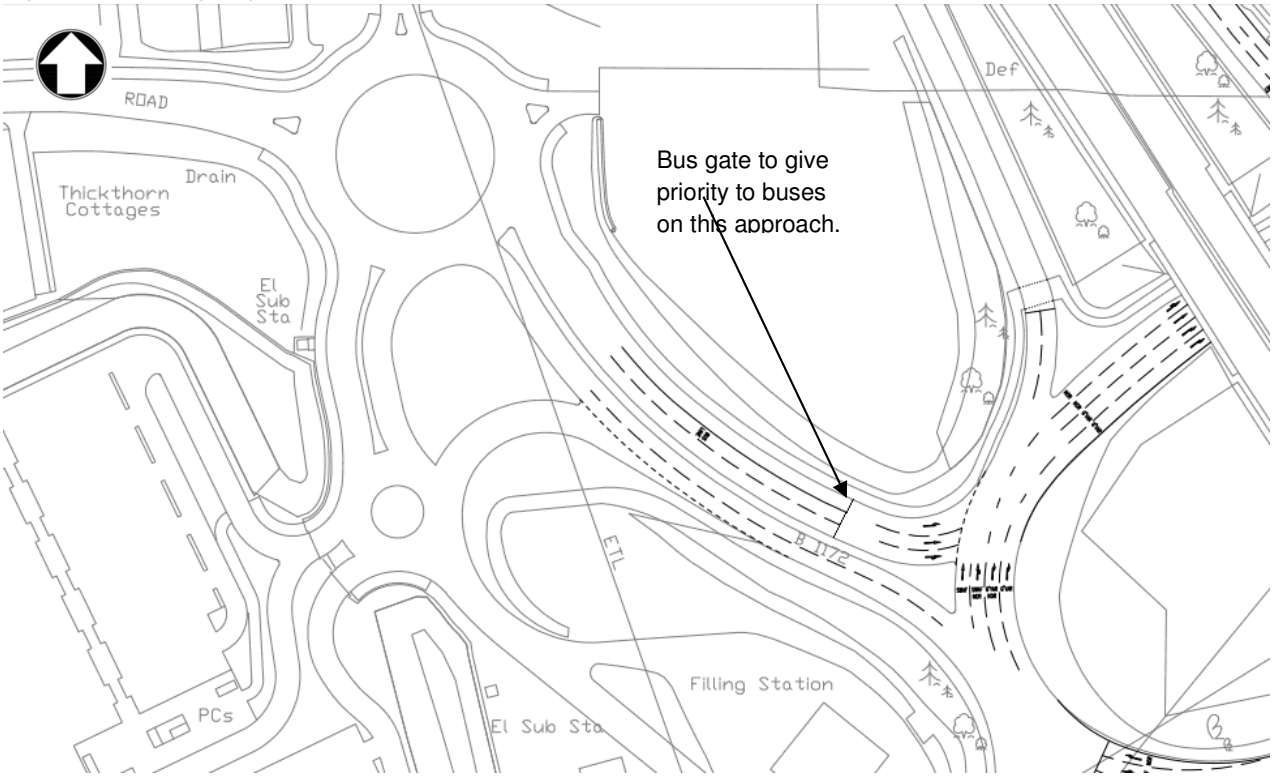
This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers slight to moderate operational improvements to the A47 (South) on-slip and circulatory carriageway on the approach to the on-slip. It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

5.4 Option 16 A bus gate on the B1172 (West) on the entry to the roundabout

This option provides a bus gate at the end of the existing bus lane on the B1172 on the immediate approach to Thickthorn Interchange. This would allow buses to benefit further from the existing bus lane since they would not have to merge with general traffic. General traffic is held back until buses have progressed through the bus gate.

This would require localised widening on the B1172 to accommodate a traffic island to site the traffic signal post and signal heads. Advance loops could be located within the Park and Ride site to prime the signals at Thickthorn Interchange, and a trigger loop provide at the beginning of the bus lane (at the exit of the roundabout).

Figure 5.4: Bus gate provided on the B1172



Source: Mott MacDonald

5.4.1 Key Considerations

General traffic could only be held at the bus gate for a particular length of time before queues extend back through the roundabout and in turn block the park and ride egress, and therefore defeat the object of this option.

This may require bus lane enforcement so that general traffic does not take advantage of the bus gate.

The proposed layout should emphasise to general traffic that they still have to give-way at the roundabout entry by either signing or ensuring that there is sufficient distance between the bus gate and the give-way line, otherwise this may create 'failed to give-way at the junction' type collisions.

Table 5.4: Option 16 Review

Category	Advantages	Disadvantages
Operational	Buses would benefit further from the bus lane provision by avoiding queuing vehicles at the roundabout entry.	Slight delay to general traffic on the B1172 when the bus gate is activated.
Safety		
Indicative cost	**Low cost**.	
Constructability	Minor construction involved that would have negligible impact on traffic when compared against the major schemes considered.	
Environmental	May reduce the number of car trips on the network as a result of modal shift.	
Modal shift	Motorists would see buses bypassing the queues therefore this may encourage modal shift.	
Promoter's Objectives	Meets some of the bus operators' aspirations, but does not improve the capacity of the interchange.	

5.4.2 Summary

This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only slightly improves the progression of eastbound buses through the interchange. It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

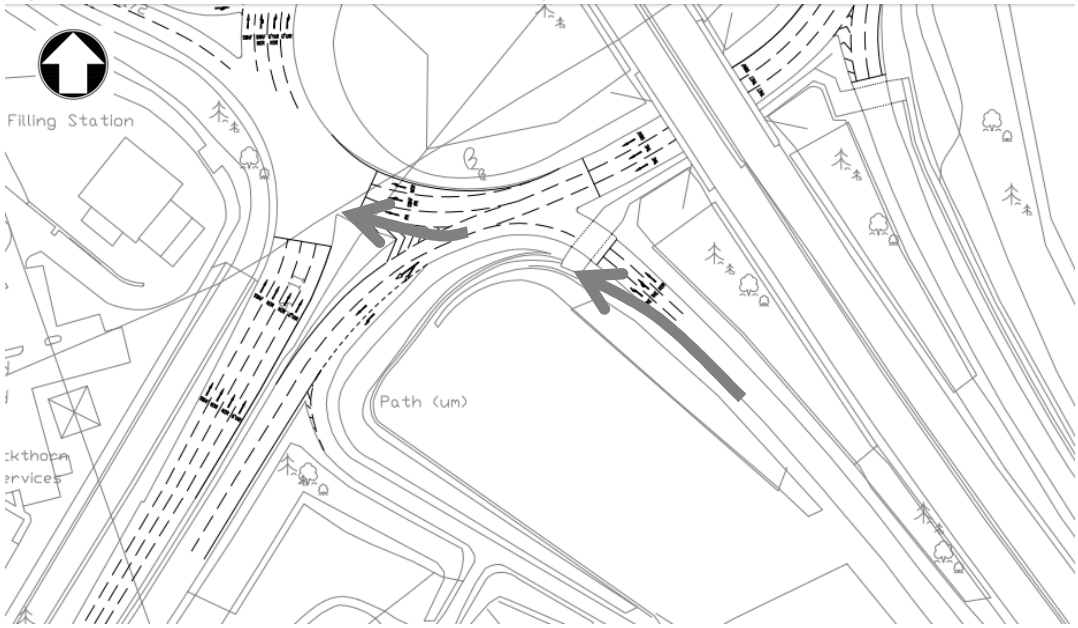
5.5 Option 17 An additional flared lane on the A47 (South) off-slip, on the entry to the roundabouts

This option would provide an additional flared lane on the A47 (south) off-slip and also widening on the circulatory carriageway on the south-western quadrant of the interchange increasing the number of lanes from three to four.

This would increase the stop line saturation flows which could either improve the operational performance of the associated stop lines or alternatively more green time could be given to more critical approaches.

Furthermore, the off-slip currently flares from one lane to two lanes along the length of the slip road and then flares to three lanes in the vicinity of the roundabout entry. This option could consider extending the length of the flared lanes by widening into the nearside verge.

Figure 5.5: Flared lane on the A47 (South) off-slip



Source: Mott MacDonald

5.5.1 Key Considerations

The crossing distance for the Pegasus crossing on this approach would be increased and therefore the clearance period after the green man may cancel out any benefit from adding an additional lane to the approach. However, if the demand on this crossing is infrequent it may not adversely affect this improvement.

Table 5.5: Option 17 Review

Category	Advantages	Disadvantages
Operational	Either a moderate improvement to the operational performance of the associated stop lines; Or additional green time could be given to more critical approaches, therefore marginally increasing the operational capacity of the interchange.	The effectiveness of the widening may be reduced depending on the demand for the Pegasus crossing.
Safety	It may reduce queuing on the A47 (South) off-slip and allow vehicles to more safely exit the mainline carriageway and slow on the approach to the entry to the roundabout. In turn this could reduce shunt type collisions.	
Indicative cost	**Low cost.**	
Constructability	Minor construction involved that would have negligible impact on traffic when compared against the major schemes considered.	
Environmental		Some tree loss and potential loss of habitats.
Modal shift		The option would reduce congestion at the interchange which could make public transport less attractive.
Promoter's Objectives	This treatment could be used to improve the operation of the A47 (South) off-slip or alternatively marginally improve the operational capacity of the interchange. Either way would help towards meeting the Promoters' objectives.	

5.5.2 Summary

This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers slight to moderate operational improvements to the A47 (South) off-slip. It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

5.6 Option 18 A left turn link from the A11 (West) to the B1172 via a new park and ride link

This option would form an access and egress to the park and ride site from the A11 (West) including a left-turn link from the park and ride site towards Hethersett on the B1172. This would remove all traffic currently turning left on the A11 (West) at the Thickthorn Interchange travelling towards either the park and ride site or Hethersett on the B1172.

In 2012 traffic flows, this would remove in the order of 110 vehicles in the morning peak period and 47 vehicles in the evening peak period.

In 2017 traffic flows, this would remove in the order of 128 vehicles in the morning peak period and 50 vehicles in the evening peak period.

In 2032 traffic flows, this would remove in the order of 147 vehicles in the morning peak period and 64 vehicles in the evening peak period.

Figure 5.6: A11 (West) Park and Ride Access/Egress with Left-turn Egress on the B1172

Source: Mott MacDonald

5.6.1 Key Considerations

The traffic flows undertaking this manoeuvre are moderate but reduce considerably during the assessment years, and whilst this option would initially improve the current situation in traffic terms, its effectiveness would be eroded over time.

The internal road layout within the park and ride site would require some means of access control to prevent rat-running through the site during congested periods.

This option may require additional physical measures to prevent rat-running vehicles U-turning on the B1172 to avoid queuing on the A11 (West).

Table 5.6: Option 18 Review

Category	Advantages	Disadvantages
Operational	Removes all of the left turning traffic from the A11 (West) on the approach to the Thickthorn Interchange.	The effectiveness of this option reduces over time as the number of vehicles undertaking this manoeuvre reduces over time to negligible numbers.
Safety		There is a relatively short weave length between the park and ride site egress on the A11 (West) and the roundabout entry to Thickthorn Interchange.
Indicative cost	**Low cost.**	
Constructability	Minor construction involved that would have negligible impact on traffic when compared against the major schemes considered.	
Environmental		Some tree loss and potential loss of habitats.
Modal shift	This option would improve access to the park and ride site thus improving the appeal of public transport. It would also allow left-turning vehicles from the A11 (West) to bypass Thickthorn Interchange.	
Promoter's Objectives	This option would go towards meeting the aspirations of the bus operators.	

5.6.2 Summary

This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers slight to moderate operational improvements to the A11 (West) and offers slight relief to the existing park and ride roundabout access. It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

5.7 Option 19 A Free Flow Lane from the A11 (East) to the A47 (South)

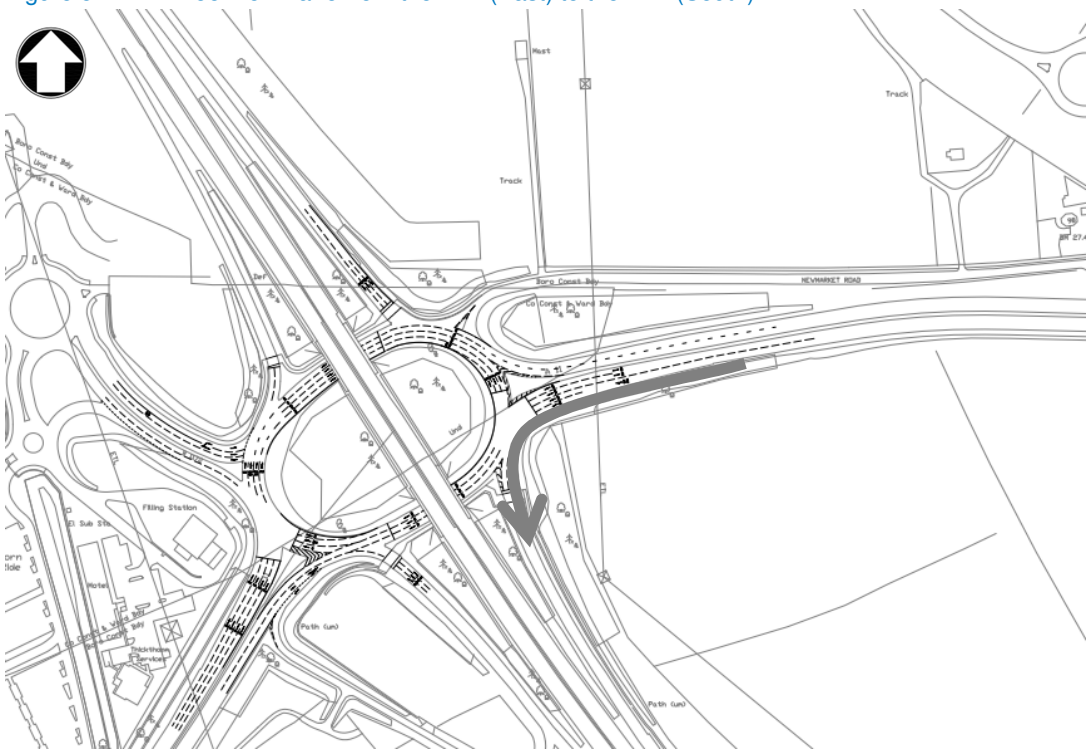
This option provides a free-flow left turn lane from the A11 (East) to the A47 (South) on slip which would require widening on both of these carriageways. The free-flow lane could merge with the two lanes on the A47 (South) on-slip or could involve widening the slip road and providing a ghost island merge (which may require the removal of the existing footbridge over the A47 (South).

In 2012 traffic flows, this would remove in the order of 228 vehicles in the morning peak period and 426 vehicles in the evening peak period.

In 2017 traffic flows, this would remove in the order of 264 vehicles in the morning peak period and 446 vehicles in the evening peak period.

In 2032 traffic flows, this would remove in the order of 303 vehicles in the morning peak period and 578 vehicles in the evening peak period.

Figure 5.7: A Free Flow Lane from the A11 (East) to the A47 (South)



Source: Mott MacDonald

5.7.1 Key Considerations

This option may require the removal of the existing footbridge over the A47 (South) which serves Cantley Lane and Cantley Lane South.

There is an existing Pegasus crossing on the A47 (South) which would require a traffic island between the traffic lanes to store crossing equestrians, and would involve widening into the verge in the order of 6.65m.

Table 5.7: Option 19 Review

Category	Advantages	Disadvantages
Operational	Removes all of the left turning traffic from the A11 (East) on the approach to the Thickthorn Interchange.	
Safety	Could reduce the number of collisions at the entry to the roundabout since there is no longer a conflict between traffic movements.	
Indicative cost	**Low cost.**	
Constructability	Most of the construction occurs off-line. Minimal online construction which can be managed to maintain traffic flows.	A Pegasus crossing is provided on the A47 (South) off-slip. If a segregated free-flow lane was provided here an island large enough to safely store equestrians would need to be provided between the free-flow lane and the ahead lanes, thus increasing the widening required on the entry radius. In turn this widening would encounter existing earth bunds and embankments present adjacent to the A47 and A11, which could involve retaining structures or re-grading.
Environmental	Less queuing of traffic with less start/stop driving characteristics therefore improving air quality.	Some tree loss and potential loss of habitats.
Modal shift		The option would reduce congestion at the interchange which could make public transport less attractive.
Promoter's Objectives	This option would go towards meeting the aspirations of the bus operators.	

5.7.2 Summary

This option, if implemented on its own is unlikely to meet the aspirations of neither the Promoters nor the bus operators since it only offers moderate operational improvements to the A11 (East). It is considered that this option is best suited to be implemented with other measures to best meet the Promoters' objectives.

5.8 Option 20 Tear Drop Option

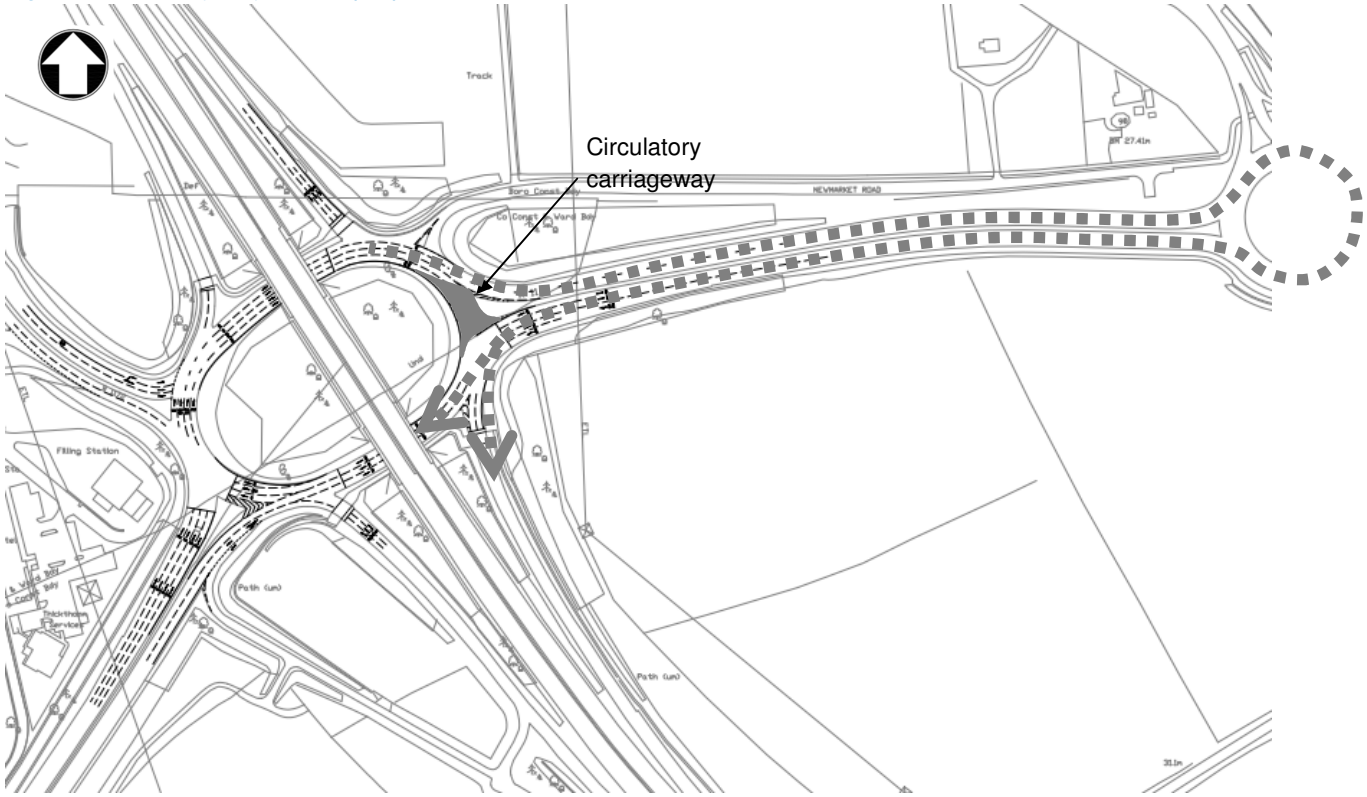
This option involves partial closure of the circulatory carriageway at Thickthorn Interchange opposite the A11 (East) approach. This re-routes all traffic at this point from the circulatory carriageway, and in particular the heavy west to south flow via the Round House Way roundabout. In turn this closure leaves the A11 (East) entry onto Thickthorn Interchange unopposed. The success of this option hinges upon whether Round House Way roundabout can accommodate the additional traffic that is re-routed through it.

In 2012 traffic flows, this would reroute (via the Round House Way roundabout) in the order of 1782 vehicles in the morning peak period, and 1612 vehicles in the evening peak period.

In 2017 traffic flows, this would reroute (via the Round House Way roundabout) in the order of 2065 vehicles in the morning peak period, and 1690 vehicles in the evening peak period.

In 2032 traffic flows, this would reroute (via the Round House Way roundabout) in the order of 2368 vehicles in the morning peak period, and 2187 vehicles in the evening peak period.

Figure 5.8: A11 (East) Teardrop Option



Source: Mott MacDonald

5.8.1 Key Considerations

This option is likely to create a dominant U-turn manoeuvre at the Round House Way roundabout which will reduce opportunities for traffic (on the other approach arms) to enter the roundabout, and in turn may require signal control to regulate the flow of traffic at this roundabout.

At present there are four lanes of traffic on the northern half of the circulatory carriageway at Thickthorn Interchange which will require rationalisation into two since there are only two exit lanes onto the A11 (East).

Table 5.8: Option 20 Review

Category	Advantages	Disadvantages
Operational	The A11 (West) entry to Thickthorn interchange would be unopposed and therefore significantly improves the operational capacity of this approach; May encourage drivers to travel via an alternative route, thus reducing traffic flows at Thickthorn interchange.	This option re-routes a significant volume of traffic via Round House Way roundabout thus adversely affecting the operational capacity of the roundabout.
Safety		Drivers unfamiliar with the road layout may become hesitant on the circulatory carriageway due to the unusual layout and in turn lead to shunt type collisions.
Indicative cost	**Medium Cost**	
Constructability	Minimal online construction which can be managed to maintain traffic flows.	
Environmental		Increased generation of noise and air pollution as a consequence of the convoluted route via Round House Way roundabout.
Modal shift		Does not directly improve provision for public transport, however other options previously discussed could be combined with this option in order to do so.
Promoter's Objectives	Increases the capacity of the interchange to accommodate an increase in traffic flows.	

5.8.2 Summary

This option, if implemented on its own is likely to contribute towards the aspirations of the Promoters since it would moderately increase the operational capacity of the interchange, albeit reducing the operational capacity of Round House Way roundabout. In its current form this option goes towards improving bus journey times and reliability since it improves the progression of traffic through the interchange, but this benefit may be lost if measures were not implemented at Round House Way roundabout. It is considered that other measures in addition to this option would be required at Round House Way roundabout and further bus priority measures to meet the aspirations of the scheme Promoter.

5.9 Option 21 Alternative Tear Drop Option

This option involves partial closure of the circulatory carriageway at Thickthorn Interchange opposite the A11 (East) approach and an extension to the circulatory carriageway to accommodate the re-routed traffic. This option would re-route all traffic at this point from the circulatory carriageway, and in particular the heavy west to south flow via the proposed junction located on the A11 East between Thickthorn interchange and Round House Way Roundabout (method of control to be confirmed).

Subsequently, the length of A11 eastbound carriageway between Thickthorn Interchange and Round House Way roundabout effectively becomes redundant but this can be reallocated to westbound traffic.

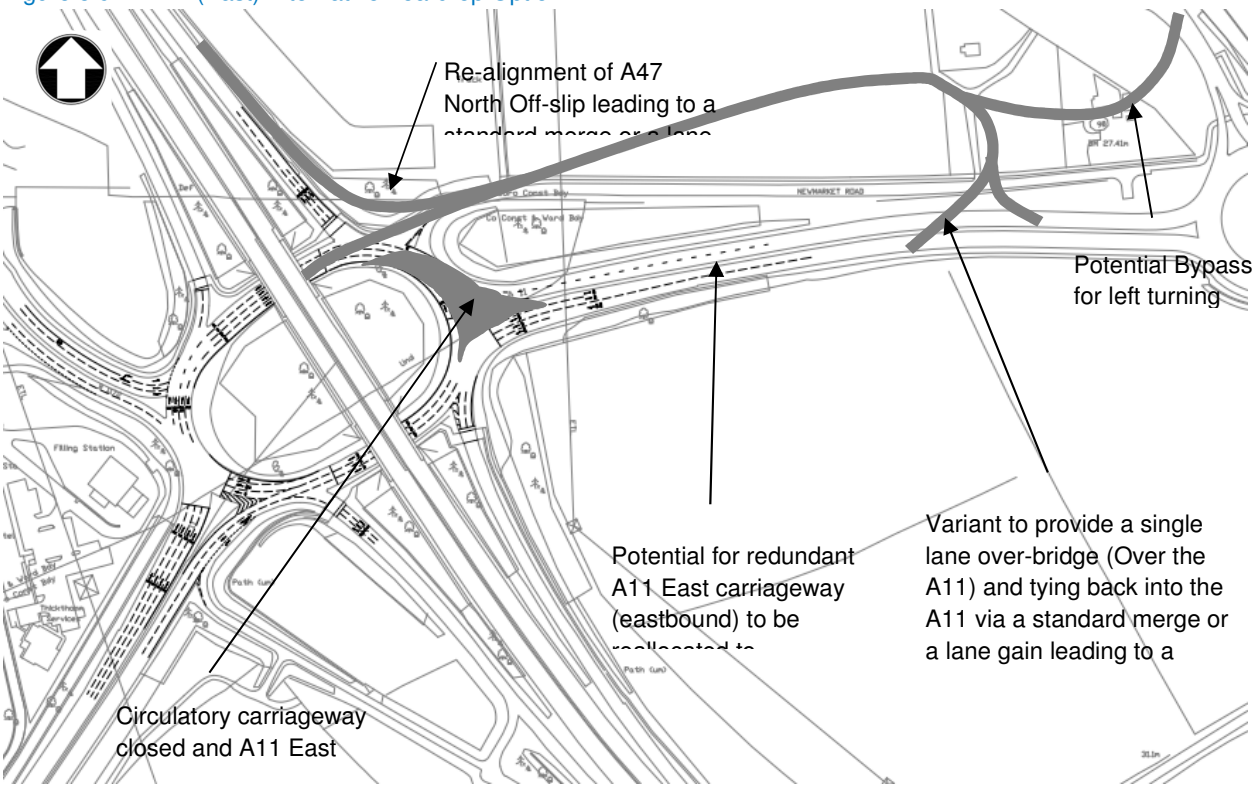
In turn this closure leaves the A11 (East) entry onto Thickthorn Interchange unopposed. The success of this option hinges upon whether Round House Way roundabout can accommodate the additional traffic that is re-routed through it.

In 2012 traffic flows, this would reroute (via the proposed new junction) in the order of 1782 vehicles in the morning peak period, and 1612 vehicles in the evening peak period.

In 2017 traffic flows, this would reroute (via the proposed new junction) in the order of 2065 vehicles in the morning peak period, and 1690 vehicles in the evening peak period.

In 2032 traffic flows, this would reroute (via the proposed new junction) in the order of 2368 vehicles in the morning peak period, and 2187 vehicles in the evening peak period.

Figure 5.9: A11 (East) Alternative Teardrop Option



Source: Mott MacDonald

5.9.1 Key Considerations

The method of control of the proposed junction on the A11 East between Thickthorn Interchange and Roundhouse Way Roundabout will need further consideration to accommodate the re-routed traffic whilst maintaining the throughput of westbound traffic.

At present there are four lanes of traffic on the northern half of the circulatory carriageway at Thickthorn Interchange which may require rationalisation and/or consideration of an additional eastbound bus lane.

Access would need to be maintained to the residential property on 'Old' New Market Road. This could be achieved by tying into the proposed new link.

There are potential variations to the above option which would improve its operation, namely:-

- Remove signal control from the A47 (North) off-slip and convert this to a standard merge or a lane gain arrangement; and
- Remove the junction from the A11 (East) where the teardrop link ties in, by providing a single lane over-bridge.

Table 5.9: Option 21 Review

Category	Advantages	Disadvantages
Operational	The A11 (West) entry to Thickthorn interchange would be unopposed and therefore significantly improves the operational capacity of this approach; May encourage drivers to travel via an alternative route, thus reducing traffic flows at Thickthorn interchange.	This option re-routes a significant volume of traffic via the A11 East approach which may have an adverse effect on traffic travelling westbound on this link.
Safety		
Indicative cost	**Medium Cost**	
Constructability	Minimal online construction which can be managed to maintain traffic flows.	
Environmental		Increased generation of noise and air pollution as a consequence of the slightly convoluted route via Round House Way roundabout.
Modal shift		Does not directly improve provision for public transport, however other options previously discussed could be combined with this option in order to do so.
Promoter's Objectives	Increases the capacity of the interchange to accommodate an increase in traffic flows.	

5.9.2 Summary

This option, if implemented on its own is likely to contribute towards the aspirations of the Promoters since it would increase the operational capacity of the interchange. In its current form this option goes towards improving bus journey times and reliability since it improves the progression of traffic through the interchange. It is considered that other measures in addition to this option would be required at Round House Way roundabout and further bus priority measures to meet the aspirations of the scheme Promoter.

6 Short List of Options

6.1 Initial Options Sifting

The purpose of this chapter is to arrive at a short list of the most viable options whittled down from those presented earlier in the report following due consideration of their attributes. The rationale for short listing the options is a judgement on the key considerations, their pertinent advantages/disadvantages and the initial summary previously discussed with each option.

6.1.1 Consolidation of Similar Options

Option 1 and Option 10 are very similar and provide a new access to the park and ride site from the A11 (West), the only difference between the options is where they tie into the existing park and ride site's internal road network. Therefore these options have been consolidated into one option and are referred to as Option 1 from this point onwards in the document.

6.1.2 Discounted Options

It is considered that Option 2 does not provide any operational or bus priority benefits at Thickthorn interchange. It is a scheme that facilitates other schemes which require the closure of the 'old' New Market Road. Therefore this option is discounted from the list, but if other options require this treatment then it is assumed that this closure is incorporated in that option.

Both option 5 and option 6 propose grade separated links over the A47 at Thickthorn Interchange (i.e. a three-level interchange) which would involve elevated structures, some 14-15m high and would require large approach embankments. Whilst option 5 and option 6 could deliver the promoters' objectives when combined with other measures it is considered that they should be discounted, because other options do not have associated adverse environmental impacts and constructability issues of the same magnitude.

Option 8 proposes the provision of a hamburger roundabout which would actually reduce the operational capacity of the interchange since it increases the required number of signal stages within the cycle of the junction. Although this option may create some spare capacity on the northern half of the circulatory, the option is likely to create greater congestion at the southeast quadrant of the junction which in turn may gridlock the gyratory as queues extend beyond the exits of the roundabout. Furthermore, it is considered that it would not achieve good VFM since it is an expensive option and is therefore discounted at this stage.

Option 7 was discounted following previous investigations due to its associated constructability issues along with its conflicts with the recently upgraded network of pylons/towers which surround the junction. Whilst it achieves the aspirations of the Promoter in terms of traffic capacity and bus priority, it is unlikely to fit within the funding envelope of the scheme and therefore it is discounted on affordability grounds.

6.2 Option Categories

It is apparent from the remaining options that they all offer different solutions with varying success and cannot be compared against one another on an equal basis. Therefore to provide an unbiased selection process the options were allocated into four categories, namely:-

- Minor improvements;
- Bus priority improvements;

- Slip roads improvements; and
- Major scheme improvements.

Table 6.1 provided on the following page indicates which category the options have been allocated into and whether an option has been discounted (as discussed above).

Table 6.1: Option Categories

Improvement Category	Options	Discounted
Minor	Option 1 – New Access to the park and ride site from the A11 (West)	
	Option 2 – Closure of 'Old' New Market Road arm with alternative re provision of A11 (East)	✘
	Option 3 – Closure of Cantley Lane South egress on the A47 (South) off-slip	
	Option 4 – Closing B1172 park and ride access and re-providing access via a new roundabout on the A11 (West)	
Bus Priority	Option 11 – Bus lane on the circulatory carriageway	
	Option 12 – Bus only link road over/under the A47	
	Option 16 – A bus gate on the B1172 (West) on the entry to Thickthorn Interchange	
Slip Road	Option 9 – Cantley Lane improvements	
	Option 14 – Free flow lane from the A47 (North) off-slip to the A11 (East)	
	Option 15 – Widening the A47 (South) on-slip to a three-lane exit from the roundabout	
	Option 17 – An additional flared lane on the A47 (South) off-slip on the entry to the roundabout	
	Option 18 – A11 (West) Park and Ride Access/Egress with Left-turn Egress on the B1172	
	Option 19 – A free flow lane from the A11 (East) to the A47 (South)	
Major Scheme	Option 5 – Grade separation for the A11 right turn movements at the interchange	✘
	Option 6 – Grade separation for the A11 straight ahead movements at the interchange	✘
	Option 7 – New grade separated roundabout with an increased inscribed circle diameter	✘
	Option 8 – Hamburger roundabout	✘
	Option 13 – An A11 east to west bypass	
	Option 20 – A11 East teardrop	
	Option 21 – A11 East teardrop alternative	

Note: Option 10 consolidated with Option 1

As a reminder the principal objectives of this study are to:-

- Enable the Thickthorn Interchange to accommodate additional traffic arising from planned growth in the Norwich area; and
- Enhance bus priority through the interchange to meet the aspirations of local bus operators.

Whilst the minor improvements, slip road improvements and bus priority improvements provided in **Table 6.1** (above) help towards increasing the operational capacity at the interchange and enhance bus priority, they are not considered to unlock sufficient capacity at the interchange to wholly meet the needs of the principal objectives. Therefore, these options could either be used to complement others or implemented

as interim measures on a phased delivery to meet the needs of the interchange as the traffic flows increase overtime.

Option 13 Option 20, and Option 21 are considered to offer the best capacity improvement and be the options that are most likely to meet the growth envisaged in the JCS. However no option directly enhances bus priority provision at the interchange and would need to be combined with bus priority options in **Table 6.1** to achieve this.

6.3 Potential Add-on Do-minimum Options

6.3.1 Bus Priority

Options 13, 20 and 21 do not directly enhance public transport at the interchange. Instead they create spare capacity which would facilitate the progression of buses through the interchange. However, buses would share the carriageway with general traffic and therefore this benefit would be eroded over time as traffic flows and congestion increases. To overcome this, these options could be combined with one of the bus priority options from **Table 6.1** to maintain bus priority at the interchange.

- Option 11 – involves the provision of a bus lane on the northern section of the circulatory which in the absence of A11 east to west traffic would benefit buses without adversely affecting general traffic. Similarly, a bus lane on the southern section of the circulatory of the interchange could be implemented to achieve a similar effect;
- Option 12 – provides a bus only link over the A47 north of Thickthorn Interchange via a grade separated highway. This option offers the greatest degree of bus priority compared against all other bus priority options and is also the option that is least likely to be affected by an increase in congestion at the interchange. However, it would be considered as a lavish extra when considering the number of buses that would use this facility. . Therefore this option is considered as an add on in future years when congestion is affecting the journey time and reliability of buses travelling through the interchange; and
- Option 16 – Provides a bus gate on the B1172 and would maximise the benefit of the existing bus lane on this approach.

Therefore Option 11 and Option 16 are considered suitable as Do-minimum options.

6.3.2 Heavy Movement towards the A47 (South)

It can be seen from the traffic flows that there is a heavy movement from the A11 in both directions (from the East and from the West) and travelling towards the A47 (South) in both peak periods. Options which could aid with the progression of these heavy movements through the interchange include:-

- Option 15 facilitates the west to south manoeuvre from the A11 (West) to the A47 (South) by increasing the capacity on the circulatory and on the A47 (South) on-slip; and
- Option 19 facilitates the east to south manoeuvre from the A11 (East) to the A47 (South) by providing a free-flow left turn lane on the A11 (East) approach.

Both options are similar in that they require widening on the A47 (South) on-slip and could be implemented together, but this would require significant widening into the verge in the order of 10.3m to include a staggered island for the existing Pegasus crossing.

If Option 15 was implemented on its own it would need the carriageway to be widened into the verge in the order of 3.65 metres.

If Option 19 was implemented on its own, it would require widening into the verge in the order of 6.65m to accommodate an island to segregate the free-flow left turn lane from the other lanes whilst providing a storage area to serve as a refuge for vulnerable road users to cross the carriageway.

It is considered impractical to implement both of these options together (Options 15 and 19) due to the widening required (i.e. 10.3m) since it would require moderate earthworks to overcome the level differences between the carriageway and the adjacent land in this location.

The west to south movement is the largest flow of traffic between the two movements which is served by Option 15. Furthermore Option 15 requires less land take and therefore would achieve better VFM than Option 19.

Therefore option 15 is considered suitable as a Do-minimum option.

6.3.3 Link to the B1172

Similar to Option 18, a vehicular link could be provided from the park and ride site to the B1172. This option would only compliment Option 13 since it removes traffic from Thickthorn Interchange.

Therefore this option is not considered suitable as a Do-minimum option but it is considered appropriate to combine it with Option 13.

6.3.4 A47 (South) off-slip

During the assessment years the A47 (South) off-slip sees a significant increase in traffic flows. The pressure on the A47 (South) off-slip could be eased by Option 17 which would provide a flared lane on the approach to the roundabout entry.

It is important to note that this would increase the crossing distance for the existing Pegasus Crossing, but the demand on this crossing is considered to be low and therefore this concern is of low importance.

Therefore Option 17 is considered suitable as a Do-minimum option.

6.4 Do-minimum Options

Options that do not wholly meet the Promoter's objectives but still offer some congestion relief, and could be implemented at the interchange without significant disruption to general traffic during construction will be considered as Do-minimum options.

Furthermore Do-minimum options are those that compliment the Do-something options (i.e. they do not become redundant or require removal once a Do-something option is implemented).

The options that could be implemented as Do minimum options include:-

- Option 1 Left in access to the park and ride site from the A11 (West) and/or Option 18 A left turn link from the A11 (West) to the B1172 via a new park and ride link;
- Option 15 Widening the A47 (South) on-slip to a three-lane exit from the roundabout;
- Option 16 A bus gate on the B1172 (West) on the entry to the roundabout;
- Option 17 An additional flared lane on the A47 (South) off-slip, on the entry to the roundabouts; and
- Option 19 A Free Flow Lane from the A11 (East) to the A47 (South).

Option 14 has not been included in the above list since the traffic flows on this movement (i.e. north to east) only negligibly increase during the assessment years and therefore it is considered that this option would not improve the capacity of the interchange as a whole. However, this option may be required as an add on to the Do-something options to maintain capacity on this approach.

6.5 Do-Something Options.

Following a review of the options previously considered in other investigations, it is apparent that there are two options (plus a variant option) that could deliver the objectives of the promoters and meet the aspirations of the local bus operators. The remaining options would only go towards meeting the Promoters' Objectives.

Option 13, Option 20 and Option 21 (when combined with other options as discussed above) could be referred to as Do-Something options.

7 Traffic Assessment

7.1 Introduction

This section of the report will summarise the findings of the traffic modelling undertaken at Thickthorn Interchange and at Round House Way Roundabout. The junctions will be modelled in three scenarios, namely:-

- Existing traffic flows (2012);
- Opening year traffic flows (2017); and
- Design Year 2021.

7.2 Existing Traffic Flows (2012)

Traffic counts were undertaken by Sky High – Count On Us on Wednesday 25th April 2012. The existing layout of the A47 / A11 Newmarket Road / Norwich Road and the A11 New Market Road / Round House Way junctions has been modelled for the 2012 existing scenario. From these traffic counts the AM Peak is shown to be 0745 – 0845 and the PM Peak between 1645 – 1745 (See Appendix A).

The existing layout of the A47 / A11 Newmarket Road / Norwich Road junction has been modelled using TRANSYT. An ARCADY model has been built to represent the existing junction layout of the A11 New Market Road / Round House Way roundabout.

The results for the existing layout modelling assessment for these junctions are summarised below in Table 7.1.

Table 7.1: TRANSYT - Thickthorn Interchange

		AM Peak		PM Peak	
Node	Approach / Link	DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**86**	**9**	33	2
	A47 (N) ahead / 102	71	7	47	4
	A47 (N) ahead/right / 103	71	7	47	4
	Circulatory at A47 (N) nearside / 104	**87**	**19**	61	10
	Circulatory at A47 (N) middle lane / 105	77	8	35	2
	Circulatory at A47 (N) offside / 106	44	6	46	3
201 – Newmarket Road	Newmarket Road / 201	2	0	2	0
	Circulatory at Newmarket Road nearside / 205	20	0	15	0
	Circulatory at Newmarket Road middle lane left / 202	36	0	29	0
	Circulatory at Newmarket Road middle lane ahead / 203	28	0	26	0
	Circulatory at Newmarket Road offside / 204	8	0	7	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	36	3	52	6
	A11 (E) ahead / 302	61	7	65	9
	A11 (E) ahead/right / 303	61	7	65	9

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	A11 (E) right / 304	27	2	31	3
	Circulatory at A11 (E) nearside / 305	49	13	60	18
	Circulatory at A11 (E) offside / 306	72	13	69	9
4 – A47 (S)	A47 (S) left / 401	80	11	71	8
	A47 (S) ahead/left / 402	73	10	64	7
	A47 (S) ahead/right / 403	51	6	39	4
	Circulatory at A47 (S) nearside / 404	82	9	80	7
	Circulatory at A47 (S) middle lane / 405	68	6	75	6
	Circulatory at A47 (S) offside / 406	36	3	38	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	43	5	49	6
	A11 (W) ahead / 502	50	12	28	6
	A11 (W) right / 503	78	13	86	16
	Circulatory at A11 (W) nearside / 504	63	4	77	8
	Circulatory at A11 (W) middle lane / 505	58	6	59	7
	Circulatory at A11 (W) offside / 506	76	4	45	2
6 – B1172 Norwich Road	B1172 left / 601	15	0	21	0
	B1172 ahead / 602	51	1	31	0
	B1172 ahead/right / 603	34	0	30	0
	Circulatory at B1172 nearside / 604	28	0	39	2
	Circulatory at B1172 middle lane / 605	30	0	15	0
	Circulatory at B1172 middle lane / 606	50	2	29	0
	Circulatory at B1172 offside / 607	46	8	48	10
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	47	5	54	10
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	23	2	32	4

The results show that the A11 Thickthorn Interchange is currently operating within capacity, with a maximum Degree of Saturation (DoS) of 87% on the nearside circulatory lane at the A47 North in the AM Peak and 86% on the A11 West right turn lane.

Table 7.2: ARCADY - A11 New Market Road / Round House Way existing junction

Approach	AM Peak		PM Peak	
	Maximum RFC	Queue (Vehicles)	Maximum RFC	Queue (Vehicles)
Round House Way	0.602	2	0.538	1
A11 Newmarket Road (East)	0.548	1	0.809	4
A11 Newmarket Road (West)	**0.909**	**9**	0.492	1

In ARCADY an approach with a Maximum RFC above 0.85 is considered to be operating over capacity. The results show that in the AM Peak the A11 New Market Road / Round House Way roundaboutis operating over capacity with a Maximum RFC of 0.909 and a queue of 9 vehicles on the A11 Newmarket Road (West) approach. The junction is shown to be operating within capacity in the PM Peak with a Maximum RFC of 0.808 on the A11 Newmarket Road (East) approach with a queue of 4 vehicles.

7.3 Opening Year Flows (2017)

Table 7.3: TRANSYT - Thickthorn Interchange

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**100**	**18**	44	3
	A47 (N) ahead / 102	83	8	61	5
	A47 (N) ahead/right / 103	83	8	61	5
	Circulatory at A47 (N) nearside / 104	**100**	**37**	59	7
	Circulatory at A47 (N) middle lane / 105	89	12	34	2
	Circulatory at A47 (N) offside / 106	50	11	45	6
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road nearside / 205	24	0	15	0
	Circulatory at Newmarket Road middle lane left / 202	42	0	31	0
	Circulatory at Newmarket Road middle lane ahead / 203	33	0	25	0
	Circulatory at Newmarket Road offside / 204	9	0	7	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	40	4	58	6
	A11 (E) ahead / 302	68	8	74	10
	A11 (E) ahead/right / 303	67	8	74	10
	A11 (E) right / 304	30	3	35	3
	Circulatory at A11 (E) nearside / 305	58	12	58	15
	Circulatory at A11 (E) offside / 306	86	16	82	13
4 – A47 (S)	A47 (S) left / 401	**93**	**16**	78	9

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	A47 (S) ahead/left / 402	84	13	71	8
	A47 (S) ahead/right / 403	59	7	42	4
	Circulatory at A47 (S) nearside / 404	**96**	**21**	82	7
	Circulatory at A47 (S) middle lane / 405	79	8	76	6
	Circulatory at A47 (S) offside / 406	42	4	38	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	50	6	50	6
	A11 (W) ahead / 502	58	15	28	6
	A11 (W) right / 503	**90**	**19**	87	17
	Circulatory at A11 (W) nearside / 504	74	6	86	10
	Circulatory at A11 (W) middle lane / 505	66	7	65	8
	Circulatory at A11 (W) offside / 506	88	7	50	2
6 – B1172 Norwich Road	B1172 left / 601	18	0	22	0
	B1172 ahead / 602	62	3	33	0
	B1172 ahead/right / 603	44	1	33	0
	Circulatory at B1172 nearside / 604	33	0	41	2
	Circulatory at B1172 middle lane / 605	34	0	16	0
	Circulatory at B1172 middle lane / 606	58	4	31	0
	Circulatory at B1172 offside / 607	54	12	50	11
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	54	13	56	9
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	27	3	33	4

In the AM Peak the results show the Thickthorn Interchange is predicted to be operating over capacity in 2017 at three of the nodes. At the A47 (N) approach to the junction the DoS on the A47 (N) left turn lane is 100% and the nearside circulatory at the A47 (N) lane has a DoS of 100%. The A47 (S) left turn lane has a DoS of 93% and the nearside circulatory at this approach has a DoS of 96%. The A11 (W) right turn lane is also over capacity with a DoS of 96%. The results show that the junction operates within capacity in the PM Peak with a maximum DoS of 87% on the A11 (W) right turn lane.

Table 7.4: ARCADY - A11 New Market Road / Round House Way existing junction

Approach	AM Peak		PM Peak	
	Maximum RFC	Queue (Vehicles)	Maximum RFC	Queue (Vehicles)
Round House Way	0.879	6	0.580	1
A11 Newmarket Road (East)	0.636	2	0.848	5
A11 Newmarket Road (West)	**1.055**	**97**	0.515	1

The results show that the A11 New Market Road / Round House Way roundaboutis predicted to operate over capacity in 2017 in the AM Peak with a maximum RFC of 1.055 on the A11 Newmarket Road West approach. The junction is predicted to operate within capacity in the PM Peak with a maximum RFC of 0.847 on the Newmarket Road West approach.

7.4 Proposed Do-minimum Options

This section of the report summarises the findings of the modelling undertaken on the proposed Do-minimum options using Opening Year (2017) flows.

7.4.1 Do-minimum 2017 – Option 11

This option involves changing Lane 1 on the Norwich-bound portion of the circulatory carriageway to a bus-only lane. The remaining three lanes would be reallocated as Lane 2 to Norwich and Lane 3 and Lane 4 to Great Yarmouth. There are 19 buses in the AM Peak and 16 buses in the PM Peak which would use this bus lane. This option also involves widening the A47 (North) to a four lane entry to the roundabout.

Table 7.5: Thickthorn Interchange– 2017 Option 11

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	70	8	29	3
	A47 (N) ahead / 102	**105**	**23**	74	5
	A47 (N) ahead/right / 103	**105**	**23**	73	5
	Circulatory at A47 (N) nearside / 104	3	0	3	0
	Circulatory at A47 (N) middle lane / 105	**166**	**517**	83	11
	Circulatory at A47 (N) offside / 106	47	15	43	7
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road nearside / 205	2	0	1	0
	Circulatory at Newmarket Road middle lane left / 202	61	6	45	0
	Circulatory at Newmarket Road middle lane ahead / 203	32	0	25	0
	Circulatory at Newmarket Road offside / 204	9	0	7	0

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
3 – A11 Newmarket Road (E)	A11 (E) left / 301	40	4	56	6
	A11 (E) ahead / 302	68	8	71	10
	A11 (E) ahead/right / 303	67	8	71	10
	A11 (E) right / 304	30	3	33	3
	Circulatory at A11 (E) nearside / 305	58	7	60	14
	Circulatory at A11 (E) offside / 306	82	16	85	14
4 – A47 (S)	A47 (S) left / 401	**93**	**16**	78	9
	A47 (S) ahead/left / 402	84	13	71	8
	A47 (S) ahead/right / 403	59	7	42	4
	Circulatory at A47 (S) nearside / 404	94	20	82	7
	Circulatory at A47 (S) middle lane / 405	78	7	76	6
	Circulatory at A47 (S) offside / 406	41	3	38	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	50	6	50	6
	A11 (W) ahead / 502	58	15	28	6
	A11 (W) right / 503	**90**	**19**	87	17
	Circulatory at A11 (W) nearside / 504	74	6	86	10
	Circulatory at A11 (W) middle lane / 505	65	7	65	8
	Circulatory at A11 (W) offside / 506	88	7	51	2
6 – B1172 Norwich Road	B1172 left / 601	15	0	20	0
	B1172 ahead / 602	51	1	30	0
	B1172 ahead/right / 603	62	3	36	1
	Circulatory at B1172 nearside / 604	33	0	41	2
	Circulatory at B1172 middle lane / 605	2	0	1	0
	Circulatory at B1172 middle lane / 606	92	33	47	7
	Circulatory at B1172 offside / 607	54	12	50	11
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	54	8	56	7
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	27	3	33	4

Flaring the A47 North left turn approach has reduced the DoS and MMQ from 100% and 18 PCUs to 70% and 8 PCUs in the AM Peak. In the PM Peak this approach operates well within capacity and therefore the flare does not affect the results significantly. Reducing the number of general traffic lanes on the Norwich-bound portion of the circulatory carriageway to accommodate a bus lane has detrimental affects on the operation of the junction in the AM Peak. The DoS on the circulatory at the A47 North middle lane is

predicted to increase to 166% with a MMQ of 517 PCUs. This option is therefore not considered feasible unless improvements are made to general traffic lane provision.

7.5 Do-minimum 2017 – Option 15

This option provides an additional lane on the exit of the roundabout on the A47 (South) on-slip and widens the circulatory carriageway from three lanes to four (on the north-eastern quadrant). It has been assumed that the crossing width will increase to 11metres to accommodate the additional lane.

Table 7.6: Thickthorn Interchange– 2017 Option 15

		AM Peak		PM Peak	
Node	Approach / Link	DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**100**	**18**	48	3
	A47 (N) ahead / 102	1	8	67	5
	A47 (N) ahead/right / 103	83	8	67	5
	Circulatory at A47 (N) nearside / 104	**100**	**37**	58	5
	Circulatory at A47 (N) middle lane / 105	89	12	33	2
	Circulatory at A47 (N) offside / 106	50	11	44	6
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road nearside / 205	24	0	15	0
	Circulatory at Newmarket Road middle lane left / 202	69	18	31	0
	Circulatory at Newmarket Road middle lane ahead / 203	33	0	25	0
	Circulatory at Newmarket Road offside / 204	9	0	7	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	42	4	58	6
	A11 (E) ahead / 302	71	8	74	10
	A11 (E) ahead/right / 303	71	8	74	10
	A11 (E) right / 304	31	3	35	3
	Circulatory at A11 (E) nearside / 305	40	12	41	14
	Circulatory at A11 (E) offside / 306	84	16	82	13
4 – A47 (S)	A47 (S) left / 401	**93**	**16**	78	9
	A47 (S) ahead/left / 402	84	13	71	8
	A47 (S) ahead/right / 403	59	7	42	4
	Circulatory at A47 (S) nearside / 404	**96**	**19**	82	7
	Circulatory at A47 (S) middle lane / 405	79	8	76	6
	Circulatory at A47 (S) offside / 406	42	3	38	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	50	6	50	6
	A11 (W) ahead / 502	58	15	28	6

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	A11 (W) right / 503	**90**	**19**	87	17
	Circulatory at A11 (W) nearside / 504	74	6	86	10
	Circulatory at A11 (W) middle lane / 505	66	7	65	8
	Circulatory at A11 (W) offside / 506	88	7	50	2
6 – B1172 Norwich Road	B1172 left / 601	18	0	22	0
	B1172 ahead / 602	62	3	33	0
	B1172 ahead/right / 603	44	1	33	0
	Circulatory at B1172 nearside / 604	33	0	41	2
	Circulatory at B1172 middle lane / 605	34	0	16	0
	Circulatory at B1172 middle lane / 606	58	4	31	0
	Circulatory at B1172 offside / 607	54	12	50	11
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	54	13	59	14
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	27	3	33	4

The results for this option predict a decrease in the DoS and MMQ on the circulatory at the A47 South on slip from 58% and 12 PCUs to 40% and 12 PCUs in the AM Peak and from 58% and 15 PCUs to 41% and 14 PCUs in the PM Peak. The other results for the junction remain relatively unchanged when compared with the existing junction in 2017.

7.6 Do-minimum 2017 – Option 16

This option provides a bus gate at the end of the existing bus lane on the B1172 on the immediate approach to Thickthorn Interchange.

Table 7.7: Thickthorn Interchange– 2017 Option 16

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**100**	**18**	44	3
	A47 (N) ahead / 102	83	8	61	5
	A47 (N) ahead/right / 103	83	8	61	5
	Circulatory at A47 (N) nearside / 104	**100**	**37**	59	7
	Circulatory at A47 (N) middle lane / 105	89	11	34	2
	Circulatory at A47 (N) offside / 106	50	10	45	5
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road	24	0	15	0

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	nearside / 205				
	Circulatory at Newmarket Road middle lane left / 202	42	0	31	0
	Circulatory at Newmarket Road middle lane ahead / 203	33	0	25	0
	Circulatory at Newmarket Road offside / 204	9	0	7	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	40	4	61	7
	A11 (E) ahead / 302	68	8	78	11
	A11 (E) ahead/right / 303	67	8	77	11
	A11 (E) right / 304	30	3	36	3
	Circulatory at A11 (E) nearside / 305	58	12	56	16
	Circulatory at A11 (E) offside / 306	86	16	79	12
4 – A47 (S)	A47 (S) left / 401	93	16	78	9
	A47 (S) ahead/left / 402	84	13	71	8
	A47 (S) ahead/right / 403	59	7	42	4
	Circulatory at A47 (S) nearside / 404	**96**	**21**	82	7
	Circulatory at A47 (S) middle lane / 405	79	8	76	6
	Circulatory at A47 (S) offside / 406	42	4	38	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	50	6	50	6
	A11 (W) ahead / 502	58	15	28	6
	A11 (W) right / 503	**90**	**19**	87	17
	Circulatory at A11 (W) nearside / 504	74	6	86	10
	Circulatory at A11 (W) middle lane / 505	66	7	65	8
	Circulatory at A11 (W) offside / 506	88	7	50	2
6 – B1172 Norwich Road	B1172 left / 601	18	0	22	0
	B1172 ahead / 602	62	4	33	1
	B1172 ahead/right / 603	45	1	32	0
	Circulatory at B1172 nearside / 604	33	0	41	2
	Circulatory at B1172 middle lane / 605	34	0	16	0
	Circulatory at B1172 middle lane / 606	58	4	31	0
	Circulatory at B1172 offside / 607	54	12	50	11
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	54	13	56	7
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	27	3	33	3

This option does not affect the operational results of the junction although it would improve the priority for buses on the B1172 approach. However, there is minimal queuing predicted on this approach in both the AM and PM Peaks with a MMQ of 3 and 1 PCUs respectively in the 2017 existing scenario. Buses are therefore unlikely to experience delay on this approach in the existing scenario and therefore the bus gate would not improve this.

7.7 Do-minimum 2017 – Option 17

This option would provide an additional flared lane on the A47 (south) off-slip and also widening on the circulatory carriageway on the southwestern quadrant of the interchange increasing the number of lanes from three to four.

The lanes on the A47 (south) off-slip have been allocated as Lane 1 and Lane 2 to Thetford, Lane 3 to B1172 / A47(N) and Lane 4 to Norwich.

Table 7.8: Thickthorn Interchange– 2017 Option 17

		AM Peak		PM Peak	
Node	Approach / Link	DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**100**	**18**	48	3
	A47 (N) ahead / 102	83	8	67	5
	A47 (N) ahead/right / 103	83	8	67	5
	Circulatory at A47 (N) nearside / 104	**100**	**37**	58	5
	Circulatory at A47 (N) middle lane / 105	89	12	33	2
	Circulatory at A47 (N) offside / 106	50	11	44	6
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road nearside / 205	24	0	15	0
	Circulatory at Newmarket Road middle lane left / 202	42	0	31	0
	Circulatory at Newmarket Road middle lane ahead / 203	33	0	25	0
	Circulatory at Newmarket Road offside / 204	9	0	7	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	42	4	61	7
	A11 (E) ahead / 302	71	8	78	11
	A11 (E) ahead/right / 303	71	8	77	11
	A11 (E) right / 304	31	3	36	3
	Circulatory at A11 (E) nearside / 305	56	13	56	15
	Circulatory at A11 (E) offside / 306	84	16	79	13
4 – A47 (S)	A47 (S) left / 401	88	20	41	6
	A47 (S) ahead / 402	46	4	81	9
	A47 (S) ahead/right / 403	64	8	40	4
	Circulatory at A47 (S) nearside / 404	89	12	85	8

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	Circulatory at A47 (S) middle lane / 405	73	7	78	6
	Circulatory at A47 (S) offside / 406	39	3	40	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	50	6	47	6
	A11 (W) ahead / 502	58	15	27	5
	A11 (W) right / 503	**90**	**19**	82	15
	Circulatory at A11 (W) nearside / 504	44	3	57	7
	Circulatory at A11 (W) middle lane / 505	66	7	73	8
	Circulatory at A11 (W) offside / 506	88	8	56	2
6 – B1172 Norwich Road	B1172 left / 601	18	0	22	0
	B1172 ahead / 602	62	3	33	0
	B1172 ahead/right / 603	44	1	33	0
	Circulatory at B1172 nearside / 604	33	0	41	2
	Circulatory at B1172 middle lane / 605	34	0	16	0
	Circulatory at B1172 middle lane / 606	58	4	31	0
	Circulatory at B1172 offside / 607	54	12	50	10
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	54	5	56	8
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	27	3	33	4

The results show that this option improves the operational performance of the junction with all approaches predicted to operate within capacity in both peak periods with the exception of the A11 West right turn approach. The DoS and MMQ on this approach is 90% and 19 PCUs which is the same as the 2017 existing scenario. The DoS on the A47 South left turn approach is predicted to decrease from 93% to 88% and on the nearside circulatory at the A47 South from 96% to 89%. The impacts of this option in the PM Peak are minimal.

7.8 Do-minimum 2017 – Option 18

This option would form an access to the park and ride site from the A11 (West) including a left-turn link from the park and ride site towards Hethersett on the B1172. This would remove all traffic currently turning left on the A11 (West) at the Thickthorn Interchange travelling towards either the park and ride site or Hethersett on the B1172. There are currently 128 PCUs carrying out this manoeuvre in the AM Peak and 50 PCUs in the PM Peak.

Table 7.9: Thickthorn Interchange– 2017 Option 18

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**100**	**18**	44	3
	A47 (N) ahead / 102	83	8	61	5
	A47 (N) ahead/right / 103	83	8	61	5
	Circulatory at A47 (N) nearside / 104	**100**	**37**	59	7
	Circulatory at A47 (N) middle lane / 105	89	11	34	2
	Circulatory at A47 (N) offside / 106	50	9	45	6
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road nearside / 205	24	0	15	0
	Circulatory at Newmarket Road middle lane left / 202	42	0	31	0
	Circulatory at Newmarket Road middle lane ahead / 203	33	0	25	0
	Circulatory at Newmarket Road offside / 204	9	0	7	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	40	4	58	6
	A11 (E) ahead / 302	68	8	74	10
	A11 (E) ahead/right / 303	67	8	74	10
	A11 (E) right / 304	30	3	35	3
	Circulatory at A11 (E) nearside / 305	58	14	58	15
	Circulatory at A11 (E) offside / 306	86	16	82	13
4 – A47 (S)	A47 (S) left / 401	**93**	**16**	78	9
	A47 (S) ahead/left / 402	84	13	71	8
	A47 (S) ahead/right / 403	59	7	42	4
	Circulatory at A47 (S) nearside / 404	96	21	82	7
	Circulatory at A47 (S) middle lane / 405	79	8	76	6
	Circulatory at A47 (S) offside / 406	42	3	38	2
5 - A11 Newmarket Road (W)	A11 (W) left / 501	38	4	45	5
	A11 (W) ahead / 502	58	15	28	6
	A11 (W) right / 503	**90**	**19**	87	17
	Circulatory at A11 (W) nearside / 504	74	6	86	10
	Circulatory at A11 (W) middle lane / 505	66	7	65	8
	Circulatory at A11 (W) offside / 506	88	7	50	2
6 – B1172 Norwich Road	B1172 left / 601	18	0	22	0
	B1172 ahead / 602	62	3	33	0
	B1172 ahead/right / 603	44	1	33	0

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	Circulatory at B1172 nearside / 604	33	0	41	2
	Circulatory at B1172 middle lane / 605	34	0	16	0
	Circulatory at B1172 middle lane / 606	58	4	31	0
	Circulatory at B1172 offside / 607	54	12	50	11
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	54	15	56	9
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	27	3	33	4

This option improves the operation of the A11 West left turn approach. The DoS and MMQ on this approach is predicted to decrease from 50% and 6 PCUs to 38% and 4 PCUs in the AM Peak and from 50% and 6 PCUs to 45% and 5 PCUs in the PM Peak. These improvements in the operation of the junction are minimal and all other approaches are relatively unaffected.

7.9 Traffic Summary

7.9.1 Existing Layout 2012 Results

Thickthorn Interchange, in its current layout is operating **within** capacity in 2012. There are two links that are approaching capacity, namely:-

- A47 North – left turn (Link 101); and
- Circulatory lane on the approach to the A47 North (Link 104).

Round House Way Roundabout, in its current layout is operating **over** capacity in 2012. The A11 west (eastbound) approach is operating over capacity with a maximum RFC of 0.909 and a queue of 9 vehicles.

7.9.2 Do-minimum 2017 Results

Thickthorn Interchange, in its current layout would operate **over** capacity in 2017 during the AM peak period but would operate **within** capacity in the PM peak period. There are three nodes that are operating over capacity, namely:-

- A47 North approach (Node 1);
  - A47 (N) left turn lane (link 101) is 100%; and
  - nearside circulatory at the A47 (N) lane has a DoS of 100%.
- A47 South approach (Node 4);
  - A47 (S) left turn lane has a DoS of 93%; and
  - nearside circulatory at this approach has a DoS of 96%;
- A11 West approach (Node 5);
  - A11 (W) right turn lane is over capacity with a DoS of 96%.

Round House Way Roundabout is predicted to operate over capacity in 2017 in the AM Peak with a maximum RFC of 1.055 on the A11 Newmarket Road West approach. However, the roundabout is

predicted to operate within capacity in the PM Peak with a maximum RFC of 0.847 on the Newmarket Road West approach but it is acknowledged that this is close to its operational capacity.

7.9.3 Do-minimum Options

The modelling results of the Do-minimum Options assessed with opening year (2017) flows are summarised in Table 7.10 below. The table provides a high level indication of the modelling outputs in terms of operational capacity and queuing, and also an indication whether an option is considered suitable as a Do-minimum option, or an option that can be a 'bolt on' to the Do something options.

Table 7.10: Do Minimum Option Results

Option Reference	Degree of Saturation %	Queue lengths PCUs	Commentary
11	Significant increase	Significant increase	Adversely affects general traffic on the circulatory carriageway of Thickthorn interchange and can only be implemented with other improvements.
15	Moderate decrease	No change	This improvement only targets the A47 South onslip. Therefore it is considered that this would achieve a low VFM score.
16	No change	No change	Modelling indicates that this approach does not experience delay or queuing in either peak periods. Therefore buses should not experience queuing or delays when travelling on this approach
17	Moderate decrease	Moderate decrease	This improvement directly improves the operational capacity of the A47 South off-slip and also the interchange as a whole.
18	Minor decrease	Minor decrease	This option negligibly improves the operational capacity of the A11 West approach with no improvement to the operational capacity of the junction.

From Table 7.10 above it can be seen that Option 15 and Option 17 offer moderate improvements to the operational capacity of the junction in their locality. Whilst Option 15 does offer a moderate improvement on the A47 (south) on-slip it is likely to achieve a low VFM score due to the necessary widening works on the on-slip and therefore only Option 17 should be progressed as a Do minimum option. Options 16 and 18 would only provide a minor improvement to the operational capacity of the junction and therefore it is considered that they too would achieve a low VFM score and should not be progressed further.

Option 11 significantly reduces the operational capacity of Thickthorn interchange because it removes a general traffic lane and re-allocates it to bus only. Whilst this would achieve a low VFM score it would achieve the Promoter's aspiration to promote bus priority at the interchange. This option could only be

implemented if surplus capacity was created on the circulatory of the interchange (i.e. implemented with a DO-something option).

7.10 Do-Something Options

The Do-something options are those that can considerably increase the operational capacity of the interchange and are most likely able to meet the growth envisaged in the JCS.

7.10.1 Design Year Flows (2032)

Table 7.11: TRANSYT - Thickthorn Interchange existing junction

		AM Peak		PM Peak	
Node	Approach / Link	DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**107**	**31**	49	4
	A47 (N) ahead / 102	88	11	68	6
	A47 (N) ahead/right / 103	88	11	68	6
	Circulatory at A47 (N) nearside / 104	**133**	**229**	81	17
	Circulatory at A47 (N) middle lane / 105	84	16	46	2
	Circulatory at A47 (N) offside / 106	59	5	54	4
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road nearside / 205	25	0	20	0
	Circulatory at Newmarket Road middle lane left / 202	39	0	24	0
	Circulatory at Newmarket Road middle lane ahead / 203	37	0	32	0
	Circulatory at Newmarket Road offside / 204	10	0	9	0
3 – A11 Newmarket Road (E)	A11 (E) left / 301	50	5	70	9
	A11 (E) ahead / 302	86	12	89	16
	A11 (E) ahead/right / 303	86	12	89	16
	A11 (E) right / 304	38	3	42	4
	Circulatory at A11 (E) nearside / 305	63	20	71	21
	Circulatory at A11 (E) offside / 306	92	18	93	17
4 – A47 (S)	A47 (S) left / 401	**106**	**43**	**106**	**34**
	A47 (S) ahead/left / 402	96	21	96	18
	A47 (S) ahead/right / 403	68	9	58	6
	Circulatory at A47 (S) nearside / 404	**121**	**126**	**103**	**46**
	Circulatory at A47 (S) middle lane / 405	90	11	96	20
	Circulatory at A47 (S) offside / 406	48	4	48	3
5 - A11 Newmarket	A11 (W) left / 501	54	7	66	9

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
Road (W)	A11 (W) ahead / 502	63	17	38	8
	A11 (W) right / 503	**98**	**30**	**116**	**96**
	Circulatory at A11 (W) nearside / 504	95	14	**105**	**49**
	Circulatory at A11 (W) middle lane / 505	85	10	79	11
	Circulatory at A11 (W) offside / 506	114	48	61	7
6 – B1172 Norwich Road	B1172 left / 601	22	0	31	0
	B1172 ahead / 602	75	5	47	1
	B1172 ahead/right / 603	56	2	46	1
	Circulatory at B1172 nearside / 604	38	0	52	3
	Circulatory at B1172 middle lane / 605	39	0	21	0
	Circulatory at B1172 middle lane / 606	63	5	40	0
	Circulatory at B1172 offside / 607	62	17	56	16
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	62	12	67	12
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	31	3	43	5

The results show that the Thickthorn Interchange is predicted to operate over capacity on a number of approaches in both the AM and PM Peaks in 2032.

Table 7.12: ARCADY - A11 New Market Road / Round House Way existing junction

Approach	AM Peak		PM Peak	
	Maximum RFC	Queue (Vehicles)	Maximum RFC	Queue (Vehicles)
Round House Way	1.014	18	0.925	10
A11 Newmarket Road (East)	0.729	3	1.099	140
A11 Newmarket Road (West)	**1.211**	**323**	0.668	2

The results show that the A11 New Market Road / Round House Way roundabout is predicted to operate over capacity on the A11 Newmarket Road (West) approach in the AM Peak and on the A11 Newmarket Road (East) approach in the PM Peak in 2032.

7.10.2 Option 13

To model this option, the traffic flows travelling from the A11 West approach to the A11 East approach have been removed from the TRANSYT model. As discussed in Section 7.9.3 Options 11, and 17 will be added to this option to further enhance its operational improvements whilst improving bus priority at the interchange.

ARCADY modelling software has indicated that the level of carriageway provision for a fourth arm on Round House Way roundabout in order to accommodate this re-routing traffic requires the following geometries:-

Table 7.13: A11 New Market Road / Round House Way Four Arm Roundabout Amended Geometries

	Approach Road Half Width	Entry Width	Flare Length	Entry Radius	Diameter
Round House Way	-	-	-	-	-
A11 Newmarket Road (East)	10	13	35	-	-
A11 Newmarket Road (West)	-	-	-	-	-
Bypass Approach	10	13	40	35	86

Table 7.14: ARCADY - A11 New Market Road / Round House Way Four Arm Roundabout

	AM Peak		PM Peak	
Approach	Maximum RFC	Queue (Vehicles)	Maximum RFC	Queue (Vehicles)
Round House Way	0.000	0	0.000	0
A11 Newmarket Road (East)	0.565	1	0.853	6
A11 Newmarket Road (West)	0.777	3	0.475	1
Bypass Approach	**0.880**	**7**	0.372	1

It can be seen in Table 7.14 above that the A11 New Market Road / Round House Way Four Arm Roundabout it just exceeding its operational capacity in 2032.

Table 7.15: TRANSYT - Thickthorn Interchange

		AM Peak		PM Peak	
Node	Approach / Link	DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	**63**	**8**	34	8
	A47 (N) ahead / 102	**95**	**14**	86	8
	A47 (N) ahead/right / 103	**95**	**13**	86	8
	Circulatory at A47 (N) nearside / 104	**2**	**0**	2	0
	Circulatory at A47 (N) middle lane / 105	82	18	49	3
	Circulatory at A47 (N) offside / 106	58	11	57	9
201 – Newmarket Road	Newmarket Road / 201	3	0	2	0
	Circulatory at Newmarket Road middle lane left / 202	32	0	18	0
	Circulatory at Newmarket Road middle lane ahead / 203	37	0	35	0
	Circulatory at Newmarket Road	10	0	9	0

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
	offside / 204				
3 – A11 Newmarket Road (E)	A11 (E) left / 301	60	3	65	5
	A11 (E) ahead / 302	53	3	59	5
	A11 (E) ahead/right / 303	55	3	84	9
	A11 (E) right / 304	89	7	77	7
	Circulatory at A11 (E) nearside / 305	47	6	55	17
	Circulatory at A11 (E) offside / 306	69	17	64	12
4 – A47 (S)	A47 (S) left / 401	**76**	**19**	**76**	**16**
	A47 (S) ahead/left / 402	40	4	39	3
	A47 (S) ahead/right / 403	56	7	48	5
	Circulatory at A47 (S) nearside / 404	**67**	**9**	**34**	**6**
	Circulatory at A47 (S) middle lane / 405	50	7	70	6
	Circulatory at A47 (S) offside / 406	58	8	55	3
5 - A11 Newmarket Road (W)	A11 (W) left / 501	62	8	73	11
	A11 (W) ahead / 502	36	8	29	6
	A11 (W) right / 503	**55**	**7**	**66**	**9**
	Circulatory at A11 (W) nearside / 504	42	4	**54**	**10**
	Circulatory at A11 (W) middle lane / 505	64	8	68	10
	Circulatory at A11 (W) offside / 506	86	7	53	3
6 – B1172 Norwich Road	B1172 left / 601	18	0	28	0
	B1172 ahead / 602	61	1	42	0
	B1172 ahead/right / 603	43	1	43	1
	Circulatory at B1172 nearside / 604	16	0	34	0
	Circulatory at B1172 middle lane / 605	21	0	17	0
	Circulatory at B1172 middle lane / 606	57	7	48	7
	Circulatory at B1172 offside / 607	30	2	34	5
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	62	3	73	9
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	31	3	43	5

The results for the bypass option show the Thickthorn roundabout is predicted to operate within capacity on all approaches in the AM and PM Peak with the exception of the A47 (N) approach. The DoS on this approach is predicted to be 95% on both the middle and offside lanes.

7.10.3 Option 20

The success of this option hinges upon whether Round House Way roundabout can accommodate the additional traffic that is re-routed around it. Therefore to ascertain if this option worked, the Round House Way Roundabout was modelled in ARCADY with the re-routed traffic from Thickthorn Interchange undertaking a u-turn manoeuvre. The modelling results are shown in Table 7.16 below.

Table 7.16: ARCADY - A11 New Market Road / Round House Way existing junction

	AM Peak		PM Peak	
Approach	Maximum RFC	Queue (Vehicles)	Maximum RFC	Queue (Vehicles)
Round House Way	0.000	0	0.000	0
A11 Newmarket Road (East)	0.836	5	1.439	450
A11 Newmarket Road (West)	**1.808**	**2209**	1.318	588

It can be seen from Table 7.16 above that Round House Way roundabout cannot accommodate this additional re-assigning traffic from Thickthorn Interchange. There are two solutions to this problem, either upgrade the existing Round House Way Roundabout, or pursue the improvements proposed in Option 21. It is considered that the necessary improvements to Round House Way roundabout will have constructability issues because the roundabout is so over capacity. Therefore this option is discounted at this stage in favour of progressing Option 21.

7.10.4 Option 21

As discussed in Section 7.9.3 Options 11 and 17 will be added to this option to further enhance its operational improvements whilst improving bus priority at the interchange.

Table 7.17: TRANSYT - Thickthorn Interchange

		AM Peak		PM Peak	
Node	Approach / Link	DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
1 – A47 (N)	A47 (N) left / 101	88	12	34	3
	A47 (N) ahead / 102	**133**	**67**	86	8
	A47 (N) ahead/right / 103	**132**	**66**	86	8
	Circulatory at A47 (N) nearside / 104	3	0	3	0
	Circulatory at A47 (N) middle lane / 105	**91**	**15**	80	18
	Circulatory at A47 (N) offside / 106	**101**	**45**	**93**	**10**
	Circulatory at A47 (N) middle lane / 107	**103**	**53**	56	7
3 – A11	A11 (E) / 301	68	23	90	43

Node	Approach / Link	AM Peak		PM Peak	
		DoS (%)	MMQ (PCUs)	DoS (%)	MMQ (PCUs)
Newmarket Road (E)	Circulatory at A11 (E) nearside / 305	76	17	**97**	**33**
	Circulatory at A11 (E) offside / 306	**94**	**18**	**115**	**69**
4 – A47 (S)	A47 (S) left / 401	**96**	**30**	**97**	**27**
	A47 (S) ahead/left / 402	50	5	51	4
	A47 (S) ahead/right / 403	71	9	61	6
	Circulatory at A47 (S) nearside / 404	**103**	**41**	**95**	**25**
	Circulatory at A47 (S) middle lane / 405	81	8	90	17
	Circulatory at A47 (S) offside / 406	41	3	44	6
5 - A11 Newmarket Road (W)	A11 (W) left / 501	60	8	59	8
	A11 (W) ahead / 502	71	21	34	7
	A11 (W) right / 503	**110**	**78**	**104**	**52**
	Circulatory at A11 (W) nearside / 504	45	4	**79**	**13**
	Circulatory at A11 (W) middle lane / 505	60	7	**96**	**15**
	Circulatory at A11 (W) offside / 506	**90**	**10**	77	4
6 – B1172 Norwich Road	B1172 left / 601	22	0	31	0
	B1172 ahead / 602	75	6	47	1
	B1172 ahead/right / 603	56	2	48	1
	Circulatory at B1172 nearside / 604	38	0	52	2
	Circulatory at B1172 middle lane / 605	40	5	21	0
	Circulatory at B1172 middle lane / 606	67	7	40	0
	Circulatory at B1172 offside / 607	56	15	63	17
7 – Crossing on A47 (S) exit	A47 (S) ahead / 3001	58	6	71	10
8 – Crossing on A47 (N) exit	A47 (N) ahead / 6001	31	3	43	5

The results show that this option is predicted to operate over capacity in both the AM and PM Peaks with a number of approaches with a DoS of above 90% and some above 100%.

7.11 Do-Something Modelling Summary

The modelling results of the DO-Something options modelled in the Design Year 2032 can be seen in the above section of the report. The key findings of this modelling exercise are as follows:-

- The **existing** Thickthorn Interchange is predicted to operate over capacity on a number of approaches in both the AM and PM Peaks;
- The **existing** A11 New Market Road / Round House Way roundabout is predicted to operate over capacity on the A11 Newmarket Road (West) approach in the AM Peak and on the A11 Newmarket Road (East) approach in the PM Peak;
- Thickthorn interchange as per **Option 13 (Bypass Option)** is predicted to operate within capacity on all approaches in the AM and PM Peak with the exception of the A47 (N) approach. The DoS on this approach is predicted to be 95% on both the middle and offside lanes;
- The A11 New Market Road / Round House Way Four Arm Roundabout in association with **Option 13 (Bypass Option)** is just exceeding its operational capacity in 2032;
- The A11 New Market Road / Round House Way roundabout as per **Option 20 (Teardrop Option)** cannot accommodate the additional re-assigned traffic from Thickthorn Interchange and is significantly over capacity. Therefore it is considered that the necessary junction upgrades to accommodate this additional traffic would not achieve a good VFM; and
- **Option 21 (Teardrop variant)** is predicted to operate over capacity in both the AM and PM Peaks with a number of approaches with a DoS of above 90% and some above 100%.

The option that performs best in traffic terms is option 13 the (bypass option). The do-something models are adversely affected by the bus lane provision on the circulatory carriageway because this removes a general traffic lane. If this were removed all options would perform better operationally, but would not meet the Promoter's aspirations of bus priority provision.

Whilst option 13 (bypass option) performs better operationally, it is important to appraise both Do-something options holistically and therefore the options will be assessed in the following chapter

8 Appraisal Framework

8.1 Categories and Scoring Assessment

To demonstrate that the two do-something options have been considered objectively, they have been appraised in accordance with the Department for Transport's Transport Analysis Guidance (TAG) using the New Approach to Transport Appraisal (NATA) methodology. The guidance provides a framework for assessing schemes against the Government's objectives for transport namely:

- Environment;
- Safety;
- Economy;
- Accessibility; and
- Integration.

The above objectives (assessment criteria) have been included in an Appraisal Summary Table (AST) which allows all options to be compared against each other on a consistent basis. In addition to the Government's Transport Objectives we have added Deliverability, Acceptability and fit with the Promoter's Objectives.

The options considered within the various studies are presented later in this report which includes a description of the option, a schematic, key considerations, a table of their associated advantages and disadvantages and a summary of the options' viability. An AST has been prepared to appraise the short listed options.

Table 8.1: Appriasal Summary Table

Category	Option 1	Option 2	Option 3
Accessibility			
Safety			
Economy			
Integration			
Acceptability			
Deliverability			
Promoter's Objectives			
Promoted / Rejected			

Source: Mott MacDonald

All options have been appraised against the above categories, and if sufficient information was available, they were also scored against the sub-categories using the following matrix.

Scoring Matrix

Adverse	Slight Adverse	Neutral	Slight Benefit	Benefit

It should be noted that the scoring matrix is a comparative scale used to differentiate options and does not necessarily imply detrimental impacts.

8.2 Accessibility

This NATA objective is to improve access to facilities for those without private transport and to reduce severance. Improving access has been considered by means of a high level and subjective review of points of access including the following:

- To improve access to the transport system;
- To increase option values; and
- To reduce severance.

8.3 Safety

This NATA objective is to reduce the loss of life, injuries and damage resulting from collisions and associated crime. It is also concerned with personal security through both design and the location of facilities. The measures for this objective are:

- To reduce accidents; and
- To improve security.

8.4 Economy

This NATA objective is to support sustainable economic activity and delivery of VFM. A high level indication on the capital cost of the scheme can be provided based on the estimates provided in the respective reports.

8.5 Environment

This NATA objective is to protect and enhance the built and natural environment. It includes direct and indirect impacts locally, and while some can be quantified, others are more difficult to define. At this early stage of the options' development it is not possible to assess certain measures; however all of the environment objectives are listed below for reference:

- To reduce noise;
- To protect and enhance the landscape;
- To protect heritage of historic resources: this criteria has been scoped out of this assessment;
- To protect the water environment;
- To encourage physical fitness: this has been scoped out of this assessment because neither option has an impact on this criteria;
- To improve journey ambience; and
- To improve air quality and to reduce green house gases.

It is assumed that for all options considered in this appraisal, best practise methods and appropriate mitigation will be applied.

In terms of the environment, the comparison of the do-something options has focussed on qualitative information and professional judgement rather than quantitative information.

8.6 Integration

This NATA objective is to ensure that the scheme takes cognisance of the government's integrated transport policy, more specifically:

- Transport interchange – improving modal interchange at the adjacent park and ride site; and
- Land use policy – any designs should be appropriate for future local, regional and national land use policies i.e. how well would the proposed upgrades would serve the surrounding land uses.

8.7 Other Criteria

In addition to the Government's core objectives for transport appraisal above, the guidance for the appraisal process also recommends the consideration of supporting analyses for practicality (deliverability), public acceptability and scheme objectives.

8.7.1 Deliverability

This supporting appraisal area considers the procurement, monitoring and delivery issues for the scheme, generally covering project governance and risk considerations; ensuring that the scheme takes cognisance of how it will be implemented and delivered, specifically:

- Disruption during construction;
- Programme risks and how they will be managed; and
- Scheme outturn cost risks and their management.

8.7.2 Acceptability

The acceptability of the scheme to the public, stakeholders and politically requires careful consideration and management. In addition to engagement with key stakeholders and consultation with the general public, the appraisal should also consider the degree of strategic and local government support for the scheme. It is likely to include high level consideration of:

- Alignment of the scheme objectives and outcomes against the policy context, the national, regional and local area objectives and aspirations (strategic fit);
- Testing of acceptability of the solution through consultation with stakeholders and the public;
- Impacts on third parties (such as land acquisition); and
- Disruption during construction and likely mitigation measures.

8.7.3 Promoters Objectives

The ASTs also consider how the options meet the Promoter's Objectives, namely:-

- To enable Thickthorn Interchange to accommodate additional traffic arising from planned growth in the Norwich area; and
- To enhance bus priority through the interchange to meet the aspirations of local bus operators and also to promote sustainable transport.

8.8 Do-Something Option Appraisal Summary Table

The Do-something options are appraised in the Table 8.1 below.

Table 8.2: Appriasal Summary Table

Category		Option 13 (Bypass Option)	Option 21 (Tear Option Variant)
Accessibility		This option has the potential to reduce severance by providing a means of access which bypasses the congested Thickthorn Interchange which could cater for pedestriansand cyclists. Furthermore this could enhance access to the adjacent park and ride site. Both options create opportunities to release adjacent land parcels for development.	Both options create opportunities to release adjacent land parcels for development.
Safety		Both options reduce congestion at the interchange and therefore would remove the start-stop characteristics of queuing vehicles which in turn may reduce shunt type collisions.	Both options reduce congestion at the interchange and therefore would remove the start-stop characteristics of queuing vehicles which in turn may reduce shunt type collisions.
Economy		Both options contribute towards improved economic activity since they can accommodate the potential growth in traffic. However Option 13 performs better than Option 21.	This option is considered to be cheaper than Option 13 since this option does not involve the construction of underpass, underneath the A47. Both options contribute towards improved economic activity since they can accommodate the potential growth in traffic. However Option 13 performs better than Option 21.
Environment	Noise	Both options provide an alignment that runs near to residential properties which may increase the level of noise pollution that these dwelling would be exposed to. However these impacts could be mitigated with the provision of noise barriers and/or landscaping.	Both options provide an alignment that runs near to residential properties which may increase the level of noise pollution that these dwelling would be exposed to. However these impacts could be mitigated with the provision of noise barriers and/or landscaping.
	Landscape	Both options provide an alignment that runs near to residential properties which has a visual impact on the landscape surrounding these properties. However these impacts could be mitigated with the provision of tree planting and landscaping.	Both options provide an alignment that runs near to residential properties which has a visual impact on the landscape surrounding these properties. However these impacts could be mitigated with the provision of tree planting and landscaping
	Water Environment	With the exception of the attenuation pond next to Round House Way roundabout, there are no water courses in the immediate vicinity of the Interchange.	With the exception of the attenuation pond next to Round House Way roundabout, there are no water courses in the immediate vicinity of the Interchange.
	Journey Ambience	Both options improve journey ambience for motorists travelling through the junction since congestion and delay will be reduced. Option 13 performs better in traffic terms and will reduce congestion greater than option 21.	Both options improve journey ambience for motorists travelling through the junction since congestion and delay will be reduced.
	Air Quality	Both options reduce congestion levels at the junction and therefore minimise the stop-start characteristics that are associated with increased levels of air pollution.	Both options reduce congestion levels at the junction and therefore minimise the stop-start characteristics that are associated with increased levels of air pollution.

Category	Option 13 (Bypass Option)	Option 21 (Tear Option Variant)
		This option marginally increases the journey distance that a significant volume of traffic would undertake and there this is likely to increase the levels of air pollution at the junction.
Integration	This option enhances public transport provision in terms of priority and improved access.	This option enhances public transport provision in terms of priority but not to the same extent as option 13.
Acceptability	Both options come in close proximity to a number of residential properties that are likely to experience adverse effects as a consequence of the option.	Both options come in close proximity to a number of residential properties that are likely to experience adverse effects as a consequence of the option.
Deliverability	The majority of construction takes place off carriageway and the impacts to general traffic can be managed and mitigated. However, the construction of the A47 underpass poses the biggest risk to the option.	The majority of construction takes place off carriageway and the impacts to general traffic can be managed and mitigated. The method of construction is relatively straight forward.
Promoter's Objectives	Wholly meets the aspirations of the Promoter.	Goes towards meeting the Promoter's aspirations but does not perform as well as Option 13.

From Table 8.1 above it can be seen that Option 13 (Bypass Option) performs best overall. Whilst there are some adverse impacts on adjacent residential dwellings it is considered that with appropriate mitigation that these impacts could be reduced.

9 Conclusion

9.1 Conclusion

The following conclusions were made based on the outcome of the traffic assessment of the Do-minimum and Do-something options.

9.1.1 Do-minimum

Option 15 and Option 17 offer moderate improvements to the operational capacity of the junction in their locality. Whilst Option 15 does offer a moderate improvement on the A47 (south) on-slip it is likely to achieve a low VFM score due to the necessary widening works on the on-slip and therefore only Option 17 should be progressed as a Do minimum option. Options 16 and 18 would only provide a minor improvement to the operational capacity of the junction and therefore it is considered that they too would achieve a low VFM score and should not be progressed further.

Option 11 significantly reduces the operational capacity of Thickthorn interchange because it removes a general traffic lane and re-allocates it to bus only. Whilst this would achieve a low VFM score it would achieve the Promoter's aspiration to promote bus priority at the interchange. This option could only be implemented if surplus capacity was created on the circulatory of the interchange (i.e. implemented with a DO-something option).

9.1.2 Do something

Option 13 offers a significant improvement in the operational capacity of the Thickthorn Interchange. The A11 Newmarket Road (East) approach to the Roundhouse Way roundabout would require widening to operate within capacity.

Option 20 is not considered a suitable solution as the Roundhouse Way roundabout junction cannot accommodate the additional u-turning traffic.

Option 21 offers some improvement to the operational capacity of the Thickthorn Interchange but the removal of the general traffic lane on the northern circulatory for a bus only lane has detrimental impacts on the operation of the junction in particular in the AM Peak.

9.1.3 Appraisal Summary Table

The Do-something options were appraised in Section **Error! Reference source not found.** using the Department for Transport's Appraisal Criteria. This assessment indicated that Option 13 (Bypass Option) was the best performing option.

Appendices

Appendix A. Traffic Count Data

Appendix B. Traffic Growth Factors