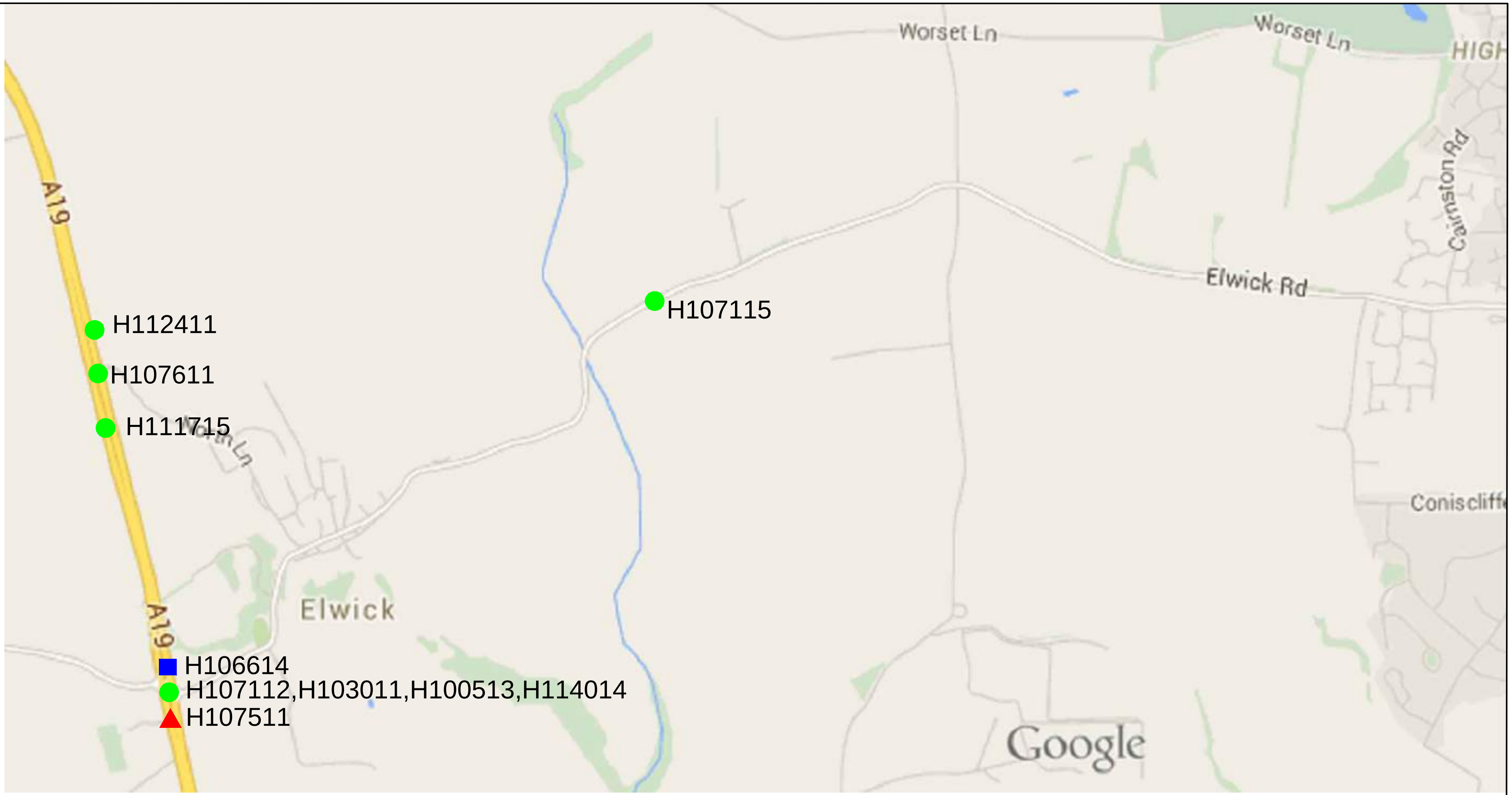
Appendix A

Accident Data



Slight

Serious

Fatal

TITLE
A19 / Elwick - Accidents 2011 - 2016

HARTLEPOOL BOROUGH COUNCIL
Department of Regeneration and Neighbourhoods
Alastair Smith Assistant Director Neighbourhoods

DRAWN PJN	DATE May 2016
SCALE NTS	
DRG. NO. .	

A19 ELWICK CROSSROADS

GD04 Safety Risk Assessment

Report No. 491064.AB.02.06/001

Prepared for

Highways England

July 2016

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July 2016		Mark Powell	Mark Cooper	Peter Franklin

Contents

Executive Summary

Highways England has placed holding directions on planning applications for the proposed residential developments of Quarry Farm phase 2 and High Tunstall, citing concerns as regards the impact that the additional traffic would have on safety at the A19 Elwick Crossroads. A GD04/12 safety risk assessment has therefore been prepared to establish:

- The level of risk for the existing layout.
- The level of risk with additional traffic for each individual development (Quarry Farm phase 2 and High Tunstall) separately. Since the two developments are proposed to be similar in size, this has been approximated by just analysing the larger of the two developments (Quarry Farm phase 2). This scenario is referred to as the 'with development' scenario.
- The volume of additional traffic that can be accommodated at the junction before the risk is considered unacceptable. This scenario is referred to as the 'test to destruction' scenario.

Since the scheme is currently at the feasibility/options stage, stages 7 to 10 of GD04/12 have not been considered within this report. These additional stages should be developed as the scheme progresses.

The assessment considers the risks to Population 3 (road users) only, since the other Populations (workers and other parties) would not be affected by the proposals, as demonstrated in section 2 of this report.

As part of the assessment, the following aspects have been considered:

- Collision data collected for the A19 section at Elwick Crossroads has been used to assess the risk associated with the existing junction arrangement for each population.
- The risk to each population as a consequence of the development-generated traffic has been assessed via analysis of the scale of the forecast increases in turning movements at the junction and analysis of the predicted increases in queue lengths.

The hazards resulting from the additional development traffic at Elwick Crossroads have been identified as:

- A19 northbound right turning vehicles being struck by A19 southbound traffic
- A19 northbound right turning vehicles running into the back of stationary vehicles in the right turn lane
- A19 northbound vehicles running into the back of stationary vehicles in the main carriageway if the capacity of the right turn lane is exceeded

The GD04/12 safety risk assessment shows that the overall risk classification is medium for both the existing and 'with development' scenarios. The overall classification of medium for both the existing and 'with development' scenarios means that additional control measures are needed to reduce the risk rating to a level which is equivalent to a test of 'reasonably required'.

The overall risk score has increased from 21 for the existing situation to 37 for the 'with development' scenario. Additionally, the number of hazards classified as medium has increased from 1 to 2, whilst the number classified as low has reduced from 2 to 1. The derivation of the risk scores for the existing and 'with development' scenarios is presented in sections 4 and 5 respectively.

The risk assessment suggests that, without additional control measures, road users carrying out the following manoeuvres at Elwick Crossroads would be at a considerably increased risk of harm for the 'with development' scenario when compared with the baseline:

- travelling northbound on the A19
- turning right into Elwick Road from the A19 northbound

The following risk control measures have been considered to manage the increased safety risk:

- option 1 - replacement of the existing at-grade junction with a grade-separated junction
- option 2 - closure of both gaps in the central reservation at Elwick Crossroads
- option 3 - prohibition of the right turn movement from the A19 northbound into Elwick Road
- option 4 - introduction of a reduced speed limit on the A19 through the junction
- option 5 - replacement of the existing junction with an at-grade roundabout
- option 6 – signalisation of the existing junction

A high-level assessment of these options suggests that options 2 and 3 would eliminate the increased risks at Elwick Crossroads and should be considered further. A more detailed assessment of the safety impacts at other junctions nearby (e.g. A19/North Lane and A19/A179) and quantification of journey time dis-benefits would be needed as part of this further assessment.

The cost of option 1 is considered to be disproportionate to the identified risks. Option 4 does not go far enough to manage the safety risk and hence the residual risks are not considered tolerable. There are also significant additional dis-benefits associated with this option. Options 5 and 6 have been discounted since there are significant dis-benefits associated with both of these options, as discussed in section 6.

If none of the above options are implemented, then some of the residual safety risk would be classified as medium, but with higher risk scores than existing, and the population subjected to the increase in safety risk (road users) would gain no benefit from the proposals. In this case, the increase in safety risk is considered to be unreasonable. In addition, the increased risk of serious casualties would not be supportive of Highways England's general target to reduce the number of people killed or seriously injured on the network in 2020 by 40% compared to the average for 2005 to 2009.

The 'test to destruction' scenario was not undertaken in light of the results of the 'with development' scenario.

Stage 1 – Determine the Scope

1.1 Introduction to GD04/12

The DMRB standard GD04/12 - Standard for Safety Risk Assessment on the Strategic Road Network, which from this point forward is referred to as GD04/12, was issued in November 2012 and sets out the approach to safety risk management which must be applied where safety should be a consideration. It is a mandatory methodology and there can be no departure to avoid or omit the process.

GD04/12 is designed to improve the investment decisions for matters affecting safety. The standard considers individual risk, rather than collective risk, to allow comparisons to be made between populations and different roads with very different traffic flows. It also introduces the concept of transferring risk between populations. Where the assessment indicates the risk should not be mitigated, it is on the basis the money would be better spent elsewhere. These populations are:

- Population 1 – Workers - People directly employed by Highways England and who work on the strategic road network (SRN), e.g. Traffic Officers.
- Population 2 – Workers - People in a contractual relationship with Highways England, including Agency National Vehicle Recovery Contract operatives, all workers engaged in traffic management activities and incident support services, and any other activities where live traffic is present (such as persons carrying out survey and inspection work).
- Population 3 – Users - Other parties, including road users, the police and emergency services and non-motorised "Users" such as equestrians, cyclists and pedestrians, as well as those others not in a contractual relationship with Highways England, such as privately contracted vehicle recovery and vehicle repair providers.
- Population 4 – Other Parties - Third parties including any person or persons who could be affected by the SRN, but who are neither using it, nor working on it, i.e. living or working adjacent to the SRN, using other (non-Highways England) transport networks that intersect with the SRN (e.g. local roads, railways) and those who are living or working in properties owned by Highways England.

GD04/12 adopts a safety risk management process that consists of 10 stages. These stages are listed below and form the basis of this assessment:

- Stage 1 – Determine the scope
- Stage 2 – Identify the Hazards
- Stage 3 – Identify the relevant criteria for populations
- Stage 4 – Consider existing risk exposure for each population
- Stage 5 – Risk analysis, assessment and evaluation
- Stage 6 – Risk control decisions
- Stage 7 – Document safety decision in a safety risk report
- Stage 8 – Handover of safety risk report to operators

- Stage 9 – Update and refresh the safety risk report when change proposed
- Stage 10 – Monitor and review safety risk report assumptions

Since the scheme is at the feasibility/options stage currently, stages 7 to 10 have not been considered within this report. These would be developed as the scheme progresses.

The author of this report, Mark Powell, is an Associate Director with CH2M and has significant experience in traffic engineering, road safety auditing and analysis of risk on the strategic road network. Mark's CV and his assessment of competence against the criteria set out in GD04/12 Table 8 appear in Appendix 1.

1.2 Background

Elwick Crossroads is an at-grade staggered crossroads on the A19 dual carriageway road situated within the borough of Hartlepool. Figure 1 shows the location of the junction.

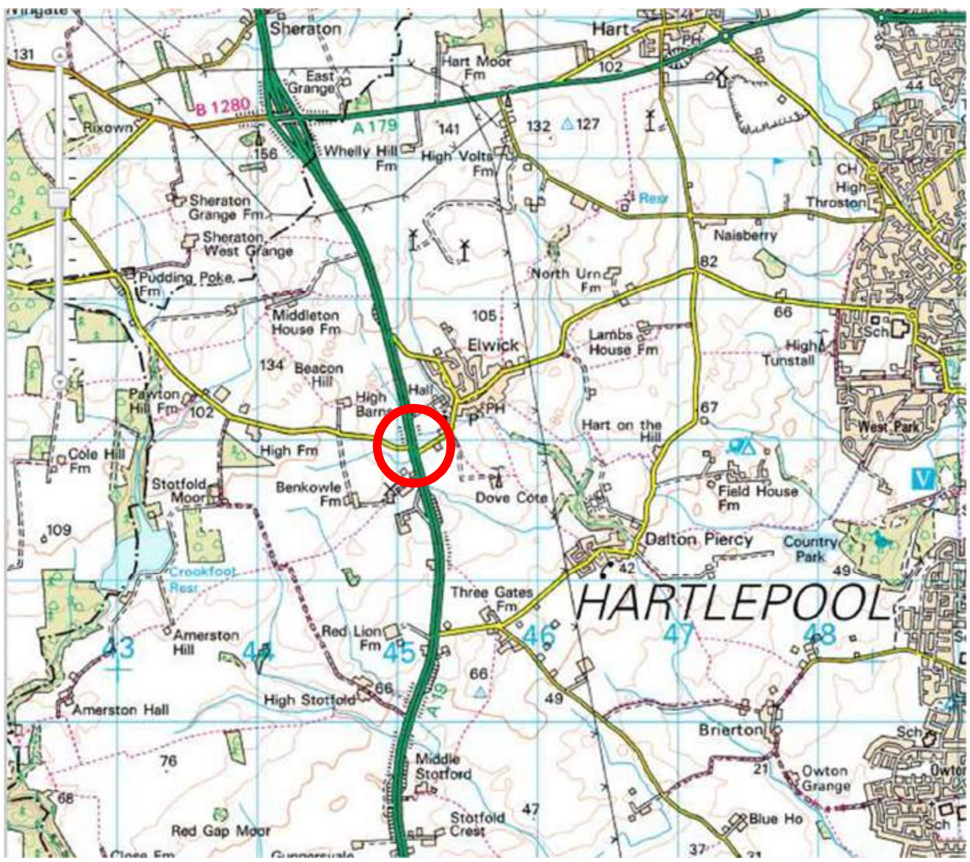


Figure 1 – Elwick Crossroads location plan

The A19 dual carriageway is oriented north-south through the junction and is de-restricted (70mph speed limit). The annual average daily flow (AADF) of traffic for this section of the A19 was 52,526 in 2015. The western and eastern arms of the junction are Coal Lane and Elwick Road respectively. Coal Lane is a single carriageway de-restricted road (60mph speed limit), whilst Elwick Road operates with a 30mph speed limit. The stagger between the 2 side roads is approximately 33m, with Elwick Road to the south of Coal Lane. The layout of the junction is shown in Figure 2.

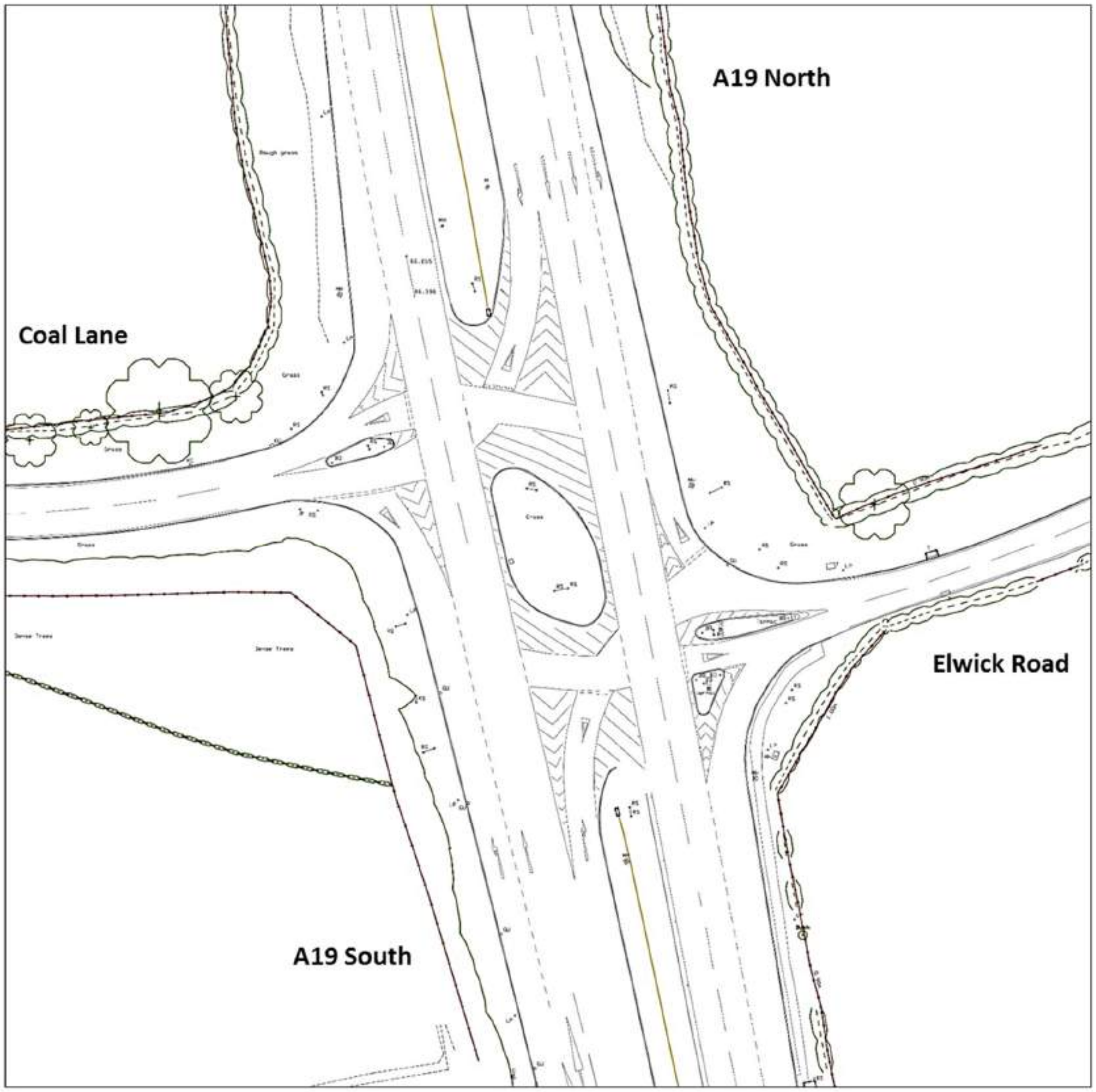


Figure 2 – Elwick Crossroads layout

A classified turning movement survey was undertaken at Elwick Crossroads on Thursday 19 March 2015. The 2015 existing morning and evening peak hour turning movements are shown in Appendix 2. The A19 northbound right turn movement during the evening peak hour was 170 vehicles.

The following 2 developments are proposed in the area between the A19 and Hartlepool:

- Quarry Farm phase 2 (220 dwellings)
- High Tunstall (1,200 dwellings, of which 208 are in planning and the remainder are to be allocated in the Local Plan)

A total of 3 committed developments are also located within the same area, as follows:

- Quarry Farm phase 1 (85 dwellings)
- Hart reservoir (52 dwellings)
- Coniscliffe Road (39 dwellings)

Traffic generated by all 5 of these developments would access the A19 via Elwick Crossroads.

The 2015 traffic survey has been used, together with information supplied by Highways England for the developments, to build a picture of future turning movements at the junction.

The trip rates assumed for the committed and proposed residential developments were based on those accepted by Highways England for a development similar in scale and location to the developments considered in this assessment. These trip rates (vehicles per dwelling) are presented in table 1.

Time Period	Direction	Trip Rate
AM Peak Hour 08:00 – 09:00	Arrivals	0.174
	Departures	0.548
	Total	0.722
PM Peak Hour 17:00 – 18:00	Arrivals	0.463
	Departures	0.296
	Total	0.759

Table 1 – Trip rates used for committed and proposed residential developments

Highways England has advised that the distribution of new residential traffic for developments in this area is typically 70% to/from Hartlepool and 30% to/from the A19 via Elwick Crossroads. Consequently, our assessment assumes that 30% of development traffic would feed through Elwick Crossroads. In lieu of other information being provided, it has been assumed that the north/south split of development traffic at Elwick Crossroads would be in the same proportions as existing traffic.

Figures showing the forecast turning movements for committed and proposed developments are included in Appendix 3. The base + committed + development traffic flows are shown in Appendix 4. Estimates of the forecast absolute and percentage increases in flows resulting from the developments are also included in Appendix 4. This calculation suggests that the A19 northbound right turn movement would increase by about a third (committed development + Quarry Farm phase 2) compared with the existing situation, and that the Elwick Road left turn movement would increase by approximately 50%.

Highways England has placed holding directions on the planning applications for Quarry Farm phase 2 and the 208 dwellings at High Tunstall, citing concerns as regards the impact that the additional traffic would have on safety at Elwick Crossroads. Appendix 5 includes a letter dated 27 April 2016 addressed to Hartlepool Borough Council (HBC), which sets out in detail the reasons for the holding directions.

There were a total of 11 Personal Injury Collisions (PICs) in the vicinity of Elwick Crossroads (covering a length 500m north and south of the junction) during the 10-year period between 1 January 2006 and 31 December 2015, which equates to a rate of 1.1 collisions per year. Two of the 11 collisions were fatal, 2 were serious and the remaining 7 resulted in slight injury. The Killed or Serious Injury (KSI) ratio was 36.4% over the 10-year period analysed. A Poisson test of collision frequency has been undertaken, the results of which indicate that there were no single years when the number of collisions differed significantly from the average. Table 2 shows a breakdown of the number of casualties resulting from collisions of a similar type. The Fatal and Weighted Injury (FWI) casualties per year for each collision type is also shown in this table. Table 2 shows that the collision type with the highest FWI per year was the A19 northbound right turn across the A19 southbound movement. There have been no PICs involving vehicles turning left out of Elwick Road in the 10-year period analysed. The FWI casualty rate for Elwick Crossroads (1km study length) has been calculated to be 29.46 FWIs per billion vehicle miles. This is considerably higher than the national average FWI casualty rate for D2AP roads (7.00 FWIs per billion vehicle miles for the period 2012-2014). Descriptions of the collisions and a collision plot are shown in Appendix 6.

Collision type and movement	Casualties			FWIs per year
	Fatal	Serious	Slight	
A19 SB (loss of control or lane change)	0	2	4	0.024
A19 NB (loss of control)	0	0	3	0.003
A19 NB right turn across A19 SB	2	2	1	0.221
Elwick Road right turn across A19 SB	1	0	0	0.100
Coal Lane right turn across A19 SB	0	0	3	0.003
A19 NB right turn shunt in queue	0	0	1	0.001
Elwick Road right turn across A19 NB	0	0	1	0.001
Total	**3**	**4**	**13**	**0.353**

FWI = fatal casualties + (0.1 x serious casualties) + (0.01 x slight casualties)

Table 2 – Summary of collisions at Elwick Crossroads (2006 to 2015)

A queue survey was carried out on the A19 northbound right turn movement over a 7 day period in February and March 2016. The survey recorded queue lengths of 8 vehicles or more on 44 separate occasions for periods totalling 31 minutes and 47 seconds. Forty-two of the 44 separate occasions took place during the evening peak period on a week-day. A technical note summarising the results of the queue survey is included in Appendix 7. The data collected during the queue survey has been used to derive a queue probability distribution, in order to estimate the frequency of queues of a specified length being present within the right turn lane. The method assumes that the frequency and length of queues would follow a Chi Squared distribution. The queue probability distribution has only been derived for a week-day evening peak period, since the queue survey demonstrated that this was the period when queue lengths were at their greatest. The queue probability distribution for a week-day evening peak period for the A19 right turn lane is shown in Figure 3. The distribution suggests that for approximately 30% of the 2-hour evening peak period, the queue length is likely to be greater than 2 vehicles. The distribution also suggests that for 99% of the 2-hour period the queue length will be less than 12 vehicles. Appendix 8 includes further detail of the method used to derive the distribution.

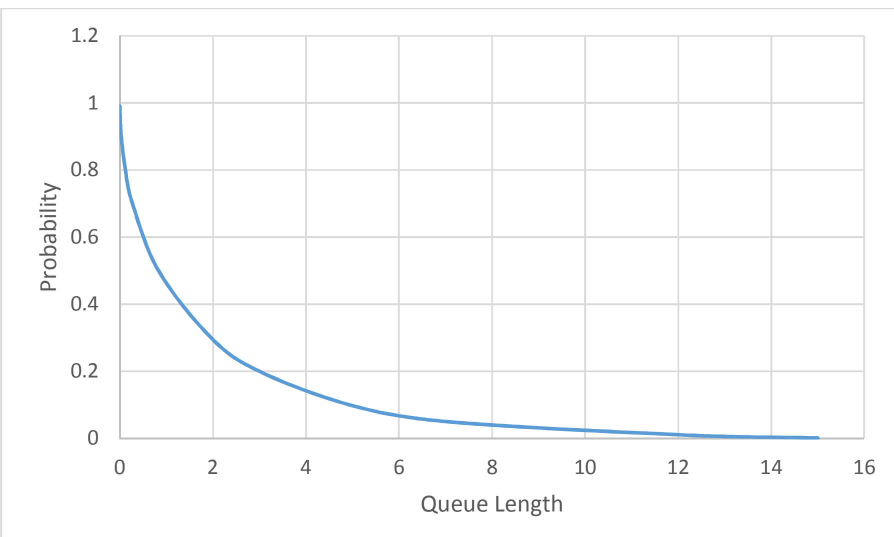


Figure 3 – A19 northbound right turn lane queue length distribution (estimated)

TD42/95 'Geometric Design of Major/Minor Priority Junctions' paragraph 7.40 states that a right turn lane for a major/minor priority junction of this type must have a 10m turning length, to allow long vehicles to position themselves correctly for the right turn, and a deceleration length in accordance with the values shown in table 7/5b. The design speed for this section of the A19 is 120kph. The gradient of the A19 northbound approach to the junction is 1% (positive, up gradient). Therefore, from table 7/5b, a 110m deceleration length must be provided to meet the design standard. The turning length and deceleration length are illustrated on Figure 4.

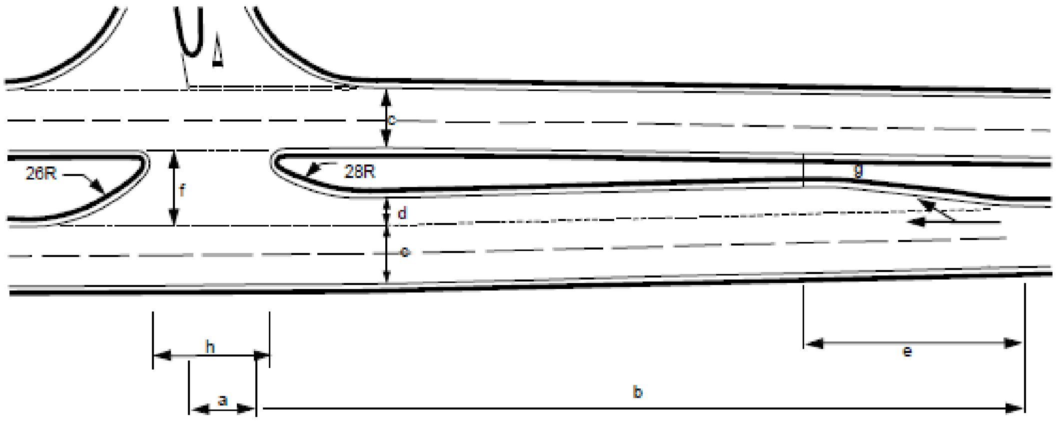


Figure 7/6 : Dual Carriageway Major/Minor Priority Junction (paras 7.20 - 7.48)

a	Turning Length (+ Queuing Length, if required)	e	Direct Taper Length
b	Deceleration Length	f	Physical Island Width
c	Through Lane Width	g	Minimum Physical Island Width
d	Turning Lane Width	h	Central Reserve Opening
			All radii shown in metres

Figure 4 – Right turn lane parameters (extract from TD42/95)

Paragraph 7.33 of TD42/95 states that where vehicles will be queuing to turn right from the major road for significant periods of time, the turning length shall be increased to allow for a reservoir queuing length to accommodate such vehicles.

Paragraph 7.41 of TD42/95 states that the deceleration lengths shown in table 7/5b are based on the assumption that vehicles will slow by one design speed step on the main carriageway before entering the deceleration length.

The A19 northbound right turn lane is 120m in length and is therefore compliant with the requirements of paragraph 7.40 of TD42/95. However, during the periods when the A19 northbound right turn queue extends beyond 10m, the distance available to drivers to decelerate off the main carriageway is reduced. The direct taper is 30m in length, so the length available for vehicles to wait prior to undertaking the right turn into Elwick Road is 90m. Assuming that an average queued vehicle covers a length of 5.75m, a maximum of 15 vehicles can be stored within the right turn lane without encroaching into the A19 northbound main carriageway.

1.3 Scope

CH2M has been commissioned to prepare a GD04/12 safety risk assessment at the A19 Elwick Crossroads. The objectives of the safety risk assessment are to establish:

- The level of risk for the existing layout.
- The level of risk with additional traffic for each individual development (Quarry Farm phase 2 and High Tunstall) separately. Since the two developments are proposed to be similar in size, this can be approximated by just analysing the larger of the two developments (Quarry Farm

phase 2). This scenario is referred to as the 'with development' scenario within the remainder of this report.

- The volume of additional traffic that can be accommodated at the junction before the risk is considered unacceptable. This scenario is referred to as the 'test to destruction' scenario within the remainder of this report.

GD04/12 states that the level of safety risk analysis must be proportionate to the safety risks being considered. For Elwick Crossroads, a semi-quantitative method is considered appropriate given the data available and the combination of hazards being assessed.

The assessment of safety risk necessarily includes making engineering judgements where there is insufficient data, however, provided the sensitivity of the result is also assessed, it can provide a robust conclusion.

As part of the assessment, the following aspects will be considered:

- Collision data collected for the A19 section at Elwick Crossroads will be used to assess the risk associated with the existing junction arrangement for each population.

- The risk to each population as a consequence of the development-generated traffic will be assessed via analysis of the scale of the forecast increases in turning movements at the junction and analysis of the predicted increases in queue lengths.

In accordance with paragraph 6.6 of GD04/12, in order to identify the decision boundaries that must be applied, the project has been characterised using the criteria shown in table 3. Because 3 of the project features are Type B and the remainder are Type A, based on the GD04/12 characterisation rules, the entire decision becomes a Type B.

Features	Type A Specialist Technical/ Coordinator Roles	Type B Professional Safety Advisors	Type C Professional Roles
What is the size of the decision impact? (geographically and in impact terms; extent of the network, number of 'Users'/'Workers')	Local, low density	Local, high density or national, low density	National, high density
What are the cost implications of the decision for the Agency?	Low	Medium	High
What is the lifetime of the decision? (how long will the Agency be affected by the decision)	Rest of the day	Months to a few years	Decades
What is the level of safety risk or uncertainty associated with the decision?	Low	Medium	High
What is the policy or stakeholder interest level? (how sensitive is it?)	Low	Medium	High

Note: Stakeholder could be many bodies, e.g. user, worker, another road authority MP etc.

Table 3 – Overall project characterisation (based on table 3 extracted from GD04/12)

Stage 2 – Identify the Hazards

2.1 Hazards

The hazards resulting from the additional development traffic at Elwick Crossroads are:

- A19 northbound right turning vehicles being struck by A19 southbound traffic
- A19 northbound right turning vehicles running into the back of stationary vehicles in the right turn lane
- A19 northbound vehicles running into the back of stationary vehicles in the main carriageway if the capacity of the right turn lane is exceeded

The collision record indicates a history of collisions involving vehicles turning right from the A19 northbound, and the committed and proposed developments would increase the frequency of this movement.

The extra traffic that would be added to the Elwick Road left turn movement is not considered to represent a significant hazard. There have been no collisions involving vehicles carrying out this movement in the last 10 years.

For the purpose of this assessment, Population 1 will not be taken into consideration since Traffic Officers do not serve the A19.

The following issues are relevant to the consideration of risks associated with population 2. There have been no collisions or near misses involving road workers in the vicinity of Elwick Crossroads in the last 10 years. No construction work is proposed and no changes are proposed to the junction layout. The forecast increase in traffic at the junction increases the likelihood of collisions and consequently the number of call-outs for incident support services. However, the size of the increase in collisions is unlikely to change the existing extremely low risk of collisions involving incident support services staff. Population 2 will therefore not be considered in stages 3 to 5 of this assessment, however is considered within stage 6, risk control decisions.

Population 3 includes any individual passing through Elwick Crossroads as a road user. Drivers of vehicles entering the junction from the two side roads turn onto the Strategic Road Network (SRN) and are therefore included within Population 3.

Possible hazards for Population 4 are limited to an individual within properties adjacent to the junction being impacted by an errant vehicle. The risk probability associated with this hazard is extremely low and it is considered that this would not significantly change as a result of the proposals. Therefore this assessment will not consider the impact that the proposals have on the risk to Population 4.

Table 4 provides a summary of the populations affected.

Population	Is population affected by options assessed?
1 - Workers – people directly employed by Highways England – TOS	Not affected
2 – Workers – people in contractual relationship with Highways England – Maintenance workers and construction workers	• Not affected by 'with development' scenario • Considered during risk control decisions
3 - Road users, police, emergency services and non-motorised 'Users' such as equestrians, cyclists and pedestrians	Affected
4 – Other parties	Not affected

Table 4 – Populations affected by the hazards identified

Consequently, this assessment considers the risks to Population 3 only. It details the change in risk and assesses whether or not the risk to this population is "Broadly Acceptable" as defined within GD04/12.

Stage 3 – Identify Relevant Criteria for Populations

3.1 GD04/12 Criteria

The relevant criteria for all populations under this GD04/12 assessment as identified in Figure 5 below are:

Users:

- If the risk is less than 1 fatality in 1 million = Broadly Acceptable (which would imply ending the assessment). If the risk is greater than 1 fatality in 10,000 = NOT acceptable. If the risk is in the 'tolerable' region, mitigation based on the 'Reasonably Required' (RR) basis should be provided.

Workers:

- If the risk is less than 1 fatality in 1 million = Broadly Acceptable (which would imply ending the assessment). If the risk is greater than 1 fatality in 1,000 = NOT acceptable. Any mitigation must be considered under the ALARP (As Low As Reasonably Practicable) system which is weighted heavily in favour of health and safety and the cost can only be taken into account when it is grossly disproportionate to the risk saved.

Other Parties:

- This is the same as Users i.e. 1 fatality in 1 million = Broadly Acceptable and 1 in 10,000 = NOT acceptable.

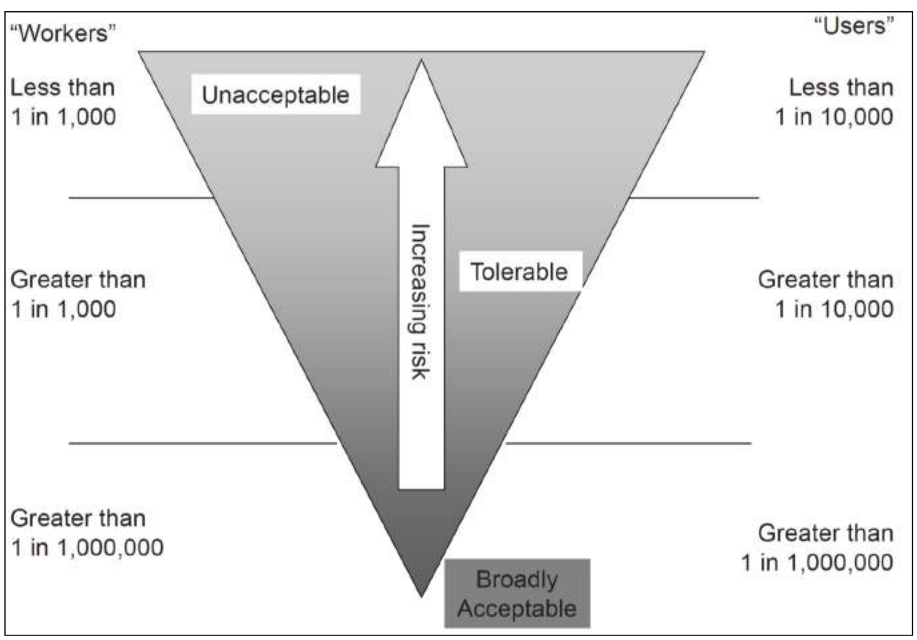


Figure 5 – Highways England exposure and tolerance levels

Since a semi-quantitative method of safety risk analysis has been used within this GD04/12 assessment, the risk classification categories included in the risk assessment tool shown in Annex C of GD04/12 are also relevant and consistent with the criteria shown in Figure 5. These risk classification categories are defined as:

- Low: Ensure assumed control measures are maintained and reviewed as necessary.
- Medium: Additional control measures needed to reduce risk rating to a level which is equivalent to a test of ‘reasonably required’ for the population concerned.
- High: Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable.

Stage 4 – Consider Existing Risk Exposure for Each Population

4.1 Introduction

The existing junction arrangement and operation will be considered as the baseline risk model. Table 4 identified that Population 3 (road users) was the only population affected by the identified hazards. Therefore, the baseline risk has only been assessed for this population. The risks associated with the 'with development' scenario will be compared with the baseline risk in section 5 of this report.

The 3 hazards identified in section 2 are considered separately in the following sections. A semi-quantitative assessment of risk is included for each hazard. Consideration will be given to the existing collision history to assess the baseline risk.

4.2 A19 northbound right turning vehicles being struck by A19 southbound traffic

There have been 2 collisions resulting in 5 casualties (2 fatal, 2 serious, 1 slight) for this collision type in the last 10 years. The collision rate is 0.2 collisions per year and the FWI rate is 0.221 FWIs per year, which equates to 63% of the total FWIs at the junction.

The baseline risk for this hazard has been assessed using the risk assessment tool included within Annex C of GD04/12. The baseline risk for this hazard has been classified as medium, with a score of 12. Derivation of this risk classification is shown in Figure 6.

The classification of medium means that additional control measures are needed to reduce the risk rating to a level which is equivalent to a test of 'reasonably required'.

Probability (P)		Severity (S)					Risk Classification (R)
		1	2	3	4	5	
		Minor	Moderate	Serious	Major	Catastrophic	Low (1–9) Ensure assumed control measures are maintained and reviewed as necessary
1	Extremely unlikely	1	2	3	4	5	
2	Unlikely	2	4	6	8	10	Medium (10–19) – Additional control measures needed to reduce risk rating to a level which is equivalent to a test of 'reasonably required' for the population concerned.
3	Likely	3	6	9	12	15	
4	Extremely Likely	4	8	12	16	20	High (20–25) – Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable
5	Almost Certain	5	10	15	20	25	

Probability that harm will occur				Most common potential severity of harm e.g.		
1	Extremely unlikely	Highly improbable, never known to occur		1	Minor harm	Minor damage or loss no injury
2	Unlikely	Less than 1 per 10 years		2	Moderate harm	Slight injury or illness, moderate damage or loss
3	Likely	Once every 5–10 years		3	Serious harm	Serious injury or illness, substantial damage or loss
4	Extremely likely	Once every 1–4 years		4	Major harm	Fatal injury, major damage or loss
5	Almost certain	Once a year		5	Catastrophic harm	Multiple fatalities, catastrophic loss or damage

Figure 6 – Baseline risk classification: right turn across A19 southbound

4.3 A19 northbound right turning vehicles running into the back of stationary vehicles in the right turn lane

There has been 1 collision resulting in 1 slight casualty for this collision type in the last 10 years. The collision rate is 0.1 collisions per year and the FWI rate is 0.001 FWIs per year.

The baseline risk for this hazard has been assessed using the risk assessment tool included within Annex C of GD04/12. The baseline risk for this hazard has been classified as low, with a score of 6. Derivation of this risk classification is shown in Figure 7.

In accordance with the principles outlined in paragraph 5.16 of GD04/12, a semi-quantitative classification of low is assumed to be equivalent to a classification of broadly acceptable. The baseline risk can therefore be considered as broadly acceptable and no additional control measures are needed.

Probability (P)		Severity (S)					Risk Classification (R)
		1	2	3	4	5	
		Minor	Moderate	Serious	Major	Catastrophic	Low (1–9) Ensure assumed control measures are maintained and reviewed as necessary
1	Extremely unlikely	1	2	3	4	5	
2	Unlikely	2	4	6	8	10	Medium (10–19) – Additional control measures needed to reduce risk rating to a level which is equivalent to a test of 'reasonably required' for the population concerned.
3	Likely	3	6	9	12	15	
4	Extremely Likely	4	8	12	16	20	High (20–25) – Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable
5	Almost Certain	5	10	15	20	25	

Probability that harm will occur				Most common potential severity of harm e.g.		
1	Extremely unlikely	Highly improbable, never known to occur		1	Minor harm	Minor damage or loss no injury
2	Unlikely	Less than 1 per 10 years		2	Moderate harm	Slight injury or illness, moderate damage or loss
3	Likely	Once every 5–10 years		3	Serious harm	Serious injury or illness, substantial damage or loss
4	Extremely likely	Once every 1–4 years		4	Major harm	Fatal injury, major damage or loss
5	Almost certain	Once a year		5	Catastrophic harm	Multiple fatalities, catastrophic loss or damage

Figure 7 – Baseline risk classification: shunts in A19 northbound right turn lane

4.4 A19 northbound vehicles running into the back of stationary vehicles in the main carriageway if the capacity of the right turn lane is exceeded

The results of the queue survey (see Appendix 7) showed that the capacity of the right turn lane was not exceeded on any of the 7 days surveyed. There have been 0 collisions resulting in 0 casualties for this collision type in the last 10 years.

The baseline risk for this hazard has been assessed using the risk assessment tool included within Annex C of GD04/12. The baseline risk for this hazard has been classified as low, with a score of 3. Derivation of this risk classification is shown in Figure 8. The likely severity has been assessed as serious, reflecting the high speed differential of the vehicles involved in any collision and the unexpected nature of the hazard, which reduces the likelihood that vehicles on the main carriageway will be able to slow down prior to impact.

In accordance with the principles outlined in paragraph 5.16 of GD04/12, a semi-quantitative classification of low is assumed to be equivalent to a classification of broadly acceptable. The baseline risk can therefore be considered as broadly acceptable and no additional control measures are needed.

Probability (P)		**Severity (S)**					**Risk Classification (R)**
		1	**2**	**3**	**4**	**5**	
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**	Low (1–9) Ensure assumed control measures are maintained and reviewed as necessary
1	Extremely unlikely	1	2	3	4	5	
2	Unlikely	2	4	6	8	10	Medium (10–19) – Additional control measures needed to reduce risk rating to a level which is equivalent to a test of 'reasonably required' for the population concerned.
3	Likely	3	6	9	12	15	
4	Extremely Likely	4	8	12	16	20	High (20–25) – Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable
5	Almost Certain	5	10	15	20	25	

Probability that harm will occur				**Most common potential severity of harm e.g.**		
1	Extremely unlikely	Highly improbable, never known to occur		1	Minor harm	Minor damage or loss no injury
2	Unlikely	Less than 1 per 10 years		2	Moderate harm	Slight injury or illness, moderate damage or loss
3	Likely	Once every 5–10 years		3	Serious harm	Serious injury or illness, substantial damage or loss
4	Extremely likely	Once every 1–4 years		4	Major harm	Fatal injury, major damage or loss
5	Almost certain	Once a year		5	Catastrophic harm	Multiple fatalities, catastrophic loss or damage

Figure 8 – Baseline risk classification: shunts on A19 northbound main carriageway with stationary vehicles waiting to turn right

Stage 5 – Risk Analysis Assessment and Evaluation

5.1 Introduction

The risks associated with the 'with development' scenario are considered within this section and compared with the baseline risks that were identified within section 4 of this report. Population 3 (road users) is the only population affected by the identified hazards, so the 'with development' risk has only been assessed for this population.

The 3 hazards identified in section 2 are considered separately in the following sections. A semi-quantitative assessment of risk is included for each hazard.

To assess the 'with development' risk, consideration will be given to:

- The existing collision history.
- The forecast increase in traffic flows at the junction.
- The forecast increase in queue lengths at the junction.

A summary of the results of the risk assessment is shown in section 5.5.

5.2 A19 northbound right turning vehicles being struck by A19 southbound traffic

There have been 2 collisions resulting in 5 casualties (2 fatal, 2 serious, 1 slight) for this collision type in the last 10 years. The collision rate is 0.2 collisions per year and the FWI rate is 0.221 FWIs per year.

The baseline risk for this hazard was classified as medium, with a score of 12.

The figures included in Appendix 4 show that the A19 northbound right turn movement is forecast to increase as follows for the 'with development' scenario compared with the existing situation:

- AM peak hour: increase of 21 vehicles, equivalent to a 40% increase on the existing flow (52 vehicles)
- PM peak hour: increase of 55 vehicles, equivalent to a 32% increase on the existing flow (170 vehicles)

Taking an average of these 2 percentage increases (40% and 32%), it is estimated that the collision rate for the 'with development' scenario would increase by 36% compared to the baseline. A 36% increase is equivalent to 0.072 collisions per year. The forecast collision rate for the 'with development' scenario is therefore estimated to be 0.272 (or 1 collision every 3.7 years).

The 'with development' risk for this hazard has been assessed using the risk assessment tool included within Annex C of GD04/12. The 'with development' risk for this hazard has been classified as medium, with a score of 16. Derivation of this risk classification is shown in Figure 9.

The classification of medium means that additional control measures are needed to reduce the risk rating to a level which is equivalent to a test of ‘reasonably required’.

The risk score has therefore increased compared with the baseline, however the risk classification is unchanged.

Probability (P)		Severity (S)					Risk Classification (R)
		1	2	3	4	5	
		Minor	Moderate	Serious	Major	Catastrophic	Low (1–9) Ensure assumed control measures are maintained and reviewed as necessary
1	Extremely unlikely	1	2	3	4	5	
2	Unlikely	2	4	6	8	10	Medium (10–19) – Additional control measures needed to reduce risk rating to a level which is equivalent to a test of ‘reasonably required’ for the population concerned.
3	Likely	3	6	9	12	15	
4	Extremely Likely	4	8	12	16	20	High (20–25) – Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable
5	Almost Certain	5	10	15	20	25	

Probability that harm will occur				Most common potential severity of harm e.g.		
1	Extremely unlikely	Highly improbable, never known to occur		1	Minor harm	Minor damage or loss no injury
2	Unlikely	Less than 1 per 10 years		2	Moderate harm	Slight injury or illness, moderate damage or loss
3	Likely	Once every 5–10 years		3	Serious harm	Serious injury or illness, substantial damage or loss
4	Extremely likely	Once every 1–4 years		4	Major harm	Fatal injury, major damage or loss
5	Almost certain	Once a year		5	Catastrophic harm	Multiple fatalities, catastrophic loss or damage

Figure 9 – ‘With development’ risk classification: right turn across A19 southbound

5.3 A19 northbound right turning vehicles running into the back of stationary vehicles in the right turn lane

There has been 1 collision resulting in 1 slight casualty for this collision type in the last 10 years. The collision rate is 0.1 collisions per year and the FWI rate is 0.001 FWIs per year.

The baseline risk for this hazard was classified as low, with a score of 6.

The increased risk associated with the additional development traffic has only been assessed for the weekday evening peak period, since the queue survey demonstrated that this was the period when queue lengths were at their greatest. The figures included in Appendix 4 show that the A19 northbound right turn movement is forecast to increase as follows for the ‘with development’ scenario compared with the existing situation:

- PM peak hour: increase of 55 vehicles, equivalent to a 32% increase on the existing flow (170 vehicles)

The queue of vehicles waiting to turn into Elwick Road from the A19 northbound right turn lane will increase as a result of the additional development traffic. The scale of this increase has been estimated using a combination of the forecast increase in traffic and the queue probability distribution. It has been assumed that the queue length would increase in proportion to the extra traffic (this is considered to be a conservative assumption, since, for short periods when flows are higher than the peak period average, longer queue lengths would occur). The ‘with development’ queue probability distribution for a week-day evening peak period for the A19 right turn lane is shown in Figure 10. The distribution suggests that for approximately 37% of the 2-hour evening peak period, the queue length is likely to be greater than 2 vehicles (from Figure 10, when Queue Length is 2, probability is 0.37). The distribution also suggests that for 1.5% of the 2-hour period, which equates to 1 minute and 48 seconds, the queue length would be greater than 15 vehicles. The storage capacity of the right turn lane is 15 vehicles, so vehicles would encroach into the A1 northbound main carriageway during this period. The 1 minute and 48 second period per week-day factors up to 8 minutes and 45 seconds per working week and 7.6 hours per year, assuming 253 working days per year.

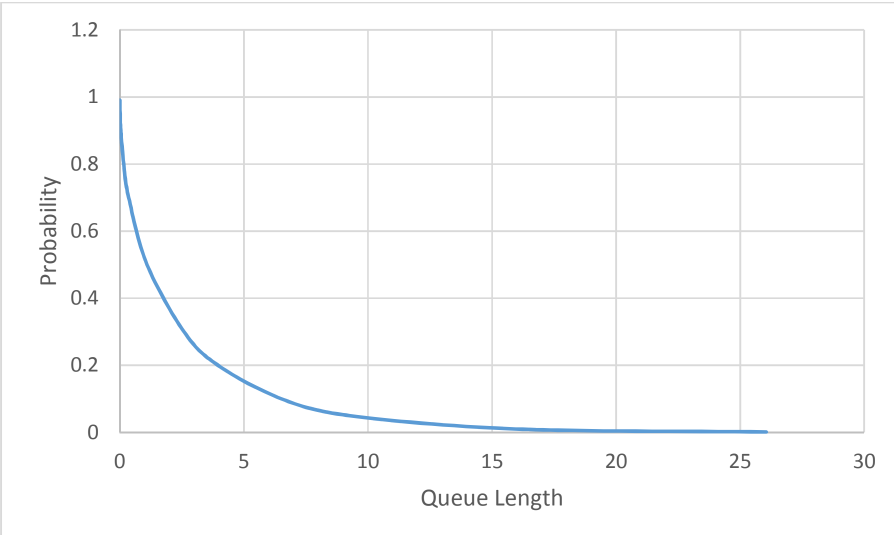


Figure 10 – A19 northbound right turn lane 'with development' queue length distribution (estimated)

It is estimated that the collision rate for the 'with development' scenario would increase by 32% compared to the baseline. A 32% increase is equivalent to 0.032 collisions per year. The forecast collision rate for the 'with development' scenario is therefore estimated to be 0.132 (or 1 collision every 7.6 years).

The 'with development' risk for this hazard has been assessed using the risk assessment tool included within Annex C of GD04/12. The 'with development' risk for this hazard has been classified as low, with a score of 6. Derivation of this risk classification is shown in Figure 11.

In accordance with the principles outlined in paragraph 5.16 of GD04/12, a semi-quantitative classification of low is assumed to be equivalent to a classification of broadly acceptable. The 'with development' risk can therefore be considered as broadly acceptable and no additional control measures are needed.

The risk score and risk classification are therefore both unchanged compared with the baseline.

Probability (P)		Severity (S)					Risk Classification (R)
		1	2	3	4	5	
		Minor	Moderate	Serious	Major	Catastrophic	Low (1–9) Ensure assumed control measures are maintained and reviewed as necessary
1	Extremely unlikely	1	2	3	4	5	
2	Unlikely	2	4	6	8	10	Medium (10–19) – Additional control measures needed to reduce risk rating to a level which is equivalent to a test of 'reasonably required' for the population concerned.
3	Likely	3	6	9	12	15	
4	Extremely Likely	4	8	12	16	20	High (20–25) – Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable
5	Almost Certain	5	10	15	20	25	

Probability that harm will occur				Most common potential severity of harm e.g.		
1	Extremely unlikely	Highly improbable, never known to occur		1	Minor harm	Minor damage or loss no injury
2	Unlikely	Less than 1 per 10 years		2	Moderate harm	Slight injury or illness, moderate damage or loss
3	Likely	Once every 5–10 years		3	Serious harm	Serious injury or illness, substantial damage or loss
4	Extremely likely	Once every 1–4 years		4	Major harm	Fatal injury, major damage or loss
5	Almost certain	Once a year		5	Catastrophic harm	Multiple fatalities, catastrophic loss or damage

Figure 11 – 'With development' risk classification: shunts in A19 northbound right turn lane

5.4 A19 northbound vehicles running into the back of stationary vehicles in the main carriageway if the capacity of the right turn lane is exceeded

There have been 0 collisions resulting in 0 casualties for this collision type in the last 10 years. The collision rate is 0 collisions per year and the FWI rate is 0 FWIs per year.

The baseline risk for this hazard was classified as low, with a score of 3.

The method used to assess the increased risk associated with the additional development traffic is similar to that used in section 5.3. The estimated flow increase and 'with development' queue distribution presented in section 5.3 is relevant to the hazard considered in this section.

The duration of the hazard of stationary vehicles being present in the main carriageway, at 7.6 hours per year, is considered to represent an occasional hazard. The likelihood of a collision resulting from the presence of the hazard is considered to lie between occasional and probable. Drivers would not be expecting stationary traffic in the offside lane of the main carriageway. The A19 northbound ahead flow for the 2-hour evening peak period is 5,529 vehicles. On average, 83 vehicles would pass through the junction in a northbound direction during the 1 minute and 48 second period when stationary vehicles are present on the main carriageway ((108s/7,200s) x 5,529 vehicles). It has been assumed that 40% of this traffic (83 x 0.4 = 33 vehicles) would be travelling in the offside lane. Therefore, it is estimated that, every week-day evening peak period, 33 vehicles travelling northbound in the offside lane would be exposed to the hazard of stationary traffic. This equates to 8,349 vehicles per year being exposed to this hazard, assuming 253 working days per year.

The probability that one of these events results in a PIC is estimated to be 1 in 3,387. The method used to derive this figure is presented in Appendix 9. It is therefore estimated that the collision rate for the 'with development' scenario would be 2.5 collisions per year (8,349/3,387). In order to further increase the level of confidence in the forecast collision rate, sensitivity analysis has been undertaken and is presented at the end of this section (5.4).

The 'with development' risk for this hazard has been assessed using the risk assessment tool included within Annex C of GD04/12. The 'with development' risk for this hazard has been classified as medium, with a score of 15. Derivation of this risk classification is shown in Figure 12.

The classification of medium means that additional control measures are needed to reduce the risk rating to a level which is equivalent to a test of 'reasonably required'.

The risk score and the risk classification have therefore both increased compared with the baseline.

Probability (P)		**Severity (S)**					**Risk Classification (R)**
		1	**2**	**3**	**4**	**5**	
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**	Low (1–9) Ensure assumed control measures are maintained and reviewed as necessary
1	Extremely unlikely	1	2	3	4	5	
2	Unlikely	2	4	6	8	10	Medium (10–19) – Additional control measures needed to reduce risk rating to a level which is equivalent to a test of 'reasonably required' for the population concerned.
3	Likely	3	6	9	12	15	
4	Extremely Likely	4	8	12	16	20	High (20–25) – Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable
5	Almost Certain	5	10	15	20	25	

Probability that harm will occur			**Most common potential severity of harm e.g.**		
1	Extremely unlikely	Highly improbable, never known to occur	1	Minor harm	Minor damage or loss no injury
2	Unlikely	Less than 1 per 10 years	2	Moderate harm	Slight injury or illness, moderate damage or loss
3	Likely	Once every 5–10 years	3	Serious harm	Serious injury or illness, substantial damage or loss
4	Extremely likely	Once every 1–4 years	4	Major harm	Fatal injury, major damage or loss
5	Almost certain	Once a year	5	Catastrophic harm	Multiple fatalities, catastrophic loss or damage

Figure 12 – 'With development' risk classification: shunts on A19 northbound main carriageway with stationary vehicles waiting to turn right

<u>Sensitivity Analysis</u>

The sensitivity of the results to changes in the 1 in 3,387 assumption has been undertaken. Scenario 1 assumes that 1 in 1,000 of these events results in a PIC and scenario 2 assumes that 1 in 5,000 of these events results in a PIC.

So, for scenario 1, the estimated collision rate for the 'with development' scenario would be 8.3 collisions per year (8,349/1,000). The 'with development' risk for this hazard would still be classified as medium, with a score of 15 (probability = 5, severity = 3).

For scenario 2, the estimated collision rate for the 'with development' scenario would be 1.7 collisions per year (8,349/5,000). The 'with development' risk for this hazard would still be classified as medium, with a score of 15 (probability = 5, severity = 3).

The results of the sensitivity analysis therefore increase the level of confidence in the risk assessment of this hazard.

5.5 Summary

A summary of the results of the risk assessment is presented in table 5. The hazards and risks presented in this table relate only to Population 3 (road users).

Hazard	Risk classification and score	
	Existing	With development
A19 northbound right turning vehicles being struck by A19 southbound traffic	Medium (12)	Medium (16)
A19 northbound right turning vehicles running into the back of stationary vehicles in the right turn lane	Low (6)	Low (6)
A19 northbound vehicles running into the back of stationary vehicles in the main carriageway if the capacity of the right turn lane is exceeded	Low (3)	Medium (15)

Table 5 – Summary of risk assessment for 'with development' scenario

Generally, the overall risk classification is defined by the hazard with the greatest risk classification. Using this method, the overall risk classification would be medium for both the existing and 'with development' scenarios. That said, the overall risk score has increased from 21 for the existing situation to 37 for the 'with development' scenario. Additionally, the number of hazards classified as medium has increased from 1 to 2, whilst the number classified as low has reduced from 2 to 1.

Stage 6 – Risk Control Decisions

The overall classification of medium for both the existing and 'with development' scenarios means that additional control measures are needed to reduce the risk rating to a level which is equivalent to a test of 'reasonably required'. The risk assessment suggests that road users carrying out the following manoeuvres at Elwick Crossroads would be at a considerably increased risk of harm for the 'with development' scenario when compared with the baseline:

- travelling northbound on the A19
- turning right into Elwick Road from the A19 northbound

The following risk control measures have been identified to manage the increased safety risk:

- option 1 - replacement of the existing at-grade junction with a grade-separated junction
- option 2 - closure of both gaps in the central reservation at Elwick Crossroads
- option 3 - prohibition of the right turn movement from the A19 northbound into Elwick Road
- option 4 - introduction of a reduced speed limit on the A19 through the junction
- option 5 - replacement of the existing junction with an at-grade roundabout
- option 6 – signalisation of the existing junction

An assessment of the benefits and dis-benefits of each control option is presented in table 6. The method used to estimate the Benefit to Cost Ratios (BCRs) is shown in Appendix 10. The method only takes account of the potential safety benefits of each option and does not include for any journey time benefits or dis-benefits.

Option	Impacts	Conclusion
1 - Replacement of the existing at-grade junction with a grade-separated junction	• Elimination of the hazard • Additional risks for workers during construction • High cost • Approximate Safety BCR of 0.27	• Cost of option is disproportionate and should not be promoted on safety grounds
2 - Closure of both gaps in the central reservation at Elwick Crossroads	• Elimination of the hazard at Elwick Crossroads • Potential transfer of the risk to another location • Journey time dis-benefits for side road traffic • Additional risks for workers during construction • Medium cost • Approximate Safety BCR of 1.41	• Option should be considered further alongside other favourable options • To develop further, would require more detailed assessment of safety impacts at other junctions nearby and quantification of journey time dis-benefits
3 - Prohibition of the right turn movement from the A19 northbound into Elwick Road	• Elimination of the hazard at Elwick Crossroads • Potential transfer of the risk to another location • Journey time dis-benefits for A19 NB right turning traffic • Additional risks for workers during construction • Medium/Low cost • Approximate Safety BCR of 2.76	• Option should be considered further alongside other favourable options • To develop further, would require more detailed assessment of safety impacts at other junctions nearby and quantification of journey time dis-benefits
4 - Introduction of a reduced speed limit on the A19 through the junction	• Small reduction in the number and severity of collisions associated with the hazard • Incompatible with the aspiration to develop the A19 as an expressway • Additional risks for workers during construction • Low cost • Approximate Safety BCR of 10.23	• Option does not go far enough to manage the safety risk • Residual risks are not considered tolerable • Significant additional dis-benefits associated with this option
5 - Replacement of the existing junction with an at-grade roundabout	• Reduction in the number and severity of collisions associated with the hazard • Incompatible with the aspiration to develop the A19 as an expressway • Significant journey time dis-benefits • Additional risks for workers during construction • High cost	• Significant dis-benefits associated with this option
6 – Signalisation of the existing junction	• Reduction in the number of collisions associated with the hazard • Incompatible with the aspiration to develop the A19 as an expressway • Significant journey time dis-benefits • Additional risks for workers during construction • High/Medium cost	• Significant dis-benefits associated with this option

Table 6 – Impacts of control options

Appendices

Appendix 1 – Author's CV and Competence Assessment

Dr Mark Powell BSc(Eng), MSc(Eng), PhD, CMILT

Employment record

- July 2013 to present, Associate director, CH2M, Leeds
- October 2012 to June 2013, Associate director, CH2M, Leeds
- October 2011 to September 2012, Team leader/associate, CH2M , Leeds
- October 2009 to September 2011, Local manager/associate, CH2M[1], Leeds
- January 2004 to September 2009, Associate, CH2M[1], Leeds
- January 1999 to December 2004, Senior consultant, CH2M[1], Leeds
- October 1997 to December 1998, Consultant, CH2M[2], Leeds
- September 1993 to September 1994, Engineer, Pell Frischmann Consultants, Wakefield
- September 1990 to August 1992, Assistant engineer, Pell Frischmann Consultants, Wakefield
- September 1989 to September 1990, Graduate engineer, Ove Arup and Partners, London

Skills and Experience Summary

- Twenty-six years of experience in transport planning and engineering, of which 18 have been in the field of road safety engineering
- Very experienced project manager, including large multi-disciplinary transport planning projects for both public and private sector clients
- Specialist in the design of facilities for all road users
- Road safety audit team leader, holding Highways England certificate of competency
- In-depth knowledge of the design manual for roads and bridges

Mark has a wealth of design experience, including junction design, traffic signal modelling, and designing for safety. Mark is a very experienced project manager of transport studies, including area, corridor and junction studies, safety studies, transport modelling and appraisal studies, transport assessments/statements and travel plans. He is experienced in accident investigation, casualty reduction schemes, designing for safety, traffic calming schemes, vulnerable road user needs, assessing departures from standard, hazard logs, Road Restraints Risk Assessment Process and GD04/12 assessments, working on projects for Highways England, Local Authorities, and private sector clients.

On the public sector side, his experience includes leading road safety audits of major highway schemes on behalf of Highways England and City of York Council, and Local Network Management Schemes (LNMS) safety, accessibility, and economy studies on behalf of Highways England. Mark has detailed knowledge of the Design Manual for Roads and Bridges, which was gained during his secondment to the Highways Agency's safe roads design team, assessing road geometry departures from standard.

On the private sector side, Mark has successfully managed a complex project developing a road safety program for road concessionaires operating in Latin America and the Caribbean. Mark has prepared

[1] While at Halcrow, a CH2M company
[2] While at Halcrow Fox, a CH2M company

transport assessments for significant residential, employment and leisure developments in town centres and edge of centre locations.

<u>Experience Record</u>

2016, Package manager, A19 N2W Hazard Log, UK
Client: Highways England

The Norton to Wynyard (N2W) scheme proposes to widen a 4.5km section of the A19 near Middlesbrough from 2 to 3 lanes. A hazard log has been prepared to satisfy a request from the Traffic, Appraisal, Modelling and Economics (TAME) team at Highways England relating to the use of user-defined collision rates within CH2M's COBALT safety assessment. The hazard log compares the Do Something risks with the safety baseline for the scheme extents (D2AP). The final choice of Do Something collision rates for input to COBALT will be determined following review of the hazard log outputs.

Responsible for preparing the hazard log, which has included using an existing hazard log for D3M and adapting this for the D2AP baseline, removing motorway hazards and adding other all-purpose hazards as necessary. Review of all assumptions and risk scores for the baseline and Do Something scenarios. This task required innovative solutions to be found to complex issues, since this was the first hazard log that had been prepared for an all-purpose road.

1998-2016, Team leader, Road Safety Audits, UK
Client: Various

Stage 1, 2, 3 and 4 Road Safety Audits of numerous urban and rural transport schemes. The audits identified road safety problems with proposed or implemented highway improvement schemes, thus assisting the client meet its crash reduction targets and providing cost savings as a result of fewer road traffic collisions.

Audit team leader, responsible for co-ordination of inputs from audit team members and others involved in the audit (for example, police) and production of the audit report. Consideration and resolution of conflicting opinions on complex highway design issues, ensuring that the audit is carried out in accordance with the relevant standard and that recommendations are realistic and take account of constraints (for example, cost).

2008-2016, Package manager, LNMS Safety and Economy Studies, UK
Client: A-one+

Economy, road safety and accessibility studies at numerous locations within MAC Areas 14 (North East), 10 (North West) and 7 (East Midlands) of Highways England's network. The studies sought to identify highway improvement schemes to reduce congestion and road traffic collisions, and improve facilities for non-car users. Also, scoping studies within Area 7 to identify suitable locations for LNMS economy schemes.

Responsible for overseeing the delivery of studies, including detailed review of turning movements and crash data, problem identification, option identification and development, traffic modelling, and economic appraisal, including completion of Scheme Appraisal Reports (SARs). Led consultation workshop with stakeholders to discuss improvement options, and presented the preferred option to the same set of stakeholders on completion of the study. Presented the conclusions from LNMS studies to Value Management (VM) meetings with Highways England.

2011-2013, Project manager, Private Sector Road Safety Program, USA
Client: Inter-American Development Bank

This project entailed development of a road safety program for road concessionaires operating in Latin America and the Caribbean. The program will help concessionaires manage their road safety performance.

Successful management of complex project, responsible for liaison with the client (based in Washington DC), TRL (sub-consultants), CH2M Buenos Aires office and others (for example, A-one+) as necessary, and co-ordination of all technical inputs. Oversaw a comprehensive review of international best practice in road safety. Used the results of the review to develop a list of best practice road safety activities for concessionaires and a set of principles for the road safety program. Advised the client on program development, including format, content, membership requirements, screening of applications, and communications and marketing strategies. Identified appropriate form of safety payment mechanism for the program, developed a framework to assess the effectiveness of the program, and identified a strategy for using the program to assist granting authorities that regulate road concessions in Latin America and the Caribbean.

2012, Engineer, Area 7 Full Switch Off (A-one+)
CH2M was commissioned by A-one+ to assess the road safety implications of switching off existing road lighting on 13 sections of the M1 motorway in the East Midlands. Switching off street lighting helps the Highways Agency achieve its objective of reducing the energy consumption and carbon emissions (CO2) of its roadside equipment.

Responsible for detailed analysis of road traffic collision data and preparation of the road safety engineer's briefing for two of the 13 sections. Design of site audit checklist and execution of site audits for all 13 sections studied. Tasks carried out in accordance with Highways Agency guidance for the removal of road lighting. Completion of tasks to challenging timescale helped the Highways Agency understand the existing level of benefit the road user receives from street lighting on these sections of the M1.

2011, Engineer, A1 Leeming to Catterick South RRRAP (A-one+)
The focus of the commission was to consider the safety of the A1 from Leases Grange (north of Leeming) to Catterick South interchange (Marne Barracks). This part of the network has a poor road safety record associated with errant vehicles colliding with roadside features. It is anticipated that the situation will be compounded, particularly on the northbound carriageway, when the network to the south is upgraded to D3M standards. Implementation of the study recommendations will reduce the severity of collisions involving vehicles inadvertently leaving the carriageway along this section of the A1, assisting the client meet its crash reduction targets and provide associated financial benefits.

Responsible for undertaking a RRRAP (Road Restraints Risk Assessment Process) assessment of the A1 northbound carriageway from Leases Grange (north of Leeming) to Catterick South interchange (Marne Barracks). This included the acquisition, collation and input of accurate data to the Highways Agency's RRRAP spreadsheet, and the identification of lengths of carriageway where new vehicle restraint systems (VRS) are required.

2008-2011, Technical advisor, Secondment to Safe Road Design Team (Highways Agency)
Part-time secondment to the safe roads design team of the Highways Agency, assessing departures from road geometry standards. The project provided the Highways Agency with a flexible resource to assist them to meet their targets for determining departure from standard applications, during periods of peak demand.

Responsible for leading a small team of advisors and for assessing complex road geometry departures from standard. Achieved year on year improvements in KPI scores. Introduced new ways of working to improve the quality of deliverables and delivery to deadlines, and to better define client and consultant responsibilities.

2002, Senior Consultant, A1 DBFO (Highways Agency)
Review and update of methodology for determining the safety benchmark and accident savings forecast for the A1 Darrington to Dishforth DBFO scheme.

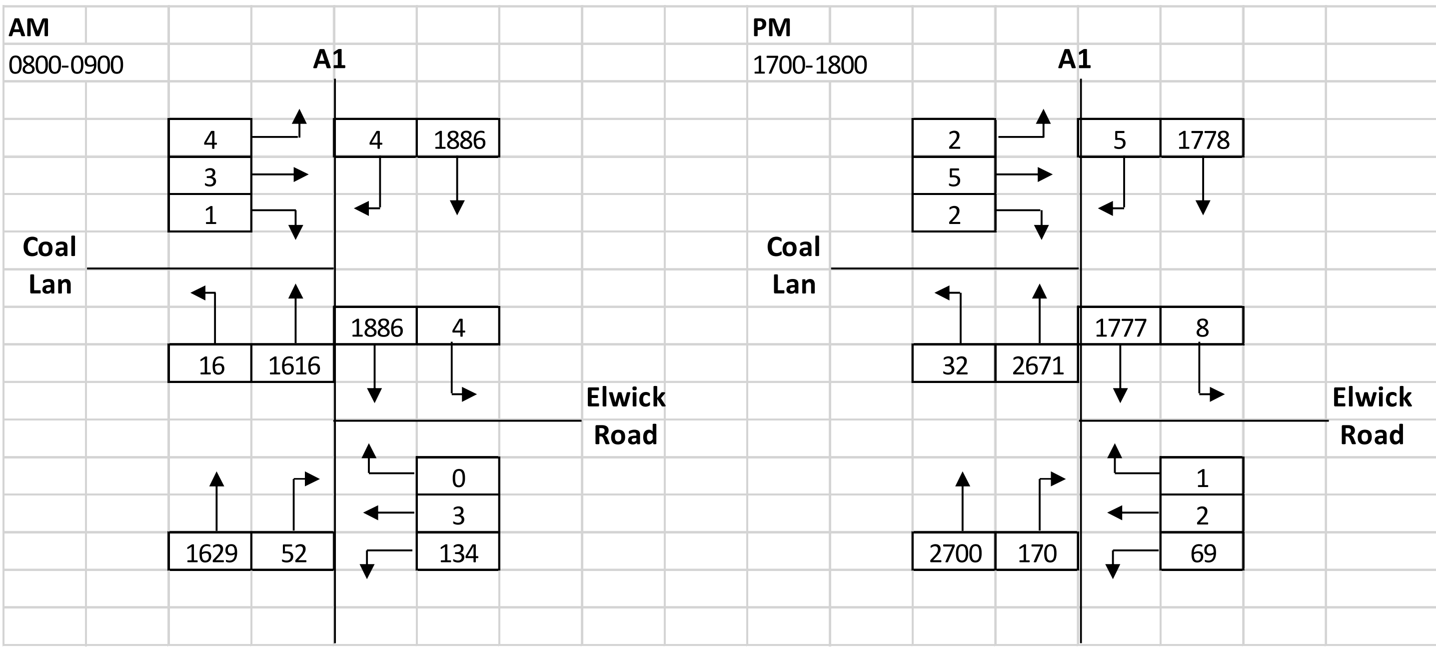
Competence Assessment

Competence areas/functions	Description	Levels of competence achievement			
		1	2	3	4
		Can lead / direct	Can guide and show	Can do independently	Can contribute
Safety risk terminology	Hazard, safety risk, hazard identification, safety risk analysis, safety risk assessment (or evaluation), safety risk control, safety risk management, safety risk versus uncertainty.		✓		
Legal context	HSWA, MHSW Regs, CDM, Road Traffic Act, Highways Act, Duty of care, corporate manslaughter, role of the HSE, reasonably required.				✓
Safety risk management principles	ALARP, GALE, precautionary principle, safety decision making, importance of evidence/audit trails, safety management systems (HSG65).			✓	
Determine the scope of projects	Consideration, definition and documentation of the project scope. The project/decision boundaries, impact on all populations, local objectives, and local problems.		✓		
Identify hazards arising from scope of project and identify safety risks to populations associated with hazards	Checklists, brainstorming, qualitative, semi-quantitative, quantitative, risk matrices.		✓		
Define appropriate criteria and tolerance for populations	Tolerability of safety risk, safety risk trade off (including individual and collective).			✓	

Competence areas/functions	Description	Levels of competence achievement			
		1	2	3	4
		Can lead / direct	**Can guide and show**	**Can do independently**	**Can contribute**
Gather, analyse, assess and evaluate relevant data	HA methodologies, event trees, fault trees, bow-tie, cause-consequence, risk modelling, measures of safety risk, data for safety risk analysis (and what to do if no data).		✓		
Analyse safety risk control options and decide preferred options	Hierarchy of safety risk control, approaches to determining 'reasonableness' and procedures for actively managing safety risks.			✓	
Decision-making	HSMS; safety policy; organisation; operational procedures; safety risk assessment methodologies; tolerability criteria; assurance; procedures for review of current approach; potential issues with the current approach.			✓	

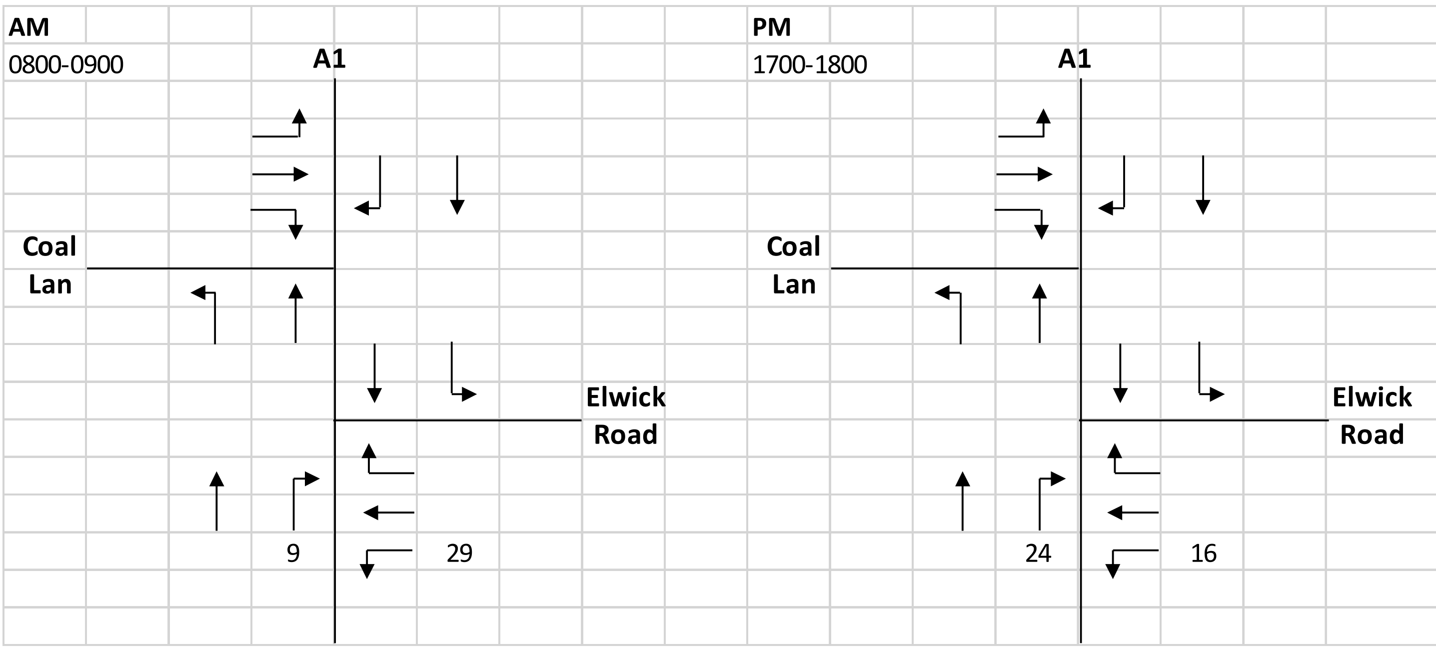
Table A1 – Assessment Checklist - GD04/12 Table 8

Appendix 2 – 2015 existing peak hour turning movements

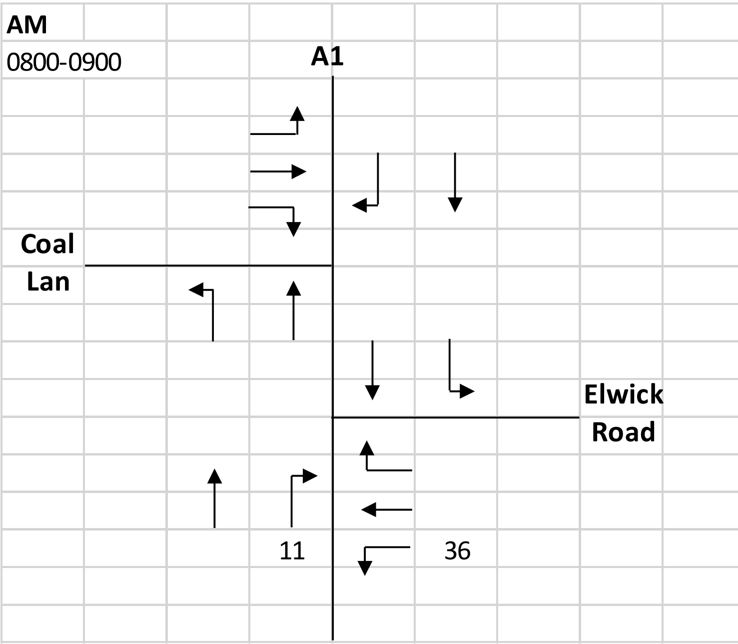


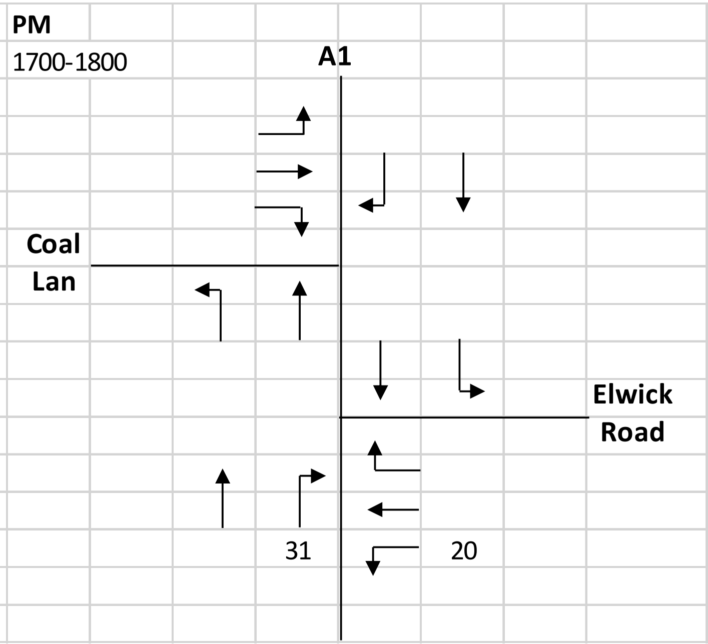
Appendix 3 – Forecast turning movements for committed and proposed developments

Committed development flows



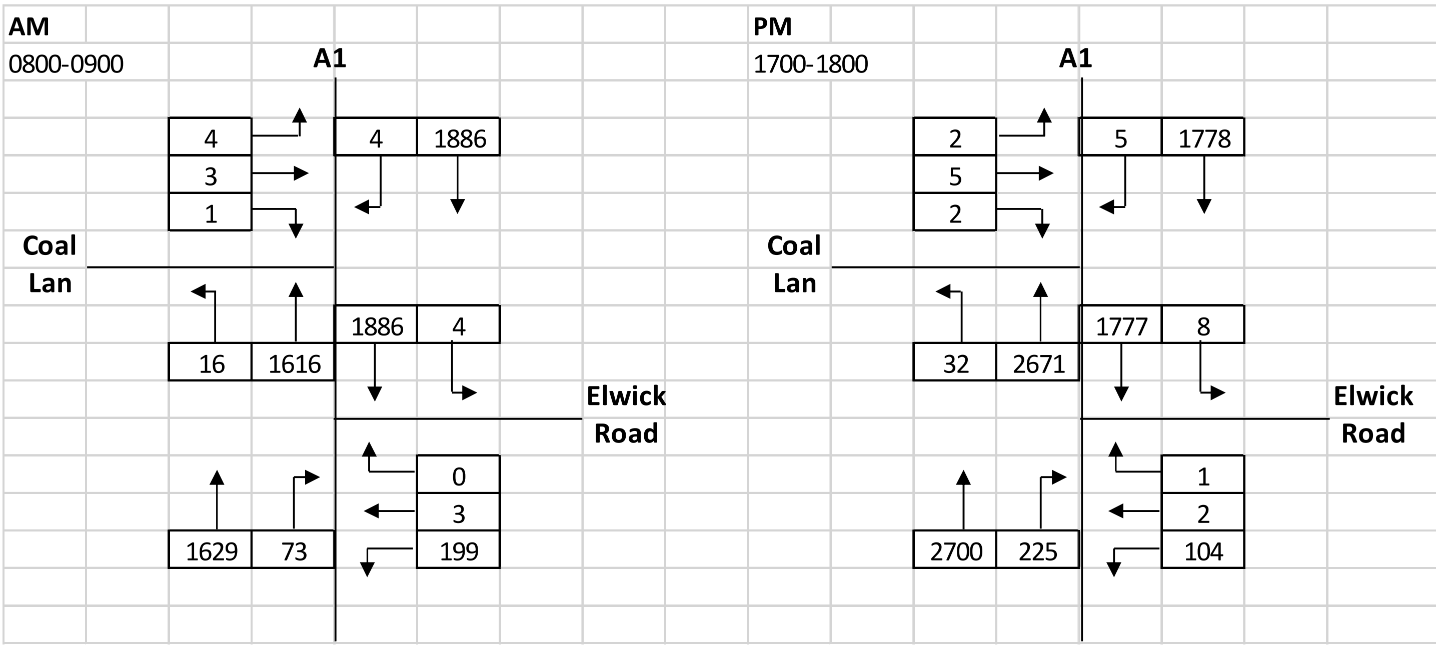
Proposed development flows



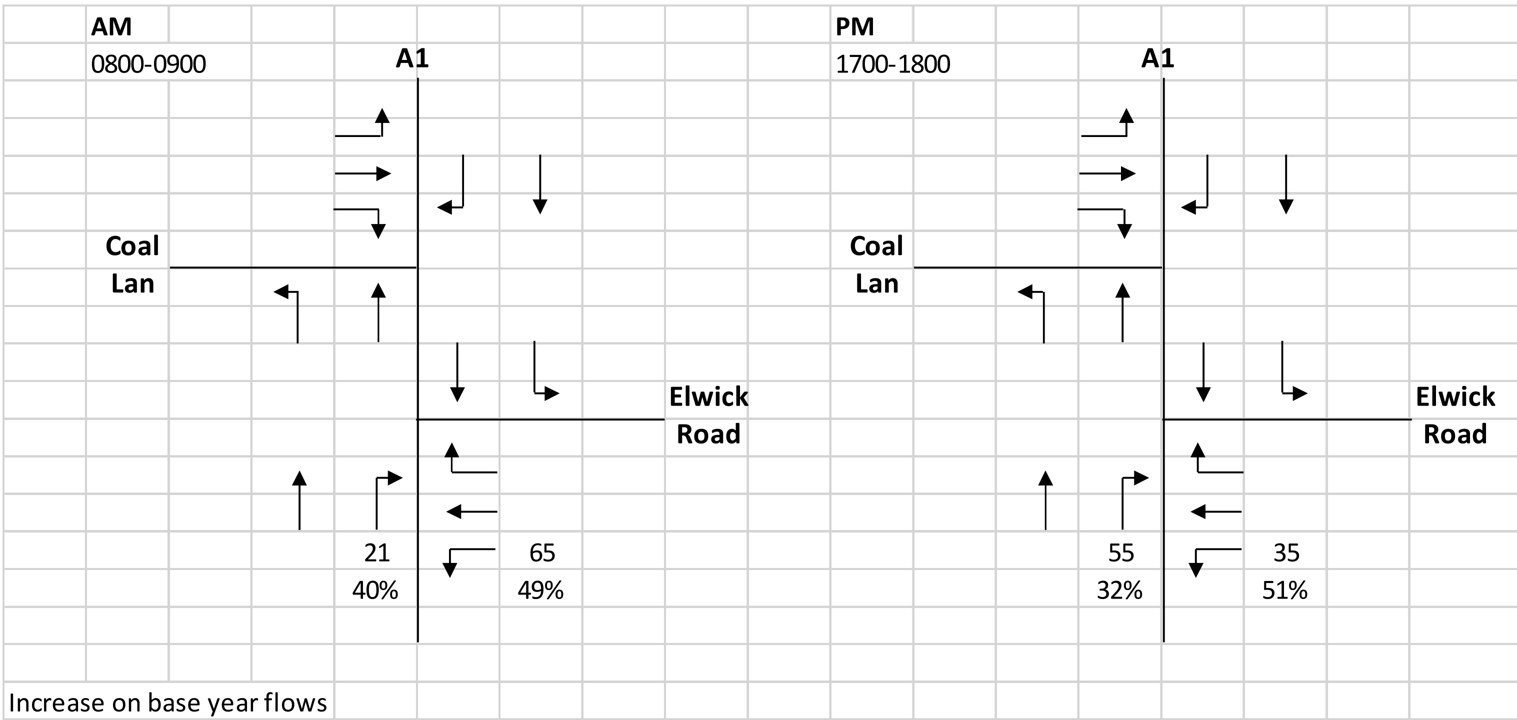


Appendix 4 – Base + committed + development traffic flows

Base + committed + development flows



Absolute and percentage increases in flows



Appendix 5 – Letter to Hartlepool Borough Council relating to the holding directions

Our ref:
Your ref:

Highways Traffic and Transport
Hartlepool Borough Council
Civic Centre
Hartlepool
TS24 8AY

Daniel Gaunt
Asset Manager (Y&NE)
3 South
Lateral
8 City Walk
Leeds LS11 9AT

Direct Line: 0300 470 2419
27 April 2016

For the attention of Mike Blair

Dear Mike

DEVELOPMENTS AROUND AND AFFECTING THE JUNCTION OF THE A19 WITH ELWICK ROAD

Thank you for arranging to undertake video surveys at the junction described above. We have arranged for those surveys to be reviewed, and we attach a note from our consultants setting out their review of the information.

From this information, you will note that the visible queue, which is a queue extending beyond seven vehicles in this context, occurs on a daily basis during the weekday evening peak periods, with a maximum total of 10m 18s during the two-hour period from 1600 to 1800 on Monday 29 February 2016 and an average (mean) of 5m 47s. In addition to this, we consider that the period where a queue of up to seven vehicles exists but is not visible on the video is likely to be significantly higher:

i) for each period of visible queuing, there will be a substantially longer period during which the queue is extending up to seven vehicles and subsequently clearing back to none.
ii) it is reasonable to assume that shorter non-visible queues will occur with greater frequency in line with the chi-squared distribution.

On the basis of this assumption therefore, we consider that the evidence demonstrates a general problem with queuing at this location.

We have also considered the layout of the junction with reference to TD42/95 ‘Geometric Design of Major/Minor Priority Junctions’. Within this document, the standard layout for a major/minor priority junction shown in Figure 7/6 is required to have a deceleration length of 110m (paragraph 7.40 and table 7/5b). The junction currently has a deceleration length of approximately 120m, which is slightly above the required standard but which would allow for only allow for a reservoir queuing length of 1 vehicle. When queuing occurs in excess of this, the lane is unable to perform its designated function for deceleration which would be likely to result in unsafe slowing of traffic in lane two of the A19 mainline.

In light of the information above, we have then considered the risks associated with the junction continuing to operate with the existing levels of queuing, or with its use being permitted to intensify. In deciding on the appropriate course of action, I have taken into account the following:

- Highways England's general target to reduce the number of people killed and seriously injured on the network in 2020 by 40% compared to the average for 2005 to 2009.
- The history of injury accidents at the junction; while significant improvements have taken place at the junction to make it as safe as reasonably possible based on its current operation, we would not wish to see the benefits eroded through the intensification of its use.
- Recommendations made by the coroner and undertakings made by Highways England and formerly the Highways Agency in relation to the closure of central reserve gaps on the section of the A19 between A689 at Wolviston and the A179 at Sheraton.
- The intended purpose of the deceleration lane and the potential impact of vehicles being forced to decelerate in the outside lane of the A19, especially in busy periods when the evidence demonstrates queuing.
- There are committed developments including the planned development at Quarry Farm phase 1 which was allowed on appeal and which is forecast to add further trips to the junction further increasing the risks.

In the absence of a safety risk assessment undertaken in accordance with GD04/12 'Standard for Safety Risk Assessment on the Strategic Road Network' and taking into account the factors above, it is my view that we would currently consider the addition of any vehicles to the existing queues to represent a severe impact on the junction. In order to verify this approach, I have commissioned an assessment under GD04/12 from our consultants, and I will provide an update once that has been completed.

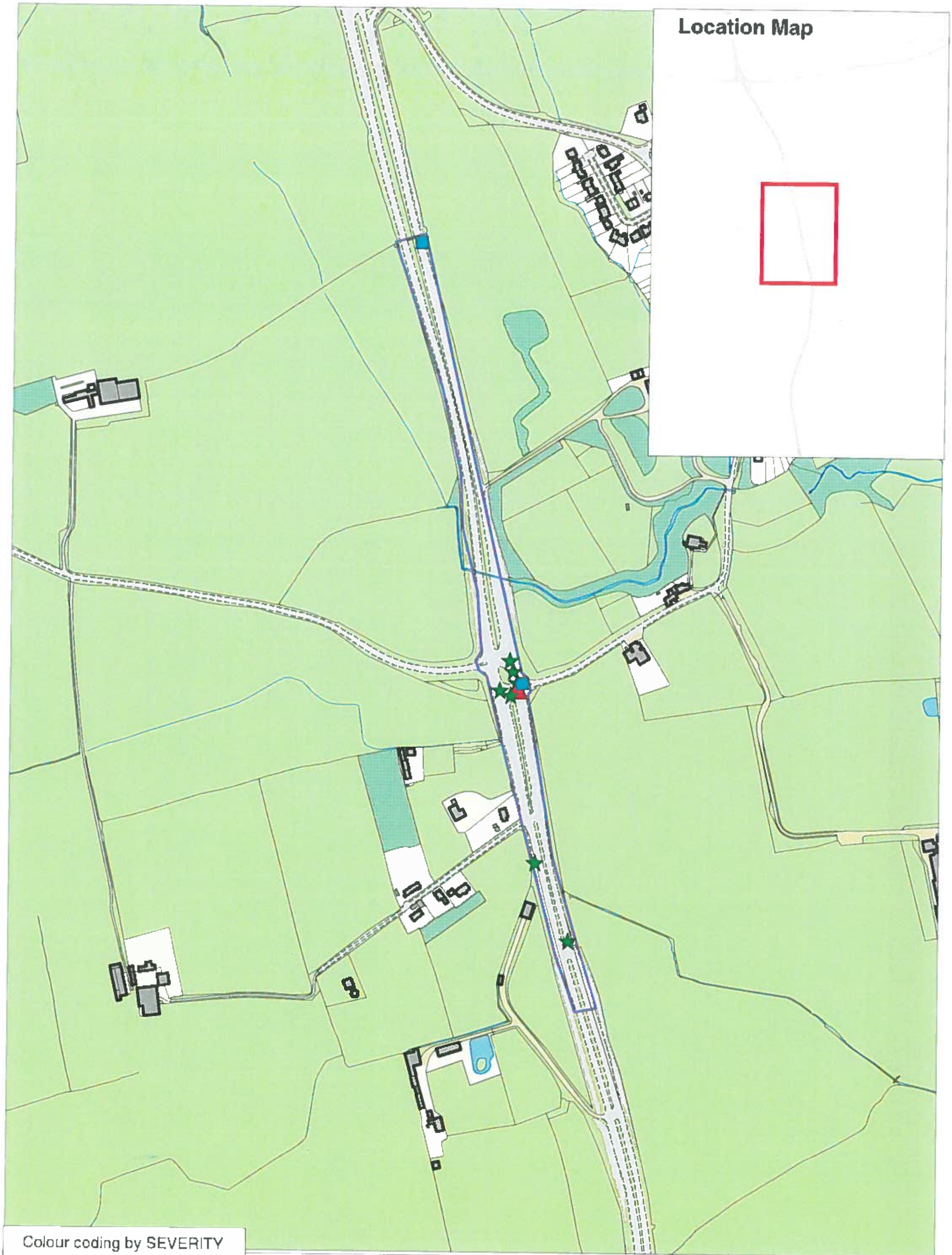
In light of this in the meantime, we intend to issue formal recommendations against grant of planning permission in respect of developments likely to result in a measurable increase in the number of trips at the junction, unless suitable mitigation can be secured which will ensure that developments do not add to the number of trips travelling through the junction. As you are aware, we have identified a range of options for mitigating such impacts and removing the problem through the construction of a compact grade separated junction West of Elwick on the A19 to replace both existing at-grade right turns at Elwick Road and North Lane, and we are currently in discussions with you and your colleagues to identify how this might be delivered along with a local road bypass of Elwick, subject to suitable funding being made available or secured via the Local Plan.

I appreciate that the issues described in this letter will be of concern to the Council, and I will be happy to meet to discuss them with you and with any developers affected. In the meantime, if you have any concerns or queries please feel free to contact me and I will be happy to address them.

Yours sincerely

Daniel Gaunt
Asset Development Team (Yorkshire and North East)
Email: daniel.gaunt@highways.gsi.gov.uk

Appendix 6 – Collision descriptions and plot



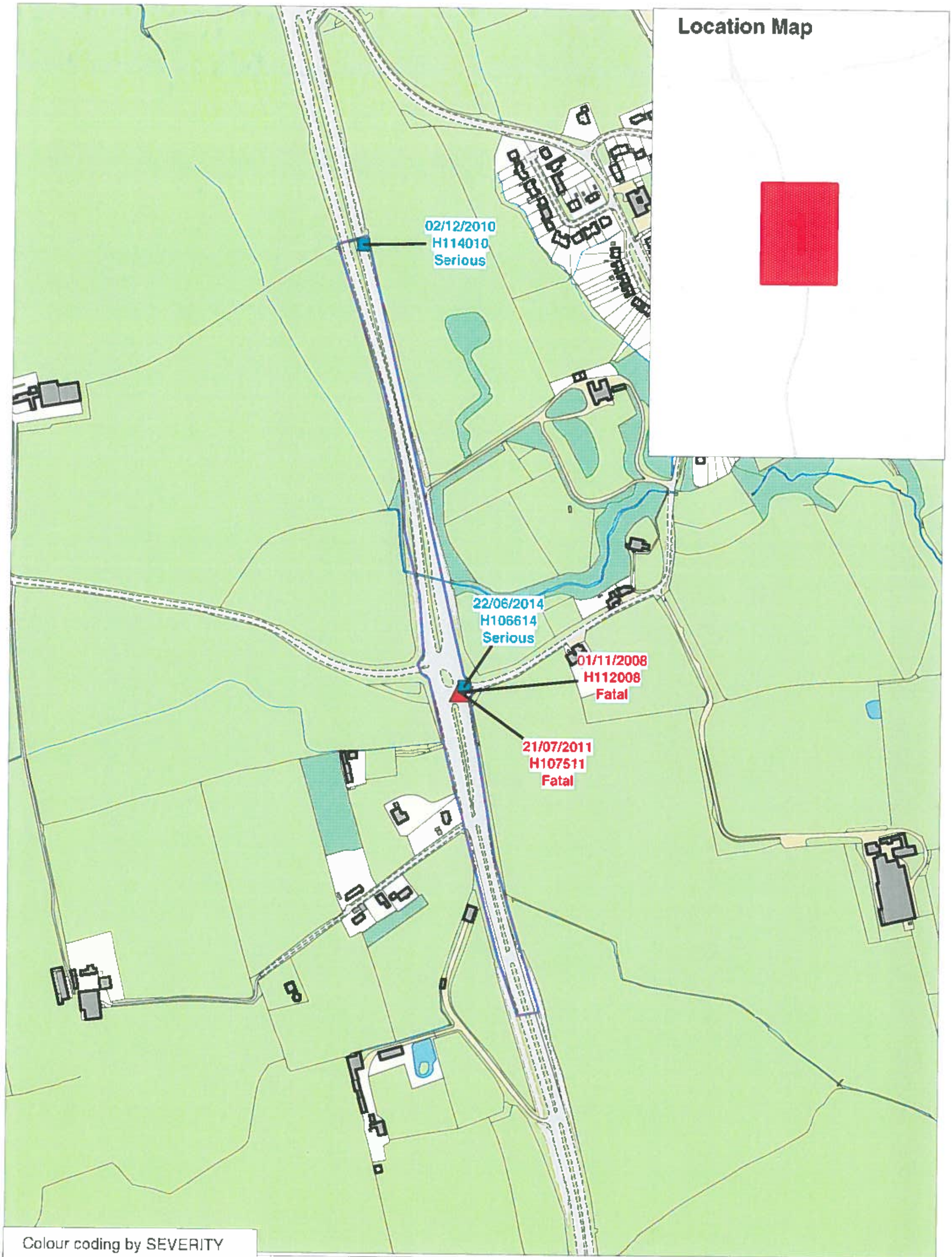
Colour coding by SEVERITY

▲	Fatal	(2)
■	Serious	(2)
★	Slight	(7)

Accidents between dates 01/01/2006 and 31/12/2015
Refined using Accidents within selected Polygons
Neil Raper - Requests for Information
Elwick - Coal Lane

SCALE	1 : 6000
DATE	17/05/2016
DRAWING No	
DRAWN BY	X Telter

BUCHANAN COMPUTING



Colour coding by SEVERITY

Fatal		(2)
Serious		(2)
Slight		(0)

Accidents between dates 01/01/2006 and 31/12/2015
Refined using Accidents within selected Polygons
Neil Raper - Requests for Information
Elwick - Coal Lane - KSI Incidents

SCALE	1 : 6000
DATE	17/05/2016
DRAWING No.	
DRAWN BY	K Tate

BUCHANAN COMPUTING

Accidents between dates **01/01/2006 and 31/12/2015** (120) months

Selection: **Notes:**

Selected using Pre-defined Query : ; Refined using Accidents within selected Polygons -Neil Raper - Requests for Information ("Elwick - Coal Lane")

Police Ref.	Date	Cas.	Sev.	P2W	Cycs	Peds	Ch	OAPs	Vis.	Manv.	Road Cond.	Time	Location
Selected Polygon:Elwick - Coal Lane													
H112008	01/11/2008	4	Fatal	0	0	0	0	1	Dark	Right	Wet/Damp	1817	A19 SOUTHBOUND, ELWICK JUNCTION
H106910	23/07/2010	1	Slight	0	0	0	0	0	Light	No turn	Dry	1606	A19 SOUTHBOUND, HARTLEPOOL AT ELWICK JUNCTION
H114010	02/12/2010	1	Serious	0	0	0	0	0	Dark	No turn	Snow	1904	A19 SOUTHBOUND, HARTLEPOOL. APPROX 300M S OF NORTH LANE,
H101411	31/01/2011	3	Slight	0	0	0	0	0	Light	No turn	Dry	1320	A19 NORTHBOUND, HARTLEPOOL. APPROX 200M PRIOR TO ELWICK
H103011	17/02/2011	1	Slight	0	0	0	0	1	Light	Right	Dry	1420	A19 HARTLEPOOL JUNC WITH ELWICK ROAD
H107511	21/07/2011	1	Fatal	1	0	0	0	1	Light	Right	Dry	1956	A19 SOUTHBOUND, HARTLEPOOL JUNC WITH ELWICK VILLAGE
H107112	30/06/2012	3	Slight	0	0	0	0	0	Light	Right	Dry	0839	A19 SOUTHBOUND, HARTLEPOOL JUNC WITH COAL LANE
H100513	15/01/2013	1	Slight	0	0	0	0	0	Light	Right	Snow	0817	A19 NORTHBOUND, HARTLEPOOL. JUNC WITH COAL LANE/ELWICK '
H106614	22/06/2014	2	Serious	0	0	0	0	0	Light	No turn	Dry	0644	A19 SOUTHBOUND, HARTLEPOOL JUNC WITH ELWICK ROAD
H114014	08/12/2014	1	Slight	0	0	0	0	0	Light	Right	Wet/Damp	1115	A19 NORTHBOUND, HARTLEPOOL JUNC WITH COAL LANE
H114714	17/12/2014	2	Slight	0	0	0	0	0	Dark	No turn	Dry	2045	A19 SOUTHBOUND, HARTLEPOOL APPROX 300M OF COAL LANE
Column Totals		20		1	0	0	0	3					
No. of Accidents				1	0	0	0	3					

Total number of accidents listed: 11

Accidents between dates **01/01/2006 and 31/12/2015** (120) months

Selection:

Notes:

Selected using Pre-defined Query : ; Refined using Accidents within selected Polygons -Neil Raper - Requests for Information ("Elwick - Coal Lane")

Police Ref.	Acc Class	Date	Time	Grid References		Casualties Ftl	Ser	Slt	Causation Factors/ Prob	Ped L M D	Light	Weather	Road Surface	Vehicle Types
Selected Polygon:Elwick - Coal Lane														
H112008	Fatal	01/11/2008	1817	445131	531903	2	2	0	501A 405A 504A	0 0 0	Dark	Fine without high winds	Wet/Damp	9 9
H106910	Slight	23/07/2010	1606	445127	531925	0	0	1	405A 710B 403A	0 0 0	Light	Fine without high winds	Dry	9 9
H114010	Serious	02/12/2010	1904	445011	532440	0	1	0	103A 410A	0 0 0	Dark	Snowing without high winds	Snow	9
H101411	Slight	31/01/2011	1320	445155	531695	0	0	3	409A 410A 509B	0 0 0	Light	Fine without high winds	Dry	9
H103011	Slight	17/02/2011	1420	445132	531911	0	0	1	505A	0 0 0	Light	Fine without high winds	Dry	9 9
H107511	Fatal	21/07/2011	1956	445133	531903	1	0	0	405A	0 0 0	Light	Fine without high winds	Dry	9 5
H107112	Slight	30/06/2012	0839	445123	531938	0	0	3	403A 406B 405A	0 0 0	Light	Fine without high winds	Dry	9 19
H100513	Slight	15/01/2013	0817	445124	531896	0	0	1	406A 103A 707A 403B	0 0 0	Light	Snowing without high winds	Snow	9 19 9
H106614	Serious	22/06/2014	0644	445138	531910	0	1	1	503A	0 0 0	Light	Fine without high winds	Dry	19
H114014	Slight	08/12/2014	1115	445111	531902	0	0	1	406A 405A 403A	0 0 0	Light	Fine without high winds	Wet/Damp	9 21
H114714	Slight	17/12/2014	2045	445196	531601	0	0	2	405A	0 0 0	Dark	Fine without high winds	Dry	19 9
Column Totals						3	4	13						

Total number of accidents listed: 11

Details of Personal Injury Accidents for Period - 01/01/2006 to 31/12/2015 (120) months

Selection:

Selected using Pre-defined Query : ; Refined using Accidents ~~within selected Polygons Neil Raper Requests for Information~~ ("Elwick - Coal Lane")

Notes:

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Vehicles: Veh No / Type / Manv / Dir / Class	Casualties: Sex / Age / Sev

Account of Accident

Selected Polygon:Elwick - Coal Lane

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H112008	Saturday	A19 SOUTHBOUND, ELWICK JUNCTION	Veh 1	Car	Going ahead	N to S	Dri	M	44	Fatal
A 19	01/11/2008		Veh 1	Car	Going ahead	N to S	FSP	F	44	Fatal
	1817hrs		Veh 2	Car	Turning right	S to NE	Dri	M	54	Serious
	Darkness: street lights present and lit		Veh 2	Car	Turning right	S to NE	FSP	F	66	Serious
E 445,131	Wet/Damp									
N 531,903	Fine without high winds									
	70 mph									

V1 TRAV S ON A19, V2 TRAV N ON SAME. ACC OCCURS WHEN V2 TURNS RIGHT ACROSS PATH OF ONCOMING V1

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H106910	Friday	A19 SOUTHBOUND, HARTLEPOOL AT ELWICK JUNCTION	Veh 1	Car	Change lane to right	N to S	Dri	F	51	Slight
A 19	23/07/2010		Veh 2	Car	Going ahead	N to S				
	1606hrs									
	(Pre-2011) Daylight:street lights present									
E 445,127	Dry									
N 531,925	Fine without high winds									
	70 mph									

BOTH VEHS TRAV S ON A19, V1 IN NEARSIDE LANE & V2 IN OFFSIDE LANE. ACC OCCURS WHEN V1 CHANGES LANES TO RIGHT & COL WITH V2

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H114010	Thursday	A19 SOUTHBOUND, HARTLEPOOL. APPROX 300M S OF NORTH LANE, ELWICK	Veh 1	Car	Going ahead	NW to SE	Dri	F	48	Serious
A 19	02/12/2010									
	1904hrs									
	Darkness: street lights present and lit									
E 445,011	Snow									
N 532,440	Snowing without high winds									
	70 mph									

V1 TRAV SE ON A19 WHEN DRIVER LOSES CONTROL OF VEHICLE IN ADVERSE WEATHER CONDITIONS, LEAVES CWAY TO NEARSIDE & COL WITH LAMPOST

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H101411	Monday	A19 NORTHBOUND, HARTLEPOOL. APPROX 200M PRIOR TO ELWICK INT	Veh 1	Car	Going ahead	S to N	Dri	F	18	Slight
A 19	31/01/2011		Veh 1	Car	Going ahead	S to N	FSP	F	20	Slight
	1320hrs		Veh 1	Car	Going ahead	S to N	RSP	F	20	Slight
	(Pre-2011) Daylight:street lights present									
E 445,155	Dry									
N 531,695	Fine without high winds									
	70 mph									

V1 TRAV N ON A19. ACC OCCURS WHEN VEH COL WITH KERB OF CENTRAL RES & THEN LEAVES CWAY TO NEARSIDE, COLLIDING WITH LAMPOST & COMING TO REST IN A FIELD

Details of Personal Injury Accidents for Period - **01/01/2006** **to** **31/12/2015** (120) months

Selection:

Notes:

Selected using Pre-defined Query : ; Refined using Accidents ~~within selected Polygons - Neil Raper - Requests for Information~~ ("Elwick - Coal Lane")

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Vehicles: Veh No / Type / Manv / Dir / Class	Casualties: Sex / Age / Sev

Account of Accident

H103011	Thursday	A19 HARTLEPOOL JUNC WITH ELWICK ROAD	Veh 1	Car	Going ahead	N to S		
A 19	17/02/2011		Veh 2	Car	Turning right	S to E	Dri	F 60 Slight
	1420hrs							
	(Pre-2011) Daylight:street lights present							
E 445,132	Dry							
N 531,911	Fine without high winds							
	70 mph							

V1 TRAV S ON A19, V2 TRAV N ON SAME. ACC OCCURS WHEN V2 TURNS RIGHT ACROSS PATH OF V1. V1 THEN LEAVES CWAY TO NEARSIDE

H107511	Thursday	A19 SOUTHBOUND, HARTLEPOOL JUNC WITH ELWICK VILLAGE	Veh 1	Car	Turning right	NE to N		
A 19	21/07/2011		Veh 2	M/C > 500 cc	Going ahead	N to S	Dri	M 71 Fatal
	1956hrs							
	(Pre-2011) Daylight:street lights present							
E 445,133	Dry							
N 531,903	Fine without high winds							
	70 mph							

V1 TRAV W FROM ELWICK VILLAGE, V2 TRAV S ON A19. ACC OCCURS WHEN V1 TURNS RIGHT OUT OF JUNC, ACROSS PATH OF ONCOMING V2

H107112	Saturday	A19 SOUTHBOUND, HARTLEPOOL JUNC WITH COAL LANE	Veh 1	Car	Going ahead	N to S	Dri	M 43 Slight
A 19	30/06/2012		Veh 1	Car	Going ahead	N to S	FSP	F 42 Slight
	0839hrs		Veh 1	Car	Going ahead	N to S	RSP	M 18 Slight
	Daylight		Veh 2	Goods < 3.5t	Turning right	NW to S		
E 445,123	Dry							
N 531,938	Fine without high winds							
	70 mph							

V1 TRAV S ON A19, V2 TRAV SE ON COAL LANE INTENDING SOUTH ON A19. ACC OCCURS WHEN V2 ENTERS CWAY INTO PATH OF V1 CAUSING V1 TO SWERVE TO AVOID COLLISION & LEAVE CWAY TO NEARSIDE

H100513	Tuesday	A19 NORTHBOUND, HARTLEPOOL. JUNC WITH COAL LANE/ELWICK TURN OFF	Veh 1	Goods < 3.5t	Wait to turn right	S to NE		
A 19	15/01/2013		Veh 2	Car	Wait to turn right	S to NE	Dri	F 29 Slight
	0817hrs		Veh 3	Car	Turning right	S to NE		
	Daylight							
E 445,124	Snow							
N 531,896	Snowing without high winds							
	70 mph							

VEHS 1 & 2 STAT IN CENTRAL RES WAITING TO TURN RIGHT & HEAD TOWARDS ELWICK, V3 TRAV N ON A19. ACC OCCURS WHEN V3 TURNS INTO CENTRAL RES BUT SKIDS DUE TO SNOW & COL WITH REAR OF V2, WHICH IS SHUNTED INTO V1. DRIVER OF V1 LEAVES SCENE.

Details of Personal Injury Accidents for Period - 01/01/2006 to 31/12/2015 (120) months

Selection:

Selected using Pre-defined Query : ; Refined using Accidents within selected Polygons -Neil Raper - Requests for Information ("Elwick - Coal Lane")

Notes:

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H106614 A 19 E 445,138 N 531,910	Sunday 22/06/2014 0644hrs Daylight Dry Fine without high winds 70 mph	A19 SOUTHBOUND, HARTLEPOOL JUNC WITH ELWICK ROAD	Veh 1	Goods < 3.5t	Going ahead	N to S	Dri	M	38	Serious
			Veh 1	Goods < 3.5t	Going ahead	N to S	FSP	M	39	Slight

Account of Accident: V1 TRAV S ON A19 WHEN DRIVER LEAVES CWAY TO NEASIDE & COL WITH BOLLARD ON TRAFFIC ISLAND AT JUNC WITH ELWICK RD

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H114014 A 19 E 445,111 N 531,902	Monday 08/12/2014 1115hrs Daylight Wet/Damp Fine without high winds 70 mph	A19 NORTHBOUND, HARTLEPOOL JUNC WITH COAL LANE	Veh 1	Car	Turning right	E to N	Dri	F	36	Slight
			Veh 2	Goods > 7.5t	Going ahead	S to N				

Account of Accident: V1 TRAV W FROM ELWICK INTENDING N ON A19, V2 TRAV N ON A19. ACC OCCURS WHEN V1 ENTERS PATH OF V2

Police Ref. / Road No. / Grid Ref.	Day / Date / Time / D/L / R.S.C / Weather / Speed	Location Description	Veh No	Type	Manv	Dir	Class	Sex	Age	Sev
H114714 A 19 E 445,196 N 531,601	Wednesday 17/12/2014 2045hrs Darkness: no street lighting Dry Fine without high winds 70 mph	A19 SOUTHBOUND, HARTLEPOOL APPROX 300M OF COAL LANE	Veh 1	Goods < 3.5t	Change lane to right	N to S	Dri	M	49	Slight
			Veh 2	Car	Going ahead	N to S	Dri	F	30	Slight

Account of Accident: BOTH VEHS TRAV S ON A19, V1 IN NEARSIDE LANE & V2 IN OFFSIDE LANE. ACC OCCURS WHEN V1 CHNAGES LANES TO THE RIGHT INTO PATH OF V2. V2 COL WITH REAR OF V1 WHICH THEN COL WITH CRASH BARRIER

Appendix 7 – Summary of queue survey

Technical Note 1 – A19 / Coal Lane / Elwick Road Video Surveys

AECOM

Project:	**Hartlepool Residential Developments**	Job No:	**60217899-1549**
Subject:	**A19 / Coal Lane / Elwick Road Video Survey Analysis**		
Prepared by:	**Declan Fay**	Date:	**22nd April 2016**
Checked by:	**Steve Moss**	Date:	**22nd April 2016**
Approved by:	**Steve Moss**	Date:	**22nd April 2016**

1. Introduction

This Technical Note provides an overview of observations made from video surveys at the A19 / Coal Lane / Elwick Road Junction in Hartlepool.

AECOM has been appointed by Highways England (HE) to undertake a review of the cumulative impact of proposed developments at High Tunstall (208 dwellings) and Quarry Farm (220 dwellings) on the Strategic Road Network (SRN) in the Hartlepool area. In recent discussions with Hartlepool Borough Council (HBC) AECOM has been informed of possible queuing and associated road safety concerns on the A19 NB right turn lane to Elwick Road at the A19 / Coal Lane / Elwick Road junction. The A19 / Coal Lane / Elwick Road junction location is shown in **Figure 1** below.

Figure 1: Junction Locations

A19 / Coal Lane / Elwick Road

In order to determine the frequency and severity of queuing at this location, an analysis of a 7 day period comprising video footage (supplied by HBC) dated from 27th February 2016 to 3rd March 2016 has been conducted. The aim of this analysis is to better understand base conditions in order to advise on the potential safety impact of development proposals in the local area. Following this review, it is considered that frequent queuing on the right turn lane in the weekday PM peak is likely constitute a potential road safety concern at the A19 / Coal Lane / Elwick Road junction.

2. Methodology

Video survey footage was analysed for the entire 24 hour period on each of the dates as listed below:

- Saturday 27th February 2016,
- Sunday 28th February 2016,
- Monday 29th February 2016,
- Tuesday 1st March 2016,
- Wednesday 2nd March 2016,
- Thursday 3rd March 2016,
- Friday 4th March 2016.

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2 City Walk
Leeds
LS11 9AR
United Kingdom

The analysis was undertaken to identify times when vehicle queues formed on the right turn lane of the A19 NB to Elwick Road. Unfortunately, the camera angle from which queuing was observed does not include the full lane length and therefore queuing was noted from this point backwards only. The distance from the point at which queuing was measured to the stop line to the north is approximately 43m (roughly 7 PCUs long based on a PCU length of 5.75m). The total length of the lane is approximately 100m which equates to a total of 17 PCUs based on a PCU length of 5.75m.

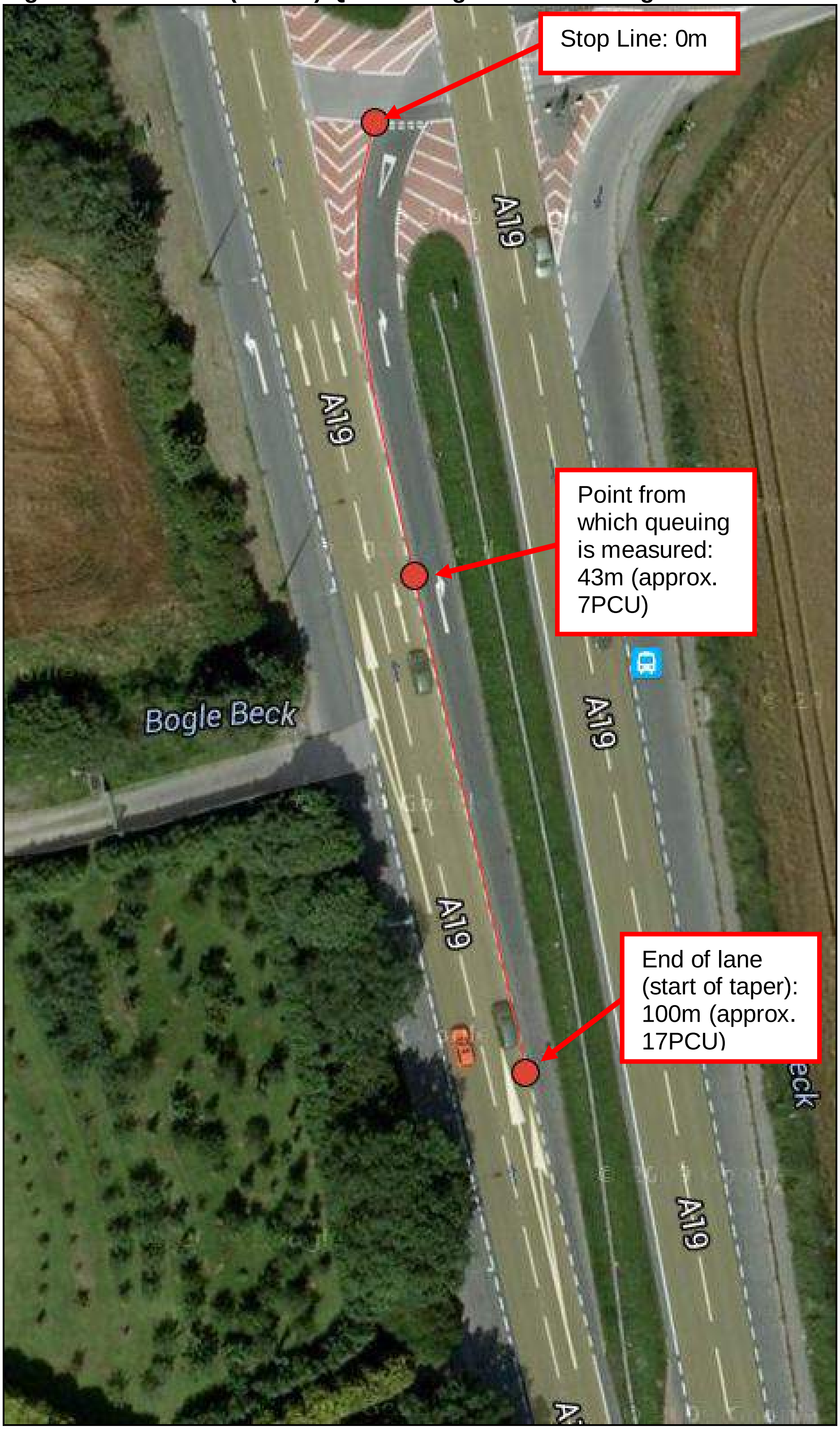
The camera angle from which queuing was observed is as shown in **Figure 2** below.

Figure 2: Camera Angle

Figure 3 overleaf also demonstrates the full lane length compared to the visible lane length and puts into context how queuing has been measured. **Figure 3** shows that surplus to the visible queue length there is approximately 7PCUs between its start and the stop line of the right turn lane. It is therefore assumed that when queuing is observed from the camera angle shown in **Figure 2**, the total queue length is that number of vehicles plus 7. This approach is described in the equation below:

Equation 1: *Assumed Total Queue Length = Visible Queue Length + 7*

Figure 3: Measured (Visible) Queue Length vs. Lane Length



3. Analysis

3.1. Weekend – Saturday and Sunday

Across the first two survey days (the weekend of Saturday 27th February and Sunday 28th February 2016) only one instance of visible queuing was observed. This occurred at 14:18:32 with a visible queue length of 1 vehicle (assumed total queue of 8 vehicles) waiting on the right turn lane for a period of 40 seconds until 14:19:12, as shown in **Figure 4**.

Figure 4: Maximum Observed Queuing Conditions (1 vehicle) on Saturday 27th February 2016

Queuing observations for Saturday 27th and Sunday 28th February 2016 are summarised in **Table 1** and **Table 2** respectively.

Table 1: Queuing Observations Saturday 27th February 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	1	8	14:18:32	14:19:12	00:00:40

Table 2: Queuing Observations Sunday 28th February 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	-	7	-	-	-

3.2. Monday

On Monday 29th February 2016, analysis of the video surveys showed queuing between the hours of 1600 and 1800. Across all other times no queuing was reported. Between 1600 and 1700, the maximum queue length was noted as 2 vehicles (assumed total queue of 9 vehicles) occurring on four occasions but never for longer than 1min 8secs.

The maximum queue observed between 1700 and 1800 was 3 vehicles (assumed total queue of 10 vehicles), occurring twice, lasting once for a period of 1min and 8secs and in another instance for 31 seconds. The maximum overall queue is shown in **Figure 5.**

Figure 5: Maximum Observed Queuing Conditions (3 Vehicles) on Monday 29th February 2016

Queuing observations for Monday 29th February 2016 have been summarised in **Table 3** below.

Table 3: Queuing Observations Monday 29th February 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	16:04:05	16:05:10	00:01:05
7	2	9	16:05:20	16:05:37	00:00:17
7	1	8	16:08:21	16:08:42	00:00:21
7	1	8	16:08:48	16:08:58	00:00:10
7	2	9	16:12:06	16:12:12	00:00:06
7	2	9	16:51:16	16:52:35	00:01:19
7	1	8	17:10:08	17:10:24	00:00:16
7	1	8	17:10:44	17:11:12	00:00:28
7	3	10	17:11:18	17:12:26	00:01:08
7	1	8	17:12:41	17:12:53	00:00:12
7	1	8	17:13:02	17:13:22	00:00:20
7	2	9	17:19:35	17:19:46	00:00:11
7	3	10	17:20:19	17:20:50	00:00:31
7	1	8	17:23:26	17:26:39	00:03:13
7	1	8	17:27:41	17:28:11	00:00:30
7	2	9	17:29:58	17:30:09	00:00:11

3.3. Tuesday

On Tuesday 1st March 2016, one instance of queuing was reported during the AM peak period between the hours of 0800 and 0900. This queue was 1 vehicle (assumed total queue of 8 vehicles) in length and was observed at 08:13:10 for a period of 2min and 14secs before dissipating around 08:15:24.

Between 1600 and 1700, queuing was also noted to occur with the largest queue being reported as 1 vehicle (assumed total queue of 8 vehicles) in length. The greatest extent of queuing was noted between 1700 and 1800 when a queue amounting to 6 vehicles (assumed total queue of 13 vehicles) was observed for a period of 1min and 6secs.

Figure 6 below shows the extent of this queuing. It should be noted that no queuing was observed at any other times throughout the day.

Figure 6: Maximum Observed Queuing Conditions (6 vehicles) on Tuesday 1st March 2016

Queuing observations for Tuesday 1st March 2016 are summarised in **Table 4** below.

Table 4: Queuing Observations for Tuesday 1st March 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	1	8	08:13:10	08:15:24	00:02:14
7	1	8	16:28:21	16:29:02	00:00:41
7	1	8	16:36:38	16:36:55	00:00:17
7	6	13	17:03:50	17:04:56	00:01:06
7	2	9	17:16:40	17:18:32	00:01:52
7	4	11	17:19:19	17:20:01	00:00:42

3.4. Wednesday

On Wednesday 2nd March 2016, queuing was observed between the hours of 1600 and 1900. Queuing occurred most regularly and to the largest extent between the hours of 1600 and 1700. The maximum queue on this day was 4 vehicles in length (assumed total queue of 11 vehicles). This queuing was noted on two occasions; once for a period of 34 seconds between 16:48:19 and 16:48:53 and another for a period of 2mins and 29secs between 16:56:02 and 16:58:31.

Figure 7 illustrates this queuing.

Figure 7: Maximum Observed Queuing Conditions (4 vehicles) on Wednesday 2nd March 2016

Queuing observations for Wednesday 2nd are summarised in **Table 5** below.

Table 5: Queuing Observations for Wednesday 2nd March

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	16:12:37	16:13:01	00:00:24
7	1	8	16:13:04	16:13:45	00:00:41
7	1	8	16:29:00	16:29:20	00:00:20
7	1	8	16:34:16	16:34:30	00:00:14
7	2	9	16:35:51	16:36:19	00:00:28
7	1	8	16:38:43	16:39:39	00:00:56
7	4	11	16:48:19	16:48:53	00:00:34
7	1	8	16:51:29	16:51:47	00:00:18
7	1	8	16:54:26	16:54:53	00:00:27
7	4	11	16:56:02	16:58:31	00:02:29
7	1	8	17:27:28	17:28:13	00:00:45
7	1	8	18:20:10	18:20:37	00:00:27

3.5. Thursday

Queuing on Thursday 3rd March 2016 has been noted to occur between 1600 and 1800. No vehicle queuing was reported throughout the remainder of the day. The maximum extent of queuing on Thursday was noted as 4 vehicles (assumed total queue of 11 vehicles) occurring between 17:24:28 and 17:15:18 for a period of 50 seconds. This is shown in **Figure 8** below.

Figure 8: Maximum Observed Queuing Conditions (4 vehicles) on Thursday 3rd March 2016

Queuing observations for Thursday 3nd March 2016 are summarised in **Table 6** below.

Table 6: Queuing Observations for Thursday 3rd March 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	16:49:02	16:49:16	00:00:14
7	1	8	16:57:51	16:58:18	00:00:27
7	4	11	17:24:28	17:25:18	00:00:50

3.6. Friday

On Friday 4th March 2016, the maximum length of queuing has been noted as 4 vehicles (assumed total queue of 11 vehicles) occurring within the hourly period from 1600 to 1700. The queue occurred exactly from 16:19:48 to 16:20:19 lasting for 31 seconds.

This is shown in **Figure 9** below.

Figure 9: Maximum Observed Queuing Conditions (4 vehicles) on Friday 4th March 2016

Queuing observations for Friday 4th March 2016 are summarised in **Table 7** below.

Table 7: Queuing Observations for Friday 4th March 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	15:49:46	15:50:46	00:01:00
7	1	8	16:12:54	16:13:28	00:00:34
7	2	9	16:16:41	16:17:39	00:00:58
7	4	11	16:19:48	16:20:19	00:00:31
7	3	10	16:23:37	16:24:38	00:01:01
7	3	10	16:32:28	16:32:47	00:00:19

4. Summary

This video survey analysis has shown that from Monday to Friday, the frequency of vehicle queuing in the PM peak period gives rise to a potential road safety concern on the right turn lane from the A19 NB to Elwick Road.

It has been shown that for Monday to Friday, in the week examined, there are several instances of visible queuing ranging from 1 vehicle (assumed total queue of 8 vehicles) to a maximum of 6PCUs (assumed total queue of 8 vehicles) in length during the PM peak. Queuing to such extents is considered to have an impact on decelerating vehicles on the mainline.

Only one instance of queuing has been noted in the AM peak period by comparison.

The maximum queue noted for each of the observed days is as outlined below in **Table 9**.

Table 8: Summary of Queuing Observations

Date	Max Visible Queue (PCU)	Max Total Queue (PCU)	Number of Times Observed	Longest Time Observed for (hh:mm:ss)
Saturday 27th February 2016,	1	8	1	00:00:40
Sunday 28th February 2016,	0	7	-	-
Monday 29th February 2016,	3	10	2	00:01:08
Tuesday 1st March 2016,	6	13	1	00:01:06
Wednesday 2nd March 2016,	4	11	2	00:02:29
Thursday 3rd March 2016,	4	11	1	00:00:50
Friday 4th March 2016	4	11	1	00:00:31

Therefore, whilst queuing on the right turn lane from the A19 to Elwick does not extend so far as to disrupt mainline traffic flow, it does severely impact the length of deceleration lane available.

Appendix 8 – Method used to derive the queue probability distribution

Table A2 shows the Chi Squared probability values (obtained from statistical tables).

Chi Squared Value	Probability[1]
0.000157	0.99
0.00393	0.95
0.0158	0.9
0.0642	0.8
0.148	0.7
0.455	0.5
1.074	0.3
1.642	0.2
2.706	0.1
3.841	0.05
6.635	0.01

1 - Probability of obtaining chi squared value through random fluctuation

Table A2 – Chi squared probability values

The queue survey suggested that the queue length is greater than 7 vehicles for approximately 6 minutes during an average week-day evening peak period. Six minutes equates to 1/20th (or 0.05) of the 2-hour evening peak period. From table A2, the chi squared value equivalent to a probability of 0.05 is 3.841. Chi squared values for the right turn queue length have been calculated using the following factor:

surveyed queue length/base chi squared value = 7/3.841 = 1.822

Table A3 shows the Chi squared values that result from the application of this factor. The values shown in this table are therefore calibrated to the queue survey data and can be used to estimate the probability of the queue length being greater than any given value.

Chi Squared Value	Probability[1]
0.000286	0.99
0.007162	0.95
0.028795	0.9
0.117001	0.8
0.269721	0.7
0.829211	0.5
1.957303	0.3
2.992450	0.2
4.931528	0.1
7	0.05
12.091903	0.01

1 - Probability of obtaining chi squared value through random fluctuation

Table A3 – Chi squared probability values factored to the A19 northbound right turn queue

The values in table A3 were used to produce Figure 3 in the main report.

Appendix 9 – Method used to derive the probability of a collision in the offside lane

The probability of a shunt collision occurring in queuing traffic on the approach to a roundabout has been estimated using data for the A19/A1068 Fisher Lane roundabout. This calculation has then been used to derive a value for the likelihood of a collision occurring in the offside lane of the A19 northbound approach to Elwick Crossroads when stationary traffic is present in this lane.

A19/A1068 Fisher Lane roundabout

Sixteen shunt collisions occurred on the A19 westbound approach to the Fisher Lane roundabout during the 5-year period from 01/08/2007 to 31/07/2012. Seven of these 16 shunts occurred upstream of the roundabout entry.

The Annual Average Daily Traffic (AADT) flow on the A19 westbound approach to Fisher Lane roundabout in 2012 was 14,990 vehicles per day. Using a combination of Google traffic and the author's knowledge of the operation of this junction, it is estimated that during the period 2007 to 2012 queuing traffic would be present on the A19 westbound approach for approximately 1.5 hours every week-day.

Therefore, the flow exposed to the hazard of queuing traffic = (1.5/24) x 14,990 = 937 vehicles per day

In a year, this equates to a flow = 937 x 253 working days = 237,061 vehicles per year

Over 5 years, the flow exposed to the hazard = 237,061 x 5 = 1,185,305 vehicles

The likelihood of a shunt in queuing traffic is therefore 1 in every (1,185,305/7) = 169,329 vehicles ... (1)

A19 Elwick Crossroads

The probability of a shunt collision occurring if a queue is present in the offside lane of the A19 northbound approach to Elwick Crossroads is considered to be higher than for the equivalent situation on approach to a roundabout. This is due to the unexpected nature of the queue in the offside lane at Elwick Crossroads, at a location where drivers would not expect to have to slow down. Whereas, on approach to a roundabout, drivers will be anticipating the need to slow down, albeit with some uncertainty as regards the available stopping distance and extent of queuing that will be present on the road ahead. The relative probability of these two hazards resulting in a collision has been assessed with reference to categories of probability that are used when preparing a hazard log. These categories are shown in table A4.

Classification	Events	Index Value	States
	If this hazard occurs then:		This hazard, if present, will:
Certain	A collision is certain	4	Definitely cause a collision
Probable	A collision is probable	3	Frequently cause a collision
Occasional	A collision will occasionally happen	2	Occasionally cause a collision
Remote	There is a remote chance of a collision	1	Infrequently cause a collision
Improbable	A collision is improbable	0	Rarely cause a collision

Table A4 – Probability that an event/state causes collisions

Each probability category is assigned an index value, as shown in table A4. The scale of scoring is logarithmic, in order to cover the necessary range of values and then present them in a manageable form. An increase of 1 in a score therefore represents a factor of 10 increase in the risk.

The probability that a queue on the A19 westbound approach to the Fisher Lane roundabout will result in a collision is considered to be remote (index value = 1). The probability that a queue in the offside lane of the A19 northbound approach to Elwick Crossroads will result in a collision is considered to lie between occasional and probable (index value = 2.5). The risk of the queue at Elwick Crossroads is therefore considered 50 times more likely to result in a collision than the queue at Fisher Lane roundabout.

Therefore, using the value at (1) from the Fisher Lane roundabout analysis,

The likelihood of a shunt in queuing traffic in the offside lane of the A19 northbound approach to Elwick Crossroads is estimated to be 1 in every (169,329/50) = 3,387 vehicles

Appendix 10 – Method used to estimate the Benefit to Cost Ratios

Approximate Benefit to Cost Ratios (BCRs) have been calculated for the following risk control measures:

- option 1 - replacement of the existing at-grade junction with a grade-separated junction
- option 2 - closure of both gaps in the central reservation at Elwick Crossroads
- option 3 - prohibition of the right turn movement from the A19 northbound into Elwick Road
- option 4 - introduction of a reduced speed limit on the A19 through the junction

The method only takes account of the potential safety benefits of each option and does not include for any journey time benefits or dis-benefits.

Option 1 – grade-separated junction

Table A5 shows the collisions that could potentially be saved if this option was implemented.

Collision type and movement	Potentially saved?	Number of collisions in 10 years
A19 SB (loss of control or lane change)	N	N/A
A19 NB (loss of control)	N	N/A
A19 NB right turn across A19 SB	Y	2
Elwick Road right turn across A19 SB	Y	1
Coal Lane right turn across A19 SB	Y	1
A19 NB right turn shunt in queue	Y	1
Elwick Road right turn across A19 NB	Y	1
Total		**6**

Table A5 – Collisions potentially saved by option 1 (10-year period)

Number of collisions per year that could potentially be saved = 0.6

It has been assumed that 100% of these collisions would be saved as a result of replacing the existing at-grade crossroads with a grade-separated junction.

A compact grade-separated junction at Elwick Crossroads has previously been costed at £11.6 million.

A Scheme Appraisal Report (SAR) has been used to estimate the BCR, assuming a scheme opening year of 2018. The BCR for option 1 was estimated to be 0.27.

Option 2 – gap closure

Table A6 shows the collisions that could potentially be saved if this option was implemented.

Collision type and movement	Potentially saved?	Number of collisions in 10 years
A19 SB (loss of control or lane change)	N	N/A
A19 NB (loss of control)	N	N/A
A19 NB right turn across A19 SB	Y	2
Elwick Road right turn across A19 SB	Y	1
Coal Lane right turn across A19 SB	Y	1
A19 NB right turn shunt in queue	Y	1
Elwick Road right turn across A19 NB	Y	1
Total		**6**

Table A6 – Collisions potentially saved by option 2 (10-year period)

Number of collisions per year that could potentially be saved = 0.6

The Highways England POPE of LNMS report (2014) suggests that schemes involving the prohibition of turning movements typically save 45% of targeted collisions. It has therefore been assumed that 45% of the 0.6 collisions per year would be saved as a result of the gap closures, which equates to 0.27 collisions per year.

It is estimated that the closure of gaps at Elwick Crossroads would cost approximately £1 million.

A Scheme Appraisal Report (SAR) has been used to estimate the BCR, assuming a scheme opening year of 2018. The BCR for option 2 was estimated to be 1.41.

Option 3 – prohibition of the right turn movement

Table A7 shows the collisions that could potentially be saved if this option was implemented.

Collision type and movement	Potentially saved?	Number of collisions in 10 years
A19 SB (loss of control or lane change)	N	N/A
A19 NB (loss of control)	N	N/A
A19 NB right turn across A19 SB	Y	2
Elwick Road right turn across A19 SB	N	N/A
Coal Lane right turn across A19 SB	N	N/A
A19 NB right turn shunt in queue	Y	1
Elwick Road right turn across A19 NB	N	N/A
Total		**3**

Table A7 – Collisions potentially saved by option 3 (10-year period)

Number of collisions per year that could potentially be saved = 0.3

The Highways England POPE of LNMS report (2014) suggests that schemes involving the prohibition of turning movements typically save 45% of targeted collisions. It has therefore been assumed that 45% of the 0.3 collisions per year would be saved as a result of prohibiting the right turn movement into Elwick Road, which equates to 0.135 collisions per year.

It is estimated that the prohibition of the right turn movement into Elwick Road would cost approximately £250,000.

A Scheme Appraisal Report (SAR) has been used to estimate the BCR, assuming a scheme opening year of 2018. The BCR for option 3 was estimated to be 2.76.

Option 4 – speed limit reduction

Table A8 shows the collisions that could potentially be saved if this option was implemented.

Collision type and movement	Potentially saved?	Number of collisions in 10 years
A19 SB (loss of control or lane change)	Y	4
A19 NB (loss of control)	Y	1
A19 NB right turn across A19 SB	Y	2
Elwick Road right turn across A19 SB	Y	1
Coal Lane right turn across A19 SB	Y	1
A19 NB right turn shunt in queue	Y	1
Elwick Road right turn across A19 NB	Y	1
Total		**11**

Table A8 – Collisions potentially saved by option 4 (10-year period)

Number of collisions per year that could potentially be saved = 1.1

The Highways England POPE of LNMS report (2014) suggests that schemes involving a speed limit reduction typically save 28% of targeted collisions. It has therefore been assumed that 28% of the 1.1 collisions per year would be saved as a result of the speed limit reduction, which equates to 0.308 collisions per year.

It is estimated that the speed limit reduction would cost approximately £150,000.

A Scheme Appraisal Report (SAR) has been used to estimate the BCR, assuming a scheme opening year of 2018. The BCR for option 4 was estimated to be 10.23.

Appendix B

Video Survey Note

Technical Note 1 – A19 / Coal Lane / Elwick Road Video Surveys

Project:	**Hartlepool Residential Developments**	Job No:	**60217899-1549**
Subject:	**A19 / Coal Lane / Elwick Road Video Survey Analysis**		
Prepared by:	**Declan Fay**	Date:	**22nd April 2016**
Checked by:	**Steve Moss**	Date:	**22nd April 2016**
Approved by:	**Steve Moss**	Date:	**22nd April 2016**

1. Introduction

This Technical Note provides an overview of observations made from video surveys at the A19 / Coal Lane / Elwick Road Junction in Hartlepool.

AECOM has been appointed by Highways England (HE) to undertake a review of the cumulative impact of proposed developments at High Tunstall (208 dwellings) and Quarry Farm (220 dwellings) on the Strategic Road Network (SRN) in the Hartlepool area. In recent discussions with Hartlepool Borough Council (HBC) AECOM has been informed of possible queuing and associated road safety concerns on the A19 NB right turn lane to Elwick Road at the A19 / Coal Lane / Elwick Road junction. The A19 / Coal Lane / Elwick Road junction location is shown in **Figure 1** below.

Figure 1: Junction Locations

A19 / Coal Lane / Elwick Road

In order to determine the frequency and severity of queuing at this location, an analysis of a 7 day period comprising video footage (supplied by HBC) dated from 27th February 2016 to 3rd March 2016 has been conducted. The aim of this analysis is to better understand base conditions in order to advise on the potential safety impact of development proposals in the local area. Following this review, it is considered that frequent queuing on the right turn lane in the weekday PM peak is likely constitute a potential road safety concern at the A19 / Coal Lane / Elwick Road junction.

2. Methodology

Video survey footage was analysed for the entire 24 hour period on each of the dates as listed below:

- Saturday 27th February 2016,
- Sunday 28th February 2016,
- Monday 29th February 2016,
- Tuesday 1st March 2016,
- Wednesday 2nd March 2016,
- Thursday 3rd March 2016,
- Friday 4th March 2016.

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The analysis was undertaken to identify times when vehicle queues formed on the right turn lane of the A19 NB to Elwick Road. Unfortunately, the camera angle from which queuing was observed does not include the full lane length and therefore queuing was noted from this point backwards only. The distance from the point at which queuing was measured to the stop line to the north is approximately 43m (roughly 7 PCUs long based on a PCU length of 5.75m). The total length of the lane is approximately 100m which equates to a total of 17 PCUs based on a PCU length of 5.75m.

The camera angle from which queuing was observed is as shown in **Figure 2** below.

Figure 2: Camera Angle

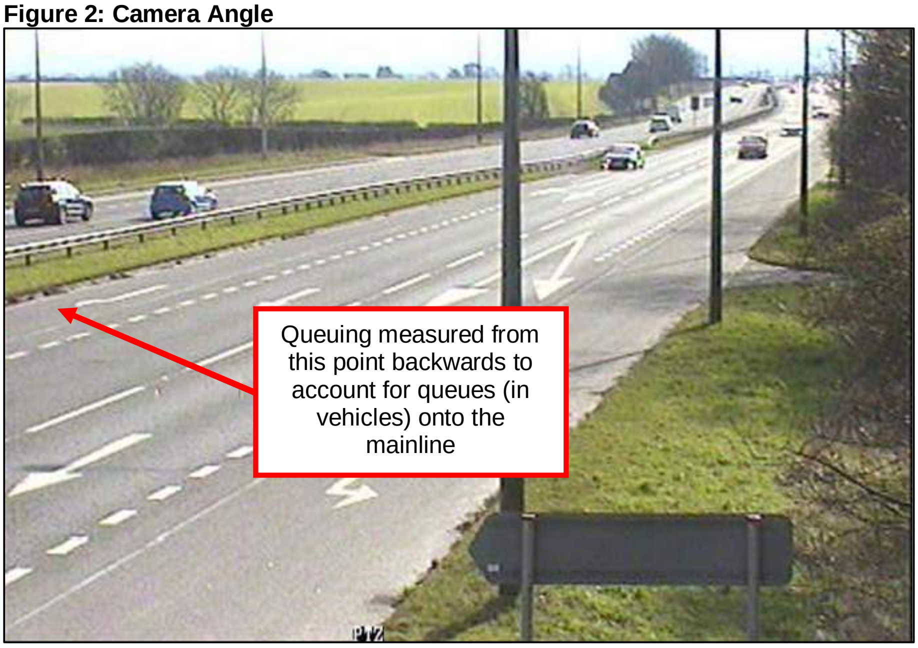
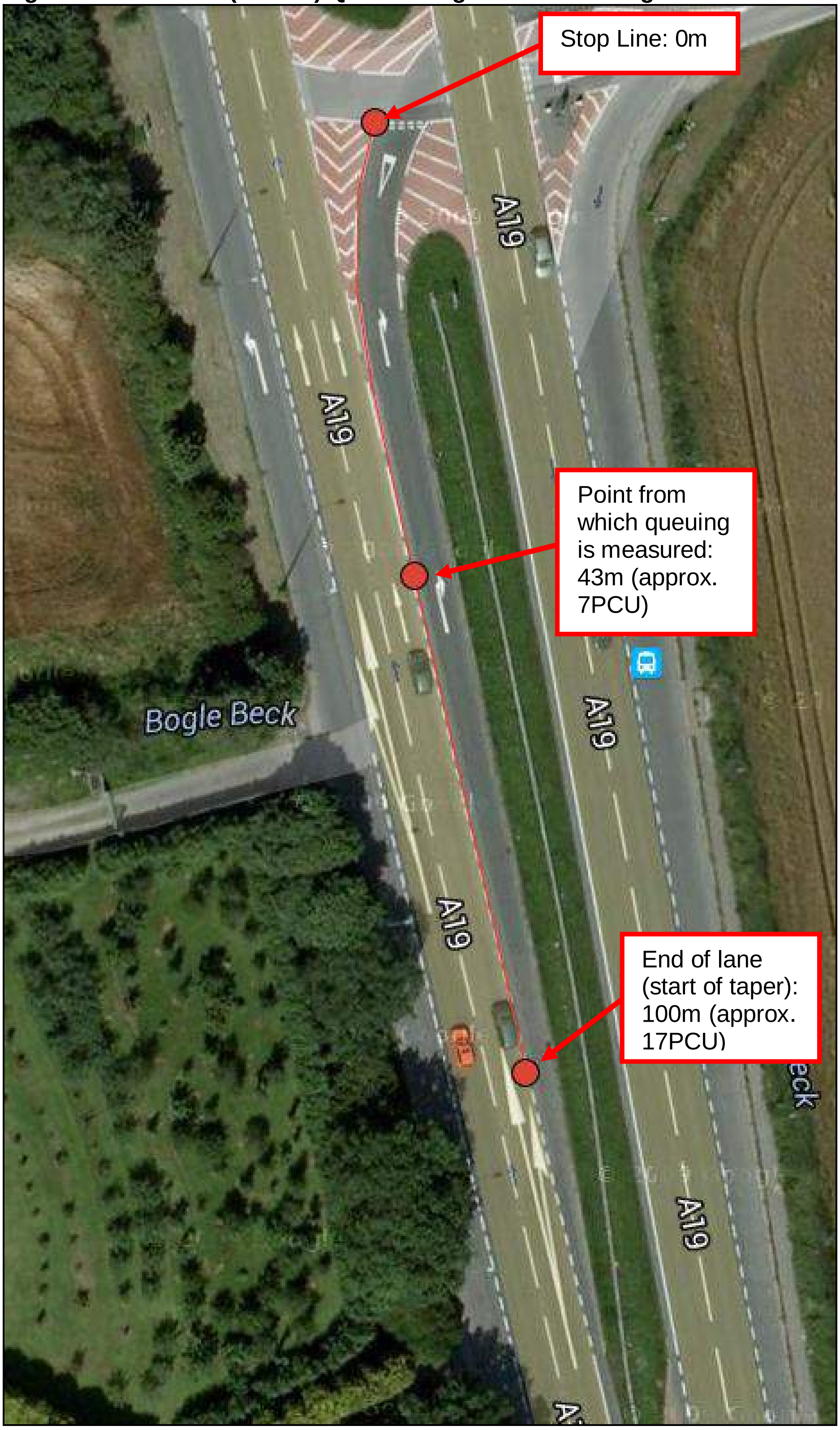


Figure 3 overleaf also demonstrates the full lane length compared to the visible lane length and puts into context how queuing has been measured. **Figure 3** shows that surplus to the visible queue length there is approximately 7PCUs between its start and the stop line of the right turn lane. It is therefore assumed that when queuing is observed from the camera angle shown in **Figure 2**, the total queue length is that number of vehicles plus 7. This approach is described in the equation below:

Equation 1: *Assumed Total Queue Length = Visible Queue Length + 7*

Figure 3: Measured (Visible) Queue Length vs. Lane Length



3. Analysis

3.1. Weekend – Saturday and Sunday

Across the first two survey days (the weekend of Saturday 27th February and Sunday 28th February 2016) only one instance of visible queuing was observed. This occurred at 14:18:32 with a visible queue length of 1 vehicle (assumed total queue of 8 vehicles) waiting on the right turn lane for a period of 40 seconds until 14:19:12, as shown in **Figure 4**.

Figure 4: Maximum Observed Queuing Conditions (1 vehicle) on Saturday 27th February 2016

Queuing observations for Saturday 27th and Sunday 28th February 2016 are summarised in **Table 1** and **Table 2** respectively.

Table 1: Queuing Observations Saturday 27th February 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	1	8	14:18:32	14:19:12	00:00:40

Table 2: Queuing Observations Sunday 28th February 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	-	7	-	-	-

3.2. Monday

On Monday 29th February 2016, analysis of the video surveys showed queuing between the hours of 1600 and 1800. Across all other times no queuing was reported. Between 1600 and 1700, the maximum queue length was noted as 2 vehicles (assumed total queue of 9 vehicles) occurring on four occasions but never for longer than 1min 8secs.

The maximum queue observed between 1700 and 1800 was 3 vehicles (assumed total queue of 10 vehicles), occurring twice, lasting once for a period of 1min and 8secs and in another instance for 31 seconds. The maximum overall queue is shown in **Figure 5.**

Figure 5: Maximum Observed Queuing Conditions (3 Vehicles) on Monday 29th February 2016

Queuing observations for Monday 29th February 2016 have been summarised in **Table 3** below.

Table 3: Queuing Observations Monday 29th February 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	16:04:05	16:05:10	00:01:05
7	2	9	16:05:20	16:05:37	00:00:17
7	1	8	16:08:21	16:08:42	00:00:21
7	1	8	16:08:48	16:08:58	00:00:10
7	2	9	16:12:06	16:12:12	00:00:06
7	2	9	16:51:16	16:52:35	00:01:19
7	1	8	17:10:08	17:10:24	00:00:16
7	1	8	17:10:44	17:11:12	00:00:28
7	3	10	17:11:18	17:12:26	00:01:08
7	1	8	17:12:41	17:12:53	00:00:12
7	1	8	17:13:02	17:13:22	00:00:20
7	2	9	17:19:35	17:19:46	00:00:11
7	3	10	17:20:19	17:20:50	00:00:31
7	1	8	17:23:26	17:26:39	00:03:13
7	1	8	17:27:41	17:28:11	00:00:30
7	2	9	17:29:58	17:30:09	00:00:11

3.3. Tuesday

On Tuesday 1st March 2016, one instance of queuing was reported during the AM peak period between the hours of 0800 and 0900. This queue was 1 vehicle (assumed total queue of 8 vehicles) in length and was observed at 08:13:10 for a period of 2min and 14secs before dissipating around 08:15:24.

Between 1600 and 1700, queuing was also noted to occur with the largest queue being reported as 1 vehicle (assumed total queue of 8 vehicles) in length. The greatest extent of queuing was noted between 1700 and 1800 when a queue amounting to 6 vehicles (assumed total queue of 13 vehicles) was observed for a period of 1min and 6secs.

Figure 6 below shows the extent of this queuing. It should be noted that no queuing was observed at any other times throughout the day.

Figure 6: Maximum Observed Queuing Conditions (6 vehicles) on Tuesday 1st March 2016

Queuing observations for Tuesday 1st March 2016 are summarised in **Table 4** below.

Table 4: Queuing Observations for Tuesday 1st March 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	1	8	08:13:10	08:15:24	00:02:14
7	1	8	16:28:21	16:29:02	00:00:41
7	1	8	16:36:38	16:36:55	00:00:17
7	6	13	17:03:50	17:04:56	00:01:06
7	2	9	17:16:40	17:18:32	00:01:52
7	4	11	17:19:19	17:20:01	00:00:42

3.4. Wednesday

On Wednesday 2nd March 2016, queuing was observed between the hours of 1600 and 1900. Queuing occurred most regularly and to the largest extent between the hours of 1600 and 1700. The maximum queue on this day was 4 vehicles in length (assumed total queue of 11 vehicles). This queuing was noted on two occasions; once for a period of 34 seconds between 16:48:19 and 16:48:53 and another for a period of 2mins and 29secs between 16:56:02 and 16:58:31.

Figure 7 illustrates this queuing.

Figure 7: Maximum Observed Queuing Conditions (4 vehicles) on Wednesday 2nd March 2016

Queuing observations for Wednesday 2nd are summarised in **Table 5** below.

Table 5: Queuing Observations for Wednesday 2nd March

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	16:12:37	16:13:01	00:00:24
7	1	8	16:13:04	16:13:45	00:00:41
7	1	8	16:29:00	16:29:20	00:00:20
7	1	8	16:34:16	16:34:30	00:00:14
7	2	9	16:35:51	16:36:19	00:00:28
7	1	8	16:38:43	16:39:39	00:00:56
7	4	11	16:48:19	16:48:53	00:00:34
7	1	8	16:51:29	16:51:47	00:00:18
7	1	8	16:54:26	16:54:53	00:00:27
7	4	11	16:56:02	16:58:31	00:02:29
7	1	8	17:27:28	17:28:13	00:00:45
7	1	8	18:20:10	18:20:37	00:00:27

3.5. Thursday

Queuing on Thursday 3rd March 2016 has been noted to occur between 1600 and 1800. No vehicle queuing was reported throughout the remainder of the day. The maximum extent of queuing on Thursday was noted as 4 vehicles (assumed total queue of 11 vehicles) occurring between 17:24:28 and 17:15:18 for a period of 50 seconds. This is shown in **Figure 8** below.

Figure 8: Maximum Observed Queuing Conditions (4 vehicles) on Thursday 3rd March 2016

Queuing observations for Thursday 3nd March 2016 are summarised in **Table 6** below.

Table 6: Queuing Observations for Thursday 3rd March 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	16:49:02	16:49:16	00:00:14
7	1	8	16:57:51	16:58:18	00:00:27
7	4	11	17:24:28	17:25:18	00:00:50

3.6. Friday

On Friday 4th March 2016, the maximum length of queuing has been noted as 4 vehicles (assumed total queue of 11 vehicles) occurring within the hourly period from 1600 to 1700. The queue occurred exactly from 16:19:48 to 16:20:19 lasting for 31 seconds.

This is shown in **Figure 9** below.

Figure 9: Maximum Observed Queuing Conditions (4 vehicles) on Friday 4th March 2016

Queuing observations for Friday 4th March 2016 are summarised in **Table 7** below.

Table 7: Queuing Observations for Friday 4th March 2016

Max Unseen Queue (PCU)	Max Visible Queue (PCU)	Max Total Queue (PCU)	Visible Queue Starts (hh:mm:ss)	Visible Queue Ends (hh:mm:ss)	Visible Queue Time (hh:mm:ss)
7	2	9	15:49:46	15:50:46	00:01:00
7	1	8	16:12:54	16:13:28	00:00:34
7	2	9	16:16:41	16:17:39	00:00:58
7	4	11	16:19:48	16:20:19	00:00:31
7	3	10	16:23:37	16:24:38	00:01:01
7	3	10	16:32:28	16:32:47	00:00:19

4. Summary

This video survey analysis has shown that from Monday to Friday, the frequency of vehicle queuing in the PM peak period gives rise to a potential road safety concern on the right turn lane from the A19 NB to Elwick Road.

It has been shown that for Monday to Friday, in the week examined, there are several instances of visible queuing ranging from 1 vehicle (assumed total queue of 8 vehicles) to a maximum of 6PCUs (assumed total queue of 8 vehicles) in length during the PM peak. Queuing to such extents is considered to have an impact on decelerating vehicles on the mainline.

Only one instance of queuing has been noted in the AM peak period by comparison.

The maximum queue noted for each of the observed days is as outlined below in **Table 9**.

Table 8: Summary of Queuing Observations

Date	Max Visible Queue (PCU)	Max Total Queue (PCU)	Number of Times Observed	Longest Time Observed for (hh:mm:ss)
Saturday 27th February 2016,	1	8	1	00:00:40
Sunday 28th February 2016,	0	7	-	-
Monday 29th February 2016,	3	10	2	00:01:08
Tuesday 1st March 2016,	6	13	1	00:01:06
Wednesday 2nd March 2016,	4	11	2	00:02:29
Thursday 3rd March 2016,	4	11	1	00:00:50
Friday 4th March 2016	4	11	1	00:00:31

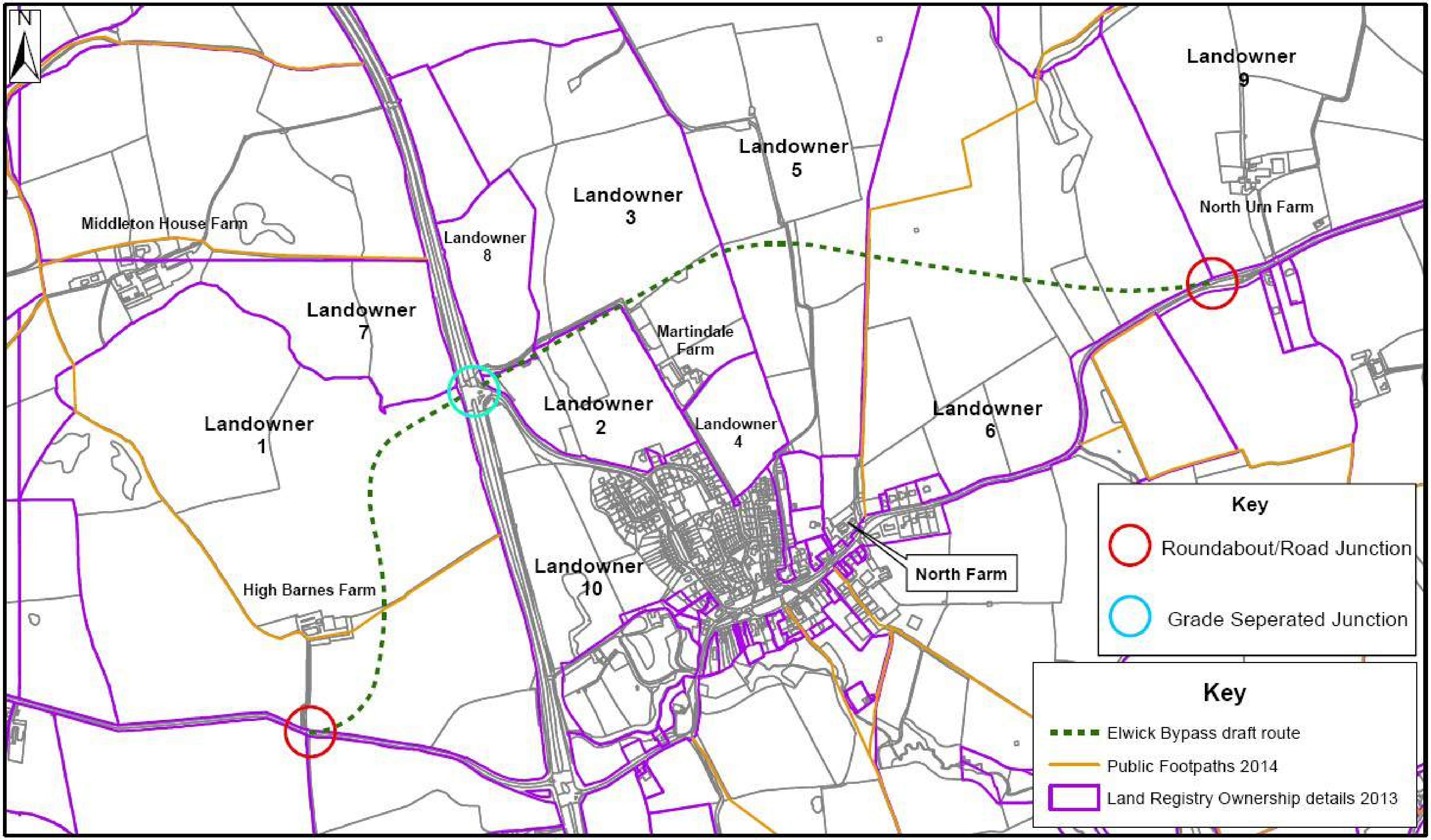
Therefore, whilst queuing on the right turn lane from the A19 to Elwick does not extend so far as to disrupt mainline traffic flow, it does severely impact the length of deceleration lane available.

Appendix C

Preferred Option Outline Plans

Appendix 1 – Indicative Bypass Route

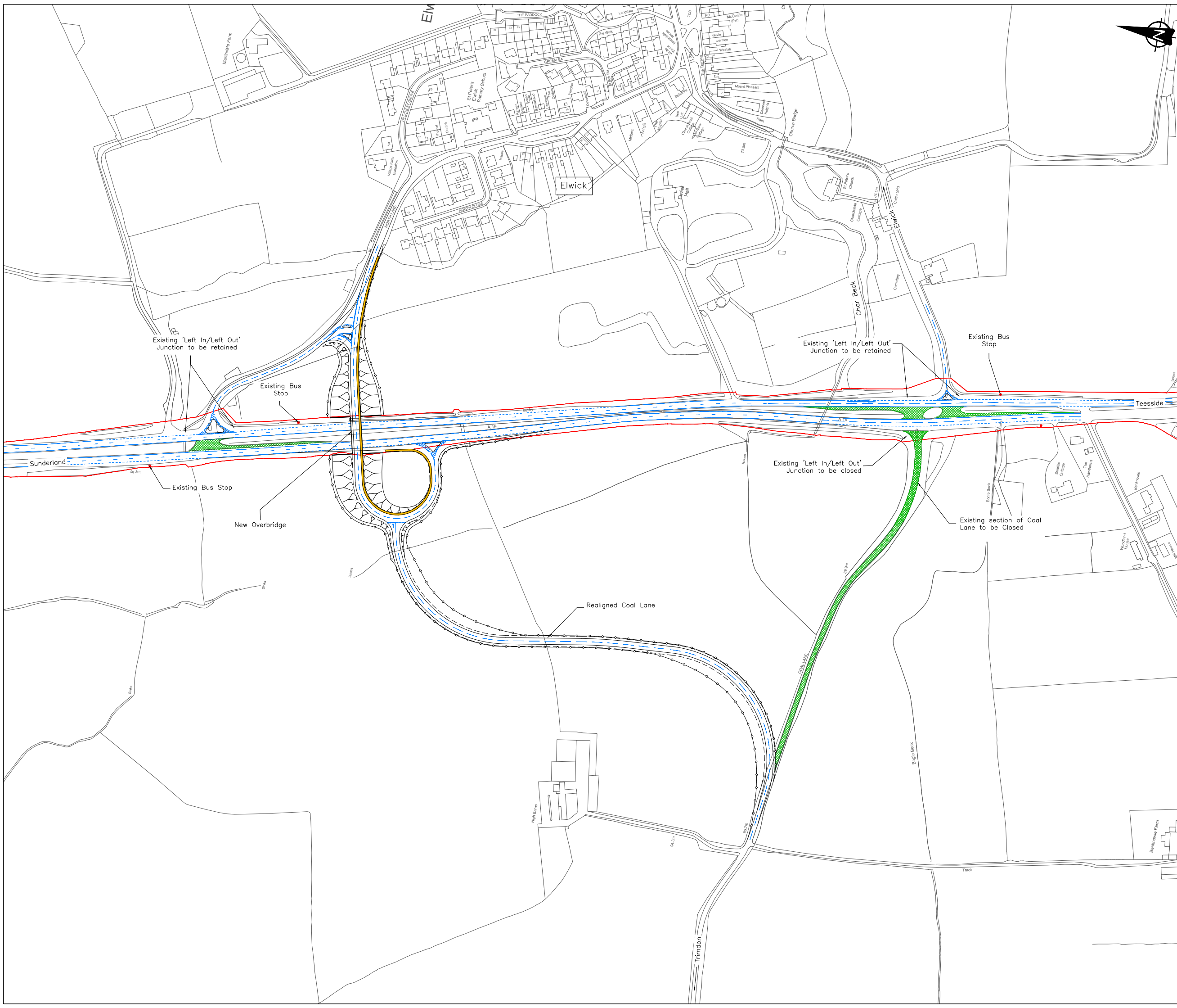
Proposal for route of Elwick Bypass and Grade Seperated Junction



TVU

Sub Title:	Elwick Bypass route
Scale:	1:10,000
Date:	8th February 2016
Drawn By:	Heritage & Countryside Section

Hartlepool Borough Council
Regeneration & Neighbourhoods Department
Heritage and Countryside
Edgar Philips Building
1 Church Street
Hartlepool, TS24 7DS Tel: 01429 523524



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

- Bridge abutments and wingwalls
- Back of verge
- New Fence line
- New Footpath
- Earthwork slopes
- Area of central reserve gaps/existing highway to be permanently closed
- Proposed road markings
- Existing Trunk Road Highway Boundary
- Existing Bus Stops

FOR INFORMATION

Revision	By	Checked	Approved	Date	Description
0	MTE	ADE	TG	26.11.14	For Information

Client
HIGHWAYS AGENCY
an Executive Agency of the Department for Transport

Halcrow Hyder

Project
PCF Package I
A19 Elwick GSJ

Drawing
Option 5
Compact Grade Separated Junction
Overbridge South of North Lane Junction

Drawn by	MTE	Date:	14.11.2014
Checked by	ADE	Date:	21.11.2014
Authorised by	TG	Date:	26.11.2014

Drawing No. 653781.CC.0000.006 — Revision 0

Drawing Scale: 1:2000 — Plot Scale: 1:1

Sheet size A1

\\tees-fs-01\transportation\Projects\000000 PCF Package I\Drgs\Outgoing\AutoCad\A19 Elwick GSJ\653781.CC.0000.006 - Option 5 - North In Jct - Coal Jct remains.dwg

Appendix D

Highways England Junction Options Report

Highways Agency

Project Support Framework

Area 14 Feasibility and Elements of Preliminary Design Study Package I

Package Order 1333 – A19 Elwick Crossroads Milestone 1 Summary Report

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28 November 2014

Report No: 1333/MS1 Document No. 653781.CC.001 Version: 1

Halcrow Hyder

HIGHWAYS AGENCY

Highways Agency
Project Support Framework

A19 Elwick Crossroads
Milestone 1 Summary Report

Halcrow Hyder JV

Author:	Andrew Eley	Andrew Eley
Checker:	Tony Gilbey	Tony Gilbey
Approver:	Cliff Collings	Cliff Collings

Report No: 1333/MS1/ **Doc. No:** 653781.CC.001 **Version:** 1 **Date:** 28/11/2014

Contents Amendment Record - This report has been issued and amended as follows:

Issue	Version	Description	Date	Signed
1	0	Draft	28/11/2014	CC
1	1	Final	12/01/2015	CC

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Halcrow Hyder

Contents

1 Introduction

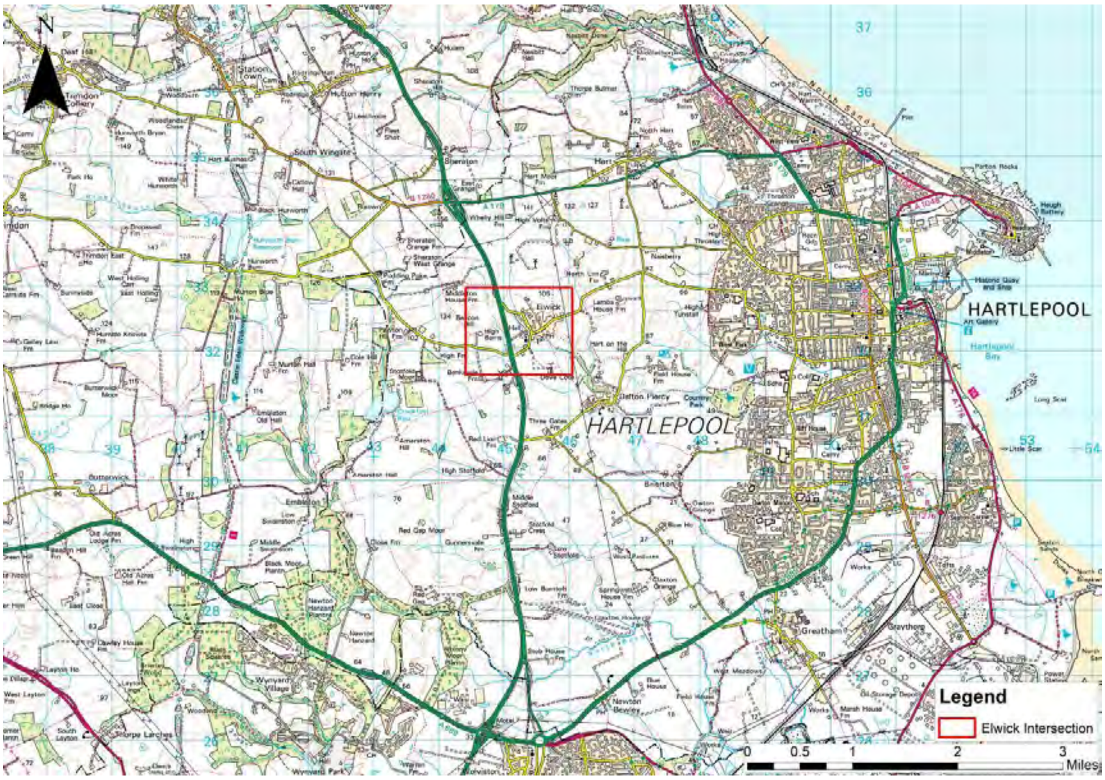
The scheme to upgrade the existing A19 at-grade staggered junction to the west of Elwick village forms part of the Area 14 Feasibility and Elements of Preliminary Design Study Package I along with the following schemes:

- A66 Elton Interchange
- A174/A1053 Greystones Roundabout
- A19 Norton to Wynyard Widening

The existing at-grade staggered junction continues to have a poor safety record despite various road marking and traffic sign improvement schemes, the last of which was carried out in 2008.

The Highways Agency (HA) brief is to initially identify options to upgrade the at-grade staggered junction to a Compact Grade Separated (CGS) junction. The viability and acceptability of a CGS junction will need to be confirmed by an assessment of accidents, delays, costs and environmental impact. Refer to figure 1.1 below:

Figure 1.1: A19 Elwick Interchange



Although the brief only specifically refers to the at-grade staggered junction, the existing at-grade T-junction approximately 0.8km north of the staggered junction has also been considered as both junctions provide access to Elwick village.

In accordance with the brief, consideration of options for A19 central reserve gap closures between the A689 Wynyard and A179/B1280 Sheraton junctions is included within this report.

The A19 trunk road in this area is maintained and operated by Autolink Concessionaires (A19) Limited under a Design Build Finance and Operate (DBFO) concession.

1.1 Purpose of the Report

This report has been compiled to inform decision makers and stakeholders on how the economic, environmental and operational assessments will be undertaken and how they will be supported by the traffic modelling work, taking account of budgetary, programme, environmental and spatial constraints.

The report gives an early indication of significant risks and should be used to inform the development of the options identified taking account of the constraints.

The report will:

- Define the scope, methodology, assumptions and associated risks of the transport assessment
- Define the scope and content of the environmental assessment
- Identify the data and outstanding survey requirements
- Provide indicative options drawings together with initial scheme costs and programmes

1.2 Current stage of the project

The scheme is being developed in accordance with the HA NDD Portfolio Control Framework and is currently in the Needs Phase of the programme lifecycle.

This report has been produced at the end of milestone 1, the initial feasibility assessment.

Milestone 2 is at the end of options development and milestone 3 is at the end of preliminary design. The current programme for milestones 1 to 3 is contained in **Annex B**.

2 Project Definition

Project title:

AT14 PSF Studies: A19 Elwick Crossroads

PIN:

14/15 I

Road and Geographic Location:

Junctions of the A19 with Coal Lane (Staggered junction) and North Lane (T-junction) both to the west of Elwick village.

Project Description:

Identification of options for improvement of the A19 Elwick at-grade junctions.

Status:

Milestone 1 – Initial Feasibility Assessment

3 Existing Layout

The two existing junctions on the A19 trunk road west of Elwick village are located between the grade separated junctions with the A689 near Wolviston and Wynyard to the south and the A179 near Sheraton to the north. This is a rural area to the west of Hartlepool within the boundary of Hartlepool Borough Council. Between the A689 and A179 junctions the A19 is a Dual 2 lane All Purpose (D2AP) road having at-grade junctions with two minor roads providing access to Elwick, one providing access to Trimdon and one providing access to Dalton Piercy and several direct accesses to properties and farms all incorporating central reserve gaps. A minor road links Elwick with the western part of Hartlepool.

The A19 is lit throughout from just south of the Dalton Piercy at-grade junction to the A179 grade separated junction. The safety barrier in the central reserve is of steel construction.

The existing at-grade junction of the A19 with Coal Lane consists of a right/left staggered junction south west of Elwick village and includes deceleration and acceleration lanes for the side roads. The minor road west of the A19 provides access to individual properties and farms and to Trimdon village. The minor road east of the A19 provides access to Elwick village. The central reserve gaps allow right turns from the A19 in both directions to the side roads and from the side roads to the A19.

The existing at-grade junction of the A19 with North Lane consists of a T-junction north west of Elwick village and includes deceleration and acceleration lanes for the side road. North Lane east of the A19 provides access to Elwick village. The central reserve gap allows right turns from the A19 northbound to North Lane and from North Lane to the A19 northbound.

Road marking and traffic sign improvement schemes have been carried out to both junctions consisting of enhanced markings and red surfacing at the junctions, 'SLOW' markings within areas of red surfacing on the A19 in advance of the junctions and re-mounting of signs on longer posts to improve visibility.

The minor watercourses of Bogle Beck and Char Beck cross the A19 close to the staggered junction at Coal Lane.

4 Review of the Data

4.1 Utility Companies

A list of utility companies has been produced based on the geographical area under consideration and an initial request for information (C2 enquiry) has been made to the companies on the list. Responses to the request have not yet been received. Autolink has provided information obtained from utility companies in April 2014.

4.2 Stakeholders

A list of stakeholders will be produced based on the geographical area by the end of milestone 2, options development. This will form part of the Public Consultation Plan to be produced by milestone 2. Autolink has provided contact details for parish and borough councils and Cleveland police. No consultation has taken place with stakeholders other than with Autolink to obtain background information and with the HA.

4.3 Topographical Survey

There is no topographical survey available for the junction locations. A survey will need to be carried out preferably to inform the preliminary design to be undertaken by milestone 3 once the options to be developed have been selected.

A request has been made to obtain LIDAR survey data for the A19 between the A689 and A179 junctions.

4.4 Traffic Modelling

Refer to the Appraisal Specification Report – Traffic in **Annex E.**

4.5 Accident Data

Autolink has provided accident data for the period 1st January 2009 to 31st December 2013 for the A19 between the A689 and A179 junctions. No data has been obtained for the side roads in the vicinity of their junctions with the A19.

4.6 Drainage

Autolink has provided drainage layouts for an improvement of the A19 between Wolviston and Elwick dated 1990 which includes pipe sizes, invert and cover levels. Drainage layouts for the A19 between the A689 and A179 junctions have also been provided but these are un-dated and only include pipe sizes.

It is likely that a survey will be required to establish the condition of the drainage.

4.7 Environmental

Environmental information has been obtained from EnvIS and other web-based sources. This has also been supplemented by a review of a drive-through video and a preliminary walkover survey. The data has been used to produce an initial review of the baseline environment to identify the major constraints for proposed options. This is contained in **Annex D**.

4.8 Geotechnical

Autolink has provided a link to the GIS based Geotechnical Asset Management Plan (GAMP).

As the scheme is currently at the stage of identifying options to improve the existing junctions, no previous Statement of Intent or Preliminary Sources Study Report (PSSR) are available.

In accordance with HD22 Managing Geotechnical Risk, a Statement of Intent has been prepared and is contained in **Annex C.**

To determine the geotechnical category, the complexity of the project has been identified together with the geotechnical activities that may be involved. The Statement of Intent identifies known or suspected geotechnical risks and states the scope, purpose, estimated programme and cost of the initial geotechnical assessments.

4.9 Structures

There are no existing structures within the vicinity of the two existing Elwick junctions, except for two culverts where the A19 crosses Bogle Beck and Char Beck but no details of the culverts have been obtained.

5 Constraints

The initial investigations have revealed some constraints which may have an impact on improvement options. These constraints are listed in the following table together with the potential impact and mitigation measures.

Initial risks have been identified and a risk register is being prepared. The risks should be considered as part of the ongoing process of identifying constraints to improvement options.

Constraint	Potential Impact	Mitigation
3rd Party Land.	Proposals for a Compact Grade Separated junction will require acquisition of land outside of the highway boundary.	The design to be undertaken to minimise the land area required and consider the size and shape of remaining land parcels. Land ownership information to be obtained from the Land Registry.
Utility Company Apparatus.	Protection or diversion of utility apparatus.	Obtain up to date information on utility apparatus. Avoid or minimise the impact on utility apparatus, (C2 Notices issued, waiting for responses).
Commercial and residential properties.	A small number of properties are located in the vicinity of the existing Coal Lane staggered junction.	The design to be undertaken to avoid direct impact on the properties and also to minimise indirect impacts e.g. visual effects.
Cemetery.	A small cemetery is located on the north side of the minor road to the east of the A19 at the Coal Lane junction.	The design to be undertaken to avoid direct impact on the cemetery and also to minimise indirect impacts e.g. visual effects.
Bogle and Char Becks.	Worsen existing flooding problem.	The design to be undertaken to avoid direct impact on the watercourses if possible. Where impact is unavoidable then a flood risk assessment to be undertaken.
Environment.	Adverse impact on habitat and species.	The design to be undertaken to minimise adverse impact on the environment. Where adverse impact is unavoidable mitigation measures to be proposed.
Local road network.	Change in traffic patterns resulting in adverse impacts on the existing network.	Produce forecast traffic model to identify and quantify adverse impacts to inform the identification and selection of options.

6 Options

The existing at-grade staggered junction at Coal Lane is perceived as having a poor safety record despite the implementation of various road marking and traffic sign improvement schemes. There have been four slight and one fatal accident in the immediate vicinity of the junction between 2009 and 2013 (5 years).

The HA brief is to initially identify options to upgrade the at-grade staggered junction to a Compact Grade Separated (CGS) junction. The existing at-grade T-junction at North Lane approximately 0.8km north of the staggered junction has also been considered as both junctions provide access to Elwick village.

On the basis of the brief, several options for a CGS junction have been developed as follows:

- Option 1: Overbridge North of Coal Lane Staggered Junction, existing left in/left out junctions retained
- Option 2A: Overbridge at Coal Lane Staggered Junction, new left in/left out junctions to the north
- Option 2B: Overbridge at Coal Lane Staggered Junction, new northbound left in/left out junction to the north, new southbound left in/left out junction to the south
- Option 3: Overbridge North of Coal Lane Staggered Junction, new northbound left in/left out junction to the south, existing southbound left in/left out junction retained
- Option 4: Overbridge South of North Lane T-Junction, realignment of Coal Lane adjacent to the A19
- Option 5: Overbridge South of North Lane T-Junction, realignment of Coal Lane west of the A19
- Central Reserve Gap Closures, between the A689 Wynyard and A179 Sheraton Junctions

Option 1

This option reproduces all the existing through and turning traffic movements of the existing Coal Lane staggered junction. The existing central reserve gaps will be closed including provision of continuous safety barrier.

A new bridge will be provided over the A19 to the north of Coal Lane with new compact connector roads forming new priority junctions with Coal Lane and the minor road to the east of the A19. The layout of the new priority junctions may need to be amended once the design year Annual Average Daily Traffic (AADT) and peak hour flows have been forecast. The existing left in/left out junctions with both A19 carriageways will be retained. It has been assumed that the overbridge will be a single span to avoid disruption to A19 traffic during construction of a pier in the central reserve.

A footpath has been included in the verge of the compact connector roads to provide a grade separated pedestrian crossing of the A19. The embankment for the connector road to the east of the A19 is likely to extend into Char Beck and therefore a culvert has been included to accommodate the watercourse.

Acquisition of third party land will be required on both sides of the A19. It is assumed that the small areas of land that will remain between the connector roads and the existing minor roads on both sides of the A19 will also need to be acquired because of their likely unsuitability for continued agricultural use.

This option will enable the existing staggered junction to remain open during construction of the new junction.

It has been assumed that for this option the central reserve gap at the North Lane T-junction will be closed but that the southbound left in/left out junction will remain open.

To develop the design further, potential departures from standard need to be identified and discussed with the HA and Autolink.

A drawing showing the initial proposed layout for option 1 is contained in **Annex A**.

Option 2A

This option reproduces all the existing through and turning traffic movements of the existing Coal Lane staggered junction. The existing central reserve gaps will be closed including provision of continuous safety barrier.

A new bridge will be provided over the A19 at the centre of the Coal Lane staggered junction providing a minor road through link over the A19. New compact connector roads located to the north of this link form new priority junctions with the link and with new left in/left out junctions with both A19 carriageways. The layout of the new priority junctions may need to be amended once the design year Annual Average Daily Traffic (AADT) and peak hour flows have been forecast. It has been assumed that the overbridge will be a single span to avoid disruption to A19 traffic during construction of a pier in the central reserve.

A footpath has been included in the verge of the through link to provide a grade separated pedestrian crossing of the A19. A footpath has been included along the bottom of the embankment on the east side of the A19 to maintain a route to the footpath along the east side of the A19.The connector road to the east of the A19 will extend into Char Beck and therefore a culvert has been included to accommodate the watercourse.

Acquisition of third party land will be required on both sides of the A19. It is assumed that the small areas of land that will remain between the connector roads and the through link on both sides of the A19 will also need to be acquired because of their likely unsuitability for continued agricultural use.

This option will require the existing staggered junction to be closed during construction of the new junction.

It has been assumed that for this option the central reserve gap at the North Lane T-junction will be closed but that the southbound left in/left out junction will remain open.

To develop the design further, potential departures from standard need to be identified and discussed with the HA and Autolink.

A drawing showing the initial proposed layout for option 2A is contained in **Annex A**.

Option 2B

This option is very similar to option 2A, the only difference being that the compact connector road to the east of the A19 is on the south side of the minor road through link.

The connector road will not affect Char Beck and therefore there will be no need to provide a culvert. The land acquisition to the east of the A19 will be different from that for option 2A.

It has been assumed that for this option the central reserve gap at the North Lane T-junction will be closed but that the southbound left in/left out junction will remain open.

A drawing showing the initial proposed layout for option 2B is contained in **Annex A**.

Option 3

This option is similar to option 1, the differences being that Coal Lane will be re-aligned to continue as the link using the overbridge and a new compact connector road will be provided to the west of the A19 on the south side of the realigned Coal Lane. The new connector road will require a new left in/left out junction with the northbound A19 carriageway but could utilise the existing junction deceleration and acceleration lanes.

The land acquisition to the west of the A19 will be different from that for option 1.

It has been assumed that for this option the central reserve gap at the North Lane T-junction will be closed but that the southbound left in/left out junction will remain open.

A drawing showing the initial proposed layout for option 3 is contained in **Annex A**.

Option 4

This option reproduces all the existing turning traffic movements of the existing North Lane T-junction. The existing central reserve gap will be closed including provision of continuous safety barrier.

A new bridge will be provided over the A19 to the south of the North Lane T-junction. North Lane will be re-aligned to use the overbridge and continue as a new compact connector road forming a new left in/left out junction with the northbound A19 carriageway. The existing left in/left out junction with the southbound A19 carriageway will be retained and the existing North Lane leading from the junction will form a compact connector road with a new priority junction with the re-aligned North Lane. The layout of the new priority junction may need to be amended once the design year Annual Average Daily Traffic (AADT) and peak hour flows have been forecast.

It has been assumed that the overbridge will be a single span to avoid disruption to A19 traffic during construction of a pier in the central reserve. A footpath has been included in the verge of the re-aligned North Lane to provide a grade separated pedestrian crossing of the A19.

The northbound left in/left out junction of Coal Lane with the A19 will be closed and Coal Lane re-aligned parallel with the A19 to form a priority junction with the new compact connector road. The layout of the new priority junction may need to be amended once the design year flows have been forecast. It has been assumed that the central reserve gaps at the Coal Lane staggered junction will be closed but the southbound left in/left out junction will remain open.

Acquisition of third party land will be required on both sides of the A19. It is assumed that the small area of land that will remain within the loop of the new connector road will also need to be acquired because of its likely unsuitability for continued agricultural use.

This option will enable both existing junctions to remain open during construction of the new junction.

To develop the design further, potential departures from standard need to be identified and discussed with the HA and Autolink.

A drawing showing the initial proposed layout for option 4 is contained in **Annex A**.

Option 5

This option is very similar to option 4, the difference being that the re-alignment of Coal Lane will be further to the west of the A19. The northbound left in/left out junction of Coal Lane with the A19 will be closed as in option 4.

The land acquisition to the west of the A19 will be different from that for option 4.

It has been assumed that for this option the central reserve gaps at the Coal Lane junction will be closed but that the southbound left in/left out junction will remain open.

A drawing showing the initial proposed layout for option 5 is contained in **Annex A**.

Central Reserve Gap Closures

As part of the scheme brief for the A19 Elwick Crossroads scheme, the potential for central reserve gap closures beyond the two junctions at Elwick is to be considered. Therefore the proposals would look to eliminate right-in and right-out turning manoeuvres at all central reserve gaps on the A19 between the A689 Wynyard and A179 Sheraton Interchanges. Existing Side Road left-in and left-out manoeuvres will be maintained, with further consideration to be given to the closure of field accesses directly from the A19.

The existing gaps within the central reserve would be closed by extending the existing steel barrier and modification of road markings. Where existing NMU facilities exist at these gap locations, consideration would be given to maintaining the facilities by the provision of an overlap in the central reserve safety barriers to allow crossing of the A19.

7 Summary

Option	Advantages	Disadvantages	Estimated Cost	Estimated Programme
Option 1				
Overbridge North of Coal Lane Staggered Junction. New connector roads north of side roads. Existing left in/left out junctions retained.	Maintains all movements at Coal Lane staggered junction.	Affects Char Beck, requires culvert.	£8.12M*	6 years**
	Removes right turns into and out of side roads.	Requires third party land.		
	Retains existing left in/left out junctions at Coal Lane staggered junction and North Lane T-junction.	Potentially longer journey for traffic from North Lane to A19 northbound.		
	Coal Lane staggered junction can remain open during construction.			
Option 2A				
Overbridge at Coal Lane Staggered Junction. New connector roads north of side roads. New left in/left out junctions required.	Maintains all movements at Coal Lane staggered junction.	Coal Lane staggered junction closed during construction.	£9.60M*	6 years**
	Removes right turns into and out of side roads.	Requires new left in/left out junctions at Coal Lane staggered junction.		
	Retains existing left in/left out junction at North Lane T-junction.	Affects Char Beck, requires culvert.		
		Requires third party land.		
		Potentially longer journey for traffic from North Lane to A19 northbound.		

Option	Advantages	Disadvantages	Estimated Cost	Estimated Programme
Option 2B				
Overbridge at Coal Lane Staggered Junction. New connector roads one to north and one to south of side roads. New left in/left out junctions required.	Maintains all movements at Coal Lane staggered junction.	Coal Lane staggered junction closed during construction.	£9.70M*	6 years**
	Removes right turns into and out of side roads.	Requires new left in/left out junctions at Coal Lane staggered junction.		
	Retains existing left in/left out junction at North Lane T-junction.	Requires third party land.		
	Does not affect Char Beck, no culvert.	Potentially longer journey for traffic from North Lane to A19 northbound.		
Option 3				
Overbridge North of Coal Lane staggered Junction. New connector roads one to north and one to south of side roads. Existing southbound left in/left out junction retained.	Maintains all movements at Coal Lane staggered junction.	Affects Char Beck, requires culvert.	£8.80M*	6 years**
	Removes right turns into and out of side roads.	Requires new northbound left in/left out junction at Coal Lane staggered junction.		
	Retains existing southbound left in/left out junctions at Coal Lane staggered junction and North Lane T-junction.	Requires third party land.		
	Coal Lane staggered junction can remain open during construction.	Potentially longer journey for traffic from North Lane to A19 northbound.		

Option	Advantages	Disadvantages	Estimated Cost	Estimated Programme
Option 4				
Overbridge South of North Lane T-Junction. New connector road and realigned Coal Lane west of A19.	Maintains all movements at North Lane T-junction.	Closure of Coal Lane staggered junction northbound left in/left out junction.	£11.57M*	6 years**
	Removes right turns into and out of side roads.	Affects Char Beck to the west of the A19.		
	Retains existing southbound left in/left out junctions at Coal Lane staggered junction and North Lane T-junction.	Potentially longer journey for traffic to/from Coal Lane to/from the south.		
	North Lane T-junction can remain open during construction.	Requires larger area of third party land than options 1 to 3.		
		Greater impact on agricultural use than options 1 to3.		
Option 5				
Overbridge South of North Lane T-Junction. New connector road and realigned Coal Lane further west of A19 than option 4.	Maintains all movements at North Lane T-junction.	Closure of Coal Lane staggered junction northbound left in/left out junction.	£11.09M*	6 years**
	Removes right turns into and out of side roads.	Potentially longer journey for traffic to/from Coal Lane to/from the south.		
	Retains existing southbound left in/left out junctions at Coal Lane staggered junction and North Lane T-junction.	Requires larger area of third party land than options 1 to 3.		

Option	Advantages	Disadvantages	Estimated Cost	Estimated Programme
	North Lane T-junction can remain open during construction.	Greater impact on agricultural use than options 1 to3.		
Central Reserve Gap Closures				
	Improves trunk road safety by eliminating cross carriageway turning movements.	Longer journeys required for local residents.	£0.63M*	6 Years***
*The cost estimate allows for an element of risk. **The programme dates have developed following the traditional Procurement method, i.e. detailed design undertaken prior to tender and Contractor involvement. ***Assumes that the central reserve closures will be carried out at the same time as the A19 Elwick Junction Improvements.				

8 Recommendation

Following completion of Milestone 1, it is recommended that the scheme progresses to Milestone 2 immediately in order to meet the current programme.

Works in Milestone 2 will consider and assess the options included within this report and take on-board the scoping requirements outlined in the Appraisal Specification Report, Traffic and Environmental inputs contained in **Annexes D & E**.

ANNEXES

Annex A: Options Drawings

Option 1: Overbridge North of Coal Lane Junction

Option 2A: Overbridge at Coal Lane Junction

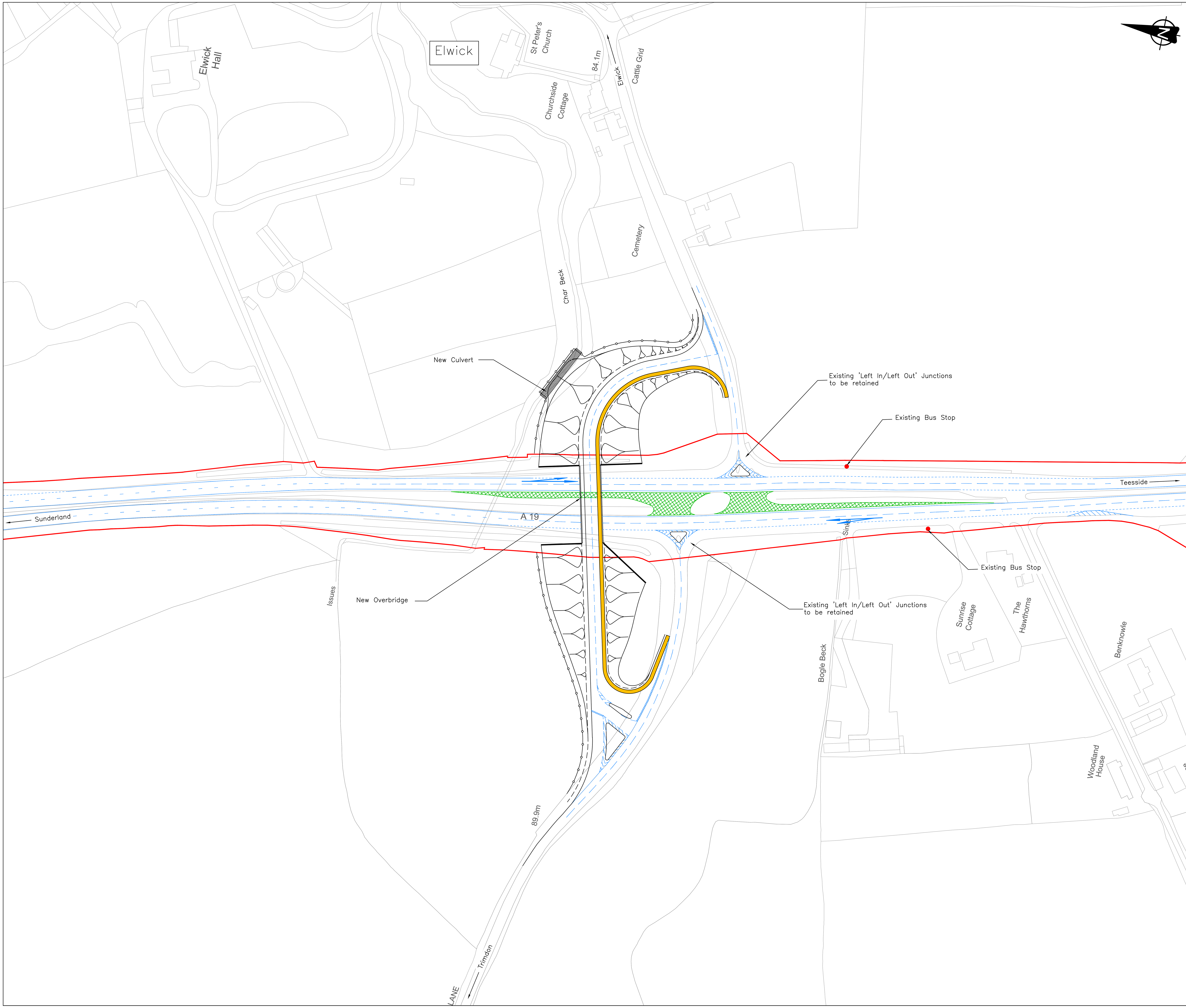
Option 2B: Overbridge at Coal Lane Junction

Option 3: Overbridge North of Coal Lane Junction

Option 4: Overbridge South of North Lane Junction

Option 5: Overbridge South of North Lane Junction

Central Reserve Gap Closures, between the A689 Wynyard and A179 Sheraton Junctions, Layout 1 to 3



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

- Bridge abutments and wingwalls
- Back of verge
- New Fence line
- New Footpath
- Earthwork slopes
- Area of central reserve gaps/existing highway to be permanently closed
- Proposed road markings
- Existing Trunk Road Highway Boundary
- Existing Bus Stops

FOR INFORMATION

Revision	By	Checked	Approved	Date	Description
0	MTE	ADE	TG	26/11/14	For Information

Client

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an Executive Agency of the Department for Transport

Halcrow Hyder

Project

PCF Package I
A19 Elwick GSJ

Drawing

Option 1
Compact Grade Separated Junction
Overbridge North of Coal Lane Junction

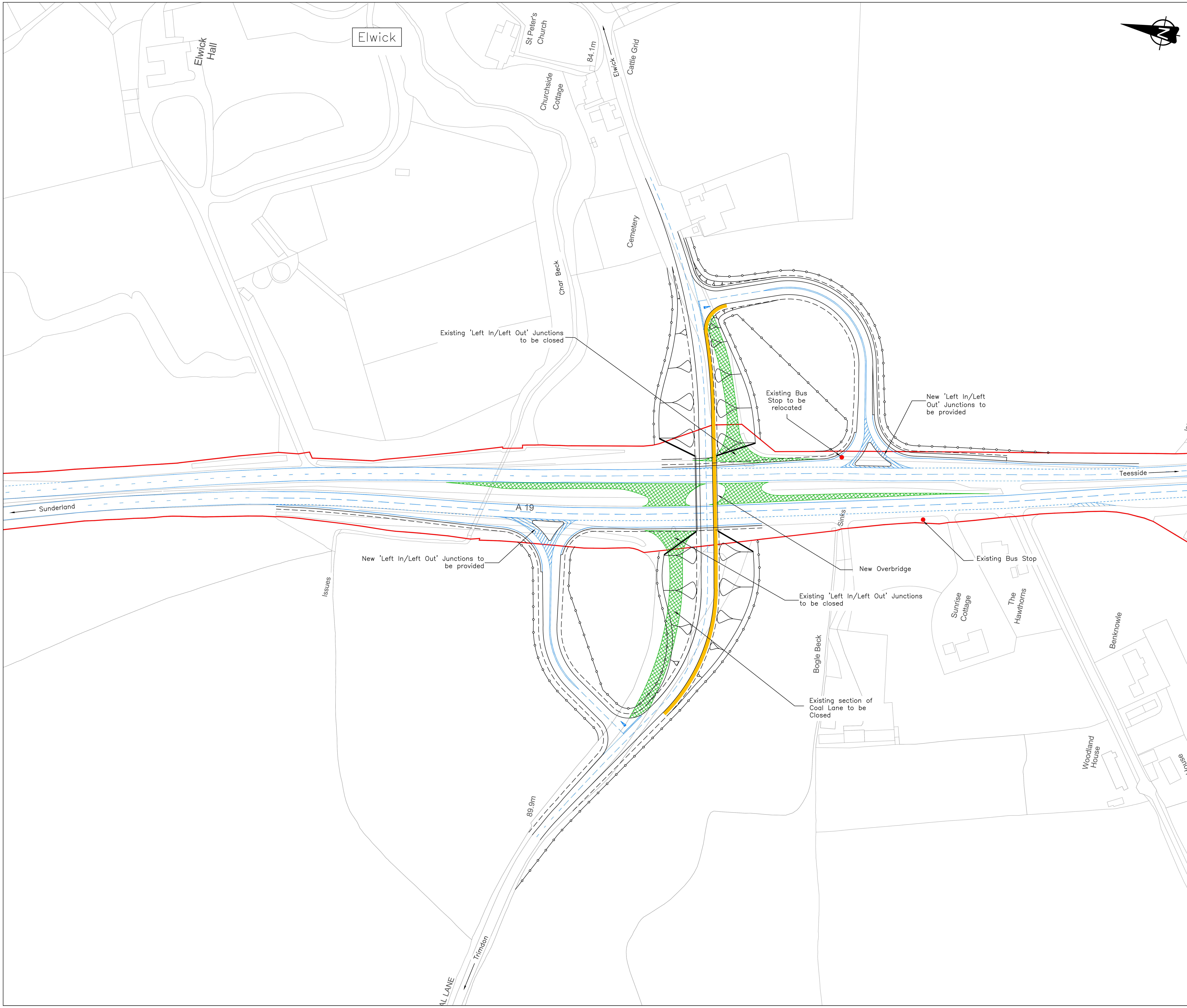
Drawn by	MTE	Date:	17/11/2014
Checked by	ADE	Date:	21/11/2014
Authorised by	TG	Date:	26/11/2014

Drawing No. 653781.CC.0000.001
Revision 0

Drawing Scale: 1:1000
Plot Scale: 1:1

Sheet size A1

\\tees-fs-01\transportation\Projects\000000 PCF Package I\Drgs\Outgoing\AutoCad\A19 Elwick GSJ\653781.CC.0000.001 - Option 1 - Coal Ln Jct - Brg North.dwg



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

- Bridge abutments and wingwalls
- Back of verge
- New Fence line
- New Footpath
- Earthwork slopes
- Area of central reserve gaps/existing highway to be permanently closed
- Proposed road markings
- Existing Trunk Road Highway Boundary
- Existing Bus Stops

FOR INFORMATION

Revision	By	Checked	Approved	Date	Description
0	MS	AE	TG	21/11/14	For Information

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PCF Package I
A19 Elwick GSJ

Drawing

Option 2B
Compact Grade Separated Junction
Overbridge at Coal Lane Junction

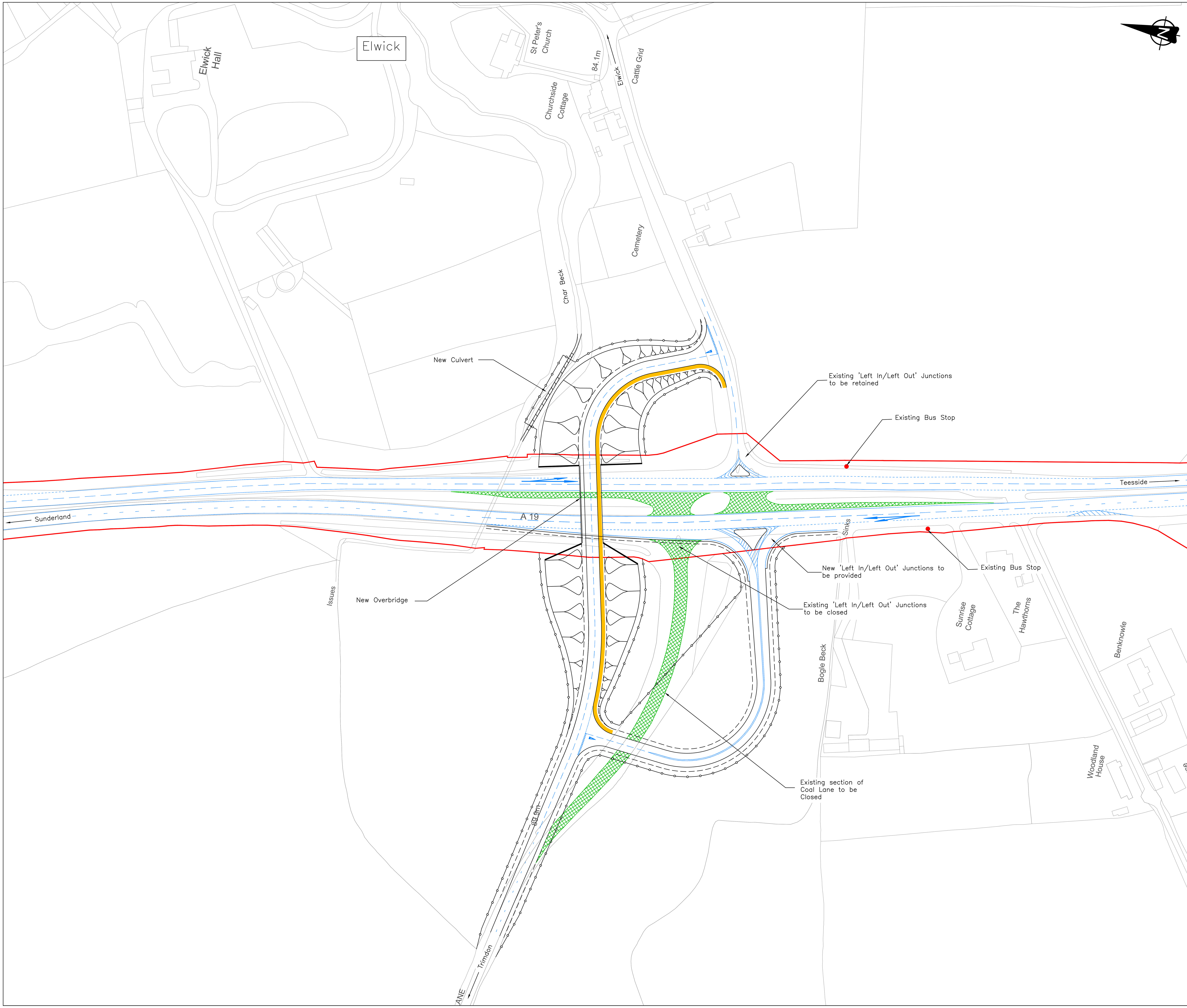
Drawn by MS Date: 20/11/14
Checked by AE Date: 20/11/14
Authorised by TG Date: 21/11/14

Drawing No. 653781.CC.0000.003
Revision 0

Drawing Scale: 1:1000 Plot Scale: 1:1

Sheet size A1

\\tees-fs-01\transportation\Projects\000000 PCF Package I\Drgs\Outgoing\AutoCad\A19 Elwick GSJ\653781.CC.0000.003 - Option 2B - Coal Ln Jct - Brg centralised.dwg



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

- Bridge abutments and wingwalls
- Back of verge
- New Fence line
- New Footpath
- Earthwork slopes
- Area of central reserve gaps/existing highway to be permanently closed
- Proposed road markings
- Existing Trunk Road Highway Boundary
- Existing Bus Stops

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Revision	By	Checked	Approved	Date	Description
0	MS	AE	TG	21/11/14	For Information

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PCF Package I
A19 Elwick GSJ

Drawing

Option 3
Compact Grade Separated Junction
Overbridge North of Coal Lane Junction

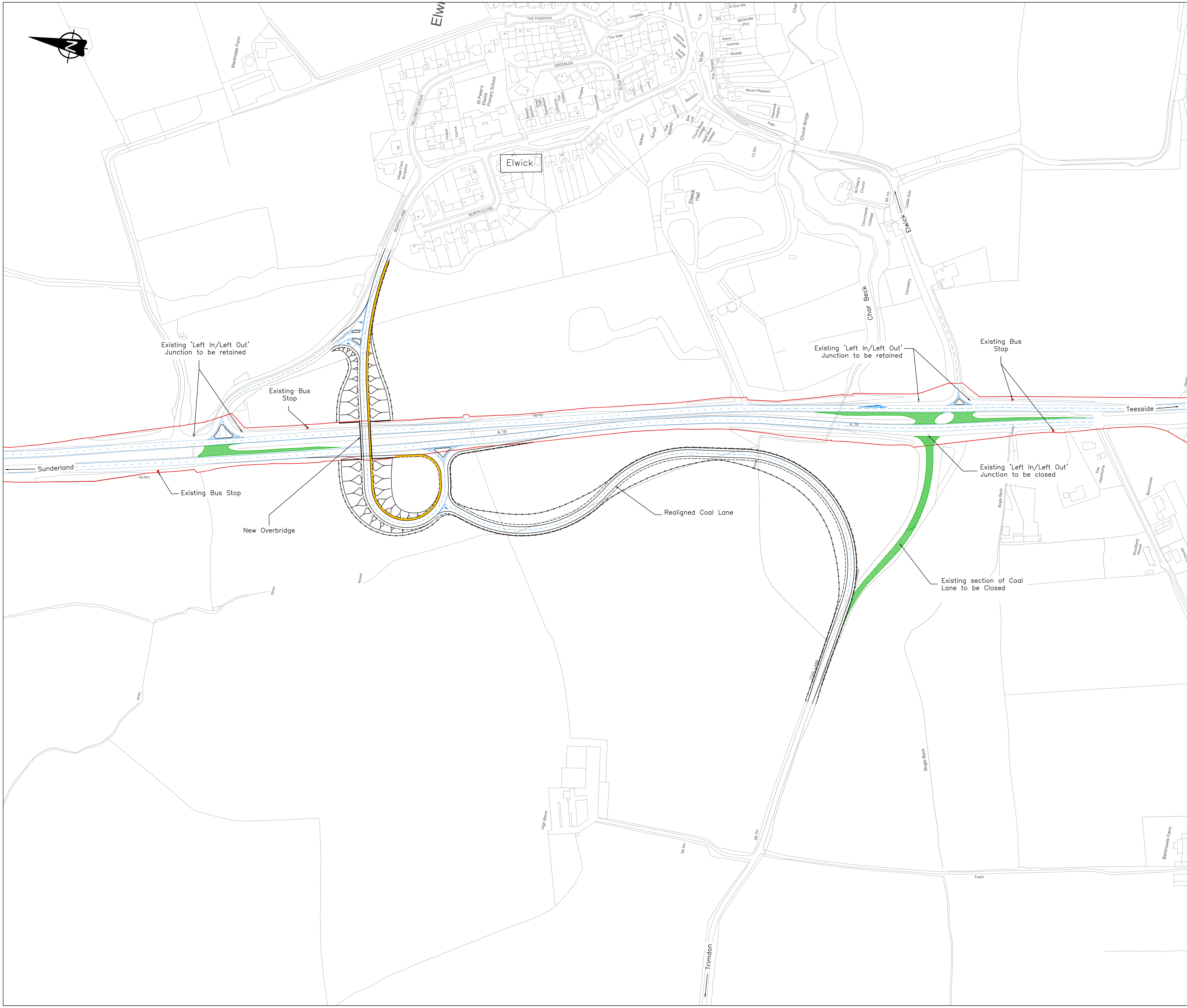
Drawn by	MS	Date:	20/11/14
Checked by	AE	Date:	20/11/14
Authorised by	TG	Date:	21/11/14

Drawing No. 653781.CC.0000.004 — Revision 0

Drawing Scale: 1:1000 — Plot Scale: 1:1

Sheet size A1

\\tees-fs-01\transportation\Projects\000000 PCF Package I\Drgs\Outgoing\AutoCad\A19 Elwick GSJ\653781.CC.0000.004 - Option 3 - Coal Ln Jct - Brg North - diff conn rds.dwg



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

- Bridge abutments and wingwalls
- Back of verge
- New Fence line
- New Footpath
- Earthwork slopes
- Area of central reserve gaps/existing highway to be permanently closed
- Proposed road markings
- Existing Trunk Road Highway Boundary
- Existing Bus Stops

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Revision	By	Checked	Approved	Date	Description
0					

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PCF Package I
A19 Elwick GSJ

Drawing

Option 4
Compact Grade Separated Junction
Overbridge South of North Lane Junction

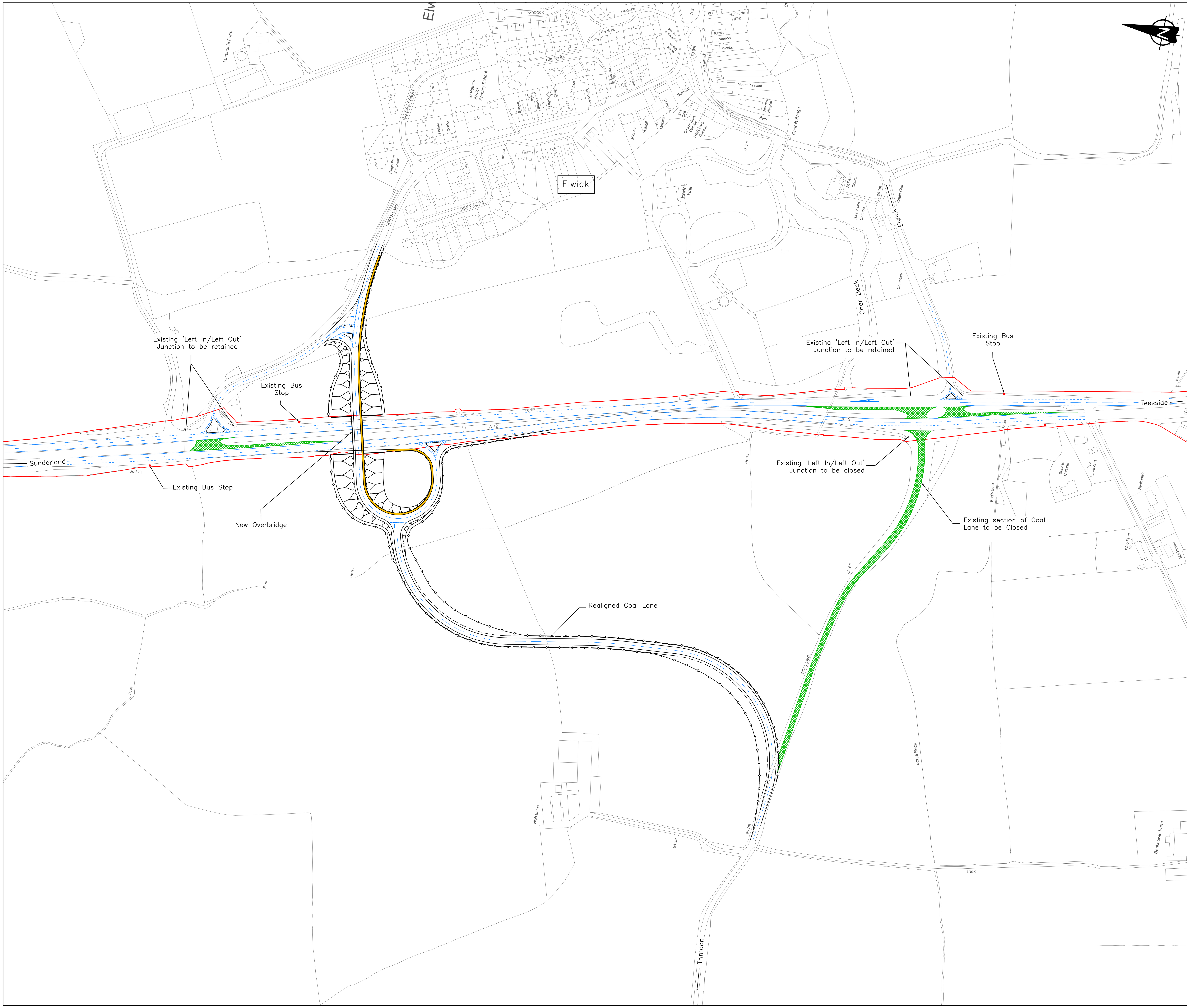
Drawn by	MTE	Date:	11.11.2014
Checked by	ADE	Date:	21.11.2014
Authorised by	TG	Date:	26.11.2014

Drawing No. 653781.CC.0000.005 — Revision 0

Drawing Scale: 1:2000 — Plot Scale: 1:1

Sheet size A1

\\tees-fs-01\transportation\Projects\000000 PCF Package I\Drgs\Outgoing\AutoCad\A19 Elwick GSJ\653781.CC.0000.005 - Option 4 - North In Jct - Coal In west Jct removed.dwg



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

Bridge abutments and wingwalls

Back of verge

New Fence line

New Footpath

Earthwork slopes

Area of central reserve gaps/existing highway to be permanently closed

Proposed road markings

Existing Trunk Road Highway Boundary

Existing Bus Stops

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Revision	By	Checked	Approved	Date	Description
0	MTE	ADE	TG	26.11.14	For Information

Client

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Project

PCF Package I
A19 Elwick GSJ

Drawing

Option 5
Compact Grade Separated Junction
Overbridge South of North Lane Junction

Drawn by	MTE	Date:	14.11.2014
Checked by	ADE	Date:	21.11.2014
Authorised by	TG	Date:	26.11.2014

Drawing No. 653781.CC.0000.006

Revision 0

Drawing Scale: 1:2000

Plot Scale: 1:1

Sheet size A1

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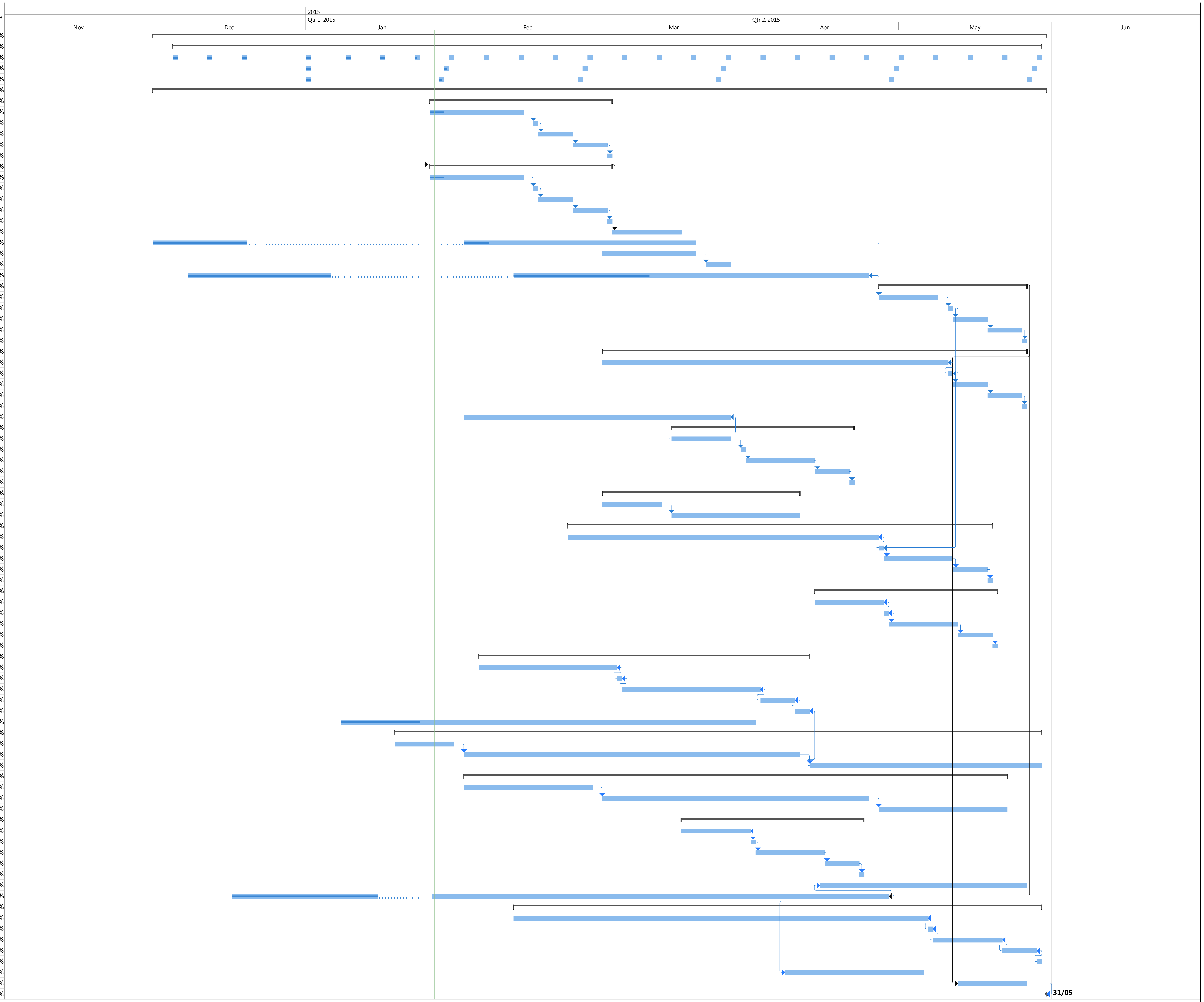
Annex B: Scheme Development Programme

ID	Task Name	Duration	Start	Finish	% Complete
1	**Package I - A19 Elwick Crossroads Programme MS2**	**122 days**	**Mon 01/12/14**	**Sun 31/05/15**	**9%**
2	**PO Reporting**	**118 days**	**Fri 05/12/14**	**Fri 29/05/15**	**25%**
3	Weekly Update	118 days	Fri 05/12/14	Fri 29/05/15	**25%**
29	Monthly Meeting/Reporting	106 days	Thu 01/01/15	Thu 28/05/15	**25%**
36	Financial Reporting	105 days	Thu 01/01/15	Wed 27/05/15	25%
43	**Options Development**	**122 days**	**Mon 01/12/14**	**Sun 31/05/15**	**8%**
44	**Project Management Plan**	**27 days**	**Mon 26/01/15**	**Tue 03/03/15**	**11%**
45	Prepare Draft PMP	15 days	Mon 26/01/15	Fri 13/02/15	20%
46	Submit Draft PMP to HA	1 day	Mon 16/02/15	Mon 16/02/15	0%
47	HA MP Review PMP	5 days	Tue 17/02/15	Mon 23/02/15	0%
48	Amendments to PMP	5 days	Tue 24/02/15	Mon 02/03/15	0%
49	Submit Final PMP	1 day	Tue 03/03/15	Tue 03/03/15	0%
50	**Risk Management Plan**	**27 days**	**Mon 26/01/15**	**Tue 03/03/15**	**11%**
51	Prepare Draft Risk Management Plan	15 days	Mon 26/01/15	Fri 13/02/15	20%
52	Submit Draft Risk Management Plan to HA	1 day	Mon 16/02/15	Mon 16/02/15	0%
53	HA MP Review Risk Management Plan	5 days	Tue 17/02/15	Mon 23/02/15	0%
54	Amendments to Risk Management Plan	5 days	Tue 24/02/15	Mon 02/03/15	0%
55	Submit Final Risk Management Plan	1 day	Tue 03/03/15	Tue 03/03/15	0%
56	Qualitative Risk Assessment	10 days	Wed 04/03/15	Tue 17/03/15	0%
57	Accident Data Collection and Analysis	50 days	Mon 01/12/14	Fri 20/03/15	40%
58	Traffic Data Collection	15 days	Mon 02/03/15	Fri 20/03/15	0%
59	Assess Projected Traffic Growth to feed into PAR	5 days	Mon 23/03/15	Fri 27/03/15	0%
60	Update Dynameq meso Model	65 days	Mon 08/12/14	Fri 24/04/15	50%
61	**Prepare PAR**	**22 days**	**Mon 27/04/15**	**Tue 26/05/15**	**0%**
62	Prepare Draft PAR	10 days	Mon 27/04/15	Fri 08/05/15	0%
63	Submit Draft PAR to HA	1 day	Mon 11/05/15	Mon 11/05/15	0%
64	HA MP Review PAR	5 days	Tue 12/05/15	Mon 18/05/15	0%
65	Amendments to PAR	5 days	Tue 19/05/15	Mon 25/05/15	0%
66	Submit Final PAR	1 day	Tue 26/05/15	Tue 26/05/15	0%
67	**Technical Appraisal Report**	**62 days**	**Mon 02/03/15**	**Tue 26/05/15**	**0%**
68	Prepare Draft TAR	50 days	Mon 02/03/15	Mon 11/05/15	0%
69	Submit Draft TAR to HA	1 day	Mon 11/05/15	Mon 11/05/15	0%
70	HA MP Review TAR	5 days	Tue 12/05/15	Mon 18/05/15	0%
71	Amendments to TAR	5 days	Tue 19/05/15	Mon 25/05/15	0%
72	Submit Final TAR	1 day	Tue 26/05/15	Tue 26/05/15	0%
73	Initial Consultation; Police, LA & MAC	40 days	Mon 02/02/15	Fri 27/03/15	0%
74	**Public Consultation Plan**	**27 days**	**Mon 16/03/15**	**Tue 21/04/15**	**0%**
75	Prepare Draft PCP	10 days	Mon 16/03/15	Fri 27/03/15	0%
76	Submit Draft PCP to HA	1 day	Mon 30/03/15	Mon 30/03/15	0%
77	HA MP Review PCP	10 days	Tue 31/03/15	Mon 13/04/15	0%
78	Amendments to PCP	5 days	Tue 14/04/15	Mon 20/04/15	0%
79	Submit Final PCP	1 day	Tue 21/04/15	Tue 21/04/15	0%
80	**Statutory Undertakers Estimates**	**30 days**	**Mon 02/03/15**	**Fri 10/04/15**	**0%**
81	Prepare and Submit C3 Notices	10 days	Mon 02/03/15	Fri 13/03/15	0%
82	Receive C3 Estimates	20 days	Mon 16/03/15	Fri 10/04/15	0%
83	**Environmental Assessment**	**62 days**	**Mon 23/02/15**	**Tue 19/05/15**	**0%**
84	Prepare Draft EAR	45 days	Mon 23/02/15	Mon 27/04/15	0%
85	Submit Draft EAR to HA	1 day	Mon 27/04/15	Mon 27/04/15	0%
86	HA MP Review EAR	10 days	Tue 28/04/15	Mon 11/05/15	0%
87	Amendments to EAR	5 days	Tue 12/05/15	Mon 18/05/15	0%
88	Submit Final EAR	1 day	Tue 19/05/15	Tue 19/05/15	0%
89	**Departures from Standard Checklist**	**27 days**	**Tue 14/04/15**	**Wed 20/05/15**	**0%**
90	Prepare Draft Departures from Standard Checklist	10 days	Tue 14/04/15	Tue 28/04/15	0%
91	Submit Draft Departures from Standard Checklist to HA	1 day	Tue 28/04/15	Tue 28/04/15	0%
92	HA MP Review Departures from Standard Checklist	10 days	Wed 29/04/15	Tue 12/05/15	0%
93	Amendments to Departures from Standard Checklist	5 days	Wed 13/05/15	Tue 19/05/15	0%
94	Submit Final Departures from Standard Checklist	1 day	Wed 20/05/15	Wed 20/05/15	0%
95	**Preliminary Sources Study and Annex A**	**47 days**	**Thu 05/02/15**	**Mon 13/04/15**	**0%**
96	Prepare Draft PSS	20 days	Thu 05/02/15	Thu 05/03/15	0%
97	Submit Draft PSS to HA	1 day	Thu 05/03/15	Fri 06/03/15	0%
98	HA MP Review PSS	20 days	Fri 06/03/15	Fri 03/04/15	0%
99	Amendments to PSS	5 days	Fri 03/04/15	Fri 10/04/15	0%
100	Submit Final PSS	1 day	Fri 10/04/15	Mon 13/04/15	0%
101	Engage DV to Arrange Access to 3rd Party Land	60 days	Thu 08/01/15	Wed 01/04/15	20%
102	**Geotechnical Surveys**	**95 days**	**Mon 19/01/15**	**Fri 29/05/15**	**0%**
103	Produce Contract and Specification for Ground Investigation	10 days	Mon 19/01/15	Fri 30/01/15	0%
104	Procure Ground Investigation Contractor	50 days	Mon 02/02/15	Fri 10/04/15	0%
105	Field Works (inc Mobilisation)	35 days	Mon 13/04/15	Fri 29/05/15	0%
106	**Topographical Surveys**	**80 days**	**Mon 02/02/15**	**Fri 22/05/15**	**0%**
107	Produce Specification for Topographical Surveys	20 days	Mon 02/02/15	Fri 27/02/15	0%
108	Procure Topographical Surveys	40 days	Mon 02/03/15	Fri 24/04/15	0%
109	Survey Works (inc Mobilisation)	20 days	Mon 27/04/15	Fri 22/05/15	0%
110	**Summary of Technical Approvals Required**	**27 days**	**Wed 18/03/15**	**Thu 23/04/15**	**0%**
111	Prepare Draft Summary of Technical Approvals	10 days	Wed 18/03/15	Tue 31/03/15	0%
112	Submit Draft Summary of Technical Approvals to HA	1 day	Wed 01/04/15	Wed 01/04/15	0%
113	HA MP Review Summary of Technical Approvals	10 days	Thu 02/04/15	Wed 15/04/15	0%
114	Amendments to Summary of Technical Approvals	5 days	Thu 16/04/15	Wed 22/04/15	0%
115	Submit Final Summary of Technical Approvals	1 day	Thu 23/04/15	Thu 23/04/15	0%
116	Provisional land plans for land estimate	30 days	Wed 15/04/15	Tue 26/05/15	0%
117	Developed Options Plans	80 days	Wed 17/12/14	Tue 28/04/15	17%
118	**Gap Closures Report**	**77 days**	**Thu 12/02/15**	**Fri 29/05/15**	**0%**
119	Prepare Draft Feasibility and Options Report	60 days	Thu 12/02/15	Thu 07/05/15	0%
120	Submit Draft Feasibility and Options Report to HA	1 day	Thu 07/05/15	Fri 08/05/15	0%
121	HA MP Review Feasibility and Options Report	10 days	Fri 08/05/15	Fri 22/05/15	0%
122	Amendments to Feasibility and Options Report	5 days	Fri 22/05/15	Fri 29/05/15	0%
123	Submit Final Feasibility and Options Report	1 day	Fri 29/05/15	Fri 29/05/15	0%
124	Budget Scheme Estimate	20 days	Wed 08/04/15	Tue 05/05/15	0%
125	End of Stage Report	10 days	Wed 13/05/15	Tue 26/05/15	0%
126	Completion of Options Development	0 days	Sun 31/05/15	Sun 31/05/15	0%



Project: A19 Elwick Crossroads - Jan 2015
Date: Tue 27/01/15

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

Annex C: Statement of Intent

Annex D: Appraisal Specification Report – Environment

Initial Environmental Assessment

Annex E: Appraisal Specification Report - Traffic

Traffic Modelling

Economic Assessment

Operational Assessment

Safe roads, Reliable journeys, Informed travellers

HIGHWAYS AGENCY

Highways Agency
Project Support Framework

Appraisal Specification Report - Traffic
A19 Elwick Crossroads

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27 November 2014

Project Reference: 653781 Version: 0

Halcrow Hyder

Highways Agency
Project Support Framework

Appraisal Specification Report - Traffic

Halcrow Hyder JV

Author:	Richard Frost	Richard Frost
Checker:	Tim Lund	Tim Lund
Approver:	Tony Gilbey	Tony Gilbey

Project Reference: 653781 **Version:** 0 **Date:** 27/11/2014

Contents Amendment Record - This report has been issued and amended as follows:

Issue	Version	Description	Date	Signed
1	0	Draft	28/11/2014	TG

This report has been prepared for the Highways Agency in accordance with the requirements as stated in the PSF Tender Documents Vol 2 Framework Information & Scope dated 05/05/10. Halcrow Hyder JV cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

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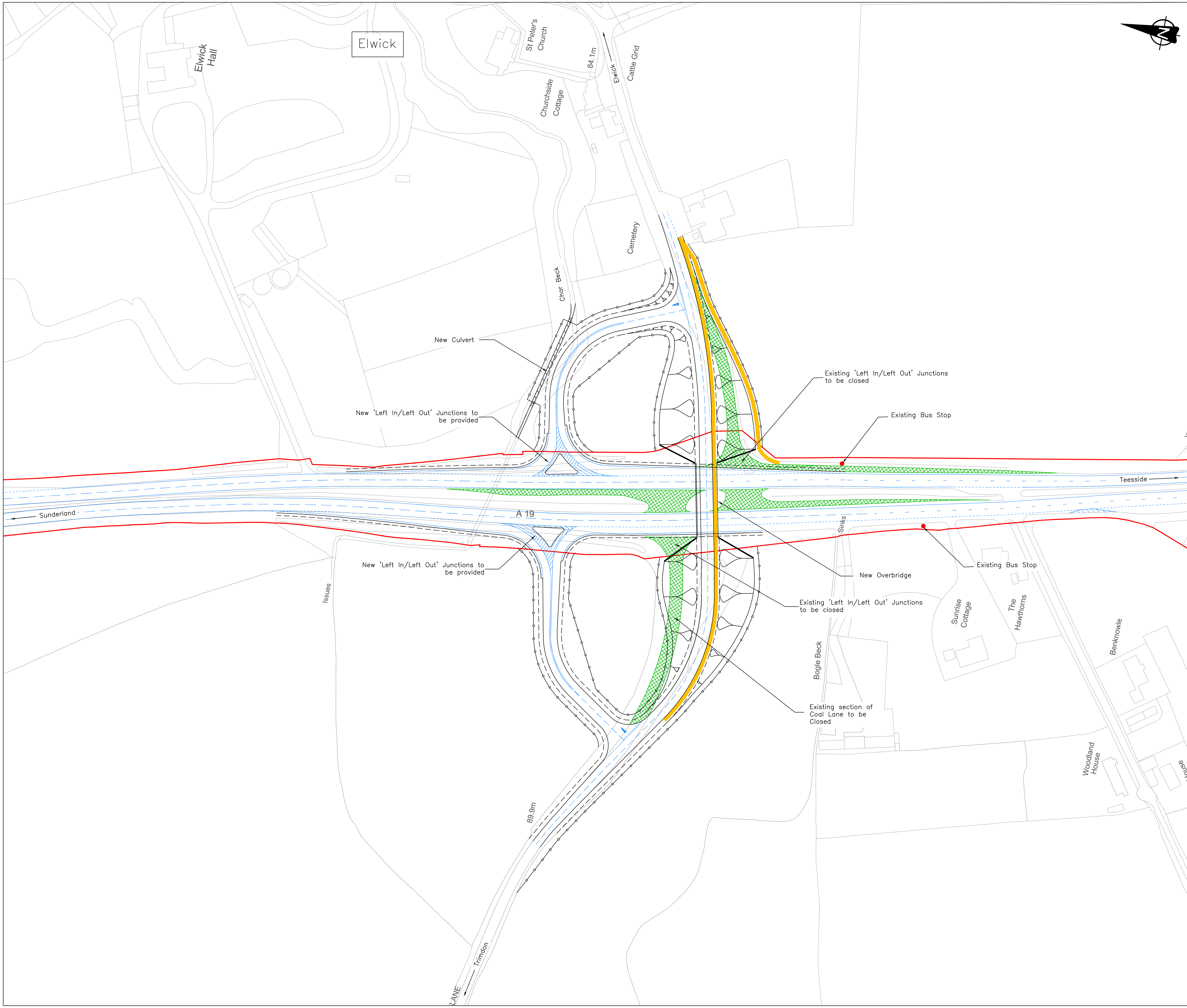
Wiltshire,
SN4 0QD
Tel +44(0)1793 812479

1. Methodology

Following discussions with Paul McKee HA TAME, the proposed appraisal methodology is given below. The list below does not include any tasks associated with the environmental assessment:

1. Obtain accident data for the most recent five year period throughout the length of the scheme (source: Autolink);
2. Calculate the current accident rate for the scheme area and identify accident trends;
3. Use industry standard publications (e.g. RoSPA and POPE) to determine appropriate annual accident savings for the scheme and determine opening year accident rate;
4. Carry out traffic counts at both the Coal Lane junction and the North Lane junction and all central reserve gaps between the A689 Wynyard and A179 Sheraton Interchanges;
5. Assess the projected traffic growth over the lifetime of the scheme (up to 60 years) based on NTEM and TEMPRO;
6. Extend the Dynameq meso model to cover the Elwick junctions to assess journey time benefits; and
7. Undertake PAR V6.4 assessment t obtain Value Management (VM) score and Benefit Cost Ratio (BCR).



Notes:

1. All dimensions are in metres unless otherwise stated.
2. Do not scale from this drawing.

Key:

- Bridge abutments and wingwalls
- Back of verge
- New Fence line
- New Footpath
- Earthwork slopes
- Area of central reserve gaps/existing highway to be permanently closed
- Proposed road markings
- Existing Trunk Road Highway Boundary
- Existing Bus Stops

FOR INFORMATION

Revision	By	Checked	Approved	Date	Description
0	MS	AE	TG	21/11/14	For Information

Client

HIGHWAYS AGENCY

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Halcrow Hyder

Project

PCF Package I
A19 Elwick GSJ

Drawing

Option 2A
Compact Grade Separated Junction
Overbridge at Coal Lane Junction

Drawn by	MS	Date:	20/11/14
Checked by	AE	Date:	20/11/14
Authorised by	TG	Date:	21/11/14

Drawing No. 653781.CC.0000.002

Revision 0

Drawing Scale: 1:1000

Plot Scale: 1:1

Sheet size A1

\\tees-fs-01\transportation\Projects\000000 PCF Package I\Drgs\Outgoing\AutoCad\A19 Elwick GSJ\653781.CC.0000.002 - Option 2A - Coal Ln Jct - Brg centralised.dwg

2. Timescales

Milestone 2 options development stage for the A19 Elwick Crossroads scheme is scheduled to be completed by the end of May 2015. The proposed date of delivery of the PAR assessments is displayed in Table 3.1, below:

Delivery programme

No	Scheme	Deliverable	Date
1	A19 Elwick Crossroads	Traffic Surveys	Mar 2015
		Model Development	Mar/Apr 2015
		PAR	Apr 2015

3. Risks

The above dates will enable the HHJV to meet the timescales set out in the scheme brief for Milestone 2 (options Development). The principal risks to these deliverables in terms of timescales are:

- if additional traffic surveys are needed to ensure that the base year model replicates existing flows and delays, this may delay completion of the modelling and PAR assessment;
- if the base year validation is found to be poor, revalidation may be needed. This could impact on completion of the PAR; and
- delays in obtaining information/ traffic data/ models from third parties.

Appendix E

EAST Assessment Summary

Early Assessment and Sifting Tool - *Saved Option*

Option name/no.	**Overbridge Coal Lane Junction**
Date	13/06/16
Description	Provision of an compact grade separated junction with overbridge at the staggered junction of Coal Lane and A19 and associated works to maintain all existing movements. Gap closures at Coal lane and North Lane. Realignment of northbound A19

Strategic

Identified problems and objectives	Existing problems relate to safety concerns and ability of the junction to operate safely with additional traffic from forthcoming housing developments. Objective 1: To support the diversification and growth of the Hartlepool economy by unlocking the potential for	
Scale of Impact	2	It will have a modest overall impact as it will allow a
Fit with wider transport and government objectives	3	It will support economic growth by improving the
Fit with other objectives	3	
Key uncertainties	Key uncertainties still remain in relation to capacity requirements of the junction and	
Degree of consensus over outcomes	2	Limited consultation has taken place with key

Economic

Economic growth	4. Amber/green	Improves the reliablity and resilience of the A19
Carbon emissions	2. Red/amber	It could potentially cause longer journeys for traffic from
Socio-distributional impacts and the regions	4. Amber/green	It will improve accessibility particularly for non-motorised
Local environment	2. Red/amber	It could also cause longer journeys for traffic from North
Well being	4. Amber/green	The scheme will reduce accidents, severance and
Expected VfM Category	4. Low 1-1.5	Scheme would provide safety benefits but would not

Managerial

Implementation timetable	5. 2-5 years	Required to be undertaken prior to work on widening the
Public acceptability	2	Consultation with residents will be required with the
Practical feasibility	3	Planning permission required
What is the quality of the supporting evidence?	3	Highways Agency Option Report
Key risks	Affects Char Beck and would require culvert, requires third party land, Coal Lane staggered junction would remain closed during construction, need to divert utility	

Financial

Affordability	3	It will facilitate only a limited amount of housing	
Capital Cost (£m)	04. 10-25	Still some uncertainty over junction costs due to the	
Revenue Costs (£m)	01. None		
Cost profile	Cost profile does not consider costs for construction and maintenance.		
Overall cost risk	4	Other costs	High level cost estimates have been

Commercial

Flexibility of option	3	Options to amend the design exist and their suitability
Where is funding coming from?	Options include LGF3, prudential borrowing, Highways England	
Any income generated (£m)	No	

Early Assessment and Sifting Tool - *Saved Option*

Option name/no.	**Overbridge and Bypass**
Date	13/06/16
Description	Provision of a compact grade separated junction including overbridge to the south of the North Lane junction with the A19 and associated works to maintain all existing movements. Provision of a bypass to link with the new junction to the north of Elwick. Closure of gaps at Coal Lane and North

Strategic

Identified problems and objectives		
Scale of Impact	4	It will have a significant impact as it will allow a
Fit with wider transport and government objectives	4	It will support economic growth through enabling of
Fit with other objectives	4	The scheme is aligned with SEP Priority 3 and is
Key uncertainties	Key uncertainties still remain in relation to capacity requirements of the junction and	
Degree of consensus over outcomes	3	Limited consultation has taken place with key

Economic

Economic growth	5. Green	Facilitates and enables housing development. Improves
Carbon emissions	2. Red/amber	Will increase the number of journeys through the
Socio-distributional impacts and the regions	5. Green	It will improve accessibility particularly for non-motorised
Local environment	1. Red	Will increase the number of journeys through the
Well being	4. Amber/green	The scheme will reduce accidents, severance and
Expected VfM Category	2. High 2-4	

Managerial

Implementation timetable	5. 2-5 years	Required to be undertaken prior to work on widening the
Public acceptability	4	Consultation with residents will be required but bypass is
Practical feasibility	4	Planning permission required but scheme is within the
What is the quality of the supporting evidence?	4	AIMSUM model, Highways Agency Option Report,
Key risks	Affects Char Beck to the west of the A19. Requires significant area of third party land, with greater impact on agricultural use.	

Financial

Affordability	5. Affordable	Much of the cost will be reclaimed from dependent	
Capital Cost (£m)	04. 10-25	Still some uncertainty over bypass costs as dicussions	
Revenue Costs (£m)	01. None		
Cost profile	Cost profile does not consider costs for construction and maintenance.		
Overall cost risk	3	Other costs	High level cost estimates have been

Commercial

Flexibility of option	4	There is still flexibility to change the junction design and
Where is funding coming from?	LGF3, prudential borrowing, Highways England, housing developers	
Any income generated (£m)	Yes	Don't know

Early Assessment and Sifting Tool - *Saved Option*

Option name/no.	**A19 Gap Closures**
Date	13/06/16
Description	Closure of central reserve gaps on the A19 at Coal Lane with modifications to A19/A179 and A19/A689 junctions as required to deal with re-routed traffic.

Strategic

Identified problems and objectives		
Scale of Impact	1. Small impact	Low impact tackling only the safety issues concerning
Fit with wider transport and government objectives	2	Will have a neglible or negative impact on economic
Fit with other objectives	2	Does not support the SEP objectives.
Key uncertainties	It is currently unclear what alterations would be required to the A19/A179 and	
Degree of consensus over outcomes	2	Separate study by Highways England has been

Economic

Economic growth	2. Red/amber	Does not facilitate additional housing development in
Carbon emissions	2. Red/amber	It will increase existing journey distances and times
Socio-distributional impacts and the regions	2. Red/amber	It will reduce local accessibility by requiring traffic to use
Local environment	2. Red/amber	It will increase existing journey distances and times
Well being	2. Red/amber	severance and negatively impact on access to local
Expected VfM Category	4. Low 1-1.5	

Managerial

Implementation timetable	3. 6-12 months	Relatively inexpensive and easy to implement measures.
Public acceptability	2	Unlikely to be unpalatable due to impact it would have on
Practical feasibility	2	Schems of a similar nature have been completed in
What is the quality of the supporting evidence?	4	Highways England Gap Closure Study
Key risks	Public acceptablility	

Financial

Affordability	5. Affordable	Low cost scheme	
Capital Cost (£m)	02. 0-5		
Revenue Costs (£m)	01. None		
Cost profile	Cost profile does not consider costs for construction.		
Overall cost risk	5. Low risk	Other costs	Not applicable

Commercial

Flexibility of option	5. Dynamic	Scheme can easily be modified if circumstance change
Where is funding coming from?	Highways England	
Any income generated (£m)	No	

Appendix F

Tees Valley Multi Modal Model Details

Tees Valley Unlimited

Tees Valley Multi Modal Model

Local Model Validation Report

Draft 2 | 26 February 2016

Job number 240436-00

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ARUP

Document Verification

ARUP

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Appendices

1 Introduction

Tees Valley Unlimited (TVU) requested that Arup provide assistance in updating the Tees Valley Model (TVM). TVU maintain a multi-modal transport model of the Tees Valley in order to inform transport investment in the Tees Valley, across all modes. The original TVM was calibrated and validated to a 2005 base year and is based on data which pre dates that year. The model was based in the CubeTrips software.

TVU and Arup have developed a wholly new multi modal model based in the Cube Voyager software, calibrated and validated to a 2014 base year built from synthetic data. The objective of the commission is to provide TVU with the tools to assess transport schemes; using a TAG (Transport Analysis Guidance) based multi-modal model (as far as can be achieved within current budgets) within the CUBE Voyager platform. Schemes to be assessed are likely to include:

- Major highways schemes;
- Traffic impacts of major developments;
- Public Transport (PT) improvements, both rail and bus based;
- Demand management measures such as car park and ride etc.

At the inception of the project it was accepted that new Origin/Destination (O/D) data either from road-side interview surveys (RSIs) or mobile phone data was currently prohibitively expensive and would be disproportionate to the scale of schemes the model is anticipated to be required to test. However, should a business case be required for a major scheme / schemes of the scale whereby up to date data could be justified, then the model has been developed in such a way as it could be updated with such information.

This report has been written in line with advice for writing Local Model Validation Reports (LMVR) in TAG M3-1 Highway Assignment Modelling, Appendix F. As TAG does not include equivalent advice for writing LMVRs for Public Transport (PT) or Demand Models, the highway specific advice has been suitably adjusted to include coverage of the PT and Demand Models.

2 Model Standards

2.1 Validation Criteria and Acceptability Guidelines

The model has been developed following the principles set out in WebTAG.

2.1.1 Highways

Model standards for developing highway models can be found in TAG M3.1 'Highway Assignment Modelling'. The validation of a highway assignment model includes comparisons of the following:

- assigned flows and counts totalled for each screenline or cordon, as a check on the quality of the trip matrices;
- assigned flows and counts on individual links and turning movements at junctions as a check on the quality of the assignment; and
- modelled and observed journey times along routes, as a check on the quality of the network and the assignment.

For trip matrix validation, the measure used is the absolute differences between modelled flows and counts.

For link flow validation, the measures used are:

- the absolute differences between modelled flows and counts; and
- the GEH statistic which is a form of the Chi-squared statistic that incorporates both relative and absolute errors, and is defined as follows:

$$GEH = \sqrt{\frac{(M-C)^2}{(0.5\times(M+C))}}$$

where:

GEH is the GEH statistic;

M is the modelled flow; and

C is the observed flow.

For journey time validation, the measure used is the percentage difference between modelled and observed journey times, subject to an absolute maximum difference.

The validation criteria and acceptability guidelines for each of these measures are discussed below.

Comparisons at screenline level provide information on the quality of the trip matrices. The validation criterion and acceptability guideline for screenline flows are defined in **Table 1**.

Table 1: Screenline Flow Validation Criterion and Acceptability Guideline

Criteria	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

With regard to screenline validation, the following should be noted:

- Screenlines should normally be made up of more than 5 links. For screenlines of fewer links, the acceptability guideline may be relaxed pro rata between 5% for 5 links and 15% for 1 link;
- The comparisons for screenlines containing high flow routes, such as motorways, should be presented both including and excluding such routes;
- The comparisons should be presented separately for (a) roadside interview screenlines; (b) the other screenlines used as constraints in matrix estimation (excluding the roadside interview screenlines even though they have been used as constraints in matrix estimation); and (c) screenlines used for independent validation;
- The comparisons should be presented by vehicle type (preferably cars, light goods vehicles and other goods vehicles); and
- The comparisons should be presented separately for each modelled period or hour.

The validation criteria and acceptability guidelines for link flows and turning movements are defined in **Table 2** below.

Table 2: Link Flow and Turning Movement Validation Criteria and Acceptability Guidelines

Criteria	Acceptability Guideline
Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	> 85% of cases
Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases
Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	> 85% of cases
GEH < 5 for individual flows	> 85% of cases

With regard to flow validation, the following should be noted:

- The above criteria should be applied to both link flows and turning movements;
- The acceptability guideline should be applied to link flows but may be difficult to achieve for turning movements;
- The comparisons should be presented for cars and all vehicles but not for light and other goods vehicles unless sufficiently accurate link counts have been obtained; and

- The comparisons should be presented separately for each modelled period or hour.

The validation criterion and acceptability guideline for journey times are defined in **Table 3** below.

Table 3: Journey Time Validation Criterion and Acceptability Guideline

Criteria	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher)	> 85% of routes

With regard to the journey time validation, the comparisons should be presented separately for each modelled period or hour.

TAG Unit M3-1 Table 5 outlines a set of benchmark criteria used to review the extent of changes due to matrix estimation (ME). These criteria are outlined in **Table 4** below.

Table 4: Significance of Matrix Estimation Changes

Measure	Benchmark Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

The guidance identifies that any exceedances do not mean that the model is unsuitable for the intended uses. The performance of the model should be reviewed against these criteria and exceedances should be examined and assessed for their importance, particularly in relation to the area of influence of the scheme to be assessed.

2.1.2 Public Transport

The following advice from TAG Unit M3.2 Public Transport Assignment Modelling has been followed with regard to validation of the public transport model.

7.1.1 The validation of a public transport passenger assignment model should involve three kinds of check:

- *validation of the trip matrix;*
- *network and service validation; and*
- *assignment validation.*

7.1.2 Validation of the trip matrix should involve comparisons of assigned and counted passengers across complete screenlines and cordons (as opposed to individual services). At this level of aggregation, the Department's suggested guideline is that the differences between assigned and counted flows should, in 95% of the cases, be less than 15%.

7.1.3 Validation of the network should involve checks on the accuracy of the coded geometry and times/speeds in the model (i.e. for in-vehicle, access and interchange times).

7.1.4 Validation of the services should involve comparing the modelled flows of public transport vehicles with counts (as well as other features such as stopping patterns for rail, etc.).

7.1.5 Validation of the assignment should involve comparing modelled and observed:

- *passenger flows across screenlines and cordons, usually by public transport mode and sometimes at the level of individual bus or train services; and*
- *passengers boarding and alighting in urban centres.*

7.1.6 The Department's recommendation is that across modelled screenlines, modelled flows should, in total, be within 15% of the observed values. On individual links in the network, modelled flows should be within 25% of the counts, except where observed hourly flows are particularly low (less than 150 passengers per hour).

7.1.7 The validation of assignment models of separate modes should be comparatively straightforward if the network, services and trip matrices have validated satisfactorily. The validation and subsequent recalibration of an assignment model of a combined network may be considerably more problematic.

7.1.8 Wherever possible, a check should be made between the annual patronage derived from the model and annual patronage derived by the operator. Precise comparisons may be difficult but may be sufficiently accurate to provide a cross-check on the general scale of patronage, bearing in mind that operator patronage is likely to be boardings and not trips.

2.2 Convergence Criteria and Standards

2.2.1 Highways

To ensure that, during the development of the base year model, reasonable levels of convergence are achieved, a %GAP value of 0.1% is used, i.e. sufficient iterations are carried out to achieve a %GAP of 0.1% or less.

A level of convergence which is sufficient to ensure that scheme benefits can be estimated robustly above model 'noise' is essential, and a lower value of %GAP may need to be achieved. More iterations may be required in the forecast year when congestion levels are forecast to be higher, simply to achieve the base year value of 0.1%, and even more iterations will be required to achieve the lower %GAP values required for robust economic appraisal.

However, it is clearly difficult to be precise about the appropriate level of convergence at the outset of model development. As soon as is practically possible, the model 'noise' within each model run should be assessed as well as between model runs, that is, between a benchmark model run and a 'with-scheme' model run. This should assess the overall change in vehicle (or pcu) hours between assignment loops (the model 'noise') and the difference in vehicle (or pcu) hours between corresponding loops in the benchmark and 'with-scheme' model runs.

In practice, the change in vehicle hours between assignment loops within a model run should be small compared to the difference between the benchmark and 'with-scheme' model runs. Ideally, 'small' would be about 1/10th, although, in practice, larger values are not necessarily indicative of a problem. It should be noted that, while this relatively simple comparison should be done at the whole model level, scheme benefits may not always be measured using whole model outputs.

Experience has shown that %GAP values of less than 0.05% and, ideally, less than 0.035% are now routinely necessary to provide a robust basis for economic appraisal of highway schemes. The larger the model, the more difficult it will be to attain these levels. In fact, this target will often be impossible to achieve in a large model and, hence, a balance needs to be attained between practical model run times and convergence levels. The potential need for more stringent convergence standards for scheme appraisal applies to the other measures of convergence as well as to %GAP.

Table 5 summarises the most appropriate convergence measures and the values generally considered acceptable for use in establishing a base model. Tighter levels of convergence may be required for scheme appraisal.

Table 5 Summary of Convergence Measures and Base Model Acceptable Values

Measure of Convergence	Base Model Acceptable Values
%GAP	less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P)<1%	four consecutive iterations greater than 99%
Percentage of links with cost change (P2)<1%	four consecutive iterations greater than 99%

2.2.2 Public Transport

The PT model does not currently include any representation of crowding. As such the concept of convergence within the PT assignment is redundant.

2.2.3 Demand Model

TAG contains the following guidance on convergence.

6.3.7 It is beneficial to monitor and report the %GAP for not only the last iteration of demand and supply, but for several iterations in order to understand the stability of the model.

6.3.8 Tests indicate that gap values of less than 0.1% can be achieved in many cases, although in more problematic systems this may be nearer to 0.2%. Where the convergence level, as measured by the %GAP, is over 0.2% remedial steps should be taken to improve the convergence, by increasing the assignment accuracy.

The criterion for measuring convergence between demand and supply is given by the following;

$$\%GAP_n = \frac{\Sigma(C_{ijmkpn-1} \times |TRIPS_{ijmkpn} - TRIPS_{ijmkpn-1}|) \quad \times 100}{\Sigma(C_{ijmkpn-1} \times TRIPS_{ijmkpn-1})}$$

Where:

- $\%GAP_n$ is the demand/supply gap for iteration *n*
- $TRIPS_{ijmkpn}$ is the cell in the assignment matrix for iteration *n*, specific by origin *i*, destination *j*, mode *m*, purpose *k*, and period *p*
- $TRIPS_{ijmkpn-1}$ is the cell in the assignment matrix for iteration *n-1*, specific by origin *i*, destination *j*, mode *m*, purpose *k*, and period *p*
- $C_{ijmkpn-1}$ is the cell in the generalized cost resulting from assigning matrix for iteration *n-1;* specific by origin *i*, destination *j*, mode *m*, purpose *k*, and period *p*

3 Key Features of the Model

3.1 Modelled Area

TAG Unit M3-1 section 2.2 describes the modelled areas expected in highway assignment models. Paragraph 2.2.5 states;

"Within the overall modelled area (in many models encompassing the whole country), the level of modelling detail will vary. It is useful to consider this variation in terms of a classification of modelled area type as set out below.

- *Fully Modelled Area: the area over which proposed interventions have influence, further subdivided as set out below.*
  - *Area of Detailed Modelling. This is the area over which significant impacts of interventions are certain. Modelling detail in this area would be characterised by: representation of all trip movements; small zones; very detailed networks; and junction modelling (including flow metering and blocking back).*
  - *Rest of the Fully Modelled Area. This is the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude. It would be characterised by: representation of all trip movements; somewhat larger zones and less network detail than for the Area of Detailed Modelling; and speed/flow modelling (primarily link-based but possibly also including a representation of strategically important junctions).*
- *External Area: In this area impacts of interventions would be so small as to be reasonably assumed to be negligible. It would be characterised by: a network representing a large proportion of the rest of Great Britain, a partial representation of demand (trips to, from and across the Fully Modelled Area); large zones; skeletal networks and simple speed/flow relationships or fixed speed modelling."*

The guidance states that the external network area requires a suitable balance to ensure boundary flows are representative and correctly routed. It also notes that external to external movements should be considered when defining the network extent. For the TVM, this is particularly relevant for the A19, A1 and main radial movements from Teesside.

The TVM network is based on two distinct areas:

- Fully Modelled Area; and
- External area.

The internal area is defined as the 5 districts within the Tees Valley. Within the internal area, all relevant trip movements have been modelled and the area is made up of smaller zones (compared to the remainder of the model) and a detailed network. Detailed junction modelling has also been undertaken.

The external area is the area over which the impacts of interventions are considered to be low in magnitude. The purpose of this area is to feed the internal area. It consists of larger zones and less network detail than the internal area and consists of speed/flow modelling.

Figure 1 below shows the fully modelled and external areas. The fully modelled area covers the 5 districts within the Tees Valley namely;

- Darlington;
- Hartlepool;
- Middlesbrough;
- Redcar and Cleveland; and
- Stockton-On-Tees.

Figure 1: Fully Modelled and External Area

3.2 Zoning System

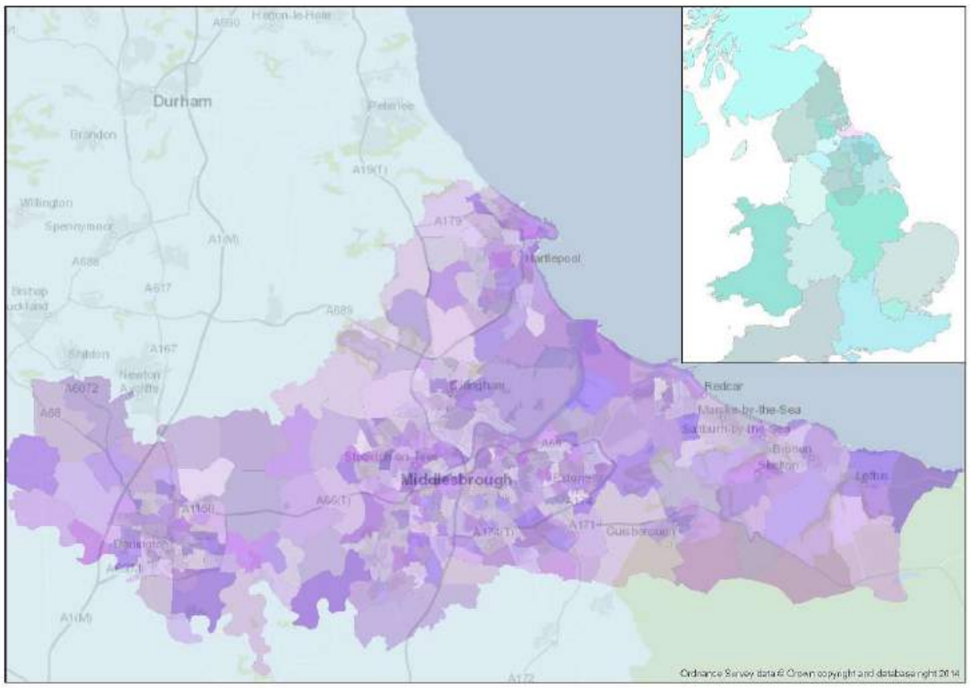
TAG Unit M3-1 section 2.3 contains the following advice for the design of the zone system;

"The design of the zoning system should be closely related to the classifications of the modelled area defined in Section 2.2. Zones should be smallest in the Area of Detailed Modelling, becoming larger for the Rest of the Fully Modelled Area and progressively much larger for the External Area. At the boundary between the classifications of area type, it is important to avoid sudden changes in average zone size and a graduated approach is desirable.

The primary building block for the zone system should be Census and administrative boundaries, and boundaries relating to national forecasts."

Accordingly the model contains 375 zones in the fully modelled area and 57 representing the external area (i.e. the rest of the UK), giving a total of 432 zones. This is shown in **Figure 2** below.

Figure 2: Zone System



3.3 Network Structure

In terms of network detail, the historic TVM networks include all Motorways, A roads, B roads and some C roads within the fully modelled area. The opportunity was taken with the redevelopment of the model to rationalise the zone and network structure. Within the original TVM there were 630 zones, with varying levels of network representation dependent upon urban area, due to the development of the model from the merger of various historic town based models. The removal of 198 zones allowed a number of minor residential roads to be removed whilst providing a uniform level of network coverage across the urban areas. Link lengths were validated as described in **Section 5.1.3**.

3.4 Time Periods

The model time periods are specified as follows.

- AM Period (07:00 - 10:00);
- Inter Peak Period (10:00 - 16:00);
- PM Period (16:00 - 19:00); and
- Off Peak Period (19:00-07:00).

The highway and PT assignment model peak hours within these time periods;

- AM Peak Hour (08:00 - 09:00);

- Inter Peak Hour (Average 10:00 - 16:00);
- PM Peak Hour (17:00 - 18:00); and
- Off Peak Hour (Average 19:00-07:00).

3.5 User Classes

The following journey purposes are modelled:

- Home based Work (HBW);
- Home based Employers Business (HBEB);
- Home based Education;
- Home based Other (HBO);
- Non-Home based Work (NHBW);
- Non-Home based Employers business (NHBEB);
- Non-Home based Other (NHBO);
- LGV (All purposes); and
- OGV (All purposes).

3.6 Assignment Methodology

3.6.1 Highway Model

The Highway model is contained within Cube Voyager's Highway Program. The assignment program builds paths based upon link costs (from speed flow curves) and junction delays (from the coding of junctions). All-or-Nothing assignments are combined using the method of successive averages to develop an equilibrium assignment.

3.6.2 Public Transport Model

During route enumeration and evaluation, the Public Transport model finds "reasonable" or "attractive" multiple discrete routes between zones, considering:

- Number of transfers;
- Spread — the margin of cost over the minimum cost route;
- Non-transit (i.e. walk) and in-vehicle costs;
- Boarding and transfer penalties by mode;
- Waiting time, derived from the combined frequency of services at stop nodes; and
- Fares (considered only for evaluation).

During loading, the PT model loads demand, in the form of trips between zone pairs. The model uses a series of models at the different decision points in a trip:

- The walk-choice model allocates trips between attractive choices at access, egress, and transfer points. Where walk and transit choices are available, it also determines the transit share;
- The service-frequency and cost model allocates the transit share at a stop between the attractive services available at that stop; and
- The alternative-alighting model apportions the share of a service to the attractive alternative alighting points of that service.

A multi-routing methodology is used to assign trips to the available generated paths using the service-frequency and cost model.

3.7 Generalized Cost Formulations and Parameter Values

The parameter values required to calculate pence per minute (PPM) and pence per kilometre (PPK) in accordance with the guidance in TAG Unit A1.3 are;

- Value of time;
- Average vehicle occupancies; and
- Average speeds.

The values of time have been taken directly from TAG Unit A1.3 as no locally calibrated values are available. Model output data has been used to generate the average speed within the highway network for each model time period.

Key guidance in Section 2.8 of TAG Unit M3-1 states;

'In principle, the basis for route choice in a highway assignment model should be generalised cost, defined as follows:

Generalised cost = (time) + (vehicle operating cost per km x distance / value of time) + ((road user charges) / value of time)

It should be noted that where user classes are defined by income group (for example where road user charges are important), the values of time used in the generalised cost formulation should very by income group.

Generalised cost is expressed in units of time. This removes the difficulty of changes in costs over time, due to inflation and other changes, which may produce inconsistencies from year to year. In this regard, time is the more stable measure to use and does not require further adjustment, beyond the change in values of time over time.'

Generalised cost parameters have been calculated in accordance with the guidance in TAG Unit A1.3. The highway assignment model contains the following user classes;

- Commute;
- Employers Business;
- Other;
- Light goods vehicles (LGV); and
- Other goods vehicles (OGV).

The Generalised Cost values used in the highway assignment model are summarised in **Table 6**.

Table 6 Calculation of PPM and PPK – Base Year 2014

User Class	PPM Pence per Minute	PPK Pence per Kilometre	Distance cost (PPK / PPM)
Work	45.03	13.26	0.29
Commute	13.32	6.93	0.52
Other	18.00	6.93	0.39
LGV	20.64	14.00	0.68
OGV	20.90	45.01	2.15

It should be noted that the values of time in the table above are based on the latest economic parameters available, i.e. those that were published by Department for Transport (DfT) in November 2014.

4 Calibration and Validation Data

4.1 Highway Data

4.1.1 Historic Data

A large number of RSI surveys have been undertaken over the last 20 years, although as these surveys are now more than 6 years old they are no longer considered to represent up to date travel patterns. The following historic RSIs were made available for use in this study however due to their age, very limited use was made of them:

- RSI surveys were conducted at 10 locations in Hartlepool during October 1995 and June 1996;
- In June 1996 and April 1997, 9 surveys were undertaken in and around the Middlesbrough conurbation;
- RSI surveys were conducted at 17 locations in Darlington during June 1997;
- Two RSI sites were undertaken in September 1998, as part of the continued investigation into traffic flows associated with the Ingleby Barwick development;
- In October 2000, three RSI surveys were undertaken on the inter-urban links between Billingham and Hartlepool;
- In November and December 2002, 26 RSI surveys were undertaken as part of the Tees Valley Transport 2010 study;
- In June 2003, as part of a study into the A66 Darlington Gateway scheme, RSIs were undertaken at three locations of the A66 Darlington bypass, and a single site to the north of Darlington to assess traffic patterns around Darlington; and
- In April 2005, five roadside interview sites were undertaken, around the Redcar & Cleveland conurbation.

4.1.2 Traffic Counts

Traffic flow information is routinely collected at continuous automatic traffic count (ATC) monitoring sites across Tees Valley by the Highways Agency (TRADS) and Local Authorities. Historic traffic counts are available over a number of years. These ATCs have comprehensive coverage across Tees Valley and as such provide almost all the volumetric data required to develop calibration screenlines for traffic model development.

The ATC data has been collated into a number of screenlines. The creation of the screenlines has been undertaken in accordance with the following guidance.

Whilst historic, the Traffic Appraisal Manual[1] contains relevant advice;

[1] Design Manual for Roads and Bridges: Volume 12 Section 1 Part 1 Traffic Appraisal Manual

"11.4.22: To validate the traffic flows estimated by the assignment model the model output should be compared with count information reserved from that assembled for the model calibration (see section 9.6). The number of validation counts required will depend upon the scale of the model: for very small schemes comparison with 10 counts or less may suffice, for a typical scheme 20 counts is the likely minimum with many more points being added as the scale of the study increases."

TAG Unit 3.1 contains the following advice regarding calibration screenlines;

"4.2.2: The density of calibration screenlines should be designed so that the majority of intra-sector movements are subject to the adjustment process (matrix estimation). In designing the calibration screenlines, account should therefore be taken of the mean length of intra-sector trips and the size of the sectors: where the mean trip length is long in relation to the size of the sector, a single calibration screenline may suffice; and where mean trip length is short in relation to the sector size, more than one calibration screenline may be required. By definition, intra-sector trips will not have been intercepted at the roadside interview sites and so the best estimate of the mean length of these trips is likely to be, in most instances, the synthetic matrices. These may be informed by some analysis of the shorter distance trips picked up by the roadside interviews as a guide."

And discusses screenlines for LGVs and OGVs also;

4.3.4: Generally, neither ATCs nor MCCs will yield counts of light and heavy goods vehicles which are sufficiently accurate for the validation of the assigned flows of these vehicle types on individual links. Validation of these vehicle types will therefore generally need to be reported for short screenlines using grouped counts which have sufficiently small confidence intervals."

The following calibration screenlines were developed;

- Screenline1, Northbound, External East;
- Screenline2, Southbound, External East;
- Screenline3, Westbound, Normanby;
- Screenline4, Eastbound Normanby;
- Screenline5, Northbound, Middlesbrough Suburban;
- Screenline6, Southbound, Middlesbrough Suburban;
- Screenline7, Northbound, Middlesbrough South;
- Screenline8, Southbound, Middlesbrough South;
- Screenline9, Northbound, Middlesbrough East;
- Screenline10, Southbound, Middlesbrough East;
- Screenline11, Northbound, A19_A66 Interchange;
- Screenline12, Southbound, A19_A66 Interchange;
- Screenline13, Eastbound Darlington North;
- Screenline14, Westbound, Darlington North;

- Screenline15, Eastbound Darlington Suburban;
- Screenline16, Westbound, Darlington Suburban;
- Screenline17, Eastbound Darlington West;
- Screenline18, Westbound, Darlington West;
- Screenline19, Northbound, Darlington South;
- Screenline20, Southbound, Darlington South;
- Screenline21, Eastbound Darlington East;
- Screenline22, Westbound, Darlington East;
- Screenline23, Northbound, Stockton North;
- Screenline24, Southbound, Stockton North;
- Screenline25, Eastbound Stockton West;
- Screenline26, Westbound, Stockton West;
- Screenline27, Northbound, Ingleby;
- Screenline28, Southbound, Ingleby;
- Screenline29, Eastbound Portrack; and
- Screenline30, Westbound, Portrack.

The screenlines are shown in **Figure 3** below.

4.1.3 Journey Time Surveys for Calibration and Validation

The DfT hold a license to distribute TrafficMaster journey time data for the highway network. Utilising GPS data collected from in-vehicle units, TrafficMaster is able to provide an extensive and detailed set of Origin-Destination (OD) information and journey time data. This data has been examined for the 12 months between September 2013 and September 2014 to provide journey time information by time period for the following routes across Teesside, shown in **Figure 4**.

Figure 3: Highway Calibration Screenlines

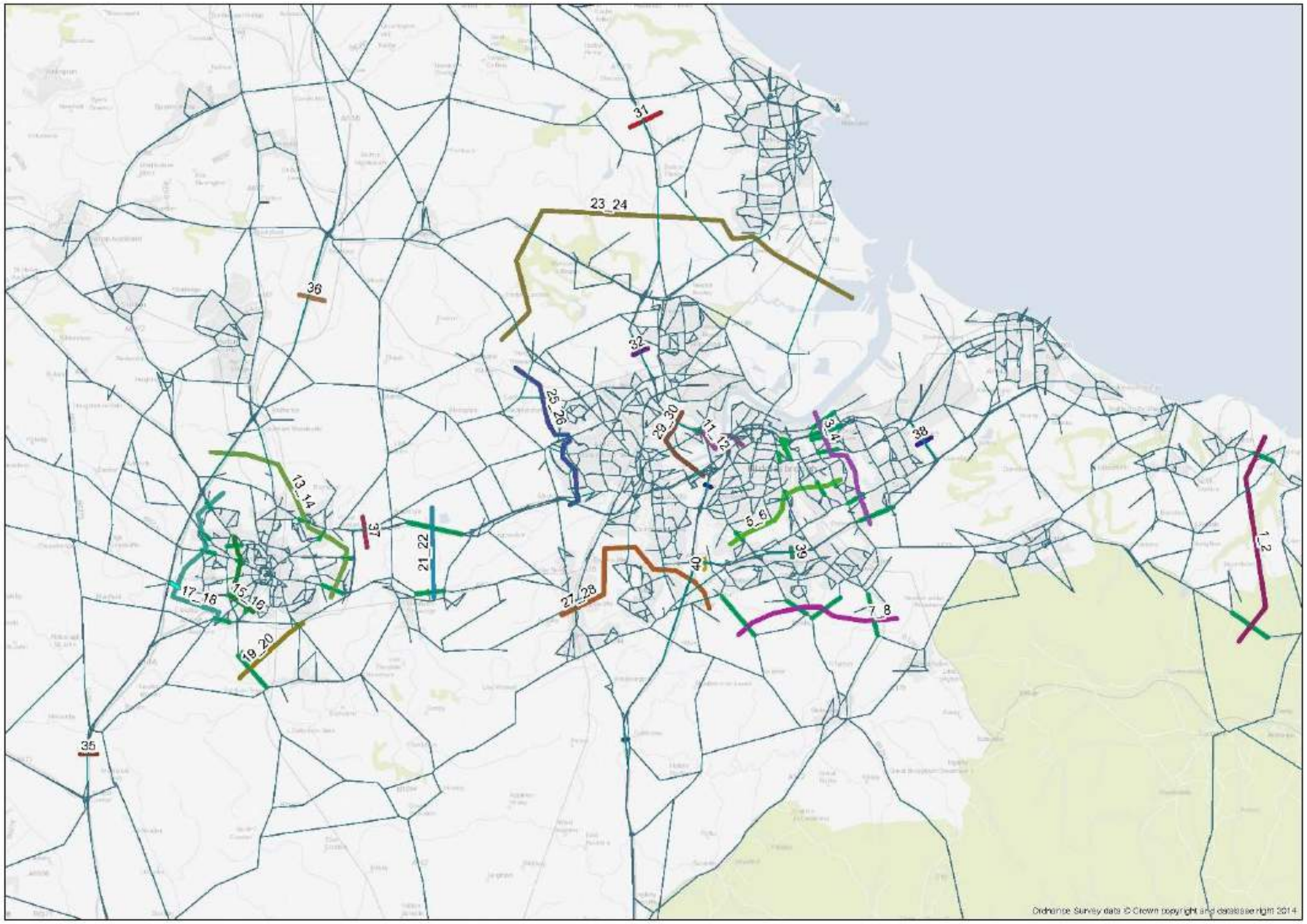


Figure 4: TrafficMaster Journey Time Data

4.2 Public Transport Data

4.2.1 Historic Data

The following historic data was made available for use in the study;

- Northern Rail Boarding Data from 2011. 24 hour total passengers boarding by station:
- Arriva Buses Boarding Data from 2014 for a selection of services. 24 hour totals total passengers boarding by stop;
- Rail Station Catchment Passenger Surveys – from 2003/2004 and some limited surveys from 2014 – sample size 600 surveys. Contains details of passenger's postcodes and mode of travel to boarding station; and
- Bus Passenger Catchment Surveys – from 2003 – sample size 190 surveys. Contains details of passenger's postcodes and mode of travel to boarding stop.

4.2.2 Ticket Data

Ticket data was made available from the bus and rail operators within the region. It is important to note that the commercial confidentiality of such data has been maintained through the development of the PT matrices which has removed all operator specific fare data.

Table 7: Public Transport Ticket Data

Operator	Data Covering Period
LENNON Data for all stations in the Northern Rail Area	12 Months in 2014
Arriva Buses	1^{st} – 31^{st} May 2014
Stagecoach Buses	23^{rd} – 28^{th} February 2015
Leven Valley Coaches	1^{st} – 31^{st} May 2014

4.2.3 PT Surveys at Bus Stations

Bus user questionnaire surveys were undertaken between the 2^{nd} and 15^{th} March 2015. Passengers waiting for buses were asked a series of questions at the following major bus interchange locations, in the Tees Valley.

- Middlesbrough Bus Station;
- Redcar Clock;
- Stockton High Street;
- Billingham Causeway;
- Hartlepool York Road; and
- Darlington Town Centre.

4.2.4 PT Link Surveys

Bus occupancy surveys were undertaken at the following locations between 2nd and 15th of March 2015.

The surveys were carried out between 08:00 and 10:00, 12;00 and 14:00 and 16:00 and 18:00. Enumerators note the number of passengers on each service as it passed the location;

Stockton Screenline

- Victoria Bridge;
- Bishopton Lane;
- Yarm Lane; and
- Norton Road.

Billingham Screenline

- Station Road; and
- Cowpen Lane.

Hartlepool Screenline

- Winterbottom Avenue; and
- York Road.

Midlesbrough Screenline

- Acklam Road;
- Marton Road;
- Kings Road; and
- Normanby Road.

Redcar Screenline

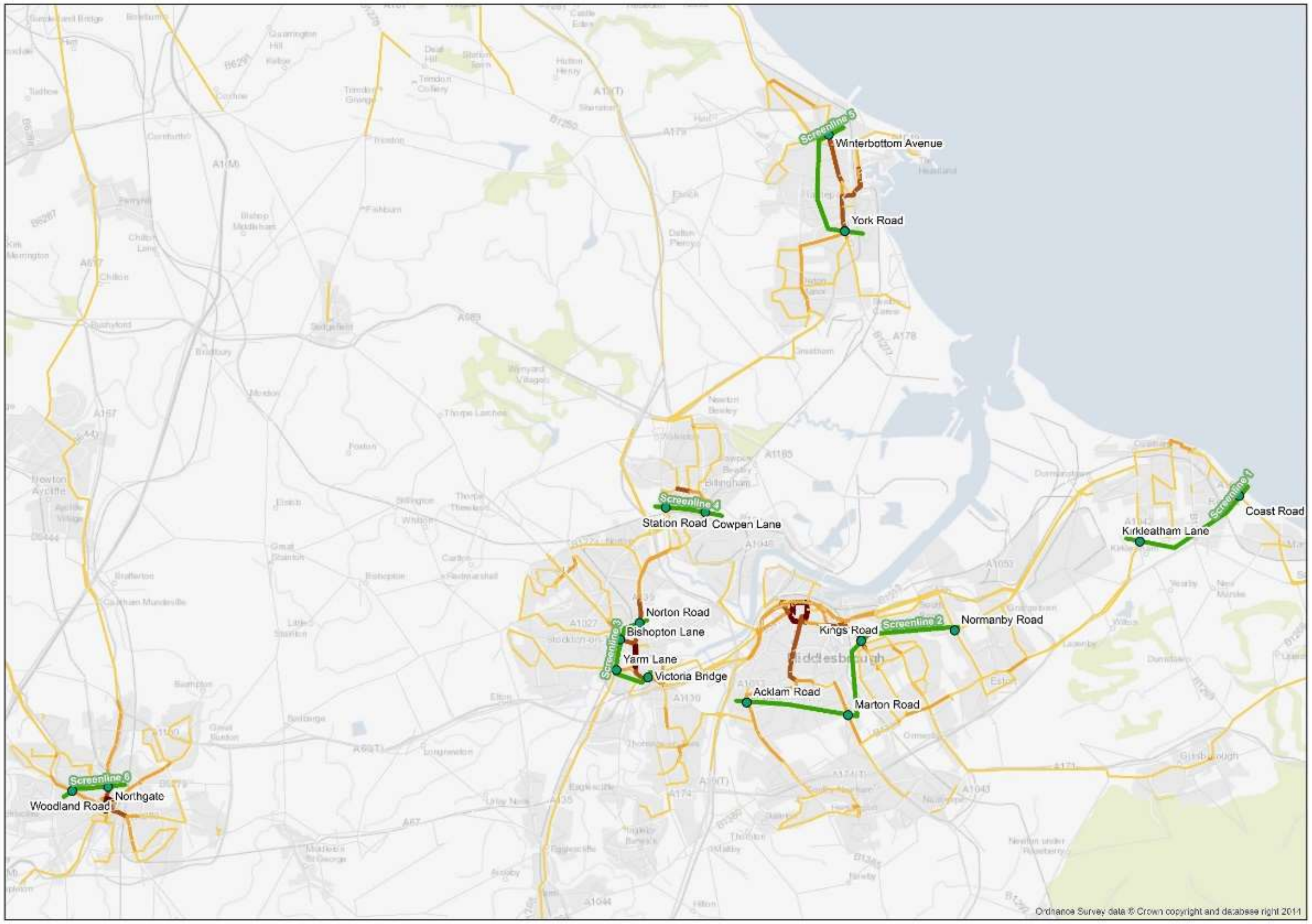
- Kirkleatham Lane; and
- Coast Road

Darlington Screenline

- Woodland Road; and
- Northgate.

The screenlines are shown in **Figure 5** below.

Figure 5: Bus Patronage Screenlines



5 Highway Model Network Development

5.1 Introduction

5.1.1 Integrated Transport Network based network

The rebuilding of the model has led to an opportunity to review the highway network where the use of the Ordnance Survey Integrated Transport Network (ITN) has been made. This has a number of benefits as follows:

- Enables outputs to be plotted on a geographically accurate basis along road centrelines which is important for the analysis of environmental impacts; and
- Provides a verified source of network data that can be used to check parts of the network such as link lengths, road types and turn restrictions and link connectivity (i.e. is the link passable with no restrictions (access control, cycle gates etc.) based on the Road Routing Information layer.

5.1.2 Junction Coding

A key part of the simulation network coding is to ensure that all modelled junctions provide an accurate representation of real-life operation. The following four junction types have been identified and reviewed for accuracy:

- Priority junctions;
- Stand-alone signalised junctions;
- Roundabouts; and
- Signalised roundabouts.

The coding of each junction has been cross-checked against imaging from 'Google Streetview', in combination with local knowledge and on-site observations. Junctions where the coding does not represent reality have been identified and re-coded as required.

Further details of the coding methodology employed for each the above junction types, along with an overview of link distance coding and cruise speeds, is provided in the following sections.

Signalised junctions have been coded through the definition of the observed signal phases. Due to the large number of signalised nodes the phase timings are optimised within the programme. However, extensive use of phase minimums and maximums have been used to prevent unrealistic timings being generated.

5.1.3 Link Distances

The ITN network correspondence has been used to generate link distances for all of the modelled links. The link lengths have been checked utilising a variety of methods:

- A check of the derived link distances against the original TVM link distances. The links with the largest discrepancies have been subject to a manual check; and
- A check of the derived link distances against those recorded within the journey time surveys. Again, any discrepancy has been checked.

The speed limits within the simulation area were identified through a mixture of site visits and local knowledge.

5.1.4 Speed Flow Curves

The original TVM was coded with a series of pre-defined speed-flow curves based upon the COBA10 classifications and converted into Cube Trips format. Cube Voyager uses a power function in order to define the speed-flow curve whereas Cube Trips used a series of linear relationships between the free flow speed, the point of flow breakdown, at capacity and a further relationship beyond the capacity speed. In addition to converting the curves into Cube Voyager format, a minimum speed of 20kph was defined. This was found to be necessary as, without this lower limit, the model became very unstable in areas of congestion leading to very poor convergence. It is considered that in areas of extreme congestion it is delays at junctions that are the most likely cause.

5.2 Zone Connectors

TAG Unit M3-1 outlines the requirements for Highway Assignment Modelling. Section 2.4 describes the guidance for centroid connectors. Each zone is accessed by a single centroid in order to minimise problems with model convergence. The structure of the TVM model has been maintained whereby the zone centroids are loaded onto nodes.

For externally located zones, the centroid has been derived from the population weighted centroid location. This has enabled the zones to be located and accessed based on their true access time, enabling the full journey length to be included within the model.

6 Highway Trip Matrix Development

6.1 Introduction

At the inception of the project it was accepted that new O/D data (either from RSIs or mobile phone data) is currently prohibitively expensive and would be disproportionate to the scale of schemes the model was currently conceived to test. However, should a business case be required for major scheme / schemes of the scale whereby up to date data could be justified, then the model has been developed in such a way as it could be updated with such information. In the absence of such data the highway trip matrix has been developed from a combination of National Trip Model (NTM) trip end data and TrafficMaster OD data.

6.2 Data Inputs

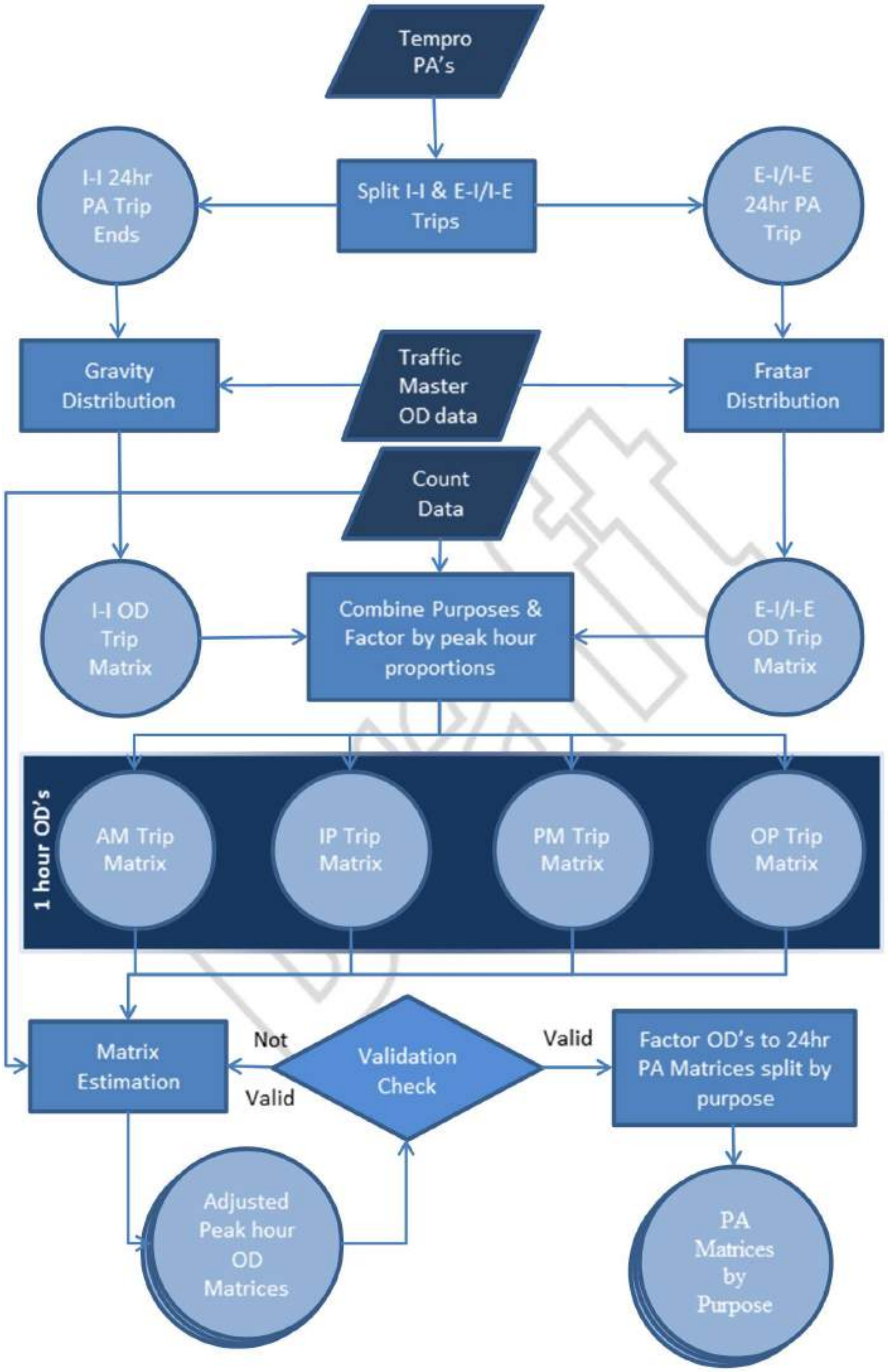
TrafficMaster data is collected from vehicles with built in satellite navigation. A trip is defined as being from where the ignition is turned on to where it is turned off. This data is collated, providing an estimate of national O/D patterns. The data is collected by vehicle class. However, it is not possible to deduce trip purpose from the O/D location, and it is very difficult to get an estimate of sample size. As such, the demand calculated from TrafficMaster data must be somehow segmented by purpose and scaled by some external data.

The National Transport Model (NTM) provides an estimate of trip ends by mode and purpose at a number of levels of spatial aggregation. This estimate is based on a number of assumptions including population, number of jobs, as well as economic forecasts. The NTM provides no origin-destination information. As such it cannot be used directly for matrix building. It does however provide a useful way to scale travel patterns calculated from other data, such as TrafficMaster.

6.3 Matrix Building Methodology

shows the methodology for the construction of the highway matrices.

Figure 6: Highway Matrix Building Methodology



6.3.1 Derive Tempro Trip Ends

Internal trips were derived from Tempro trip ends disaggregated across residential and employment address points. Census household populations and employment data have been used to proportionally weight the Tempro trip ends as seen in **Table 8**, **Figure 7** and **Figure 8**. Address points have then been used to aggregate the trip ends to the model zone level.

Table 8: Tempro Weighting Data

	Tempro Purpose	Model Purpose	Production weighted average variable	Attraction weighted average variable
Home Based	Work	Work	16-64 Population	Jobs
	Employers Business	Employers Business	16-64 Population	Jobs
	Education	Education	0-15 Population	Education Jobs
	Shopping	Other	Population	Retail Jobs
	Personal Business		Population	Retail Jobs
	Holiday/Day Trip		Population	Leisure Jobs
	Recreation		Population	Leisure Jobs
	Friends & Family		Population	Population
Non Home Based	Work	Work	Retail/Leisure/Education Jobs	Jobs
	Employers Business	Employers Business	Jobs	Jobs
	Education	Other	Retail/Leisure Jobs	Education Jobs
	Shopping		Retail/Leisure/Education Jobs	Retail Jobs
	Personal Business		Retail/Leisure/Education Jobs	Retail Jobs
	Holiday/Day Trip		Retail/Leisure/Education Jobs	Leisure Jobs
	Recreation		Retail/Leisure/Education Jobs	Leisure Jobs

Figure 7: Employment Tempro to modelled zones

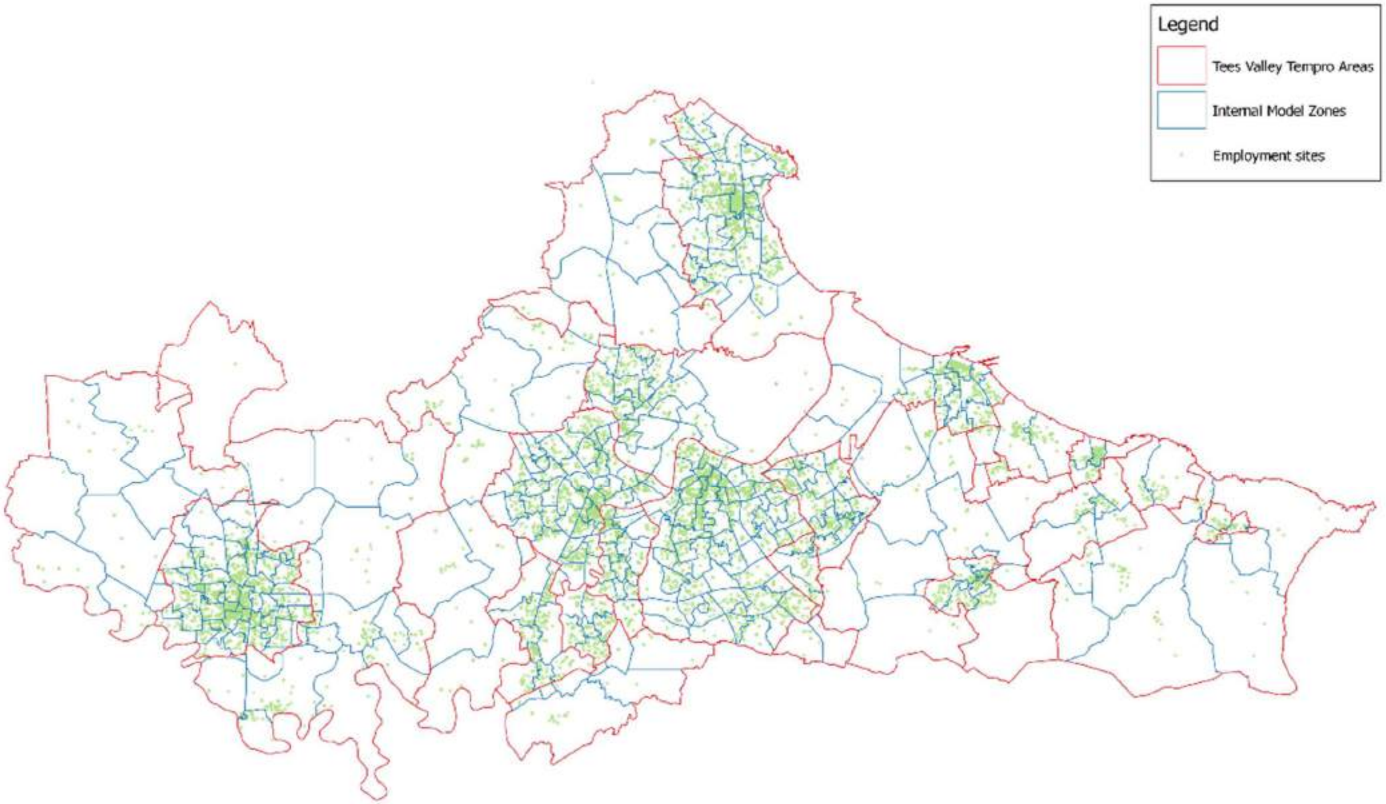
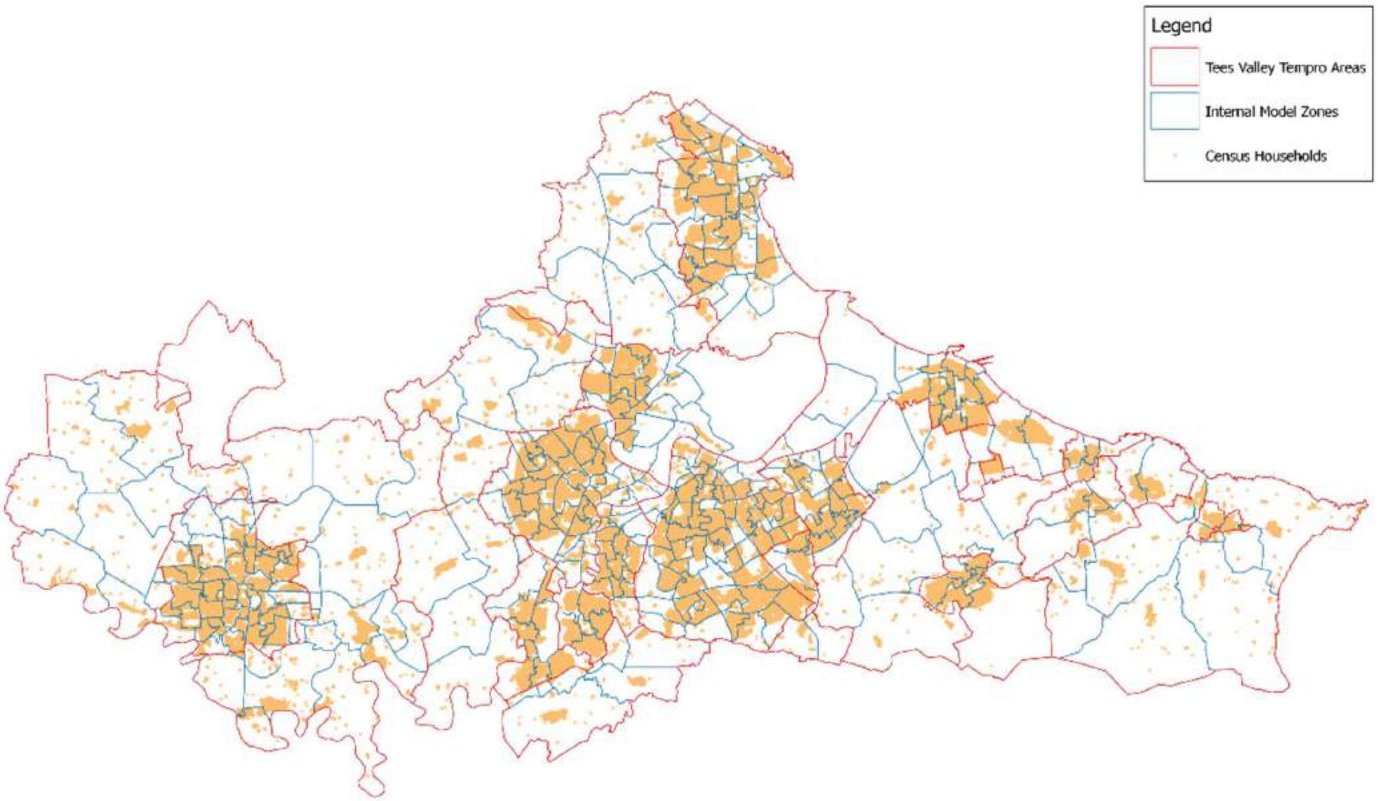


Figure 8 Household Tempro to modelled zones



6.3.2 Split Internal and External Trips

TrafficMaster data was used to split the Internal-Internal trips from the Internal-External and External-Internal trips.

6.3.3 Internal to Internal Trip Gravity Model

The Internal–Internal trip matrix was derived from a gravity model using Tempro Trip Ends, a TrafficMaster seed matrix, and friction factors based on impedances derived from the highway assignment model. The gravity model was calibrated to match average trip length distributions by purpose from the historic RSIs. This process was iterated a number of times to improve the highway assignment and thereby providing improved impedances to input into the gravity model.

6.3.4 External to Internal Fratar Process

The External–Internal distribution was developed using a simpler Furness process.

6.3.5 Split into Time Periods

The Internal-Internal and Internal-External matrices were brought together and split into time periods using National Travel Survey time period splits by purpose, shown in **Table 9**. These time period matrices were then factored to peak hour matrices using a set of locally derived peak period factors, shown in **Table 10**.

Table 9: National Travel Survey Time Period Splits

	HBW		HBEB		HBO		NHBEB	NHBO
	From home	To Home	From home	To Home	From home	To Home		
AM Period (07:00-10:00)	0.43	0.25	0.32	0.31	0.44	0.40	0.39	0.31
Inter Period (10:00-16:00)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
PM Period (16:00-19:00)	0.23	0.41	0.44	0.29	0.25	0.17	0.26	0.22

Table 10: Locally Derived Peak Hour Factors

	All Traffic
AM Period to Peak (08:00-09:00)	0.3729
Inter Peak Period to average hour	0.1666
PM Period to Peak (17:00-18:00)	0.3706

6.3.6 Matrix Estimation

Matrix Estimation was then undertaken using the traffic count screenlines shown in **Figure 3**. The ME process was run through 3 iterations. For each iteration the same prior matrix was used. The iterations differed only in respect of the assignment costs used, i.e. the assignment paths from the previous iteration were used as the basis to calculate updated PIJA factors (i.e. the proportion P of trips between origin I and destination J passing through link A) for the subsequent estimation loop. The ME process was monitored through reviewing the changes in trip totals, sector to sector movements, average trip lengths and trip end changes. These are outlined and described further in the following sections.

6.4 Monitoring changes brought about by matrix estimation

TAG Unit M3-1 Table 5 outlines a set of benchmark criteria used to review the extent of changes due to ME. These criteria are outlined in **Table 11**below.

Table 11 Significance of Matrix Estimation Changes

Measure	Benchmark Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

The guidance identifies that any exceedances do not mean that the model is unsuitable for the intended uses. The performance of the model should be reviewed against these criteria and exceedances should be examined and assessed for their importance, particularly in relation to the area of influence of the scheme to be assessed. The analysis excluded all intrazonal movements from the matrices (which were not affected through the ME process).

Table 12provides a summary of the cell and trip end changes due to ME in line with the benchmarks provided within TAG Unit M3-1. In general terms this indicates that some exceedances occur for each time period. The results of the analysis show that the initial estimate of the cell values is better than the initial estimate of the trip ends, suggesting an issue within the expansion of the TrafficMaster data to represent all traffic. This has been done using TEMPRO. As the TEMPRO database is the only database of total trip making in the country then there are no alternative methodologies easily available which may yield an improved result.

Table 12 Matrix Estimation Changes to Zonal Cell Values and Trip Ends

		AM Peak		**Inter peak**		**PM Peak**	
		Cell Values	**Trip Ends**	**Cell Values**	**Trip Ends**	**Cell Values**	**Trip Ends**
Car	**Slope**	0.931	0.881	0.968	0.913	0.974	0.927
	R-Squared	0.9453	0.9545	0.9605	0.9439	0.9663	0.9525
	Intercept	0.022	18.0	0.024	16.8	0.023	18.9
LGV	**Slope**	0.883	0.823	0.879	0.791	0.958	0.865
	R-Squared	0.8406	0.8670	0.8280	0.8426	0.9408	0.9298
	Intercept	0.007	5.08	0.005	5.16	-0.002	1.35
OGV	**Slope**	1.01	1.2	0.956	1.02	0.998	1.09
	R-Squared	0.7033	0.7345	0.7399	0.7485	0.6772	0.6947
	Intercept	0.020	5.12	0.013	4.67	0.011	3.63

Table 13provides a summary of the changes in trip length due to the estimation process. This shows that the effects of ME had limited impacts on average trip lengths. In general it can be seen that the trip length is affected most significantly during the AM and Inter Peak. In most cases, the mean journey length is shortened, as is usual with ME procedures. It is considered that, although there are exceedances of the WebTAG criteria, the ME has not had an undue distorting effect on the matrices.

Table 13 Changes in Trip Length (km) due to Matrix Estimation

		AM Peak			**Inter Peak**			**PM Peak**		
		Prior	**Post**	**% Diff**	**Prior**	**Post**	**% Diff**	**Prior**	**Post**	**% Diff**
Car	Mean	29.6	22.3	-12.7	30.9	26.6	-13.9	28.5	26.9	-5.7
	SD	53.5	43.3	-19.1	55.9	48.4	-13.4	51.9	48.0	-7.4
LGV	Mean	27.4	26.2	-4.4	27.2	27.2	0.0	28.9	27.7	-0.07
	SD	40.7	44.1	8.4	40.6	48.8	20.1	34.9	37.5	7.4
OGV	Mean	29.2	30.9	5.8	29.0	28.2	-3.0	26.5	29.0	9.3
	SD	45.1	49.4	9.6	45.0	48.6	8.1	39.3	47.9	21.9

7 Highway Model Calibration and Validation

7.1 Network Calibration

7.1.1 Analysis of Paths

The assignment of flows on the network has been checked through a series of paths on the validated network between zones representing the four compass points and the following areas;

- Hartlepool;
- Stockton;
- Darlington;
- Middlesbrough; and
- Redcar.

These paths are shown for each of the modelled periods in **Appendix A**.

7.1.2 Speed-Flow Curves used for over capacity links

Use has been made of the assumption within the COBA curves that speeds above capacity do not reduce but continue to be fixed at their capacity speed. Some programmes such as SATURN assume that the slope of the speed-flow curve is continuous beyond capacity, i.e. flows in excess of capacity lead to linearly increasing queues with a consequential linear increase in travel time and therefore reduction in effective speed. Such an assumption was tested and was found to cause unacceptable levels of instability within the highway assignment.

7.1.3 Flow Calibration

Modelled link flows have been assessed across both the calibration screenlines. **Table 14**and **Table 15** show the performance of the model in terms of link flows for all calibration screenlines and count sites. **Appendix B** contains details of individual count sites for all time periods, whilst **Table 16**to **Table 18**, summarise the data at screenline level. 30 screenlines have been used, containing a total of 142 calibration counts.

Table 14 Model Performance at Screenline Level – Calibration Counts

	AM Peak		Inter Peak		PM Peak	
	Screen line Passes	%	Screen line Passes	%	Screen line Passes	%
All Vehicles	27	90%	25	83%	28	93%

Table 15 Model Performance at Individual Site Level – Calibration Counts

	AM Peak		Inter Peak		PM Peak	
	Link Flow Passes	%	Link Flow Passes	%	Link Flow Passes	%
All Vehicles	127	89%	142	88%	121	85%

The tables show that the performance of the model across the calibration screenlines meets the flow calibration criteria.

Table 16 AM Peak Hour Screenline Calibration (All Vehicles)

Screenline	No. Counts	Passes	Obs	Mod	Pass Fail
1 External East	2	2	740	785	Pass
2 External East	2	2	660	668	Pass
3 Normanby	6	6	4570	4768	Pass
4 Normanby	6	5	3772	3732	Pass
5 Middlesbrough Suburban	4	4	3423	3482	Pass
6 Middlesbrough Suburban	4	4	2139	2223	Pass
7 Middlesbrough South	5	5	862	886	Pass
8 Middlesbrough South	5	5	954	915	Pass
9 Middlesbrough East	3	2	3845	4003	Pass
10 Middlesbrough East	3	1	3254	3366	Pass
11 A19_A66 Interchange	6	5	11656	11632	Pass
12 A19_A66 Interchange	6	5	9377	9408	Pass
13 Darlington North	7	5	5526	5113	Fail
14 Darlington North	8	7	6407	5853	Fail
15 Darlington Suburban	5	5	3113	3089	Pass
16 Darlington Suburban	5	5	2717	2741	Pass
17 Darlington West	5	4	2787	2699	Pass
18 Darlington West	5	4	2223	2500	Fail
19 Darlington South	2	2	819	823	Pass
20 Darlington South	2	2	707	744	Pass
21 Darlington East	2	1	2139	2241	Pass
22 Darlington East	2	2	2346	2303	Pass
23 Stockton North	5	4	5374	5392	Pass
24 Stockton North	5	5	5200	5169	Pass
25 Stockton West	8	8	4964	5039	Pass
26 Stockton West	8	8	4098	4190	Pass
27 Ingleby	6	6	6383	6262	Pass
28 Ingleby	5	5	3947	4020	Pass
29 Portrack	5	4	9814	10074	Pass
30 Portrack	5	4	9804	9880	Pass

Table 17 Inter Peak Hour Screenline Calibration

Screenline	No. Counts	Passes	Obs	Mod	Pass Fail
1 External East	2	2	741	758	Pass
2 External East	2	2	704	720	Pass
3 Normanby	6	6	3221	3389	Pass
4 Normanby	6	6	3110	3154	Pass
5 Middlesbrough Suburban	4	4	2889	2933	Pass
6 Middlesbrough Suburban	4	4	2075	2111	Pass
7 Middlesbrough South	5	5	695	673	Pass
8 Middlesbrough South	5	5	710	659	Pass
9 Middlesbrough East	3	3	2648	2817	Pass
10 Middlesbrough East	3	3	2546	2621	Pass
11 A19_A66 Interchange	6	5	7124	7604	Fail
12 A19_A66 Interchange	6	5	7792	7891	Pass
13 Darlington North	7	6	4472	4384	Pass
14 Darlington North	8	6	5324	4948	Fail
15 Darlington Suburban	5	5	2528	2615	Pass
16 Darlington Suburban	5	5	2327	2438	Pass
17 Darlington West	5	4	1907	2138	Fail
18 Darlington West	5	3	1735	2042	Fail
19 Darlington South	2	2	559	549	Pass
20 Darlington South	2	2	552	584	Pass
21 Darlington East	2	2	1269	1362	Pass
22 Darlington East	2	2	1283	1448	Fail
23 Stockton North	5	4	3326	3416	Pass
24 Stockton North	5	4	3455	3469	Pass
25 Stockton West	8	8	2831	2952	Pass
26 Stockton West	8	8	2897	2976	Pass
27 Ingleby	6	6	3265	3272	Pass
28 Ingleby	5	5	3565	3607	Pass
29 Portrack	5	2	7686	7872	Pass
30 Portrack	5	3	7547	7740	Pass

Table 18 PM Peak Hour Screenline Calibration

Screenline	No. Counts	Passes	Obs	Mod	Pass Fail
1 External East	2	2	778	780	Pass
2 External East	2	2	821	831	Pass
3 Normanby	6	6	3995	4213	Pass
4 Normanby	6	5	4664	4712	Pass
5 Middlesbrough Suburban	4	4	3149	3172	Pass
6 Middlesbrough Suburban	4	2	2631	2666	Pass
7 Middlesbrough South	5	5	960	1004	Pass
8 Middlesbrough South	5	3	1027	1001	Pass
9 Middlesbrough East	3	3	2996	3153	Pass
10 Middlesbrough East	3	1	3398	3553	Pass
11 A19_A66 Interchange	6	5	8679	8958	Pass
12 A19_A66 Interchange	6	4	11502	11726	Pass
13 Darlington North	7	6	6007	5688	Fail
14 Darlington North	8	6	6330	6291	Pass
15 Darlington Suburban	5	4	3206	3066	Pass
16 Darlington Suburban	5	5	3219	3317	Pass
17 Darlington West	5	5	2534	2511	Pass
18 Darlington West	5	4	2248	2607	Fail
19 Darlington South	2	2	701	714	Pass
20 Darlington South	2	2	788	765	Pass
21 Darlington East	2	2	2099	2164	Pass
22 Darlington East	2	1	2239	2296	Pass
23 Stockton North	5	4	5177	5415	Pass
24 Stockton North	5	4	5105	5110	Pass
25 Stockton West	8	8	4100	4110	Pass
26 Stockton West	8	8	4985	4975	Pass
27 Ingleby	6	6	4615	4631	Pass
28 Ingleby	5	4	5947	6094	Pass
29 Portrack	5	4	9391	9710	Pass
30 Portrack	5	4	10180	10300	Pass

7.1.4 Journey Time Validation

Journey time validation has been undertaken on 12 routes through the modelled area. Distance time diagrams for each of the journey time routes are shown in **Appendix C**. Table 19 contains a tabular comparison of modelled and observed journey times.

In the AM peak, 85% of the journey times pass the DMRB test of being within 15% or 1 minute of the measured time. In the Inter Peak hour, all but one route passes the DMRB test and in the PM test, 88% pass the test.

Table 19 Comparison of modelled and observed journey times

Route	Distance (km)	AM Peak			Inter Peak			PM Peak		
		Time (mm:ss)		DMRB Pass	Time (mm:ss)		DMRB Pass	Time (mm:ss)		DMRB Pass
		Measured	Modelled		Measured	Modelled		Measured	Modelled	
A_NB	22.1	28:26	29:39	Pass	28:03	26:49	Pass	29:26	30:37	Pass
A_SB	21.7	28:01	28:38	Pass	27:23	25:12	Pass	26:50	28:06	Pass
B_NB	13.2	24:19	21:06	Pass	18:24	18:34	Pass	18:11	19:35	Pass
B_SB	13.2	17:06	20:22	Fail	17:48	19:20	Pass	21:08	23:26	Pass
C_NB	29.9	28:53	29:31	Pass	26:18	26:22	Pass	29:16	31:42	Pass
C_SB	27.9	27:23	30:16	Pass	24:37	23:52	Pass	26:49	27:24	Pass
D_EB	15.4	22:08	22:56	Pass	19:38	19:23	Pass	21:37	21:31	Pass
D_WB	15.0	22:45	21:13	Pass	18:24	19:03	Pass	19:39	23:13	Fail
E_EB	15.1	17:37	15:06	Pass	16:35	14:12	Pass	17:52	15:16	Pass
E_WB	15.2	18:05	15:59	Pass	16:44	14:19	Pass	16:05	15:03	Pass
F_NB	19.4	21:55	21:49	Pass	22:31	20:03	Pass	21:38	20:14	Pass
F_SB	19.3	22:27	23:21	Pass	22:22	20:52	Pass	22:17	25:33	Pass
G_EB	23.3	20:24	21:02	Pass	18:04	17:54	Pass	17:59	21:23	Fail
G_WB	23.1	18:12	19:23	Pass	17:20	16:56	Pass	18:30	20:59	Pass
H_NB	15.8	15:22	16:28	Pass	15:59	14:48	Pass	17:34	16:29	Pass
H_SB	15.3	14:31	14:38	Pass	15:58	13:58	Pass	15:38	16:06	Pass
I_EB	19.3	24:03	23:28	Pass	22:17	21:48	Pass	26:08	24:29	Pass
I_WB	19.3	28:20	23:56	Fail	22:17	21:45	Pass	23:56	23:03	Pass
J_NB	13.1	17:25	16:57	Pass	18:45	16:00	Pass	19:10	17:48	Pass
J_SB	13.0	19:46	16:35	Fail	18:45	15:39	Fail	17:00	17:26	Pass
K_NB	15.7	18:22	16:26	Pass	17:10	15:24	Pass	20:40	16:58	Fail

Route	Distance (km)	AM Peak			Inter Peak			PM Peak		
		Time (mm:ss)		DMRB Pass	Time (mm:ss)		DMRB Pass	Time (mm:ss)		DMRB Pass
		Measured	Modelled		Measured	Modelled		Measured	Modelled	
K_SB	15.4	20:19	18:37	Pass	16:51	15:30	Pass	17:09	17:07	Pass
L_NB	17.9	27:31	25:00	Pass	22:59	22:08	Pass	27:05	24:30	Pass
L_SB	18.0	27:19	24:34	Pass	23:41	22:49	Pass	27:48	29:19	Pass
M_NB	16.2	16:33	14:29	Pass	14:48	13:38	Pass	15:49	15:33	Pass
M_SB	15.8	17:28	14:37	Fail	14:38	13:17	Pass	16:53	14:47	Pass
N_EB	11.1	22:08	21:22	Pass	17:06	17:35	Pass	19:00	21:01	Pass
N_WB	11.5	19:42	19:12	Pass	19:10	17:47	Pass	20:44	21:01	Pass
O_EB	24.3	32:12	32:06	Pass	30:08	31:11	Pass	31:19	34:34	Pass
O_WB	24.3	34:38	34:39	Pass	30:47	31:26	Pass	29:04	32:26	Pass
P_NB	45.2	32:57	30:26	Pass	29:41	29:23	Pass	30:33	29:55	Pass
P_SB	44.9	29:35	29:07	Pass	29:34	28:55	Pass	29:17	29:32	Pass
Q_EB	17.6	18:19	21:25	Fail	17:53	18:34	Pass	18:14	21:26	Fail
Q_WB	17.8	19:11	22:08	Fail	18:10	19:10	Pass	18:19	21:30	Fail
R_EB	26.4	22:46	21:01	Pass	23:01	20:52	Pass	22:39	21:14	Pass
R_WB	26.4	22:38	20:56	Pass	22:52	20:47	Pass	22:18	20:59	Pass
S_EB	22.1	28:10	24:13	Pass	27:33	23:49	Pass	26:24	25:12	Pass
S_WB	22.1	27:39	25:19	Pass	27:28	24:16	Pass	27:33	24:51	Pass
T_NB	15.3	25:11	21:50	Pass	24:01	20:50	Pass	23:44	22:07	Pass
T_SB	15.1	26:34	22:40	Pass	24:23	20:49	Pass	24:23	21:59	Pass

7.1.5 Model Convergence and Convergence Proximity

The highway assignment converges to a stable solution in 50 assignment iterations. **Table 20**contains the convergence stability measures.

Table 20 Convergence Stability Measures

	AM	IP	PM
Average Change in Link Cost (%)			
Final Loop	0.0112%	0.0038%	0.0093%
... and previous 3 loops:	0.0111%	0.0041%	0.0094%
	0.0123%	0.0040%	0.0097%
	0.0121%	0.0042%	0.0040%
Change in ASS-HRS (%)			
Final Loop	-0.0062%	-0.0016%	-0.0142%
... and previous 3 loops:	0.0050%	-0.0004%	-0.0051%
	-0.0085%	0.0002%	0.0006%
	-0.0062%	-0.0016%	-0.0142%
Change in PCU-KMS (%)			
Final Loop	-0.0014%	-0.0004%	-0.0014%
... and previous 3 loops:	-0.0021%	-0.0002%	-0.0024%
	-0.0020%	-0.0004%	-0.0019%
	-0.0018%	-0.0003%	-0.0015%

Once converged, the model convergence proximity is considered to be good, achieving the % Gap shown in **Table 21**below.

Table 21 Convergence Proximity (% Gap)

Peak Period	Previous Iterations			Final Iteration
AM	0.136%	0.122%	0.117%	0.105%
IP	0.024%	0.03%	0.029%	0.022%
PM	0.143%	0.113%	0.135%	0.135%

8 PT Model Development

8.1 Network Development

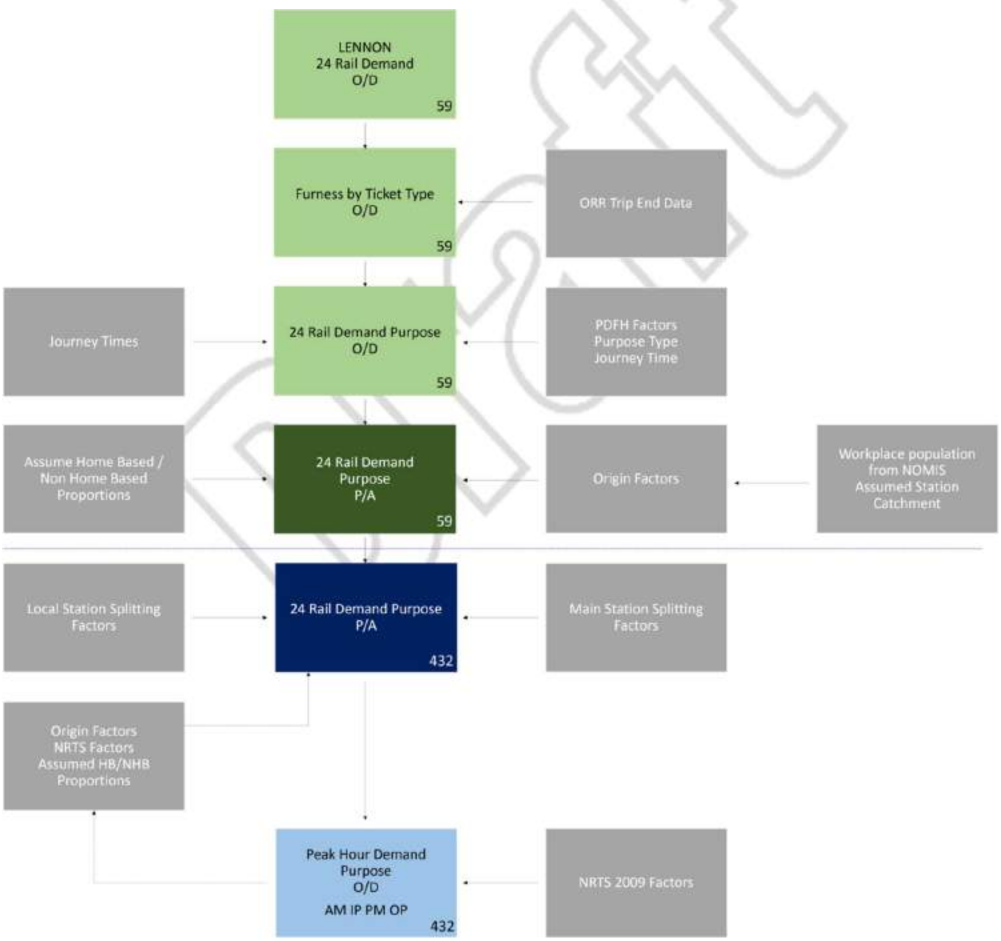
The PT Network was previously coded in the Cube Trips model and has been used as the basis for the updated Cube Voyager model.

8.2 Trip Matrix Development

8.2.1 Rail Matrices

The methodology used for developing the rail matrices is shown in **Figure 9**and is further detailed below.

Figure 9: Rail Matrix Building Process



8.2.1.1 Develop Station to Station rail demand.

Rail demand was developed from a combination of sources, including LENNON ticket data, ORR (Office of the Rail Regulator) station usage data, and historic surveys. LENNON is the rail industry's central ticketing system and is used as a common source for passenger kilometres, journeys and revenue data across the industry. LENNON holds information on all national rail tickets purchased in Great Britain and is used to allocate the revenue from ticket sales between train operating companies (TOCs).

The station-to-station matrices were divided into commute, business and 'other' using ticket type to purpose mapping (Passenger Demand Forecasting Handbook, PDFH version 5.1) and purpose splits by time band from the National Rail Travel Survey (NRTS). The business and 'other' categories were further divided into home based and non-home based trips using information from the historic surveys. The result of this process was matrices for each of the standard WebTAG recommended purpose classes.

8.2.1.2 Develop Origin Factors.

Origin Factors for internal stations were developed from NOMIS employment data for the zones close to each station. The purpose of Origin Factors are to simulate the proportion of trips from each zone which are 'Productions' rather than 'Attractions' for the home based purposes. For instance a mainly residential zone would not contain many jobs, and would therefore be predominantly a 'Production' zone, whereas a zone representing a town centre would contain a large number of jobs and would be an 'Attraction' zone. The Internal-External and External-Internal trips were given average production factors from the Internal-Internal part of the matrix. The External-External trips were given a neutral origin factor of 0.5 as, due to the large size of external zones, it was assumed they would have an equal likelihood of being an Origin as a Destination.

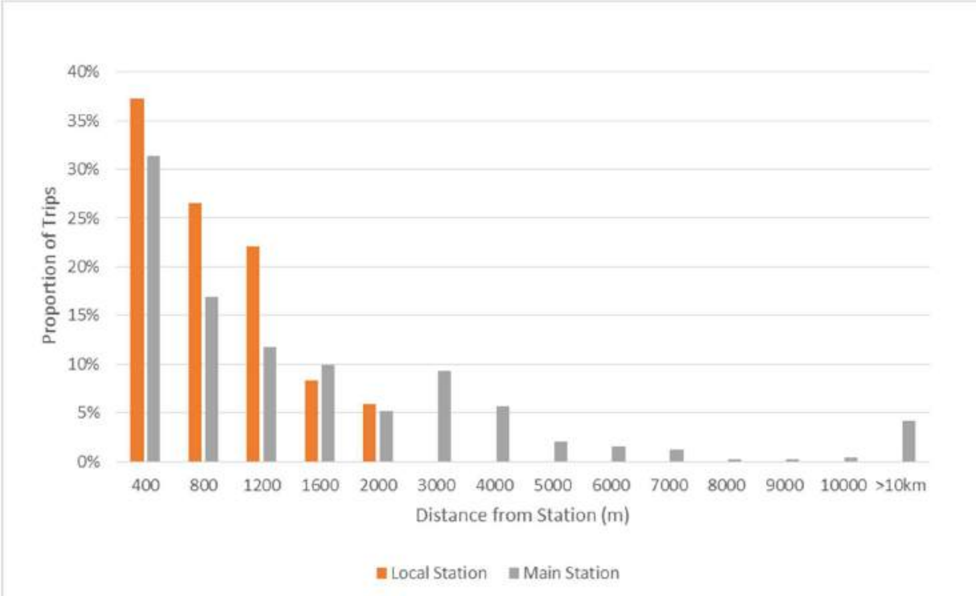
The matrices were sub-divided by car availability (car available / car not available). The proportions were informed by rail user surveys in comparable locations.

8.2.1.3 Develop Station distributions for each rail station;

The distribution of trips from each station to the surrounding zones was achieved through applying a gravity-model type procedure to distribute trips ends from stations to zones.

- Survey data (from the on train interview data) enabled a database of postcode to station relationships to be developed in terms of distance from the station to the zone.
- Stations were split into Local or Main stations depending upon the size and number of services. A spatial distribution of trips by station type was developed, as shown in **Figure 10**.
- Trips were assigned to local zones based on being within a distance of 2km for Local Stations, 6km for Main Stations and 10km for Darlington Station.
- Trip weighting (i.e. trips per zone) was based on the number of postcodes in each zone weighted by the trip distribution profile.

Figure 10: Rail Station to Zone Trip Distribution Profiles



8.2.1.4 Split into Time Periods

The 24 hour Production/Attraction matrices were then split into time periods (tour proportions) according to observed values from the N shown in **Table 22**below.

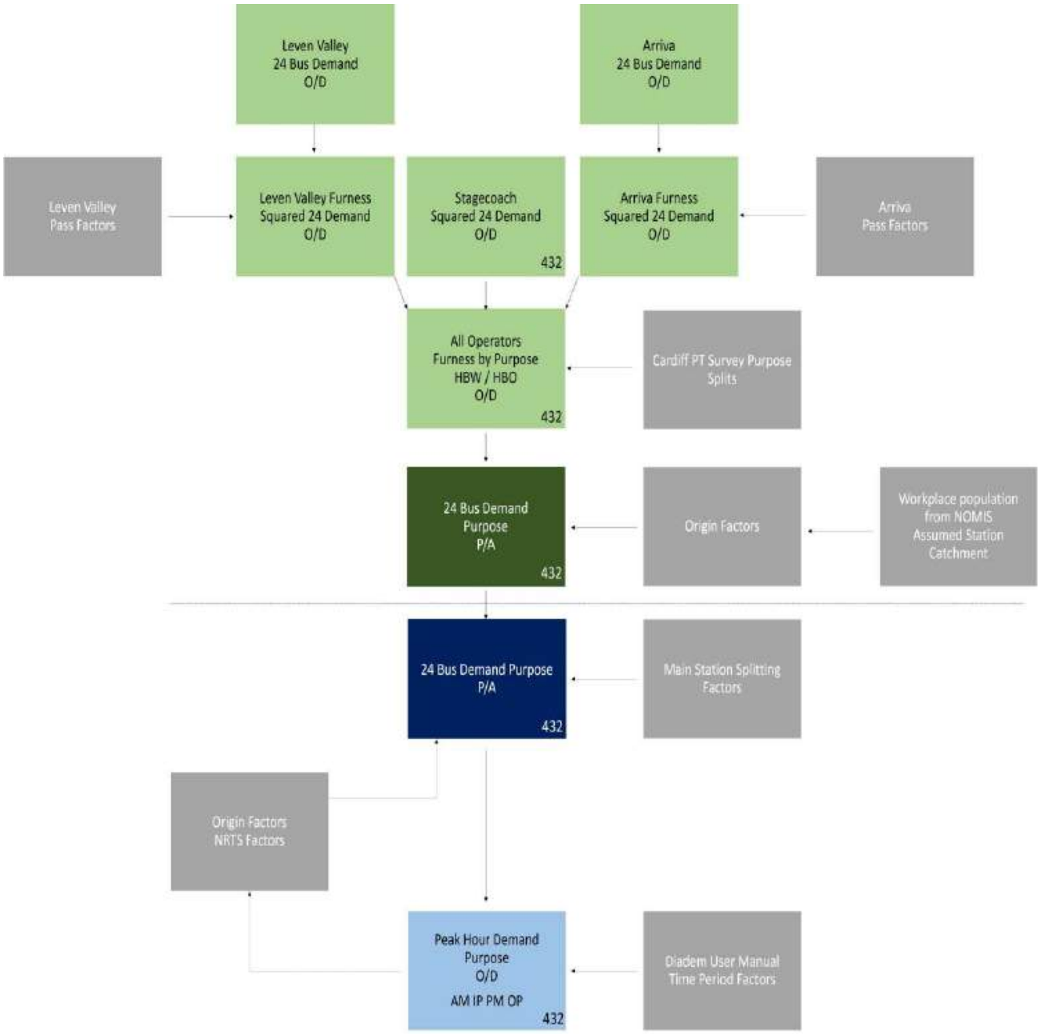
Table 22: Rail Time Period Splits

	HBW		HBEB		HBO		NHBEB	NHBO
	From home	To Home	From home	To Home	From home	To Home		
AM Period	84.2	3.8	48.7	4.2	27.0	6.64	26.4	16.8
Inter Peak	9.2	20.9	35.3	31.2	51.2	51.6	33.3	51.4
PM Period	2.5	63.5	7.8	44.0	10.3	24.3	25.9	17.3

8.2.2 Bus Matrices

The methodology used for developing the bus matrices is shown in **Figure 11** and is further detailed below.

Figure 11: Bus Matrix Building Process



8.2.2.1 Develop Stage to Stage bus demand.

Bus demand was developed from Electronic Ticket Machine (ETM) data, supplemented by passenger profiles from the interview surveys. The ETM data collected by bus operators provides much of the detail to create demand matrices, but not all. Surveys were used to confirm the distribution and to establish passenger characteristics. The principal information we gained from the surveys was:

- Origin and destination;
- Journey purpose;
- Car availability;
- Access/egress modes; and
- Home location.

ETM data provides the number of boarding passengers at each stage for each service and the alighting zones for the cash fares only. Journeys made using a pass only have ETM data for the boarding stage, with no information regarding alighting. To combine this data, boarding information in the reverse direction was used to distribute the alighters;

- for AM peak, the PM peak boarding pattern was assumed;
- for PM peak, the AM peak boarding pattern was assumed;
- for Inter Peak, the Inter Peak boarding pattern was assumed.

8.2.2.2 Develop Origin Factors.

Origin factors were developed as per the rail methodology. Trips were divided into trip purposes and car availability based on the interview survey.

8.2.2.3 Develop distributions for each bus stop;

Due to the limited catchment for each bus stop, a correspondence list was developed for each bus stop whereby a local zone was assigned. This list was developed using local knowledge, and experience from the original model.

8.2.2.4 Split into Time Periods

The 24 hour Production/Attraction matrices were then split into time periods (tour proportions) according to observed values from the National Travel Survey shown in **Table 23**below.

Table 23: Rail Time Period Splits

	HBW		HBEB		HBO		NHBEB	NHBO
	From home	To Home	From home	To Home	From home	To Home		
AM Period	71.2	4.1	44.7	4.0	39.2	9.4	24.4	24.3
Inter Peak	13.9	21.4	34.7	29.9	48.2	56.9	32.3	52.6
PM Period	5.6	59.7	10.6	42.8	6.1	23.2	26.7	14.7

8.3 Assignment Calibration and Validation

Validation involves comparing modelled and observed data. Any adjustments to the model that are intended to reduce the differences between the modelled and observed data are regarded as calibration.

The differences between modelled and observed data are quantified (using pre-defined measures) and then assessed using some criteria. The acceptability of the proportion of instances where the criteria are met is then assessed.

The key parameters used in the public transport assignment are shown in **Table 24** below

Table 24: Public Transport Assignment Parameters

		Parameter
Board Penalty (mins)	Bus	10
	Coach	10
	Rail	5
Walk Time Factor		1.5
Interchange Time Factor		1.5
Board Penalty		1.5
Value of time (£/hour)		6.23

8.3.1 Validation Criteria

The validation of a PT assignment model includes comparisons of the following:

- assigned flows and counts totalled for each screenline as a check on the bus assignment; and
- assigned boarding and alighting counts at stations as a check on the quality of the rail assignment.

8.3.2 Rail Validation

The validation criterion and acceptability guideline for link flows in WebTAG Unit 3.1 are defined in **Table 25**, as applied to passenger boarding and alightings at stations.

Table 25: Count Validation Criterion and Acceptability Guideline

Criteria	Acceptability Guideline
At individual stations, modelled flows should be within 25% of the counts, except where observed hourly flows are particularly low (less than 150 passengers per hour).	All or nearly all stations

The observed data from ORR trip ends at stations is used for comparison to the modelled data for validation purposes. The results can be seen in **Table 26** and **Table 27** below.

Table 26: Boarding Counts at Key Stations (12 Hours)

Station Name	Observed	Modelled
Hartlepool	787	428
Thornaby	938	1004
Middlesbrough	2023	1052
Redcar Central	527	958
Redcar East	183	297
Saltburn	365	463
Eaglescliffe	241	64
Darlington	4203	3686
Yarm	167	94

Table 27: Alighting Counts at Key Stations

Station Name	Observed	Modelled
Hartlepool	787	613
Thornaby	938	1224
Middlesbrough	2023	1041
Redcar Central	527	1027
Redcar East	183	320
Saltburn	365	233
Eaglescliffe	241	51
Darlington	4203	3488
Yarm	167	62

8.3.3 Bus Validation

The validation criterion and acceptability guideline for link flows in WebTAG Unit 3.1 are defined in **Table 28**, as applied to passenger flows across screenlines.

Table 28: Screenline Flow Validation Criterion and Acceptability Guideline

Criteria	Acceptability Guideline
Across modelled screenlines, modelled flows should, in total, be within 15% of the observed values.	All or nearly all screenlines

Bus occupancy surveys were undertaken at specific locations on the network with results compared to modelled data for validation. The results by period can be

The observed data from the bus surveys is used for comparison to the modelled data for validation purposes. The results can be seen in **Table 29** to **Table 31Error! Reference source not found.** below.

Table 29: Bus Screenlines AM

Screenline	Direction	Observed	Modelled
Redcar	Northbound	182	175
	Southbound	140	149
Middlesbrough	Northbound	986	578
	Southbound	364	700
Stockton	Eastbound	1042	600
	Westbound	526	611
Billingham	Northbound	136	165
	Southbound	244	159
Hartlepool	Northbound	493	546
	Southbound	432	605
Darlington	Eastbound	223	117
	Westbound	95	247
Total	**All Directions**	**4860**	**4653**

Table 30: Bus Screenlines Inter Peak

Screenline	Direction	Observed	Modelled
Redcar	Northbound	173	162
	Southbound	214	157
Middlesbrough	Northbound	596	725
	Southbound	813	672
Stockton	Eastbound	827	655
	Westbound	821	663
Billingham	Northbound	161	172
	Southbound	190	171
Hartlepool	Northbound	445	625
	Southbound	511	618
Darlington	Eastbound	164	196
	Westbound	167	184
Total	**All Directions**	**5078**	**5001**

Table 31: Bus Screenlines PM

Screenline	**Direction**	Observed	Modelled
Redcar	Northbound	121	140
	Southbound	168	128
Middlesbrough	Northbound	293	619
	Southbound	967	483
Stockton	Eastbound	434	523
	Westbound	768	527
Billingham	Northbound	169	131
	Southbound	111	139
Hartlepool	Northbound	386	516
	Southbound	372	470
Darlington	Eastbound	64	184
	Westbound	160	89
Total	**All Directions**	**4011**	**3948**

The total modelled flow across all screenlines is within 5% of observed during all time periods. During each period the flows across all screenlines are lower than observed. Considering all public transport flows together in **Table 32** to **Table 35**, i.e. the flow of both bus and rail across the PT screenlines shows that the total modelled AM peak flow is 2% larger and the total interpeak flow is 1% larger than observed. During the PM peak the modelled flow remains 4% lower than the observed. Within the 12 hour period total PT flow is within 82 people (0.45%) of the total observed flow across all screenlines.

Table 32: Public Transport Screenlines AM

Screenline	**Direction**	**Observed**	**Modelled**
	Northbound	245	590
Darlington	Southbound	562	317
	Northbound	201	295
Hartlepool 1	Southbound	301	221
	Northbound	453	375
Hartlepool 2	Southbound	240	509
	Northbound	1019	606
Middlesbrough	Southbound	458	736
	Northbound	212	191
Redcar	Southbound	229	233
	Northbound	233	210
Stockton 1	Southbound	197	215
	Eastbound	793	684
Stockton 2	Westbound	613	663
Total	**All Directions**	**5754**	**5845**

Table 33: Public Transport Screenlines Inter Peak

Screenline	Direction	Observed	Modelled
Darlington	Northbound	536	444
	Southbound	461	482
Hartlepool 1	Northbound	279	238
	Southbound	237	248
Hartlepool 2	Northbound	275	462
	Southbound	370	446
Middlesbrough	Northbound	617	742
	Southbound	834	705
Redcar	Northbound	278	197
	Southbound	211	188
Stockton 1	Northbound	214	206
	Southbound	235	202
Stockton 2	Eastbound	634	751
	Westbound	808	754
Total	**All Directions**	**5985**	**6065**

Table 34: Public Transport Screenlines PM

Screenline	Direction	Observed	Modelled
Darlington	Northbound	558	253
	Southbound	458	556
Hartlepool 1	Northbound	292	252
	Southbound	322	265
Hartlepool 2	Northbound	326	474
	Southbound	400	458
Middlesbrough	Northbound	616	758
	Southbound	851	705
Redcar	Northbound	262	204
	Southbound	269	205
Stockton 1	Northbound	250	217
	Southbound	274	212
Stockton 2	Eastbound	634	751
	Westbound	808	754
Total	**All Directions**	**6316**	**6063**

Table 35: Public Transport Screenlines 12 Hour

Screenline	Direction	Observed	Modelled
Darlington	Northbound	1339	1286
	Southbound	1480	1355
Hartlepool 1	Northbound	772	785
	Southbound	860	733
Hartlepool 2	Northbound	1053	1311
	Southbound	1009	1412
Middlesbrough	Northbound	2251	2106
	Southbound	2142	2146
Redcar	Northbound	752	592
	Southbound	709	627
Stockton 1	Northbound	696	633
	Southbound	706	629
Stockton 2	Eastbound	2060	2185
	Westbound	2228	2171
Total	**All Directions**	**18055**	**17973**

9 Demand Model Development

9.1 Variable Demand Modelling Process

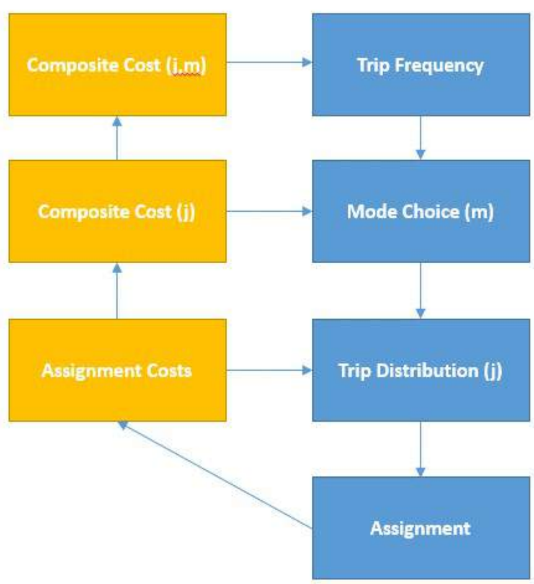
9.1.1 The Need for Variable Demand Modelling

Transport schemes that have an effect on journey times and cost will, in principle, influence the level of demand for travel. WebTAG Unit M2, 'Variable Demand Modelling', advises on the procedures to produce preliminary quantitative estimates of the potential effects of variable demand, in order to assess the need for undertaking Variable Demand Modelling. Variable Demand Modelling is required for all schemes with a capital cost of £5 million or more, unless a strong justification is made for not doing so. The Tees Valley Model is to provide TVU with the tools to assess transport schemes; using a TAG compliant approach. If the schemes assessed are to have strategic impacts on travel within the Tees Valley then it is clear Variable Demand Modelling is necessary.

9.2 Model Structure

The model takes the form of an incremental hierarchical logit. Usually bus and rail would form part of a PT nest. However, in this case, the lack of coverage of the rail network would result in few genuine choices between rail and bus: this choice is made within the assignment model.

Figure 12: Model Responses



A Park and Ride element has been included as a sub nest of the car mode choice. This is discussed further below.

The key process required to enable the validated highway matrices to be used within the demand model is the conversion of the adjusted highway O/D matrices back to 24 hour P/A matrices. The original WebTAG guidance contains advice in this regard. The following is an extract from TAG Unit 3.10.2[2]

1.3.1 There are two alternative ways of describing the travel pattern;

- *When travel patterns are constructed from roadside surveys the trips are logically described by the place the trip started and the place the trip finished, and the trip purpose of each end. This is usually known as an **Origin- Destination** (O/D) based trip pattern. Assignment models use this definition of the trip matrix.*
- *An alternative way of looking at the trip pattern is from the viewpoint of the factors that produce or attract trips, i.e. on a **Production-Attraction** (P/A) basis, with home generally being treated as the "producing" end, and work, retail etc as the "attracting" end. To properly define trip production and attraction, it is important to understand what home based and non home based trips are. Home based trips are trips where the home of the trip maker is either the origin or the destination of the trip. Non home based trips on the other hand are trips where neither end of the trip is the home of the trip maker. Trip production is usually defined as the home end of a home based trip or the origin of a non home based trip. Trip attraction on the other hand is defined as the non-home based end of a home based trip or the destination of a non home based trip. Changes in these P/A trip end forecasts over time or by scenario will lead to changes in the trip pattern. This definition of the trip matrix has normally been used in modelling travel demand.*

1.3.3 In current modelling practice, trip end modelling is usually done on a P/A basis, as with the TEMPRO forecasts, but assignment is always done on an O/D basis since the actual direction of travel at a particular point in time is important. Somewhere during a multi-stage modelling process trip matrices must be converted from a P/A basis to an O/D basis

At this stage it is important to note that, the model is an incremental model, that is that the forecasts will 'pivot' off the base matrix – i.e. it models the changes to the matrix brought about by changes in generalised cost.

TAG Unit 3.10.2 continues to discuss how such a model can be developed;

1.5.2 Whether the demand model is absolute or incremental in form, there will be a need to validate the base matrix at the network level. In practice, this means that the conversion from P/A to O-D is carried out, and the resulting matrix assigned. Then the assignment process is validated according to the procedures given in (DMRB.12.2.1).

1.5.3 Problems may be incurred when, after reasonable adjustments to the network, it is concluded that significant errors remain which are essentially attributable to the matrix. Ideally, further data should be introduced to the

[2] TAG Unit 3.10.2: Variable Demand Modelling – Scope of the Model

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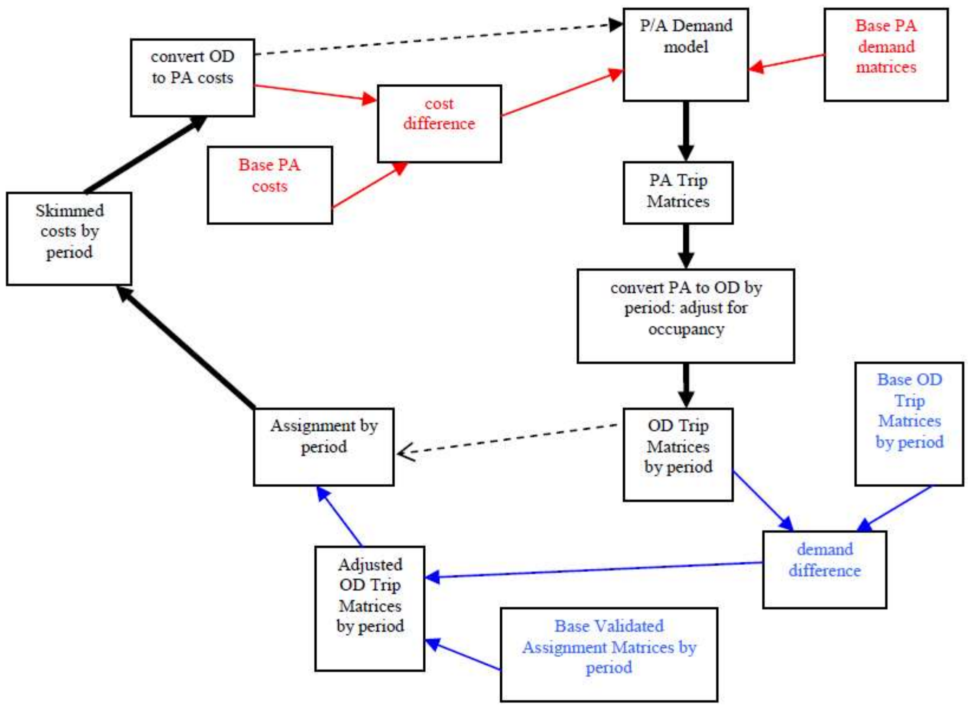
whole modelling procedure in such a way that the base P/A matrix is modified. Unfortunately, there is very little experience of how to do this, and conventional methods of "matrix estimation" (using, in particular, link counts as a source of information) only operate at an O-D level. If the O-D matrix is adjusted in this way, in order to improve the quality of the assignment, there is no direct way in which these adjustments can be conveyed to the P/A-based demand model. The result is that there will be a discrepancy between the demand model and the assignment model.

1.5.4 With the current state of knowledge, if this position is encountered, the best approach is to use an incremental version of the assignment model. Essentially, after converting the output of the demand model from P/A to O-D, the resulting matrix is not directly assigned, but is compared with a base case, and the implied changes are used to adjust an independently validated "assignment matrix". This adjustment could be done in a number of ways, proportionally, additively, or by a mixture of the two.

Note, although for the greater part of the matrix, no problems will be incurred by either an additive or a proportional approach, both these methods can give rise to problems in specific cases. It is possible that the demand model could imply a decrease in demand for a particular ij cell which causes the adjusted assignment matrix to go negative. Alternatively, a large proportionate effect predicted by the demand matrix in the case of a low base demand could correspond with a much larger cell in the assignment matrix. Some care is therefore required in applying the method, and a small amount of re- allocation between cells may be necessary, with the aim of ensuring that the total change predicted by the demand procedure is maintained.

TAG Unit 3.10.2 contains a diagram of the recommended approach.

Figure 13: Incremental 'Adjusted' Variable Demand Model



9.3 Calibration of Variable Demand Model

9.3.1 Parameters

In the same way that calibration and validation is a necessary step in demonstrating the robustness and appropriateness of assignment models, calibration and validation are essential steps in demonstrating that a Variable Demand Model is appropriately specified for use in scheme assessment.

WebTAG Unit M2 states that, wherever possible, "each variable demand response should be calibrated on local data, to reflect the local strengths of the choice mechanisms". Alternatively, they may be derived from existing locally calibrated models of the area. If these options are not available, WebTAG Unit M2 provides a set of illustrative parameter values, obtained from a review of a number of UK transport models, which "provide an acceptable approach to including variable demand modelling in transport appraisals where it is deemed too difficult to establish local values."

Producing locally calibrated parameter values is likely to be both difficult and time-consuming. For example, WebTAG Unit M2 notes that, to calibrate a trip distribution model, "the data available must be of sufficient quality and quantity. This will require that either the range of trip lengths in the observed part of the trip matrix on which the distribution parameter(s) are being calibrated is representative of the whole trip matrix or account is taken of the variation in sampling rate over the full range of trips".

It is considered that the time and cost of collecting sufficient good-quality data to calibrate parameters for each of the demand responses would not be at a proportionate level for schemes that are to be tested using the TVM. It is therefore proposed to make use of the illustrative values given in WebTAG Unit M2 and, as recommended in the guidance, to subject them to realism testing to ensure they produce reasonable results.

Table 36provides a summary of the main characteristics for the demand model.

Table 36: Summary of Demand Model Characteristics

	Demand Segment	Demand Matrix	Input format	Constrained	Logit Parameters – λ Value		
					Min	Median	Max
1	Home to work	P/A	24hr	Doubly	-0.054	-0.065	-0.113
2	Home to other	P/A	24hr	Singly	-0.074	-0.090	-0.160
3	Home to employers business	P/A	24hr	Singly	-0.038	-0.067	-0.106
4	Non home based employers business	O/D	24hr	Singly	-0.069	-0.081	-0.107
5	Non home based other	O/D	24hr	Singly	-0.073	-0.077	-0.105
6	LGV	O/D	Time period	N/A	N/A	N/A	N/A
7	OGV	O/D	Time period	N/A	N/A	N/A	N/A

9.3.2 Cost Damping

There is some evidence that the sensitivity of demand responses to changes in generalised cost reduces with increasing trip length, however as the Logit function operates in absolute terms, then there are times when the demand model overestimates changes in demand for long journeys. In order to ensure that a model meets the requirements of the realism tests it is often found that cost damping is necessary. Cost damping to the model in the form below was found to be necessary:

$$G' = \mu G^{\beta};$$

where:

G is the modelled Generalised Cost from i to j in minutes,

G' is the adjusted Generalised Cost from i to j in minutes,

β is the power which may vary from zero to one.

μ is a factor that is used such that for the average journey length $G' = G$

9.4 Demand Model Validation

WebTAG Unit M2 sets out the procedures that should be followed in terms of realism testing of a variable demand model. These procedures are designed to ensure that the variable demand behaves realistically, by changing the various components of travel costs and times and checking that the overall response of demands accords with general expectations. If it does not then the parameter values are adjusted until an acceptable response is achieved, and WebTAG Unit M2 notes that there is more scope for adjusting imported or illustrative parameter values than those that have been calibrated from local data.

The acceptability of the models responses is determined by the demand elasticies it predicts. These are measured by changing a cost or time component by a small proportional amount and calculating the proportionate change in trips made. The elasticity formulation recommended is the arc elasticity formulation:

$$e = (log(T_1)-log(T_0))/(log(C_1)-log(C_0))$$

where the subscripts $_0$ and $_1$ indicate values before and after the change in cost respectively.

WebTAG Unit M2 states that the analysis should check the elasticity of demand with respect to the demand drivers given below and provides recommended indicative elasticity values:

- 10% increase in car fuel cost;
- 10% increase car journey time; and
- 10% increase public transport fare.

A systematic approach was adopted to calibrating the demand model sensitivity parameters, which involved making incremental adjustments to the demand model parameters and cost damping function in response to the outcomes of earlier runs. In all, three key fuel price realism tests were undertaken, the results of which are presented below. The external to external and intra-zonal trips have been excluded from the calculations as they are assumed to be inelastic to cost change in the demand model. In all cases the models have been run until satisfactory convergence has been reached. Details of the parameters used and results are shown in Appendix D

9.4.1 Realism Testing –PT Fare Elasticity

To reflect the fare cost increase, the fare parameters have been changed directly in the PT assignment. The external to external and intra-zonal trips have been excluded from the calculations as they are assumed to be inelastic to cost change in the demand model. In all cases the models have been run until satisfactory convergence has been reached.

Testing concluded running a 10% fuel price increase realism test, using the high illustrative mode choice scaling parameters provided in WebTAG and no cost damping for the PT elements. The PT distribution parameters are between the median and high values. shows the results of this test.

Table 37: Test 76 Vehicle Kilometre Fuel Price Elasticity Values by Purpose and Time Period

	AM	IP	PM	OP	24 Hour
Commute	-0.29	-0.37	-0.15	0.08	-0.24
Business	-0.18	-0.19	-0.17	-0.16	-0.18
Other	-0.32	-0.29	-0.39	-0.50	-0.32
Tot	-0.30	-0.28	-0.27	-0.30	-0.29

Elasticity values have been derived on a matrix basis using the arc formulation provided in WebTAG. The overall PT trip elasticity (note that this is total PT trips and not PT kilometres travelled) with respect to increasing fuel price for trips to/from and within the Fully Modelled Area of the model is -0.29. This is within the expected range of values published in WebTAG of -0.20 to -0.9.

9.4.2 Realism Testing Fuel Cost Elasticity – Matrix Based

Following the conclusion of the PT fare testing the fuel price elasticities were recalculated. To reflect the fuel cost increase, the relevant Car VOC (or PPK) parameters have been changed directly in the generalised costs used in the highway assignment. The PPK are constructed by calculating the fuel and non-fuel components using the latest WebTAG guidance. It has been assumed that an increase in fuel costs will have no impact upon the non-fuel elements of car VOC, as such only the fuel elements of the car cost have been increased by 10%.

Early testing showed that the elasticity of internal to external trips was significantly outside of the range in the guidance. WebTAG recognises that using simple logit formulations may not be behaviourally appropriate for models containing trips with a wide range of trip lengths e.g. from intra-zonals of <2km to long distance trips >60km. WebTAG therefore suggests that for these models where outturn elasticity values are disproportionately high, a method of cost damping differentially by trip length may be appropriate.

Accordingly Test 77 involved running a 10% fuel price increase realism test, using the median illustrative highway distribution parameters provided in WebTAG with cost damping, with β set to 0.70. The parameter μ has been set by purpose such that the generalised cost for the average journey length remains equal to the undamped cost.

Table 38 shows the results of this test. The overall vehicle kilometre elasticity with respect to increasing fuel price for trips to/from and within the Fully Modelled Area of the model is -0.6. This is outside the expected range of values published in WebTAG of -0.25 to -0.35.

Table 38 Test 77 Vehicle Kilometre Fuel Price Elasticity Values by Purpose and Time Period

	AM	IP	PM	OP	24 Hour
Commute	-0.70	-0.58	-0.40	-0.14	-0.51
Business	-0.32	-0.77	-0.18	-0.01	-0.38
Other	-0.58	-0.80	-0.70	-0.65	-0.71
Tot	-0.62	-0.74	-0.52	-0.48	-0.60

[illegible]

Table 39: Test 79 Vehicle Kilometre Fuel Price Elasticity Values by Purpose and Time Period

	AM	IP	PM	OP	24 Hour
Commute	-0.57	-0.48	-0.33	-0.10	-0.42
Business	-0.35	-0.82	-0.20	-0.03	-0.41

Other	-0.51	-0.71	-0.62	-0.53	-0.62
Tot	-0.52	-0.66	-0.46	-0.40	-0.53

In order to reproduce the required elasticity it was found that β was required to be set to 0.57. The results of this test, Test 81 are shown in **Table 40**. The overall vehicle kilometre elasticity with respect to increasing fuel price for trips to/from and within the Fully Modelled Area of the model is -0.33.

Table 40: Test 81 Vehicle Kilometre Fuel Price Elasticity Values by Purpose and Time Period

	AM	IP	PM	OP	24 Hour
Commute	-0.33	-0.27	-0.19	-0.03	-0.24
Business	-0.14	-0.39	-0.07	0	-0.18
Other	-0.34	-0.48	-0.42	-0.91	-0.41
Tot	-0.32	-0.41	-0.29	-0.22	-0.33

WebTAG Unit M2 states that "the pattern of annual average elasticities shows values for employers' business trips near to -0.1, for discretionary trips near to -0.4, and for commuting and education somewhere near the average. Viewing the elasticity values by purpose shows the values follow the anticipated trend with values for the more discretionary other purpose being more elastic (-0.41) than for commute (-0.24) and business (-0.18). The elasticity values by time period also show the anticipated trend with the inter peak (-0.41), which has a higher proportion of discretionary trip making, having higher elasticity values than the morning peak (-0.32) and evening peak (-0.29) hours.

9.4.3 Realism Testing –Fuel Cost Elasticity – Network Based

Fuel price elasticity values can also be calculated on a network basis, as opposed to the matrix based values that have been presented thus far. For Test 3, a value of -0.19, see **Table 41**below, was obtained calculating the elasticity value on a network basis. It would be expected that this value should be lower than the overall value calculated on a matrix basis (-0.30) as link-based traffic flows contain a proportion of trips for external to external movements for which model responses are fixed.

Table 41: Link Based Elasticities by Time Period

	AM	IP	PM	OP	24 Hours
Fully Modelled Area	-0.21	-0.22	-0.18	-0.08	-0.18
External	-0.25	-0.25	-0.17	-0.08	-0.20
All Links	-0.23	-0.23	-0.18	-0.08	-0.19

10 Summary of Model Development and Standards Achieved

TVU and Arup have developed a wholly new multi modal model based in the Cube Voyager software, calibrated and validated to a 2014 base year built from synthetic data. The modelled area covers the 5 districts within the Tees Valley.

The highway model has been calibrated over 30 screenlines, containing a total of 142 calibration counts. At the screenline and individual count level the model calibrates to within / close to the WebTAG calibration criteria. The journey time validation has been undertaken on 12 routes through the modelled area. In all time periods the model passes the WebTAG acceptance test.

The public transport model matrices have been developed from ticket data. In general terms the model is slightly under assigning the bus network and over assigning the rail services, particularly where the bus and rail services run in close proximity. This apparent weakness should not detract from the fact that the model should be considered suitable to be used by TVU as a tool to assess transport schemes as the model can be seen to be producing reliable skim costs for both highway and public transport modes.

An appropriate level of validation of the demand model has been demonstrated with respects to the requirements of WebTAG. The overall vehicle kilometre elasticity value of -0.3 is in the middle of the published range -0.25 to -0.35. The highway model has been demonstrated to have an appropriate level of response for the different travel purposes and time periods.

In conclusion, whilst improvements to the public transport assignment could be made, the model forms a suitable basis for the testing of highway schemes within the Tees Valley Region.

Appendix A

Highway Path Checks

Appendix B

Flow Calibration

Appendix C
Journey Time Results

Appendix D

Realism Test Results and Parameters

Appendix G

TUBA Parameters

Appendix H

Economic Assessment Tables

Economy:Economic Efficiency of the Transport System (TEE)

Consumer	**Commuting user benefits**	**All Modes**	**Road**	**Public_Transport**
	Travel Time	43976	42995	981
	Vehicle operating costs	-737	-737	0
	User charges	0	0	0
	During Construction & Maintenance	0	0	0
	NET CONSUMER - COMMUTING BENEFITS	**43239**	**42257**	**981**

Consumer	**Other user benefits**	All Modes	Road	Public_Transport
	Travel Time	22915	22134	781
	Vehicle operating costs	263	263	0
	User charges	6	0	6
	During Construction & Maintenance	0	0	0
	NET CONSUMER - OTHER BENEFITS	**23184**	**22397**	**787**

Business		**All Modes**	**Road_Personal**	**Road_Freight**	**Bus_Personal**	**Bus_Freight**
	Travel Time	1754	1566	0	189	0
	Vehicle operating costs	263	263	0	0	0
	User charges	0	0	0	0	0
	During Construction & Maintenance	0	0	0	0	0
	Subtotal	**2017**	**1829**	**0**	**189**	**0**

Private Sector Provider Impacts				
	Revenue	64	0	64
	Operating costs	0	0	0
	Investment costs	0	0	0
	Grant/subsidy	0	0	0
	Subtotal	**64**	**0**	**64**

Other business Impacts				
	Developer contribution	-1	-1	0
	NET BUSINESS IMPACT	**2081**		

TOTAL	
Present Value of Transport Economic Efficiency Benefits (TEE)	**68505**

Public Accounts

		ALL MODES	Road	Public_Transport
Local Government Funding				
	Revenue	0	0	0
	Operating Costs	0	0	0
	Investment Costs	2	2	0
	Developer Contributions	-1	-1	0
	Grant/Subsidy Payments	0	0	0
	NET IMPACT	1	1	0
Central Government Funding: Transport		**ALL MODES**	**Road**	**Public_Transport**
	Revenue	0	0	0
	Operating Costs	0	0	0
	Investment Costs	19756	19756	0
	Developer Contributions	0	0	0
	Grant/Subsidy Payments	0	0	0
	NET IMPACT	19756	19756	0
Central Government Funding: Non-Transport				
	Indirect Tax Revenues	1159	1167.526	-9
TOTALS				
	Broad Transport Budget	**19756**	**19756**	**0**
	Wider Public Finances	**1159**	**1168**	**-9**

Analysis of Monetised Costs and Benefits

Greenhouse Gases		475
Economic Efficiency: Consumer Users	(Commuting)	43239
Economic Efficiency: Consumer Users	(Other)	23184
Economic Efficiency: Business Users and Providers		2081
Accidents		1746
Wider Public Finances	(Indirect Taxation Revenues)	-1159
Present Value of Benefits	**(PVB)**	**69566**
Broad Transport Budget		19756
Present Value of Costs	**(PVC)**	**19756**
OVERALL IMPACTS		
Net Present Value	**(NPV)**	**49810**
Benefit to Cost Ratio	**(BCR)**	**3.521**

Appendix I

Initial Risks

Risk Register

Project Details:	
Project Name:	Elwick Village By-Pass

Identified Risk	Impact	Likelihood	Score	Category	Mitigating Action	Lead	Target Date
Failure to secure funding	**H**	**Medium**		**Live**	Consider other gap funsing sources	HBC	
Failure to obtain planning approval	**H**	**Low**		**Live**	The scheme will help to address strate	HBC	
Cost Overruns	**M**	**Medium**		**Live**	Reappraise budget, review project des	HBC	
Programme Delays	**M**	**Low**		**Live**	Revise programme, investigate possib	HBC	
Management Changes	**L**	**Low**		**Live**	Hartlepool Council will be the strategic	HBC	
Issues with the tender process to secure a contractor	**M**	**Low**	**L**	**Live**	Develop a robust procurement plan	HBC	
Issues with construction timescales	**L**	**Low**	**L**	**Live**	Monitor progress against the constructi	HBC	
Failure to achieve outputs	**L**	**Low**	**L**	**Live**	Monitor the delivery of outputs.	HBC	
Project timescales / phasing not adhered to	**h**	**Medium**	**m**	**Live**	Rigorous project management arrange	HBC	
Varience in tender costs	**m**	**Low**	**m**	**Live**	Rigorous project management arrange	HBC	

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