A1(M) Junction 47 Study – Stage 3

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1.0 Introduction

CH2M have been commissioned by Highways England to undertake a study at Junction 47 of the A1(M) [Jn 47] which is a four-arm grade separated roundabout that connects the Strategic Road Network [SRN] with the primary road network, in the form of the A59, approximately seven miles east of Harrogate. Jn 47 has been identified through planning applications, Harrogate District Local Plan [HDLP] assessment work and the Local Enterprise Partnership [LEP] as a significant constraint to development in the area. The junction already exhibits peak hour queues and delays.

North Yorkshire County Council [NYCC] supported by the LEP successfully bid through the Local Growth Fund for money to implement a junction improvement at Jn 47. The scheme includes:

- Traffic signals on all approaches to Jn 47 of the A1(M).
- Widening on all approaches in order to accommodate left turn flares on both diverge slips, and to increase the length of both right turn flares on the A59 approaches.
- Three lane circulatory carriageway at both the north-east and south-west corners of the junction, in order to reduce conflict between exiting and queueing vehicles. Widening is needed to accommodate the introduction of a third lane.

In addition, NYCC are proposing to fund:

- The introduction of traffic signals on the A59 at the junction with the A168 Link Road including islands which are proposed to house the required signal infrastructure. Minimal kerbline changes are required at this junction.

  For the remainder of this note the above schemes will be referred to as the LEP scheme.

1.1 Purpose of this Study

Highways England is therefore looking to undertake a study which will determine:

- how much capacity will be provided by the LEP scheme and when further improvements are likely to be required; and
- Interim and final solutions for junction improvements to accommodate future likely traffic levels.

This will help with the evidence base for the Local Plan and help determine the viability of the Local Plan, help determine a consistent approach to planning applications and secure appropriate contributions or junction improvements which are consistent with the long term vision for the junction.

It is considered important that the study is carried out with full involvement of Harrogate Borough Council [HBC], NYCC and the LEP to ensure that the outcomes can be supported by all parties.

The CH2M study is to be undertaken in three discrete stages. The remainder of this technical note presents the work undertaken and findings of Stage 3 of the study, the primary objective of which is

to establish what improvement measures are required at Jn 47 to adequately mitigate for the expected growth in traffic through the junction in 2035 future year. The findings of Stage 1 of the study were reported in the October 2016 technical note *A1(M) Junction 47 Study – Stage 1* (Document Ref 679066.AF.16.13 TN002). The Stage 2 findings were reported in the December 2016 technical note *A1(M) Junction 47 Study – Stage 2* (Document Ref 679066.AF.16.19 TN003).

1.2 Stage 3

The main elements of Stage 3 of the study are set out below.

- Undertake TRANSYT modelling assessments of potential improvement schemes at Jn 47 to understand whether they will work in capacity terms and mitigate the impact of the Harrogate District Local Plan (2035 assessment).
- There are two potential mitigation schemes which only differ by whether they include 2 or three lane circulatory carriageways on the over bridges of the A1(M). Both schemes include:
    - two lanes widening to three lanes between the new Flaxby Hotel roundabout and Jn 47;
    - two lane exit from Jn 47 eastbound through the signals with the A168 link road including widening of the bridge over the A168; and,
    - two westbound lanes on the A59 approach from York from before the signals with the link road to Jn 47.
- During the modelling process, additional changes will be made to the mitigation proposals if required.
- Consideration will be given to whether the preferred scheme can be delivered in stages and the level of development each stage of the scheme could deliver.
- Identify potential land requirements (undertaken by HBC and reported separately to this note).
- Estimate indicative costs for schemes that work in capacity terms and can be delivered in land requirement terms (undertaken by HBC and reported separately to this note).

2.0 Mitigation Options 1 and 2 – TRANSYT Assessments

Mitigation Options 1 and 2 have been assessed using TRANSYT v15 software. The methodology used in determining the 2035 future year flows of the assessment is described in the October 2016 Stage 1 report preceding this note. The mitigation schemes have been assessed against both of the Harrogate Local Plan growth scenarios currently being considered. The main elements of the Option 1 and Option 2 mitigation schemes are described above. Option 1 did not include for any widening on the northern and southern circulatory carriageway sections, which pass over the A1(M) carriageway. Option 2 included widening of the northern and southern circulatory carriageway from two to three lanes.

The TRANSYT capacity and queue length outputs for the Option 2 mitigation proposals (Flaxby and Hammerton flow assessment scenarios) are presented in Tables 1 and 2 respectively. It became clear during the modelling process that neither of the identified improvement schemes would adequately mitigate the predicted 2035 traffic flows at Jn 47; the capacity and queue length outputs for Option 1 are therefore not presented within this note, given that the Option 2 mitigation represents the higher capacity improvement and, therefore, provides the better capacity and queue length outcomes.

It can be seen from Tables 1 and 2 that the junction remains significantly over capacity in 2035, despite the Option 2 mitigation measures, resulting in significant residual queuing in both the AM and PM peak periods. The only junction approaches to be within capacity in all four flow scenarios modelled are the A59 westbound approaches to the A168 signalised junction and A1(M) Jn 47. The key considerations with regards to the sections which remain over capacity are summarised below:

- Queuing in the nearside lane of the circulatory carriageway at the A59 westbound entry (A59 York) extends back through the junction in all modelled scenarios, even at lower degrees of saturation (DoS). This 'blocking back' then acts to reduce the saturation flow of upstream approaches such as the A1(M) southbound off-slip (A1(M) North), the northern circulatory carriageway and the A59 eastbound approach to the junction (A59 Harrogate).
- It is considered that the extensive queuing in the nearside circulatory lane at A59 York is due to the high right turn movement (520 to 865 pcus) in all flow scenarios, between the A59 Harrogate and the A1(M) South, which is confined to a single circulatory lane, the feeds the single lane on-slip.
- The considerable queues in the nearside lane of the A59 York circulatory, associated with vehicles travelling to the A1(M) southbound, leads to an imbalance in the use of lanes at this location by vehicles turning right from the A1(M) North to the A59 Harrogate, with the majority of vehicles being located in the offside circulatory lanes. This in turn leads to an imbalance in flows(and queues) on the downstream southern circulatory link, for the two-lane exit towards the A59 Harrogate.

TABLE 1
2035 Option 2 TRANSYT Assessment Results (Flaxby Growth Assumption)

Flaxby Growth Scenario		Option 2			
		AM 2035		PM 2035	
Approach Arm	Lane	DoS	MMQ	DoS	MMQ
A59 Harrogate	Nearside Entry	62	7	72	10
A59 Harrogate	Middle Entry	77	11	79	12
A59 Harrogate	Offside Entry	162!	176	53	6
A59 Harrogate	NS & M Feeder Lane	92!	5	100!	23
Circ @ A59 Harrogate	Nearside	51	3	55	3
Circ @ A59 Harrogate	Offside	54	2	45	2
Circ @ A59 Harrogate	NS & OS Feeder Lane	92!	5	100!	23
A1(M) North	Nearside	33	2	32	2
A1(M) North	Offside	100!	25	100!	27
A1(M) North	Single Lane Approach	253!	242	154!	143
Circ @ A1(M) North	Nearside	30	4	33	4
Circ @ A1(M) North	Middle	70	1	81	13
Circ @ A1(M) North	Offside	100!	29	61	6
A59 York	Nearside	99!	27	93!	11
A59 York	Offside	96!	23	102!	43
Circ @ A59 York	Nearside	72	5	75	5
Circ @ A59 York	Offside	31	3	49	5
Circ @ A59 York	NS & OS Feeder Lane	100!	20	62	8
A1(M) South	Nearside	83	9	76	8
A1(M) South	Offside	66	6	63	6
A1(M) South	Single Lane Approach	47	0	47	0
Circ @ A1(M) South	Nearside	68	1	59	0
Circ @ A1(M) South	Middle	92!	13	100!	35
Circ @ A1(M) South	Offside	18	0	21	0
A168 Approach	Single Lane Approach	75	4	74	4
A59 WB Approach to A168	Nearside	61	7	49	5
A59 WB Approach to A168	Middle	60	7	52	5
A59 WB Approach to A168	Offside	12	3	14	1
A59 WB Approach to A168	Single Lane Approach	86	3	72	1
A59 EB Approach to A168	Nearside	35	2	38	3
A59 EB Approach to A168	Offside	71	4	73	5

TABLE 2
2035 Option 2 TRANSYT Assessment Results (Green Hammerton Growth Assumption)

Hammerton Growth Scenario		Option 2			
		AM 2035		PM 2035	
Approach Arm	Lane	DoS	MMQ	DoS	MMQ
A59 Harrogate	Nearside Entry	54	6	70	7
A59 Harrogate	Middle Entry	71	10	100!	40
A59 Harrogate	Offside Entry	49	6	56	6
A59 Harrogate	NS & M Feeder Lane	77	1	130!	252
Circ @ A59 Harrogate	Nearside	50	2	33	3
Circ @ A59 Harrogate	Offside	61	3	53	2
Circ @ A59 Harrogate	NS & OS Feeder Lane	77	1	130!	252
A1(M) North	Nearside	39	2	33	3
A1(M) North	Offside	100!	25	64	7
A1(M) North	Single Lane Approach	232!	220	37	0
Circ @ A1(M) North	Nearside	34	5	66	9
Circ @ A1(M) North	Middle	61	2	100!	34
Circ @ A1(M) North	Offside	42	1	63	2
A59 York	Nearside	100!	31	94!	13
A59 York	Offside	94!	22	90	11
Circ @ A59 York	Nearside	96!	11	62	4
Circ @ A59 York	Offside	39	4	56	5
Circ @ A59 York	NS & OS Feeder Lane	61	6	67	5
A1(M) South	Nearside	97!	15	92!	12
A1(M) South	Offside	69	6	64	5
A1(M) South	Single Lane Approach	45	0	44	0
Circ @ A1(M) South	Nearside	59	1	46	0
Circ @ A1(M) South	Middle	91!	15	92!	17
Circ @ A1(M) South	Offside	21	0	21	0
A168 Approach	Single Lane Approach	67	3	53	3
A59 WB Approach to A168	Nearside	75	11	56	6
A59 WB Approach to A168	Middle	71	10	53	6
A59 WB Approach to A168	Offside	12	3	16	1
A59 WB Approach to A168	Single Lane Approach	107!	78	72	1
A59 EB Approach to A168	Nearside	41	2	61	4
A59 EB Approach to A168	Offside	63	4	68	4

3.0 Mitigation Option 3 - TRANSYT Assessments

In response to the unresolved capacity and queuing issues identified in the Option 2 results outputs, further improvement measures have been identified in order to adequately mitigate the predicted 2035 flows through Jn 47. These measures are in addition to the improvements already identified within Option 2; this combined set of improvements are herein referred to as Option 3. The Option 3 mitigation scheme includes the following elements, in addition to those already identified in Option 2:

- provision of a two-lane exit from Jn 47 towards the A1(M) southbound carriageway;
- widening of the north-east circulatory carriageway to provide four traffic lanes; and,
- widening of the south-east circulatory carriageway to provide four traffic lanes.

The Option 3 improvements are shown annotated on a plan of the LEP scheme and attached as Appendix A to this note.

The TRANSYT capacity and queue length outputs for the Option 3 mitigation proposals (Flaxby and Hammerton flow assessment scenarios) are presented in Tables 3 and 4 respectively, with the key considerations summarised below:

- The majority of junction entries and circulatory carriageway operate within the theoretical capacity of 90% DoS.
- Some links, most notably on the southern circulatory carriageway are predicted to operate above the theoretical capacity slightly above 90% DoS. The resulting queues at these location are moderate and do not impact on upstream links.
- The only links within the model to operate above capacity are the single lane section of the A59 westbound approach to the A168 junction and the single lane of the A59 eastbound approach which eventually widens to form the nearside and middle lane entries at Jn 47; however, it is considered that these are link capacity issues associated with the carriageway standard of the wider A59 route. In reality, the 2035 modelled levels of flow on the A59 approaches to the junction would be restricted by the single carriageway (single lane) capacity of the adjacent A59 route.

It can therefore be determined that the Option 3 mitigation scheme, when considered in the context of Harrogate Borough Council pursuing the Flaxby or Hammerton settlement within its Local Plan, will operate within capacity in 2035, in both peak periods.

TABLE 3
2035 Option 3 TRANSYT Assessment Results (Flaxby Growth Assumption)

Flaxby Growth Scenario		Option 3			
		AM 2035		PM 2035	
Approach Arm	Lane	DoS	MMQ	DoS	MMQ
A59 Harrogate	Nearside Entry	83	14	82	13
A59 Harrogate	Middle Entry	53	5	62	7
A59 Harrogate	Offside Entry	69	10	50	5
A59 Harrogate	NS & M Feeder Lane	92!	5	100!	23
Circ @ A59 Harrogate	Nearside	53	2	68	3
Circ @ A59 Harrogate	Offside	56	3	54	3
Circ @ A59 Harrogate	NS & OS Feeder Lane	46	4	17	1
A1(M) North	Nearside	87	10	82	9
A1(M) North	Offside	52	4	50	4
A1(M) North	Single Lane Approach	41	0	40	0
Circ @ A1(M) North	Nearside	67	8	58	6
Circ @ A1(M) North	Middle	66	8	82	12
Circ @ A1(M) North	Offside	86	15	66	4
A59 York	Nearside	87	14	70	9
A59 York	Offside	84	14	74	10
Circ @ A59 York	Nearside	69	5	52	5
Circ @ A59 York	Middle 1	69	5	52	5
Circ @ A59 York	Middle 2	47	4	47	2
Circ @ A59 York	Offside	47	3	47	2
Circ @ A59 York	NS & M1 Feeder Lane	72	8	62	3
Circ @ A59 York	M2 & OS Feeder Lane	15	0	15	0
A1(M) South	Nearside	84	9	79	8
A1(M) South	Offside	87	9	74	7
A1(M) South	Single Lane Approach	47	0	47	0
Circ @ A1(M) South	Nearside	90!	14	86	9
Circ @ A1(M) South	Middle	90!	13	86	9
Circ @ A1(M) South	Offside	17	0	20	1
A168 Approach	Single Lane Approach	52	3	66	3
A59 WB Approach to A168	Nearside	67	9	50	5
A59 WB Approach to A168	Middle	65	8	53	5
A59 WB Approach to A168	Offside	16	3	16	1
A59 WB Approach to A168	Single Lane Approach	86	3	72	1
A59 EB Approach to A168	Nearside	63	3	51	2
A59 EB Approach to A168	Offside	61	3	68	2

TABLE 4
2035 Option 3 TRANSYT Assessment Results (Green Hammerton Growth Assumption)

Hammerton Growth Scenario		Option 3			
		AM 2035		PM 2035	
Approach Arm	Lane	DoS	MMQ	DoS	MMQ
A59 Harrogate	Nearside Entry	72	10	88	15
A59 Harrogate	Middle Entry	48	5	79	12
A59 Harrogate	Offside Entry	47	5	47	5
A59 Harrogate	NS & M Feeder Lane	77	1	103!	43
Circ @ A59 Harrogate	Nearside	55	3	46	2
Circ @ A59 Harrogate	Offside	68	4	75	4
Circ @ A59 Harrogate	NS & OS Feeder Lane	33	3	47	5
A1(M) North	Nearside	71	7	77	8
A1(M) North	Offside	46	4	38	3
A1(M) North	Single Lane Approach	39	0	37	0
Circ @ A1(M) North	Nearside	76	10	80	13
Circ @ A1(M) North	Middle	63	5	93!	18
Circ @ A1(M) North	Offside	61	5	55	6
A59 York	Nearside	89	18	67	9
A59 York	Offside	75	11	64	8
Circ @ A59 York	Nearside	67	4	49	5
Circ @ A59 York	Middle 1	67	4	49	5
Circ @ A59 York	Middle 2	58	5	44	2
Circ @ A59 York	Offside	71	5	44	2
Circ @ A59 York	NS & M1 Feeder Lane	41	1	44	1
Circ @ A59 York	M2 & OS Feeder Lane	22	1	12	0
A1(M) South	Nearside	70	6	46	4
A1(M) South	Offside	93!	12	81	9
A1(M) South	Single Lane Approach	45	0	43	0
Circ @ A1(M) South	Nearside	88	14	78	10
Circ @ A1(M) South	Middle	93!	21	78	9
Circ @ A1(M) South	Offside	21	0	24	1
A168 Approach	Single Lane Approach	78	4	73	4
A59 WB Approach to A168	Nearside	76	12	52	5
A59 WB Approach to A168	Middle	64	8	49	5
A59 WB Approach to A168	Offside	14	3	18	1
A59 WB Approach to A168	Single Lane Approach	107!	78	72	1
A59 EB Approach to A168	Nearside	59	4	66	14
A59 EB Approach to A168	Offside	50	7	74	16

4.0 Interim Layout - TRANSYT Assessments

TRANSYT modelling undertaken by CH2M has identified Option 3 as the most suitable scheme of improvement works to further increase the capacity of Jn 47, over and above the increase provided by the upcoming LEP scheme, and to adequately mitigate the full (2035) development impact of the Harrogate Local Plan. Upon identifying the longer term (2035) junction solution, CH2M undertook further TRANSYT analysis to determine if any elements of the Option 3 mitigation could be brought forward, as an interim measure to increase junction capacity in the period between the LEP scheme implementation (2017/18) and Option 3 works (2035). Table 5 presents the TRANSYT capacity and

queue length outputs for an interim improvement which brings forward the widening of the A59 eastbound approach element of the Option 3 proposals i.e. third entry lane to Jn 47 and two full lanes extending back to Flaxby roundabout. An iterative assessment was undertaken and the results of the final year (2027) in which all junction entry and circulatory links remained below a DoS of 100% are presented in Table 5. Beyond 2027, it is considered that all remaining elements of the full Option 3 mitigation scheme will be required simultaneously, with additional circulatory carriageway capacity being required to the eastern side of the junction for right turn movements from the A1(M) North and A59 Harrogate, and additional A59 eastbound capacity being required for eastbound movements continuing along the A59 through the junction.

The CH2M Stage 2 study (Document Ref 679066.AF.16.19 TN003) identified that a 100% DoS threshold gave an estimate of 2022 as an approximation of when further improvements will be required at Jn 47, beyond the improvements provided by the LEP scheme. It can therefore be determined that the widening of the A59 eastbound approach to Jn 47 would provide adequate capacity for an additional 5 years, to 2027. Under the Flaxby Growth Assumption, this is equivalent to Local Plan growth of 6,228 dwellings with 1,136 dwellings at Flaxby settlement and 126,795 sqm of employment, of which 31,600 sqm would be the Flaxby employment site. Under the Hammerton Growth Assumption, this is equivalent to Local Plan growth of 5,840 dwellings of which 881 dwellings would be on the Hammerton site and 126,795 sqm of employment, of which 31,600 sqm would be the Flaxby employment site.

TABLE 5

2027 A59 EB Widening Interim Option Assessment Results (Flaxby and Hammerton Growth Assumptions)

2027 Interim Network		A59 EB Widening							
		Flaxby AM		Flaxby PM		Hammerton AM		Hammerton PM	
Approach Arm	Lane	DoS	MMQ	DoS	MMQ	DoS	MMQ	DoS	MMQ
A59 Harrogate	Nearside Entry	36	3	43	4	35	3	43	4
A59 Harrogate	Middle Entry	75	10	77	11	77	11	84	14
A59 Harrogate	Offside Entry	52	5	38	3	46	5	36	3
A59 Harrogate	NS & M Feeder Lane	75	1	81	2	69	1	82	2
Circ @ A59 Harrogate	Nearside	55	3	60	3	44	2	53	2
Circ @ A59 Harrogate	Offside	58	2	48	3	48	3	60	3
Circ @ A59 Harrogate	NS & OS Feeder Lane	20	3	17	0	42	3	45	4
A1(M) North	Nearside	84	7	90	8	82	6	86	7
A1(M) North	Offside	91!	9	90	8	90!	9	86	7
A1(M) North	Single Lane Approach	34	0	35	0	34	0	34	0
Circ @ A1(M) North	Nearside	90	21	89	20	87	10	98!	28
Circ @ A1(M) North	Offside	52	3	38	6	42	2	34	2
A59 York	Nearside	95!	18	79	11	94!	19	72	8
A59 York	Offside	92!	16	85	13	85	14	73	8
A59 York	Single Lane Approach	70	1	61	0	83	6	61	0
Circ @ A59 York	Nearside	90	8	73	5	86	7	71	5
Circ @ A59 York	Offside	40	4	39	4	46	0	42	0
Circ @ A59 York	NS Feeder Lane	51	7	34	5	51	6	43	3
Circ @ A59 York	OS Feeder Lane	20	2	22	2	17	0	16	0
A1(M) South	Nearside	82	7	74	6	80	7	74	6
A1(M) South	Offside	82	7	74	6	80	7	74	6
A1(M) South	Single Lane Approach	36	0	37	0	35	0	35	0
Circ @ A1(M) South	Nearside	53	3	52	8	53	3	45	2
Circ @ A1(M) South	Offside	85	9	84	19	89	11	79	9
A168 Approach	Single Lane Approach	85	8	84	8	85	8	83	7
A59 WB Approach to A168	Nearside	85	17	73	15	95!	22	73	15
A59 WB Approach to A168	Offside	29	2	30	2	27	2	34	2
A59 WB Approach to A168	Single Lane Approach	79	18	65	6	91!	39	65	6
A59 EB Approach to A168	Single Lane Approach	85	25	84	34	83	24	93!	32

5.0 Conclusions

CH2M have undertaken a series of TRANSYT model junction capacity assessments in order to identify an appropriate set of improvement measures, that will mitigate the predicted (2035) impact of the Harrogate District Local Plan (Flaxby or Hammerton growth assumption) at Jn 47 and the adjacent A168 junction.

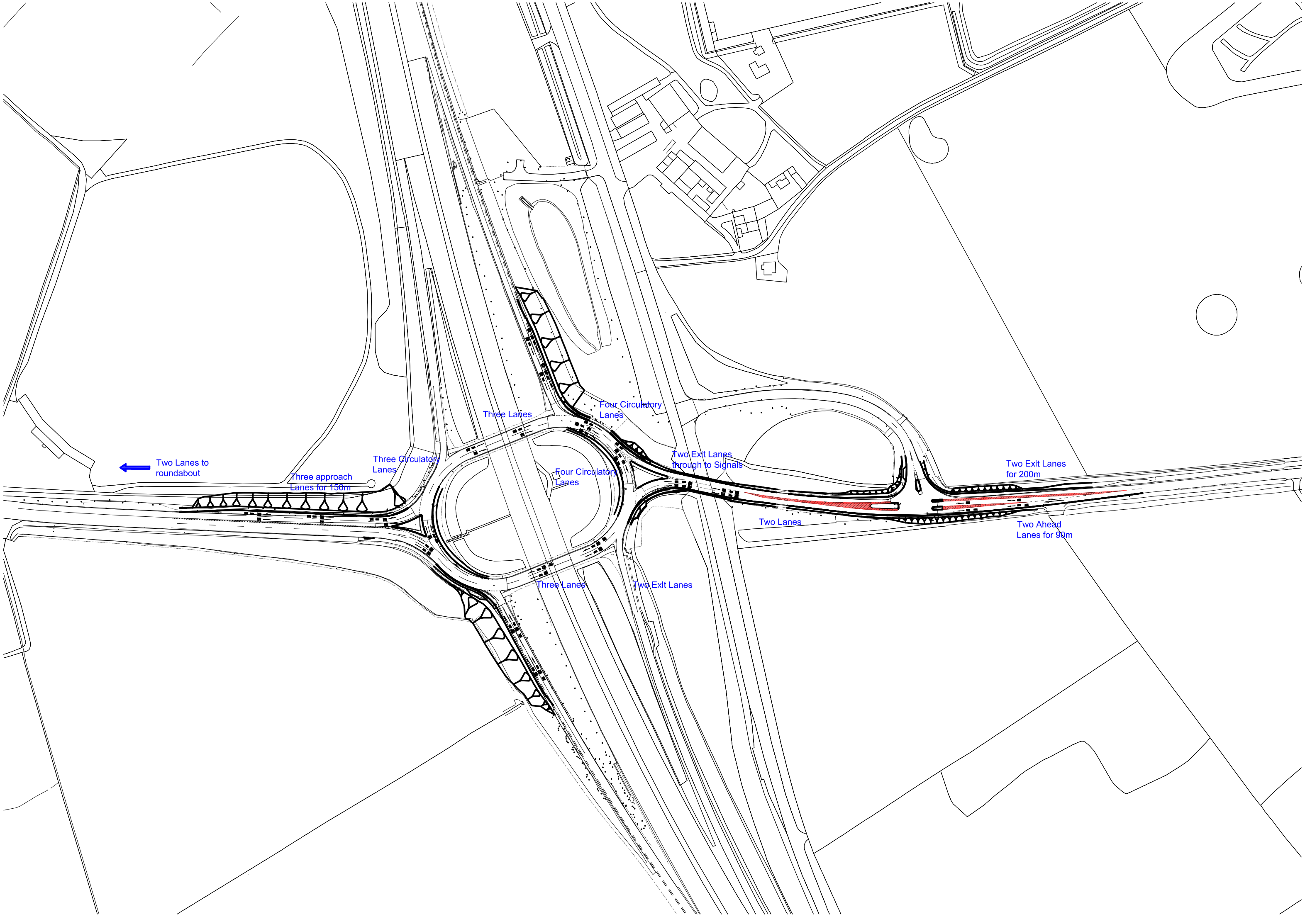
Two potential mitigation schemes, which differed by whether they included 2 or three lane circulatory carriageways on the over bridges of the A1(M), were initially assessed following an option identification workshop held in January 2017. The TRANSYT assessments indicated that neither option adequately mitigated for the impact of the predicted 2035 future year flows, with insufficient capacity on the eastern section of circulatory carriageway being a key residual issue. A third option was therefore developed, which incorporated the improvements of Option 2 with widening works on the eastern circulatory carriageway and southbound on-slip. Subsequent TRANSYT modelling has confrmed that Option 3 adequately mitigates for the impact of 2035 flows through the study area. It is therefore recommended that Option 3 is developed as the long term (to 2035) improvement option at A1(M) Jn 47 and the A168. The Option 3 improvement works briefly include the following measures, over and above the upcoming LEP scheme improvements:

- Widening to three lanes on the A59 eastbound entry to Jn 47, with a second approach lane commencing at the Flaxby roundabout;
- widening to three circulatory carriageway lanes on the over bridges of the A1(M);
- widening of the north-west circulatory carriageway to three lanes between the A59 eastbound entry and northern circulatory bridge;
- two lane exit from Jn 47 eastbound through the signals with the A168 link road including widening of the bridge over the A168;
- two westbound lanes on the A59 approach from York from before the signals with the A168 link road to Jn 47;
- provision of a two-lane exit from Jn 47 towards the A1(M) southbound carriageway;
- widening of the north-east circulatory carriageway to provide four traffic lanes; and,
- widening of the south-east circulatory carriageway to provide four traffic lanes.

The Option 3 improvements are shown annotated on a plan of the LEP scheme, attached as Appendix A to this note.

Additional TRANSYT assessments have identifed that the Option 3 element to widen the A59 eastbound approach to A1(M) Jn 47 could be introduced in isolation, to extend the period for which the junction operates within capacity to 2027 i.e. an additional 5 years over and above the equivalent period of the LEP scheme improvement, which is due to be implemted in 2017/18. Under the Flaxby Growth Assumption, this is equivalent to Local Plan growth of 6,228 dwellings with 1,136 dwellings at Flaxby settlement and 126,795 sqm of employment, of which 31,600 sqm would be the Flaxby employment site. Under the Hammerton Growth Assumption, this is equivalent to Local Plan growth of 5,840 dwellings of which 881 dwellings would be on the Hammerton site and 126,795 sqm of employment, of which 31,600 sqm would be the Flaxby employment site.

APPENDIX A


Three Lanes
Four Circulatory Lanes
Two Lanes to roundabout
Three approach Lanes for 150m
Three Circulatory Lanes
Four Circulatory Lanes
Two Exit Lanes through to Signals
Two Exit Lanes for 200m
Two Lanes
Two Ahead Lanes for 90m
Three Lanes
Two Exit Lanes