

Road Investment Programme
M25 Junction 28 Improvements
Technical Appraisal Report

November 2016

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Document control

Document Title	Technical Appraisal Report
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Distribution	Highways England Consultees, Atkins Team
Document Status	Draft

Revision History

Version	Date	Description	Author
1.1	2/9/2016	Draft	Pete George, Yogesh Patel, Steve Connors, Sarah Wallis, Tamsin MacMillan
1.2	24/10/2016	Final Draft	Yogesh Patel, Sarah Wallis
1.3	01/11/2016	Final	Yogesh Patel, Sarah Wallis
1.4	25/11/2016	Final	Yogesh Patel

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Glossary of Abbreviations

AADT	Annual Average Daily Traffic
AADT	Annual Average Weekday Traffic
AQMA	Air Quality Management Area
AST	Appraisal Summary Table
BAP	Biodiversity Action Plan
BCR	Benefit Cost Ratio
BGL	Below Ground Level
CCTV	Closed Circuit Television
COBALT	Cost Benefit Analysis
CPS	Connect Plus Services
DBFO	Design, Build, Finance and Operate
Defra	Department of Environment, Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges
EAST	Early Assessment Sifting Tool
ESR	Environmental Study Report
GEML	Great Eastern Main Line
HPI	Habitats of Principal Importance
ITS	Intelligent Transport Systems
KPI	Key Performance Indicator
LDF	Local Development Framework
LNR	Local Nature Reserve
MIDAS	Motorway Incident Detection and Automatic Signalling
MP	Major Projects
MS3	Message Sign Type 3 (Text Only)
MTS	Mayors Transport Strategy (London)
NRTF	National Road Traffic Forecasts
NMU	Non-Motorised User
NO2	Nitrogen Dioxide
NTEM	National Trip End Model
NTM	National Transport Model
PCF	Project Control Framework
PCU	Passenger Car Units
PRoW	Public Rights of Way
PTS	Professional and Technical Solutions
PVB	Present Value of Benefits

PVC	Present Value of Costs
QUADRO	Queues and Delays at Roadworks
RCC	Regional Control Centre
RIS	Road Investment Strategy
RTMC	Regional Technology Maintenance Contractor
SE LEP	South East Local Enterprise Partnership
SEP	Strategic Economic Plan
SPI	Species of Principal Importance
SPZ	Source Protection Zones
SRN	Strategic Road Network
SSSI	Site of Special Scientific Interest
SUP	Shared Use Path
TAME	Traffic Appraisal Modelling and Economics team
WebTAG	Web based Transport Analysis Guidance
WFD	Water Framework Directive
TAR	Technical Appraisal Report
TEMPRO	Trip End Model Projections
TLRN	Transport for London Road Network
TUBA	Transport User Benefit Analysis
VMS	Variable Message Sign
VMSL	Variable Mandatory Speed Limit
VOC	Vehicle Operating Cost
VSL	Variable Speed Limits

Executive Summary

Introduction

In December 2014 the Department for Transport (DfT) published the Road Investment Strategy (RIS) for the first road plan period of 2015 to 2020. The RIS sets out the list of schemes that are to be delivered by Highways England over the period covered by the RIS1 period. In the Route Strategy for the London Orbital and M23 to Gatwick corridors (April 2014) Highways England identified Junction 28 as a key junction with capacity issues.

Based on the RIS Statement, a scheme to alleviate and manage current and future congestion through the junction is described in the Client Scheme Requirements for Junction 28 as, the introduction of a new free flow link for right turning traffic between the M25 motorway anti-clockwise and the A12 east.

The need for the scheme

Based on the evidence review undertaken during PCF Stage 0, four key problems were confirmed for Junction 28:

- **Problem 1** - Congestion and delay on the Junction 28 roundabout disrupts journeys on the strategic road network and local roads
- **Problem 2** - Actual and perceived safety concerns associated with driver movements on the Junction 28 roundabout
- **Problem 3** - Resilience to incidents or accidents is poor, resulting in significant disruption and unreliable journey times
- **Problem 4** - Air quality is an issue at the junction.

Without appropriate intervention to improve the performance of Junction 28, each of these problems would be expected to deteriorate further in the future as traffic levels increase. This would result in significant consequences for the efficiency of traffic flow, road safety, network resilience, and user satisfaction. Ultimately it will reduce the ability of the junction to perform its role in supporting local and regional aspirations for development and growth.

Specifically, without intervention:

- Junction 28 will be a constraint on the wider SRN caused by the inadequate capacity of the junction and the increasingly high traffic demands
- By 2037 average delays across all movements on Junction 28 will be at least five times that experienced at present (increasing to 5 minutes on average)
- Average speeds through the junction (excluding mainline M25 and A12 movements) consequently reduce by 25% by 2037
- the ability of the junction roundabout to remain open and available in the event of an accident or incident will diminish
- the ongoing local air quality issues will be exacerbated.

The scheme specific objectives have been identified in line with addressing the agreed problems:

- To cater for future traffic demands efficiently with minimal delay and to support future development and economic growth
- To improve the network resilience and enable smoother flow of traffic and reliable journey times

- Improve road safety on the approaches to and through Junction 28
- Minimise the impact of high traffic volumes and stopping traffic on local air quality and noise.

These align closely with the current business strategies for the South East Local Economic Partnership and for local and central government. They also align well with Highways England's performance specification area and outcomes set out in their Strategic Business Plan.

Constraints

A number of planning factors and related constraints have been identified and considered which impact on the development and choice of a preferred option.

A key constraint is concerned with several environmental issues identified around Junction 28. In particular these relate to the proximity of several AQMAs, a number of Noise Important Areas, several small water courses in close proximity of the scheme, two designated Ancient Woodlands, a Site of Metropolitan Importance (SMI) for nature conservation, the several Local Wildlife Sites, a listed buildings, and designated Conservation Areas.

Another constraint relates to the proximity of the scheme to the Great Eastern Mainline railway to London to the south of Junction 28. Options that require works across the rail line would be require development in line with Network Rail discussions and processes that could delay delivery within the RIS1 road plan period.

Option identification

During Stage 0 it was confirmed that the identified problems would be best resolved through local highway intervention. A comprehensive review of the four options shortlisted at Stage 0 was completed taking account the anticipated impacts of the options together with a detailed understanding of the key issues, risks and constraints. A key focus for the refinement and development of the options was to find an option that would achieve the identified objectives and outcomes while being affordable.

Building on this initial review 5 core options have evolved together with a number of variants. Each of these has been designed to provide a new free flow link for right turning traffic between the M25 motorway anticlockwise and the A12 east as set out in the Client Scheme Requirements. The options have been refined and evolved to best manage the impacts against the identified constraints and risks, and to develop an affordable options. The core options include:

- **Option 2 – Northern link** - A two lane link with hard shoulder connecting the M25 anti-clockwise carriageway with the A12 east via a two lane link (plus hard shoulder) that hooks around the north of Junction 28 merging with the A12 to the east of Wigley Bush Lane.
- **Option 4 – Compact northern link** – This option is similar to Option 2, comprising a two lane link with hard shoulder connecting the M25 anti-clockwise carriageway with the A12 east via a two lane link (plus hard shoulder) that hooks around the north of Junction 28 merging with the A12 to the east of Wigley Bush Lane. This option assumes a new structure running parallel to the M25 to achieve a more compact layout forte junction.
- **Options 5A, 5B, 5C and 5F – Loop (cloverleaf) variants** - A single lane with hard shoulder that connects the M25 anti-clockwise carriageway with the A12 east in the form of a cloverleaf type loop located in the north-west quadrant of Junction 28. Option 5A requires a tunnel under the mainline railway for the realigned diverge from the M25, and the realignment of Nags Head Lane to the south. Options 5B and 5C assume the

exit from the M25 anti-clockwise is located further north therefore negating any implications with the mainline railway. Option 5F is essentially the same as Option 5C but with a 2 lane link road.

- **Options 5D and 5E – Loop variants** - This option connects the M25 anti-clockwise carriageway with the A12 east via a two lane loop (with hard shoulder) located in the north-west quadrant of Junction 28. However, unlike the cloverleaf options (Options 5A, 5B, 5C and 5F) the loop does not merge with the A12 under the existing Junction 28 circulatory structure. Instead the loop road crosses the M25 to the north of Junction 28 via an over-bridge structure (Option 5D) or an under pass (Option 5E) and merges with the A12 to the east of Junction 28.
- **Option 6 – Southern link** - A two lane link with hard shoulder that connects the M25 anticlockwise with the A12 east passing directly through the south-east quadrant of the junction with various multi-span viaducts to pass over the M25, Brook Street and the A12.

The assessment against achieving the objectives

Each of the options assessed perform similarly against the scheme objectives, providing strong benefits with little difference shown in terms of forecast journey times, average delays and speed. The main difference in traffic terms between the options relate to the operational performance of key design features, for example the merges and diverges, the carriageway standard of the new link, and running speed on the link or loop, etc.

Traffic

Under a 2037 Do-minimum scenario a significant deterioration in traffic conditions is expected. Average delays could be 2 or 3 times that experienced in 2014 in the AM and PM peak hours increasing up to 4 minutes in the AM and PM peaks. Average speeds through the junction (excluding mainline M25 and A12 movements) consequently reduce from around 85 kph in 2014 to around 65 kph in 2037. As a result journey times on key movements will also increase, and for example the M25 south to A12 east/Essex movement could see increases of 30% to 50%.

With the introduction of the new link road each option provides additional capacity and can accommodate a greater throughput of traffic, thereby improving the junction's performance relative to the 2037 Do-minimum situation. Each option is expected to provide a reduction in average delay of around 50%, with average speeds increasing by 20%.

The additional capacity provided in each option also increases the resilience of the junction to incidents and reducing the delays associated with incidents and lane closures. In doing so the options will also improve journey time reliability for commuting, business traffic and other users through the increased capacity provided by the new free-flow link.

Safety

It has been established that safety is currently a key issue at Junction 28. However the issue and consequences are concerned with the high occurrence of incidents and the implications on the disruption across the wider highway network as well as harm and injury. Many accidents are damage only, and of the total casualties resulting from the crashes 90% were slight injury. The level of killed and serious injuries (KSIs) is low with on average just under 1 KSI incident each year.

The impact of each option is to reduce traffic throughput using the existing roundabout, therefore reducing the number of accidents occurring on the roundabout. However, this benefit is offset by traffic using the new link and the expected number of accidents forecast to occur on the new link in each option. Hence there is a very slight negative impact on overall accidents

predicted for each of the options due the slightly longer distance travelled for M25 anti-clockwise to A12 Essex traffic.

Due to the low level of killed and serious injuries recorded at Junction 28, this scheme is not expected to contribute significantly to Highways England's KPI of reducing KSI collisions by 40% by 2020.

Non-motorised users

The study area is served by a number of footways, crossing and shared use paths, which would be traversed or impacted to some extent by all route options. These public rights of way are important public amenity resources, and in all options the availability and continuity of these would be maintained.

Cost and value for money

Cost estimates for each of the options is set out below.

	Option 2	Option 4	Option 5A	Option 5B	Option 5C	Option 5D	Option 5E	Option 5F	Option 6
Lanes on new link	2	2	1	1	1	2	2	2	2
Mid cost estimate (£million)	125.1	130.4	95.3	64.4	71.8	135.0	103.6	79.7	150.0

Against a set budget of £50 million to £100 million for the scheme, Options 5B, 5C and 5F are considered to be affordable options at this stage.

There is little difference between the benefits that can be realised for each option, reflecting that each option essentially does the same thing, and therefore achieve similar outcomes against the project objectives as discussed above. The main difference affecting the BCRs is the estimated scheme costs as well as the estimated impacts on existing transport users during construction. Options 5C and 5F show the strongest value for money with BCRs of 4.3 and 4.0 respectively, reflecting the much lower construction costs compared to other options. While Option 5B has the lowest estimated costs, it does have a very high level of impact on users during construction and hence the BCR of 2.99 is not as strong as that shown for Options 5C and 5F.

The norther loop option, Option 5D, shows the next best value for money BCR of 1.8, reflecting the higher cost estimate associated with the 2 lane loop.

Recommendation

It is recommended that the following options are taken forward to the PCF Stage 2 - Option Selection:

- Option 5B – Single lane cloverleaf loop variant 2
- Option 5C – Single lane cloverleaf loop variant 3
- Option 5F – Two lane cloverleaf loop.

Each of these options perform well in most areas of assessment. Options 5B, 5C, and 5F were shown to offer the greatest value in achieving the project objectives, and in terms of deliverability. They are all shown to give effect to the Client Scheme Requirements in terms of delivering a *new free flow link for right turning traffic between the M25 motorway anti-clockwise and the A12 east*. They also contribute to the delivery of key performance specification areas including *making the network safer, encouraging economic growth, supporting the smooth flow of traffic and improving customer satisfaction*.

This aligns well with the economic assessment which shows Options 5C and 5F with the highest economic cases at this stage (both showing very high value for money BCRs).

In the economic assessment Option 5B also shows a strong level of user benefits (PVB) but the BCR was effected by a higher level of construction impact, reducing the option to a high value for money BCR. The construction impacts in PCF Stage 1 has been based on a relatively crude methodology using the level of information available at this time. Refinements to the methodology will be pursued during Stage 2 and the construction phasing and traffic management arrangements will be reassessed to see if the disruption can be reduced and hence improve BCR for Option 5B.

Consideration of options for Stage 2 public consultation

A total of nine option variants have been identified and assessed during PCF Stage 1. It is recommended that the three options identified above for Stage 2 are taken forward to public consultation. It is important that the other options are also considered for inclusion in the public consultation events, with justification as to why they have been discounted at this stage.

1 Introduction

1.1 Background

In December 2014 the Department for Transport (DfT) published the Road Investment Strategy (RIS) for the period 2015 to 2020.

The RIS sets out a list of schemes that are to be developed by Highways England over the period covered by the RIS (2015 – 2020).

In the Route Strategy for the London Orbital and M23 to Gatwick corridors (April 2014) Highways England identified Junction 28 as a key junction with capacity issues. The capacity issues at Junction 28 are attributed to:

- high volumes of traffic on movements between the M25 and the A12 towards Essex passing through the roundabout section
- the relatively high volumes of traffic to and from Brentwood via the A1023 Brook Street, accessed via an uncontrolled intersection on the roundabout
- limited capacity on the roundabout section due to the high traffic levels and the capacity of the signalised intersections.

A scheme to alleviate and manage current and future congestion through the junction is described in the RIS Statement as *an upgrade of the junction between the M25 and the A12 in Essex, potentially including the provision of dedicated left-turn lanes and improvement of the gyratory system*. However this was misreported; the dedicated left-turn lanes and gyratory improvements were actually implemented in 2008. The description of the scheme should, more correctly, have referred to *the introduction of a new free flow link for right turning traffic between the M25 motorway anticlockwise and the A12 east*. This is set out in the current Client Scheme Requirements for M25 Junction 28.

In 2015 Atkins Ltd were commissioned by Highways England to undertake the Project Control Framework (PCF) Stage 0 - Strategy, Shaping and Prioritisation. This work confirmed the case for the need for an improvement at Junction 28 and considered initial options available for taking forward to the Option Identification stage (PCF Stage 1).

The overall aim of this PCF Stage 1 study, as set out in the Client Scheme Requirements and the PCF Handbook, is to identify and assess a full range of project options that give effect to the RIS statement, and deliver the identified project objectives.

The identified options have been considered alongside a multi-modal context, and seek to improve traffic conditions through the Junction 28 in terms of journey times, journey time reliability and safety.

1.2 Previous work

1.2.1 Summary

A number of studies have been completed over recent years that have considered options to improve Junction 28, either directly as part of the RIS programme or as localised junction improvement initiatives. The relevant projects completed are summarised below.

1.2.2 Route Investment Strategy & Option Assessment Report (2015)

Identification of provisional funding for a longer term solution to address congestion and safety issues identified in the Roads Investment Strategy. The following objectives are specified in the Option Assessment Report (OAR), produced in January 2015:

- Support the growth planned in the area
- Reduce congestion, smooth traffic flow and improve journey time reliability
- Reduce the number of accidents.

The following initial options were also identified in the OAR:

- *Short Term* – Upgrade junction technology to SCOOT to improve capacity; reconfigure junction markings to improve lane use and therefore junction capacity
- *Medium Term* - Widen some or all of the slip roads and circulatory area to increase junction capacity, queueing space and reduce the risk to mainline traffic; investigate free-flow slips bypassing signals for critical movements
- *Longer Term* – Construct bridges to create free flow for critical movements through the junction
- *Maverick Solution* – Close or divert A1023 Brook Street to reduce the pressure on the junction.

1.2.3 M25 Junction 28 / A1023 Brook Street Safety Improvements Study (2014/15)

In 2014/15 Connect Plus Services (CPS) on behalf of Highways England undertook an option study of the M25 Junction 28 / A1023 Brook Street Roundabout to examine ways to improve safety and reduce delays on the Brook Street approach.

The report considered possible improvement works in the form of additional or revised signing and road markings, as well as the signalisation of the A1023 Brook Street approach.

The study identified six options, four of which were short term, to rectify the inconsistencies in the signing and the lane designations / destination markings on the roundabout, and improve safety at a number of locations around the junction.

The analysis also developed two longer term options to further reduce accidents and increase the capacity of the junction; these proposals included:

- the addition of a free flow link between the M25 anticlockwise carriageway and the A12 eastbound carriageway, removing a significant volume of traffic from the roundabout circulatory and hence improving the performance of Junction 28
- increasing the number of circulatory lanes increased from three to four to increase the circulatory capacity – this was deemed to have minimal impact in improving the junction performance.

In summary, beyond the preferred short term option to signalise the Brook Street approach along with lane marking and signage improvements, the option for an additional free flow link was considered for further investigation as an appropriate long term solution with significant benefits.

1.2.4 Signal Upgrade Scheme (2015)

The study looked at upgrading signal infrastructure on the main roundabout – replacing ducts, upgrading the method of signal control to SCOOT¹ / MOVA², installing a new controller box,

¹ SCOOT – Split Cycle Offset Optimisation Technique.

² MOVA – Microprocessor Optimised Vehicle Actuation.

etc. The existing infrastructure was outdated, and was considered to be adversely impacting on the performance of the junction, and local congestion.

In addition to these recent projects a number of other studies concerned with improving the performance of Junction 28 have been undertaken.

- **Improvement works were undertaken in 2007/08** to improve the junction safety, and improve the circulation of traffic through the junction to deliver a reduction in vehicle queuing and journey times. The works comprised the provision of new dedicated free flow left turn lane from the M25 clockwise exit slip road to the A12 eastbound. They also included the realignment and widening of slip roads and approaches to the junction as well as the extension to the merges.
- A Five Year After (FYA) scheme opening assessment report was published in 2014. The following observations were made in this report:
 - There was no evidence of induced traffic using this junction after the completion of the improvement scheme. The report indicated a modest increase in traffic using the junction of around 8% between 2003 and 2008; below the National Road Traffic Forecast (NRTF) of 9.2%.
 - The study showed that after the completion of the improvements there was a reduction of around 30 to 50% in journey times along six predefined routes passing through the junction.
 - There is still a problem of vehicles queuing on the A1023 Brook Street approach to the roundabout.
- **Initial Upgrade Section Works** where the M25 clockwise exit slip to the A12 eastbound was subsequently altered from the dedicated free flow lane layout introduced in 2008, to a taper diverge on the slip as part of the M25 Junction 27 to Junction 30 widening under the Initial Upgrade Section works.

1.3 Timeframe

The scheme is to be funded regionally. The scheme is being developed under the RIS 1 road plan period (2015 to 2020) with construction planned to start by early 2020.

Table 1-1 sets out the timeframe over which the scheme will be developed from the current stage through to construction. This is consistent with the PCF Stage 1 Client Scheme Requirements.

Table 1-1 *Scheme timeframe within RIS 1*

Stage	Phase	Start date	End date
1	Option Phase	10/2015	10/2016
2		11/2016	06/2017
3	Development Phase	07/2017	06/2018
4		07/2018	12/2019
5		01/2020	03/2020
6	Construction Phase	03/2020	07/2022
7		07/2022	07/2023

1.4 Scheme context

The Government's Road Investment Strategy (RIS) was published in December 2014 and set's out a long-term vision for the strategic road network, together with a multi-year investment plan and high-level objectives for the first road plan period of 2015 to 2020.

The RIS identifies five overarching long-term challenges for the strategic road network (SRN), of which the following are identified as being relevant to the M25 Junction 28:

- **Access around major cities** – addressing serious congestion at the periphery of the major cities which are anticipated to be the greatest drivers of growth (particularly London) through lasting solutions which make the best use of all modes
- **Connecting outlying areas** – providing better links to support growth within outlying regions, including East Anglia
- **Building a smarter network** – unlocking the potential of smarter infrastructure and new technologies to enable the most to be made of the SRN.

1.5 Purpose of the Technical Appraisal Report (TAR)

This TAR summarises the technical aspects of the existing highway problems and describes how a suitable scheme might solve them. The TAR also describes the existing highway network in the study area, existing traffic conditions, and the condition of the surrounding environment and landscape. The planning factors that affect the potential scheme are summarised along with a description of alternative options previously considered.

A range of options for Junction 28 are considered including an assessment of how these support local planning policies, an assessment of the environmental impacts, traffic and economics factors, and a proposed programme to achieve the project objectives.

The TAR confirms the options considered for further development and consultation during Stage 2.

1.6 Structure of this report

The TAR report is arranged in 16 chapters following this introduction, supported by a number of appendices.

- **Chapter 2** summarises key aspects of the consultant's brief and the objectives of the project
- **Chapter 3** describes the existing conditions, primarily relating to traffic, engineering and environmental aspects
- **Chapter 4** sets out the planning factors which have influenced the development of the Junction 28 scheme options
- **Chapter 5** introduces the scheme options considered, including sections on the development of options in previous work and a description of the route options set out full appraisal
- **Chapter 6** presents a detailed engineering assessment of junction options, identifying anticipated engineering difficulties, including a summary of the vertical and horizontal geometry, operational issues, and works to existing and new structures
- **Chapter 7** summarises the traffic analysis undertaken, and presents traffic forecasts for use in the option development, environmental assessments and economic appraisal of the Junction 28 options
- **Chapter 8** presents the option estimates
- **Chapter 9** summarises the economic assessment
- **Chapter 10** summarises the initial safety assessment
- **Chapter 11** describes the operational characteristics and option design implications for the safe and economic operation and maintenance of the scheme
- **Chapter 12** summarises the assessment of the on- and off-road technology requirements of the project
- **Chapter 13** provides an early assessment of the implications of the scheme on the future maintenance regime
- **Chapter 14** presents a summary of the assessment of environmental impacts
- **Chapter 15** provides a summary assessment of the scheme options, including the Appraisal Summary Tables (ASTs) for the options
- **Chapter 16** provide the current programme for the scheme development and implementation
- **Chapter 17** concludes the report with a summary of the key findings and recommendation for the subsequent stages of the project, and confirms those options to be taken forward further consideration and consultation in Stage 2.

2 Planning brief

2.1 Phase objectives

The scheme is currently in PCF Stage 1 (Option Identification) and the phase objectives are therefore to:

- develop the pre-feasibility options identified in PCF0, along with new options
- assess them on their ability to achieve the overall scheme objectives through an optioneering process and to decide on a shortlist of options for Stage 2
- confirm the shortlisted options in partnership with Highways England officers
- appraise the shortlisted options against strategic objectives through understanding their impact on Highways England's key performance indicators (KPIs)
- recommend the options to be taken forward to public consultation, based on their value against the objectives, deliverability and affordability.

2.2 Project objectives

The scheme objectives have been identified (Table 2-1) in line with addressing the agreed problems and the consequences (Chapter 3). They align closely with the business strategies for Highways England, the Local Economic Partnership and for local and central government – most obviously in terms of the Government's broad goals for transport.

The desired outcomes for each scheme objective have also been considered.

In terms of safety, the problems at Junction 28 are concerned with the high occurrence of incidents and the implications on the disruption across the wider highway network as well as harm and injury. The level of killed and serious injuries (KSIs) is relatively low with on average just under 1 KSI incident each year.

Table 2-1 M25 Junction 28 project objectives and desired outcomes

Scheme objectives	Desired outcomes
To cater for future traffic demands efficiently with minimal delay and to support future development and economic growth	<ul style="list-style-type: none"> • Improve journey time reliability • Improve journey times • Increase the vehicular throughput of the junction • Support employment and housing development planned for Brentwood, Essex and Havering
To improve the network resilience and enable smoother flow of traffic and reliable journey times	<ul style="list-style-type: none"> • Improve journey time reliability • Improve journey times
Improve road safety on the approaches to and through Junction 28	<ul style="list-style-type: none"> • Reduce the severity and rate of accidents and casualties • Improve journey time reliability
Minimise the impact of high traffic volumes and stopping traffic on local air quality and noise	<ul style="list-style-type: none"> • Reduce (or at least keep to neutral) carbon-dioxide emissions and noise levels • Reduce (or at least keep to neutral) noise levels

In addition to the project specific objectives above, the Client Scheme Requirements provided by Highways England set out a number of other strategic objectives relating to the Junction 28 improvements (Table 2-2).

The project objectives above have a key role in guiding the development of the scheme options to maximise the value for money against meeting the aims of the investment in improving Junction 28. However, the strategic objectives are also important in monitoring and measuring any potential adverse impacts of the project against key Highways England indicators. These strategic objectives are closely aligned to the Highways England Strategic Business Plan which sets out the outcomes, KPIs and associated targets within the road plan period. The measurement of relevant objectives and KPIs to inform the scheme development and assess the performance of alternatives will be undertaken with close alignment to Highways England's Operational Metrics Manual (OMM)³.

As the Junction 28 Improvements are primarily focussed on addressing issues concerned with congestion, safety and journey time reliability, there is a strong alignment of the key scheme objectives and outcomes which encourage economic growth and support the smooth flow of traffic (Table 2-3).

Table 2-2 *M25 Junction 28 strategic objectives and indicators*

Overall objectives	<ul style="list-style-type: none"> • Make best use of existing infrastructure. • Suit the requirements of ongoing maintenance and minimising disruption from road works, by minimising whole life costs and the need to return to the location for a minimum of five years between schemes
Transport performance	<ul style="list-style-type: none"> • The priority is to improve the performance of the roundabout, however the performance of the A1023 and A12 west and east of the junction must also be assessed, as these are intrinsically connected. • Eliminate queueing on the M25 mainline caused by the Junction 28 off-slips, at all times of day. • Reduce the average delay (time lost per vehicle mile) through the junction during peak and off-peak periods. • Improve journey time reliability through the junction during peak and off-peak periods. • Reduce the "after" accident numbers (per annum) below the "before" accident numbers, including the severity ratio. • Avoid the need for further capacity interventions for at least ten years after opening and accommodate projected traffic demand for this period (to 2033, based on an opening year of 2023).
Environment	<ul style="list-style-type: none"> • Mitigate any Noise Important Areas on the SRN that fall within the junction. • Minimise the detrimental environmental effects of the scheme and offset by mitigation measures where technically feasible and economic to do so, taking account of costs, availability of funding and statutory obligations. • Incorporate improvements such as biodiversity, where these can be identified and support other objectives.
Economy	<ul style="list-style-type: none"> • Provide maximum value for money against its whole of life costs in accordance with the Department's WebTAG guidance (BCR adjusted for non-monetised impacts should aim to be greater than 2). • Aim to improve on Appraisal Summary Table assessment results produced during the Options Phase and Development Phase, where possible within the constraints of affordability.
Social and distributional impacts	<ul style="list-style-type: none"> • Support the growth planned in the area in published statutory plans and where possible in emerging growth studies. • Minimise detrimental impacts on vulnerable people groups and provide appropriate mitigation where technically feasible and economic to do so, taking account of costs, availability of funds and statutory obligations.

³ The OMM details definitions for the measures identified in the Performance Specification in a series of technical notes, and sets out the parameters for measuring and monitoring performance against the KPIs. It also defines and gives a performance framework for the supporting PIs both in terms of providing clarity on SRN performance as well as the improvement of existing and development of new measures for future Road Periods

Table 2-3 *Alignment with performance specification objectives*

Highways England performance specification - objectives	Junction 28 improvements - outcomes
Making the network safer	Enhanced capacity of Junction 28 to cater for forecast traffic throughput, reduce queueing and congestion and thereby reduce risk of conflicts and frequency of collisions.
Delivering better environmental outcomes	Improved air quality arising from improved performance of the junction, by reducing the levels and durations of stopping and stationary traffic.
Helping cyclists, walkers and other vulnerable users	Protected access by cyclists and pedestrians through the junction particularly between Brentwood and Havering.
Encouraging economic growth	Improved junction capacity and performance to support future economic growth in the local areas as well as along the A12 corridor and across Essex.
Keeping the network in good condition	Renewed highway infrastructure possibly contributing to any planned maintenance works as part of the renewals programme.
Supporting the smooth flow of traffic	Additional junction capacity improving the junction's ability to remain open and operational during the event of an accident or incident, thereby improving journey time reliability for local residents and businesses.
Achieving real efficiency	Potential savings realised by carrying out planned maintenance during closures for traffic management.
Improving user satisfaction	Reduced journey time delays, particularly those related to the performance of the traffic signals on the Junction 28 roundabout.

2.3 Strategic case

One of the key aims of the PCF Stage 0⁴ work was to confirm the Strategic Case for improving the M25 Junction 28; that is to test and confirm the nature and scale of the problems affecting the performance of junction.

This analysis had been achieved through a review of relevant evidence including information and data from previous and current projects looking at improvements to the junction, additional analysis. It also included engagement with Highways England and key stakeholders including Connect Plus Services (CPS), and the local highway and planning authorities. Based on this evidence review four key problems were confirmed:

- **Problem 1** - Congestion and delay on the Junction 28 roundabout disrupts journeys on the strategic road network and local roads
- **Problem 2** - Actual and perceived safety concerns associated with driver movements on the Junction 28 roundabout
- **Problem 3** - Resilience to incidents or accidents is poor, resulting in significant disruption and unreliable journey times

⁴ Road Investment Strategy – M25 Junction 28 Improvements, PCF0 Final Report (September 2015), by Atkins on behalf of Highways England.

- **Problem 4** - Air quality is an issue at the junction.

Without appropriate intervention to improve the performance of Junction 28, each of these problems would be expected to deteriorate further in the future as traffic levels increase. This would result in significant consequences for the efficiency of traffic flow, road safety, network resilience, and user satisfaction. Ultimately it will reduce the ability of the junction to perform its role in supporting local and regional aspirations for development and growth.

Specifically, without intervention the likely outcomes would include:

- Junction 28 being a constraint on the wider SRN caused by the inadequate capacity of the junction and the increasingly high traffic demands. Such a constraint would act as an inhibitor to economic growth and the attractiveness of the local areas and the A12 corridor for new businesses and residents. Without intervention average delays across all movements on Junction 28 will be at least five times that experienced at present (and could be more); average delays could increase to around 4 or 5 minutes per movement in peak periods
- The ability of the junction roundabout to remain open and available in the event of an accident or incident will diminish. In such an event local commuters, residents and businesses will suffer with increasingly longer and unreliable journey times
- Without a reduction in traffic levels and the smoothing of traffic flows the ongoing local air quality issues will be exacerbated.

2.4 Strategic context

2.4.1 Summary

There are a number of key policy drivers that have been considered as part of the study, particularly in defining how the identified problems should be addressed, and which wider objectives these should help to support. The M25 is recognised as having a widespread geographical function so therefore national, regional and local policies have been reviewed:

- **National** level Government policy statements relating to the Strategic Road Network (SRN)
- **Regional** level policy statements produced by elected authorities which relate to travel within Greater London and the East of England area
- **Local** level policy documents produced by local planning and transport authorities covering the immediate surrounds of Junction 28.

A summary of what are considered to be the key implications of these documents for this announced scheme are shown in the Table 2-4. This is followed by a summary of the key messages and implications of each.

In summary a number of issues have been identified, including a reliance on the A12 local network to connect employment and residential areas.

The South East Strategic Economic Plan (SEP) puts great emphasis on having strong links and connections with Essex and London, and achieving this is seen to be reliant on the performance of Junction 28 enabling good access via the A12 and M25 corridors. Junction 28 is already operating close to capacity and with additional growth in the future the junction will present a significant constraint on achieving future aspirations for growth and development.

Table 2-4 Policy overview

Scale	Policy document	Key implications for Junction 28 Improvements
National	Road Investment Strategy (2014)	Promote safe movement, satisfy users of the network, support efficient movement, can be delivered and operated within environmental constraints, support local access and well-being and be demonstrably cost-effective
	Highways England Business Plan	Support short-term targets as well as long-term aspirations, and not significantly impact on network availability
Regional	South East England Strategic Economic Plan	Enable local housing and employment growth in Essex and the wider South East by supporting efficient movement along the A12 and M25
	London Plan	Enable targets for employment and housing growth in outer London by providing efficient access to the M25
	Mayor's Transport Strategy	Support the smooth and efficient movement of traffic along the A12 to the west of the M25
Local	Essex Local Transport Plan (2011)	Manage the impacts of traffic on the local community, support access to strategic locations in Essex along the A12 corridor and support multimodal access for Brentwood
	Brentwood Local Plan	Ensure improvements are consistent with land use and environmental constraints and help to deliver local aspirations for housing and employment growth
	LB Havering LDF	

Nationally there is a requirement for the DfT to invest in and maintain the trunk road network, whilst making the roads less congested and polluted and maintaining high standards of safety. These themes are reiterated in regional and local policy objectives.

Other policy documents, include the Essex County Council Local Transport Plan, the Brentwood Borough Council Local Plan, the London Plan and the London Borough of Havering's Local Development Framework (LDF). These are generally supportive in principle of new transport infrastructure to address existing and future issues that could constrain economic growth and development. An overview of each of the identified problems, their timescales and key strategic policy drivers to addressing them is shown in Table 2-5.

Importantly this understanding of the problems and how they affect and/or impact on key policy drivers provides a robust basis for confirming the evidence based objectives that guide the development and delivery of a successful solution.

Equally this summary confirms that the identified problems (and the scheme objectives set out below) are strongly aligned with Highways England's eight target outcomes and objectives.

2.4.2 Highways England, Strategic Business Plan 2015 to 2020

The Highways England Business Plan sets out the outcomes, key Performance Indicators and associated targets within the RIS 1 plan period. Recognising that SRN acts a key enabler of economic growth and prosperity, and contributes significantly to people's quality of life, the Plan sets out the main activities to be undertaken to deliver the RIS. It represents the first of a series of five-year plans to incrementally deliver the Government's vision, focusing on enabling better journeys on better roads and improving the service to customers. The Plan extends across all aspects of Highways England's service delivery, relating to *modernisation* (the upgrading of major routes), *maintenance* and *operation*.

One of the key objectives is to support economic growth through alleviating congestion issues, as well as smoothing traffic when an incident occurs that can potentially disrupt the movement of traffic and goods. These are closely aligned with the problems being addressed by the Junction 28 improvement project.

2.4.3 Highways England Delivery Plan 2015 – 2020

Building on the Highways England's Strategic Business Plan the Delivery Plan sets out the how each of the strategic outcomes will be delivered.

The strategic outcomes identified include:

- **Supporting economic growth** – through a modernised and reliable network that reduces delay, creates jobs and helps business compete and opens up new areas for development
- **Safe and serviceable network** – where no one should be harmed when working or travelling on the network
- **More free flowing network** – where routine delays are more infrequent, and where journeys are safer and more reliable
- **Improved environment** – where the impact of our activities is further reduced ensuring a long-term and sustainable benefit to the environment
- **More accessible and integrated network** – that gives people the freedom to choose their mode of transport and enable safe movement across and alongside the network.

In order to measure the success of these outcomes the Delivery Plan also identifies a series of KPIs and associated targets. Many of these complement the outcomes which are set out within the RIS, and these have been key in the identification, development and assessment of alternative options for improving Junction 28.

The Delivery Plan includes specific KPIs for *Delivering better environmental* outcomes. This scheme has looked to address and/or contribute to achieving these KPIs and related outcomes wherever possible. Some of the key environmental indicators featured relate to:

- **Noise** - 1150 noise important areas mitigated by 31 March 2020
- **Air quality** - Undertake air quality testing and minimising the effects on the local environment and local residents
- **Biodiversity** - delivery of improved biodiversity, as set out in the Company's Biodiversity Action Plan
- **Cyclists, walkers and other vulnerable road users** - demonstrate consideration of VRU's and incorporate measures within the scheme for them to be able to continue to use the network as they can currently
- **Social and environmental** objectives should form part of the design solution as required either through the Highways England licence agreement or other government commitments.

Implications and relevance to proposed Junction 28 improvements

- Improvements to Junction 28 will need to align with, and assist wherever relevant with the associated KPIs and targets of Highways England's Business Plan. In particular addressing current and future congestion issues, along with smoothing traffic during incidents are key to supporting future economic growth
- The delivery of improvement should not result in significant reductions to the availability of the local network
- The Junction 28 improvements should look to contribute to the Delivering better environment outcomes

2.4.4 Department for Transport's (DfT) Roads Investment Strategy

The DfT's Roads Investment Strategy: Performance Specification details eight areas for improved performance; three of which are particularly relevant to improving Junction 28:

- Encouraging economic growth
- Supporting the smooth flow of traffic
- Delivering a Safe and Serviceable Network.

2.4.5 South East Strategic Economic Plan (2014)

The South East Strategic Economic Plan (SEP) was published in 2014 by the South East Local Enterprise Partnership (LEP). In accordance with the boundaries of the LEP, the Plan covers East Sussex, Essex, Kent, Medway, Southend and Thurrock.

The SEP seeks to help create 200,000 private sector jobs and accelerate the rate of housing completions to ultimately complete 100,000 additional homes by 2021. A major focus of the SEP is on *Corridors of Growth* with the A12 and Great Eastern Mainline corridor one of those identified. The corridor is identified as a crucial link between international gateways (in particular the ports of Harwich and Felixstowe) and wider strategic networks, as well as a key facilitator for growth in Chelmsford, Colchester, Brentwood and Maldon.

Through extensive investment in infrastructure the SEP suggests there is potential to enable the creation of approximately 19,300 jobs and 15,200 homes at key locations along the corridor. Clearly the performance of Junction 28 is key to supporting growth along this corridor.

Implications and relevance to proposed Junction 28 improvements

- The impact of future growth within Brentwood and at locations along the A12 corridor on the number of vehicles travelling through Junction 28 will need to be considered to ensure improvements match long-term needs, and that Junction 28 continues to support future growth
- Improvements to the junction should seek to support efficient movement along the M25 and A12 and seek to facilitate local growth in housing and employment

2.4.6 The London Plan (2015)

The London Plan has been prepared by the Greater London Authority and presents the long-term strategic plan for growth in London to 2036. Initially published in 2011, the Plan was recently updated (March 2015) to include minor alterations.

The Plan identifies strategic growth locations and sets minimum annual housing growth targets for each of the boroughs. These should be reflected within the targets presented by the boroughs within their individual LDFs. For the London Borough of Havering the target was set at the time for 1,170 new homes to be provided per year between 2015/16 and 2024/25.

The Plan also considers the location of employment growth. Overall, employment is projected to grow within Havering by 11% between 2011 and 2036 (from 81,000 to 90,000 jobs). Havering is identified as a potential strategic outer-London development centre for functions relating to logistics and higher education; with the former of particular importance to the A12 corridor and Junction 28. Harold Hill Industrial Estate, which is adjacent to the A12, and the King George Close Estate in Romford are also included as preferred industrial locations.

Implications and relevance to proposed Junction 28 improvements

- The junction should support good access to the M25 for industries within Greater London and seek to facilitate growth along the A12 corridor

2.4.7 The Mayor's Transport Strategy (2010)

The Mayor's Transport Strategy (MTS) was published in 2010 and sets out the transport vision for London. It details out how this is to be delivered by Transport for London and its partners over the preceding 20 years. The MTS is aligned to six key goals:

- **Support economic development and population growth** – by connecting people to jobs and allows people, goods and services to move easily within and through the capital
- **Enhance the quality of life for all Londoners** – by reducing the improving the impact of transport on health and wellbeing and making travel simpler and more pleasant
- Improve the safety and security of all Londoners
- **Tackling deprivation and supporting growth** – particularly through better connecting isolated areas and ensuring development is supported through reliable public transport access
- Reduce transport's contribution to climate change and improve its resilience.

To the west of the M25 motorway the A12 forms part of the Transport for London Road Network (TLRN). Across the TLRN the MTS specifies the need to improve road management and smooth traffic. No specific measures, however, are presented within the MTS for the A12.

Beyond road-based measures, the importance of the local rail network is set to be transformed with the opening of Crossrail in 2018. Brentwood Station is the penultimate stop of planned eastbound Crossrail services, with the terminus at Shenfield being around 3 miles to the east of Junction 28.

The development of Shenfield as a key interchange and works to improve access to Brentwood may impact on the demand for Junction 28 in terms of traffic accessing Brentwood via the A1023 Brook Street to use Crossrail. Generally the majority of traffic using Junction 28 does not have an origin or destination in London, and hence the introduction of Crossrail is not expected to have a significant impact on overall traffic levels passing through the junction.

Implications and relevance to proposed Junction 28 improvements

- Improvements to Junction 28 should support efficient and smooth traffic flows along the A12 corridor
- Improvements should support the growth and competitiveness of local businesses through access to the M25 and wider SRN

2.4.8 Essex Local Transport Plan (2011)

The current Essex Local Transport Plan (LTP) was published by Essex County Council in August 2011, and sets out the long-term approach to transport within the county. The LTP divides the County into four planning areas, with Brentwood featuring in the *Heart of Essex* area (together with the districts of Braintree, Chelmsford and Maldon). Brentwood is considered to be a centre of local importance, which sustains travel demand in its own right as well as being a home for London-bound commuters.

Improving connectivity between Essex's centres is identified as key policy objective, but it is recognised that much of the demand for Brentwood will be to London, rather than to the east (e.g. to Chelmsford).

Concerns are identified regarding the level of traffic and congestion within the town centre (with an Air Quality Management Area (AQMA) having been designated for an area known as

Wilson's Corner). Enhanced public transport access is therefore considered a key priority. Brentwood railway station is also identified as being one of growing importance for commuters – especially in line with the opening of Crossrail.

Strategically the A12 corridor is identified as being one of the most economically important routes within Essex and is regarded as key to providing connectivity for local businesses and between the M25 and the gateway ports at Harwich and Felixstowe. Whilst the junction with the M25 is not identified specifically as a priority issue, the Council regards journey time reliability as a particular area of concern along the A12 – especially around Chelmsford, and between Chelmsford and Colchester.

Implications and relevance to proposed Junction 28 improvements

- Improvements to Junction 28 should help to ensure reliable journey times along the A12 corridor into Essex and beyond
- Improvements should not lead to increased traffic volumes within Brentwood town centre
- Multi-modal access to Brentwood town centre should be supported as appropriate

2.4.9 Brentwood Local Plan (2005)

The Local Plan sets out the planning policies for the borough. The current plan was published in 2005, but is in the process of being updated.

Within the existing Local Plan the areas immediately to the east and south of Junction 28 are designated as Green Belt. The area to the north of the A12 is designated as a Special Landscape Area, which includes Lower Vicarage Wood. Proposals for new housing largely relate to previously developed locations within, or immediately adjacent to the existing built-up area of Brentwood.

The Council has prepared a new LDF to cover the period 2015 to 2030, which was subject to consultation in January and February 2016. In February 2015 early consultation was undertaken on *strategic growth options* which included a series of potential sites for new housing and employment at locations adjacent to the A12 Corridor and Junction 28. Whilst these do not presently represent locations designated for future development, they are based on sites which have been put forward by landowners and others for consideration as housing or employment sites.

Specifically, the area surrounding Junction 28 is shown as a potential location for housing-led mixed use development and possible employment uses, providing “this enhances the location as a key gateway to the borough”. Wider development options with potential implications for Junction 28 include expansion of retail activity within the town of Brentwood and a possible new junction on the A12 at Pilgrims Hatch. This would serve new development and also seek to reduce through traffic to and within the centre of Brentwood.

Implications and relevance to proposed Junction 28 improvements

- The current Green Belt and Special Landscape Area designations will need to be considered with the development and assessment of junction improvement options
- Any change of use to land adjacent to Junction 28 site may impact on longer-distance and local traffic movements, potentially impacting on the performance and operation of Junction 28
- A focus on growth adjacent to the A12 corridor and the provision of additional junctions along the A12 could impact on both the volume of commuter and business traffic on the A12 and also the use of Junction 28

2.4.10 London Borough of Havering Local Development Framework (2008)

The current LDF was adopted by the London Borough of Havering in 2008. The existing Core Strategy sets out the Council's policies for sustainable development within the borough and sets out how and where growth will be accommodated. Much of the focus of the strategy is on meeting the demands of the London housing market and in delivering economic growth to the south of the borough as part of the Thames Gateway area, and on strengthening the economic importance and vitality of the borough's main centres.

Within the maps accompanying the LDF, Junction 28 is identified within an area designated as Metropolitan Green belt. The section to the north of the A12 corridor and east of the M25 also classified as both a Metropolitan level site of nature conservation importance and a Countryside Conservation Area.

Similar to Brentwood Borough Council, the London Borough of Havering has been in the process of preparing a new Local Plan for 2016 to 2031. Public consultation took place in February 2015 on key issues and policies. It is expected that the new Local Plan will be submitted in draft for consultation in late 2015, with an examination in public in spring 2016 before formal adoption in late 2016.

Implications and relevance to proposed Junction 28 improvements

- Any changes to current land use or development policies will need to be considered where these are likely to impact on long term demand for eastbound A12 and M25 movements, and hence through Junction 28
- The improvements to Junction 28 should provide sufficient capacity to keep pace with the likely level of growth in housing and employment within the borough

Table 2-5 Overall summary of problems and causes, timescales and key policy drivers

Problem & Causes	Timescale	Key Policy Drivers
<p>Congestion and delay on the Junction 28 disrupts journeys on the strategic road network and local roads</p> <p>Key causes:</p> <ul style="list-style-type: none"> • Growing traffic demands to use M25 and A12 corridors • Local growth and development in Brentwood and Havering • Deficiencies in the design of the roundabout to cater current demand and movements, including the local connection with the A1023 Brook Street 	<p>Current and future</p>	<ul style="list-style-type: none"> • Unlocking economic growth and new housing delivery – particularly along A12 corridor and local growth around Brentwood • Addressing poor customer experience and high level of complaints • The A12 is a critical link to the strategic growth and development set out in the Economic Plan for Essex
<p>Resilience to incidents or accidents is poor, resulting in significant disruption and unreliable journey times</p> <p>Key causes:</p> <ul style="list-style-type: none"> • High number of accidents and incidents occur on the roundabout due to poor lane marking, signage, visibility and driver behaviour • Junction operating close to or at capacity, therefore inability to operate efficiently in the event of an accident or incident. • Depending on nature and location of incident the traffic levels may lead to issues on responding to the incident 	<p>Current and future</p>	<ul style="list-style-type: none"> • Smoothing traffic flows generally and maximising network availability on the SNR • Supporting economic growth and competitiveness through greater reliability in journey times • Improving user satisfaction
<p>Actual and significant perceived safety concerns associated with driver movements on the Junction 28 roundabout</p> <ul style="list-style-type: none"> • High number of accidents and incidents occur on the roundabout due to poor lane marking, signage, visibility and driver behaviour • Poor perception of safety due to confusion at traffic signals, and also with the issues with lane markings, signage and merging of traffic as Brook Street joins the roundabout 	<p>Current</p>	<ul style="list-style-type: none"> • Improving network safety issues and reducing the number of collisions on the roundabout • Smoothing traffic flows generally and maximising network availability on the SNR • Improving user satisfaction • Maintaining safe access for pedestrians and cyclists through the junction (note existing access on M25 anticlockwise exit)
<p>Air quality is an issue at the junction, with Air Quality Management Areas immediately adjacent</p> <ul style="list-style-type: none"> • Exceedances of government AQS objectives have been measured on Brook Street at the approach to the junction 	<p>Current</p>	<ul style="list-style-type: none"> • Improving environmental performance

3 Existing conditions

3.1 Description of the locality

3.1.1 Study area

Junction 28 of the M25 motorway is located to the west of Brentwood in Essex (Figure 3-1). To the west of the junction is the London Borough of Havering, with the Borough of Brentwood immediately to the east.

The junction provides a critical intersection between the M25, the key trunk route of the A12, and the A1023 which provides important local access to Brentwood. As such this junction plays a key role in connecting Chelmsford, Ipswich and Brentwood with London and other key destinations across the South East of England.

Figure 3-1 Scheme location



3.2 Existing highway network

3.2.1 M25 Junction 28

Junction 28 comprises a 3 tier grade separated junction. With the roundabout operating at grade the main A12 and M25 carriageways run below grade and above grade respectively.

The circulatory section itself comprises a five arm signalised roundabout connecting the M25 and A12, as well as the A1023 Brook Street access to Brentwood. The junction between the roundabout and the A1023 Brook Street is currently uncontrolled, operating as a priority intersection. The layout of Junction 28 is shown in Figure 3-2.

The key features Junction 28 along with the M25 motorway and A12 approaches to the junction are set out in the following sections.

Figure 3-2 M25 Junction 28 – Existing layout



M25 Junction 28 roundabout & slip roads

The current roundabout features three circulatory lanes providing for all turning movements. The flow of traffic on the roundabout is regulated by traffic signals that exist on the M25 and A12 approaches; that is all movements with the exception only of the free-flow M25 north (clockwise) to A12 east dedicated lane. The A1023 Brook Street approach is un-controlled with no traffic signals.

Most of the on- and off-slip roads generally have two lanes, and each feature flares with additional lanes as they approach the roundabout entry, except the A12 east slip road which has three lanes. The M25 north off-slip road flares to 3 lanes at the entry to the roundabout, together with the dedicated left turn link to the A12 east. Similarly the A12 west off-slip road

flares to 3 lanes at the roundabout. The M25 south and A12 east off-slip roads flare to 4 lanes on the entry to the roundabout.

Each of the exit arms from the roundabout comprise 2 lanes. The exit towards A12 east features a 2 lane exit which reduces to 1 lane after about 50 metres in advance of a lane gain merge with the dedicated left turn lane (1 lane) from the M25 north; this arm then continues as a 2 lane slip road towards the A12.

The A1023 Brook Street arm is a single 2 lane section (1 lane in each direction). It has a short flare (over approximately 30m) on the approach to the roundabout where it widens to three lanes at the give way line.

In terms of structural features the roundabout is supported by two structures spanning the A12, namely Poplars West (Structure ID 5780) and Poplars East (Structure ID 5781).

There are pedestrian and cycle crossings on the roundabout across the slip roads to and from the M25 anti-clockwise (south). The crossing with the M25 south off-slip road approach to the roundabout is controlled with the traffic signals, whereas the crossing on the exit to the M25 south is uncontrolled.

M25 motorway mainline

The M25 is a dual carriageway with 4 lanes in each direction (D4M) to the north and south of Junction 28. The section of the motorway through the junction is dual carriageway with 3 lanes in each direction (D3M) following a lane drop arrangements at each of the motorway junction diverges.

The M25 south diverge features a long auxiliary lane (approximately 1.5 kms) which then flares to two lanes at the diverge nose (Type C diverge, reference to TD22/06).

The M25 north diverge also features a long auxiliary lane (approx. 1.5 kms), however this diverge (Type D1) also features a 'tiger tail' style ghost island layout whereby the auxiliary lane continues on to the off-slip road. This initial bifurcation from lane 1 of the M25 is followed by traffic leaving lane 2 of the motorway via a conventional diverge.

The on-slip roads from the roundabout to the M25 in both directions feature 'tiger tail' ghost island layouts (Type F1) for the merge on to the motorway.

All the off-slip-roads have two lanes. The M25 south off-slip road and A12 east off-slip road widen to four lanes at the stop-line. Whereas the A12 west and M25 north off-slip roads flare to three lanes at the roundabout give way lines.

A12 mainline

The A12 is a major route connecting London with Essex and Anglia. In the vicinity of Junction 28 the A12 is of dual 2 lane carriageway standard.

There are no immediate junctions adjacent to the M25 Junction 28. The nearest junction is Gallows Corner, approximately 3.7 kms to the west Junction 28. This is a grade separated roundabout which also interfaces with the A127. Between Gallows Corner and Junction 28 the A12 is dual 2 lane standard with an intermittent adjacent footway. The area adjacent to this section of the A12 is relatively built up with predominantly residential and commercial land-uses. As such the A12 operates with a 50mph speed limit and several signalised junctions to facilitate access and egress to adjacent residential and commercial areas, as well as associated connector roads. The 50mph zone extends from Havering to approximately 300m west of Junction 28; to the east of that point the speed limit is derestricted.

To the east of Junction 28 the nearest junction is where the A1023 Chelmsford Road and Roman Road join the A12 (approximately 7 kms to the east). Along this section the A12 has a

consistent cross-section comprising two lane carriageway with 1 metre hard-strip. There are three laybys, to which two have emergency telephone facilities.

As the A12 approaches Junction 28 it operates with conventional diverges with no lane drop. In the westbound direction towards London the A12 continues 2 lanes through the junction. In the eastbound direction towards Essex the A12 initially continues with 2 lanes, but then reduces to 1 lane about half way through as it passes under the M25 carriageway.

The A12 diverges are noted to be generally similar to a conventional Type A diverge.

The A12 west diverge features traffic leaving the A12 on to a 2 lane off-slip road towards the Junction 28 roundabout. The A12 east diverge is very similar, though traffic leaving the A12 joins a wide off-slip that flares to 3 lanes immediately after the diverge ghost island marking.

The on-slip road to the A12 west from the roundabout features a 2 lane on-slip road merging with the A12.

The A12 east on-slip road is different and features successive merges. Approximately 60m east of the Junction 28 roundabout the eastbound traffic heading for the A12 merges with traffic on the dedicated left turn lane from the M25 north. This is quickly followed (after approximately 100m) with the start of a 'tiger tail' style ghost island where the offside on-slip road lane merges with the A12, with the nearside lane joining the A12 as a lane gain. The A12 eastbound carriageway then operates with three lanes for approximately 600 metres before reducing to 2 lanes again.

3.2.2 Non-motorised users – current arrangements

A small number of NMU routes have been identified within the study area around Junction 28. These are briefly described below and shown graphically in Figure 3-32.

Footways

Footways exist on the A12 and A1023. On the northern side of the A12, west of the M25 Junction 28 roundabout, a footway provides access to the vicinity of the roundabout and then to the southern side of the A12 via an uncontrolled crossing of the A12 entry slip and exit slip road. This then connects with a shared use path (SUP) to the southern side of the A12 / A1023.

Shared use paths (SUPs)

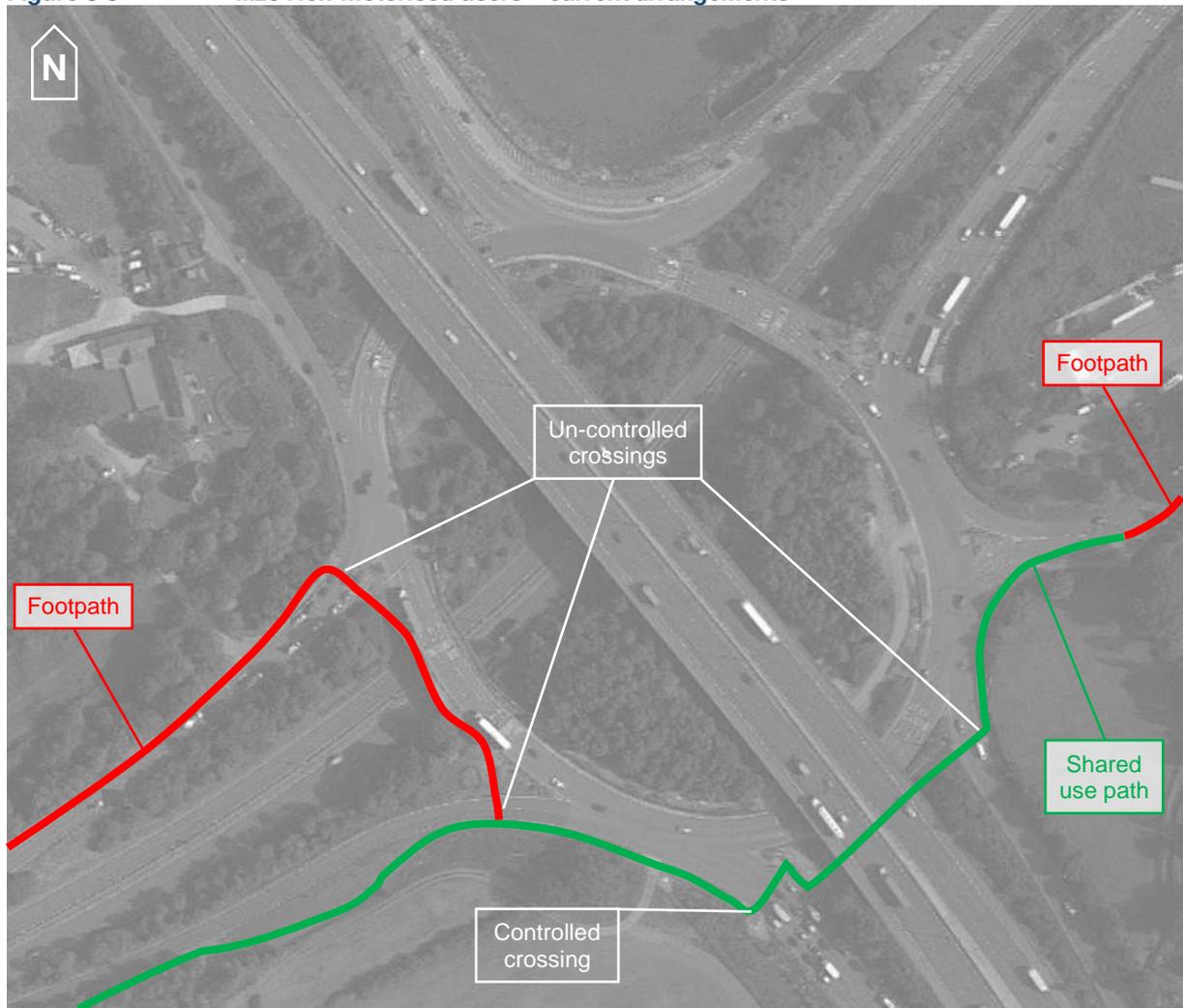
SUPs exist on the A1023 immediately east of the M25 Junction 28 roundabout junction, through the southern side of the junction via one uncontrolled and one controlled crossing point. This SUP then continues along the southern side of the A12 west of the roundabout towards Harold Wood providing a connection to National Cycle Network Route 136.

A further SUP exists on the northern side of the A12 in the vicinity of Harold Wood but this is discontinuous and does not provide a direct route to the roundabout junction on the northern side of the A12. Therefore, the only direct SUP access to and from the roundabout is currently via the SUP to the southern side of the A12. A grade separated crossing exists in the vicinity of Harold Wood to facilitate crossing movements of the A12.

National Cycle Network routes

Route 136 of the National Cycle Network crosses the A12 approximately 1 km west of the junction. It is a largely traffic free route passing through parks and green spaces connecting the village of Noak Hill and Dagnam Park north of the A12, and south to Upminster and the Thames at Rainham via Harold Hill and Hornchurch. It can therefore be assumed that local cyclists from Brentwood, Romford and areas in between will likely travel to and from this route and access it from the vicinity of the A12.

Figure 3-3 M25 Non-motorised users – current arrangements



Base map source: www.google.co.uk

3.3 Traffic

3.3.1 Traffic demand and patterns

Junction 28 of the M25 is a heavily used junction with currently up to 7500 vehicles per hour travelling through the signalised roundabout during morning and evening peaks; this does not include M25 and A12 mainline through traffic flows. Similarly during an inter-peak hour (an average hour between 10.00 and 16.00) the roundabout caters up to 5000 vehicles per hour.

Current traffic movements through the junction are shown in Appendix A. The turning movements observed during the AM peak hour are shown in Figure 3-3. Forecast 2037 turning movements are shown in Figure 3-4. Appendix B contains the future year forecast traffic movements for 2022 and 2037.

Current forecasts show that total traffic travelling through the roundabout is expected to increase by up to 30% by 2037. This would result in nearly 8500 vehicles per hour travelling through the roundabout in the morning and evening peaks. During the inter-peak flows are also expected to rise to around 6500 vehicles. The traffic growth will be constrained to the capacity of the Junction 28 circulatory. The capacity constraint is often influenced by the performance of the A1023 Brook Street un-signalised juncture, with queues from the Nags Head Lane traffic signals often blocking back on to the Junction 28 roundabout.

The turning flows through the roundabout at Junction 28 are characterised by a number of key dominant movements, particularly between the M25 (north and south) and the A12 east towards Essex.

- The M25 north to A12 east movement in the AM peak has around 800 vehicles per hour as observed in 2014, this could increase to around 1100 vehicles by 2037. This movement is currently catered by a dedicated left turn lane from the M25 exit ramp, and does not pass through the roundabout. However this lane is operating close to capacity and significant queueing and delays would be expected, particularly in the PM peak, with future demands.
- The M25 south to A12 east movement currently sees around 1000 vehicles per hour throughout the day; by 2037 these are expected to increase to 1100 vehicles per hour in both the morning and evening peaks.
- The A12 east to M25 north movement also sees high flows with nearly 900 vehicles per hour in the morning peak in 2014. This is forecast to increase to just over 1000 vehicles per hour by 2037.

In addition to the turning movements between the M25 and A12 routes Junction 28 also caters for around 1000 vehicles per hour both to and from the A1023 Brook Street. Forecasts indicate that these movements are expected to increase, however, due to capacity constraint these movements have been constrained by the A1023 Brook Street link capacity in each direction.

Local commuting trips to and from Brentwood

In assessing the problem, and hence the impact of potential solutions and options to address these, it has been important to gain a broad understanding of the wider pattern of the trips in terms of journey origins and destinations.

Without access to a current strategic model the best indication of wider travel patterns during Stage 1 was based on the 2011 Census journey to work data. Focusing on local trips to and from Brentwood, the Census data indicates that around 20,000 commuter trips are made daily from Brentwood, with approximately 17,000 travelling to Brentwood to work. Of these:

- Over half (55%) of all commuting trips within Brentwood are currently made as a driver of a car or van
- Car based commuter trips to and from Brentwood include Basildon, Havering, Chelmsford, and Thurrock (Table 3-1)
- Approximately 7000 of Brentwood's employed residents commute to work in London. Around 90% of these travel by rail, and hence are not contributing to the problems experienced at Junction 28 in peak hours.

Table 3-1 *Key car / van driver commuting trips into / out of Brentwood*

Trips from Brentwood		Trips into Brentwood	
To	No. of car / van trips	From	No. of car / van trips
Havering	1,963	Basildon	2,510
Basildon	1,686	Chelmsford	2,224
Chelmsford	1,341	Havering	1,997
Thurrock	660	Thurrock	1,112
Redbridge	593	Epping Forest	542

Figure 3-4 M25 Junction 28 – Observed turning flows (AM peak), 2014 base year

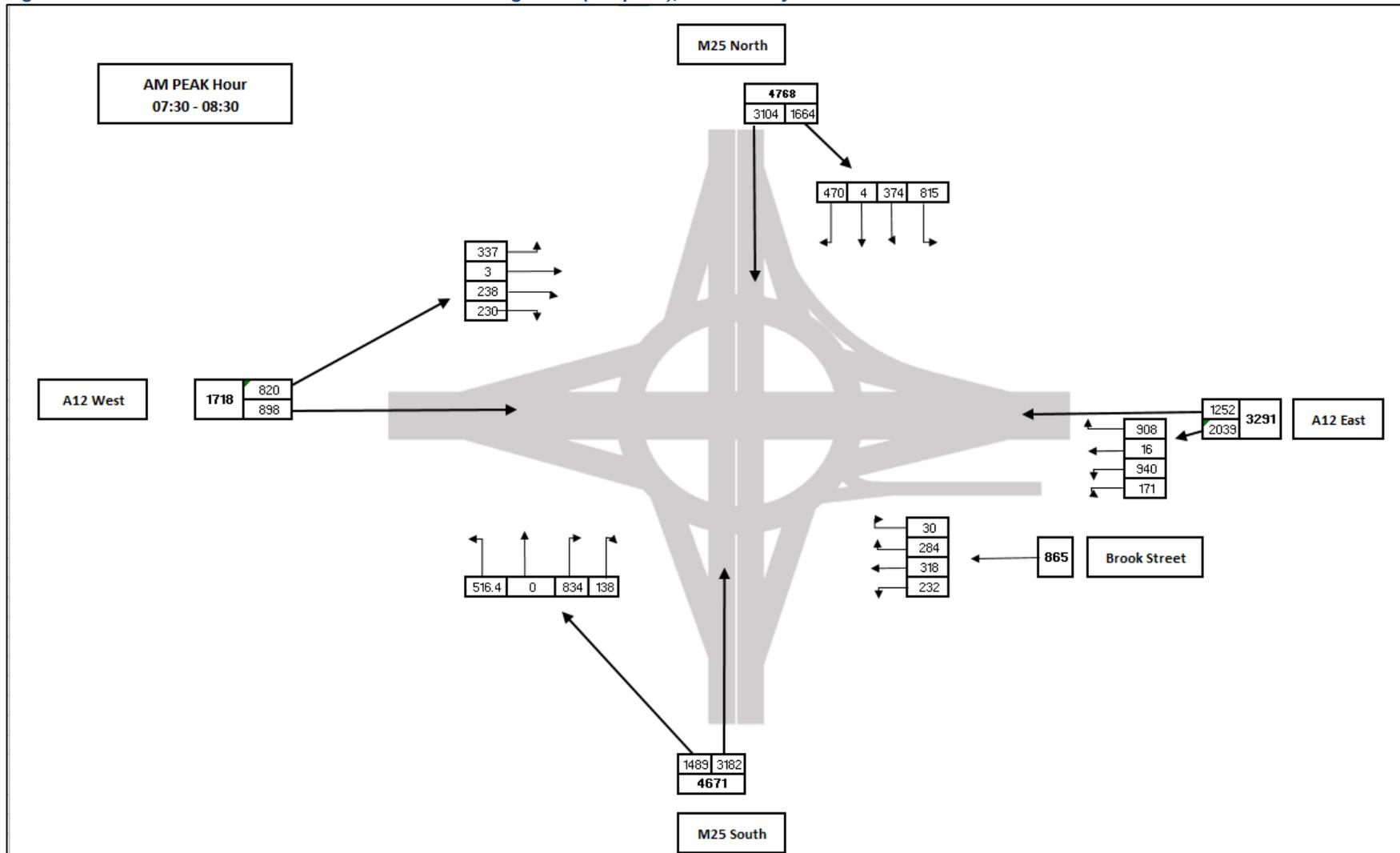
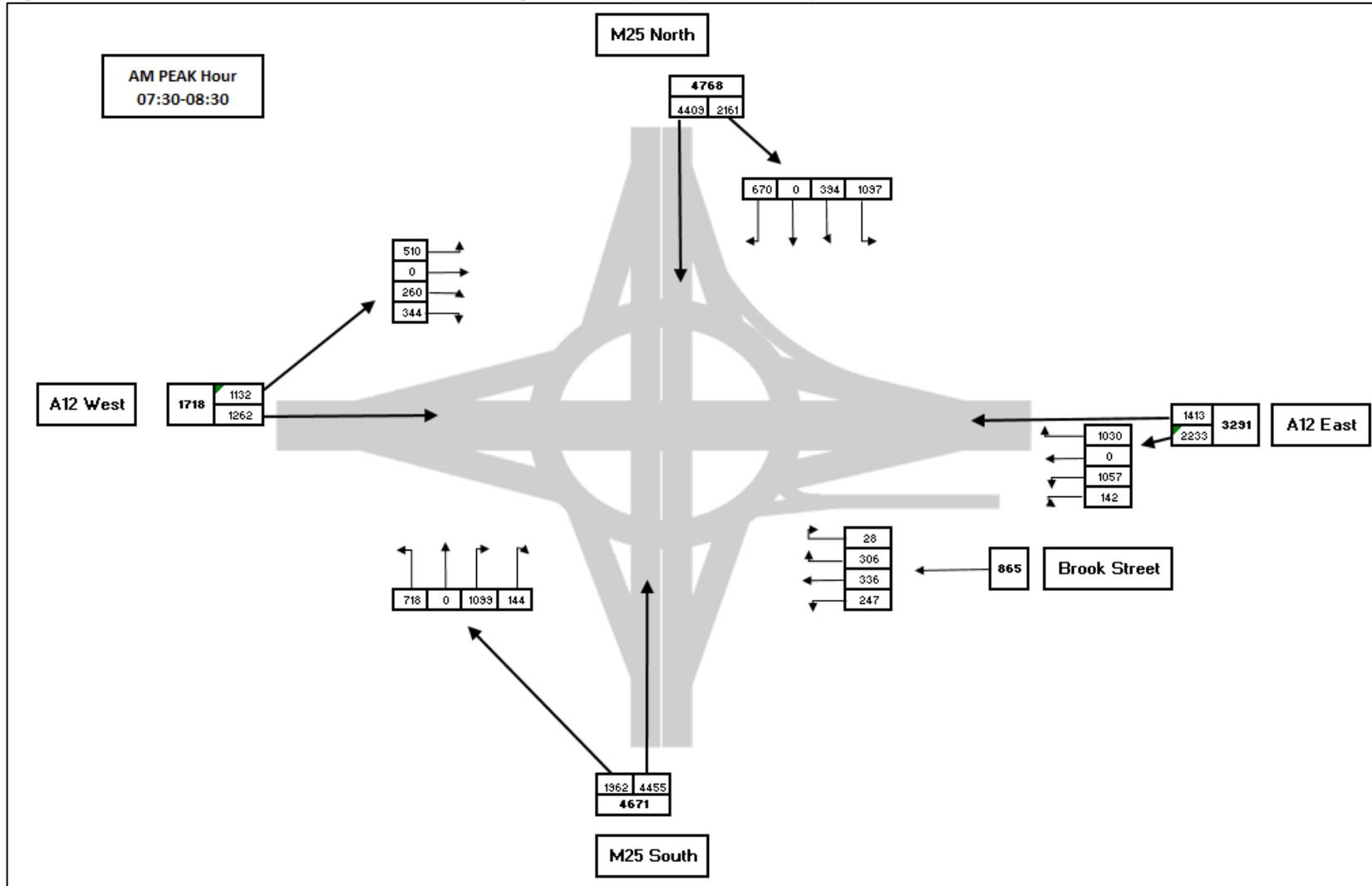


Figure 3-5 M25 Junction 28 - Forecast turning flows (AM peak), 2037 future year



3.3.2 Journey times and congestion

At present motorists currently experience congestion and delays at Junctions 28 during peak travel periods. In the AM and PM peak periods average delays of at up to 94 seconds across all movements on the junction is experienced. During the AM peak hour the total delay time across all movements is currently around 481 hours/hour (Table 3-2).

By 2037 traffic volumes using Junction 28 are expected to increase by around 30%. Without intervention to improve Junction 28 the roundabout section of the junction would operate well above capacity during the peak travel times. All the approaches will have at least one lane/movement which is operating at, or above capacity (that is with a degree of saturation >100%). As a result, during the AM peak hours the total delay time cumulative across all movements is predicted to increase from just under 500 hours/hour at present to over 1500 hours/hour by 2037. Similarly average delays per trip in 2037 is forecast to approximately double that currently experienced, increasing to around 230 seconds (four minutes) in the AM peak hour.

Several of the circulatory lanes are predicted to develop queues considerably longer than the available queue storage on these lanes. This will result in blocking back throughout the roundabout circulatory carriageway.

Conditions in the PM peak are similarly forecast to operate above the practical capacity of 90% degree of saturation. Average vehicle delays are predicted to be more than double by 2037 to 234 seconds. Total delay time in 2037 will also increase more than three times from 464 hours/hour at present to over 1500 hours/hour. Similarly total journey times are predicted to increase in both the AM and PM peak hours.

A high level and indicative link flow / capacity analysis (drawing upon TRL Report RR67) was undertaken for the key approaches to M25 Junction 28 (Table 3-3). The flow/capacity ratios indicate that the off-slip road approaches to Junction 28 are operating close to, or over capacity for all time periods, whilst the A12 approaches appear to have some spare capacity. As stated this is an indicative assessment at this stage to sense check the data. As such it indicates that there are several capacity issues at the junction that are expected to deteriorate in the future without intervention.

Table 3-2 Network performance summary

Parameter	AM Peak		PM Peak	
	2014 Base	2037 DM	2014 Base	2037 DM
Total Travel Time (Hours)	2,720	4,426	2,780	4,272
Avg. Delay (Sec)	94	227	88	234
Total Delay (Hours)	481	1,543	464	1,526

Table 3-3 Link capacity assessment for M25 Junction 28 – 2014 base year

Link	Lanes	Approximate saturation flow (RR67)	Modelled time period	Signal green time (% cycle time)	Theoretical capacity	Base year traffic flows	Ratio of flow / capacity
M25 North Off - Slip	3	5,700	AM	22	1,235	1,730	1.40
			IP	20	1,140	1,930	1.69
			PM	20	1,140	2,372	2.08
A12 East Off - Slip	4	7,600	AM	40	3,040	2,274	0.75
			IP	38	2,913	1,583	0.54
			PM	38	2,913	1,702	0.58
M25 South Off - Slip	4	7,600	AM	25	1,900	1,583	0.83
			IP	23	1,773	1,350	0.76
			PM	25	1,900	1,700	0.89
A12 West Off - Slip	3	5,700	AM	18	1,045	882	0.84
			IP	15	855	752	0.88
			PM	15	855	905	1.06

3.4 Accidents and journey time reliability

3.4.1 Accidents

Current records of accidents show that between 2010 and 2015 there have been 28 accidents reported at Junction 28 (that is on the roundabout and the adjoining slip roads and M25 merge/diverge areas). This figure does not include damage only collisions. The 28 accidents have resulted in 34 casualties of which 30 were slight injuries (90%); the level of killed and serious injury (KSIs) is low with less than 1 KSI each year. Hence the safety problem is more concerned with the high occurrence of incidents (90% slight injury plus damage only) and the implications of these on the disruption across the wider highway network, as well as harm and injury. A large proportion of these accidents have taken place at the point where the A1023 Brook Street approaches the roundabout.

Recent safety reviews (2014) of the junction have highlighted that there are inconsistencies in the signing and the lane designations on the roundabout, which in turn result in confusion and conflicting traffic movements. A number of issues identified in earlier Stage 1/2A safety audits are still outstanding. In particular the safety review of the M25 Junction 28 has highlighted:

- inconsistencies in the signing and the lane destinations/designations on the roundabout results in conflicting traffic movements
- the un-signalised A1023 Brook Street approach is identified as an accident hotspot as drivers are opposed by four traffic lanes on the circulatory.

3.4.2 Journey time reliability

With high demand for using Junction 28 and the increasing levels of traffic predicted for the future, the ability of Junction 28 to be resilient to unplanned events is poor (for example, crashes, breakdowns, weather events and road maintenance/road works). As traffic volumes increase closer to capacity in peak conditions the greater the potential variation in travel times can be, and the more difficult it gets for users to predict delays and variability. In addition, the risk and rate of accidents and injuries also contributes to the resilience issues and the resulting variability in journey times.

Available incident data for the M25 Junction 28 suggests that a significant accident or incident (e.g. breakdown) occurs on the junction at least once a month having significant traffic implications. In such events traffic flows breakdown through the roundabout section, as well as along the exit ramps from the M25 and A12 carriageways, with queued vehicles often blocking back on to the main carriageways themselves. Delays of up to an hour can be expected with several miles of queued traffic along both the A12 and M25.

3.5 Topography, land use, property and industry

Junction 28 lies in a natural hollow to the west of Brentwood. To the north east of the junction the land rises steadily from approximately 35m above ordnance datum (AOD) to over 100m at Weald Country Park approximately 2km to the north of the junction. The M25 cuts into the western face of the hillside.

To the north west of the junction the land falls towards Weald Brook, before rising towards Harold Hill on a slope which is parallel to the M25. South of the junction the land rises on a shallower gradient which is parallel to the A12.

Weald Brook (which is designated as a Main River) runs along a north-south axis on the western side of the junction. This brook flows into the River Ingrebourne just to the north of the A12 and marks a low point in the local topography. A second brook runs along an east-west axis adjacent to the southern boundary of the A12 before crossing to the northern side of the A12 approximately 500m to the east of Junction 28. It runs adjacent the northern highway boundary of the A12, crossing under the interchange in a culvert emerging to the west of the junction before flowing into Weald Brook.

3.5.1 Agricultural land

Areas of agricultural land affected by the scheme are classified Grade 3 (good to moderate) in accordance with Defra's agricultural land classification⁵. To the south of the junction the current land use is predominately arable. To the north of the junction the junction is flanked by the Maylands Golf Course to the north-west, buffered by areas of land which are currently fallow or woodland. To the east the land is primarily fallow with intermittent woodland, including an area of ancient woodland (Vicarage Wood) between the A12 and Wigley Bush Lane.

3.5.2 Residential properties

The junction sits between the conurbations of Brentwood to the east and the London Borough of Havering to the west. Whilst the main built up areas are separated from the junction area by green fields, there are businesses that abut Brook Street, Brentwood that are in close proximity to the south east of the junction.

⁵ Natural England. 2010. Agricultural Land Classification map London and the South East.

There is a small community of some 35 residential properties fronting Nags Head Lane, sited between Nags Head Lane and the mainline railway, on both sides of the M25 motorway.

To the north west of the junction there is a residential property associated with a small complex of businesses which occupy land immediately adjacent to the M25 north on-slip road. In deed access to the site is achieved via the M25 north Organic on-slip road with egress via the A12 west off-slip road.

Whilst there are few properties to the north-east of the junction, Frenches Organic Farm is located approximate 300m north of the A12 adjacent to Wigley Bush Lane and Weald Hall (equestrian) abuts the north side of Weald Park Way with an entrance joining Wigley Bush Lane. There are 4 residential properties adjacent to the east side of Weald Park Lane to the eastern extent of the study area.

3.5.3 Community land

No community land has been identified in the area of interest.

3.6 Climate

Brentwood lies in the Eastern England climate zone, which is typified by an altitude which is generally less than 60m and covers Bedfordshire, Cambridgeshire, Norfolk, Suffolk, Lincolnshire the East Riding of Yorkshire and parts of Essex and Hertfordshire.

Climate information is available from Meteorological Office data averaged over a 30 year period from 1981 to 2010. The average annual rainfall is 571.3mm per annum, peaking in October with a monthly average of 64.9mm. Annual average sunshine is 1600 hours per annum ranging from 209 hours in July to less than 49 hours in December. Average temperatures range from an average maximum of 22.2°C in July and August, to an average minimum of 1.6°C in December.

3.7 Drainage

3.7.1 Existing drainage

As-built drainage data for the M25 provided by Connect Plus Services (the Area 5 DBFO contractor) was incomplete. This assessment of the existing drainage was therefore undertaken based primarily on information available from Google Street View, from as built drainage information for the A12 from Area 6 and by applying engineering judgement.

South of Junction 28 the existing road drainage on the M25 anti-clockwise comprises linear drainage channels with an assumed carrier drain system to the nearside. On the immediate approach to the viaduct over Junction 28, drainage is by means of a kerb and gully system to the nearside. On the southern end of the viaduct surface water flows along the channel to the south with offset gullies which appear to be intended to control the flow width in the channel. The carriageway crossfall changes over the viaduct with drainage provided to the offside using a combined kerb drainage system. Beyond the viaduct there is a linear drainage channel to the offside.

North of the Junction 28 the existing drainage on the M25 clockwise is similar to M25 anti-clockwise comprising a linear drainage channel to the offside.

On the immediate approach to the M25 viaduct there is a kerb and gully system, however, at the northern end of the viaduct surface water flows along the channel to the north with offset gullies which appear to be intended to control the flow width in the channel. The carriageway crossfall changes over the viaduct with drainage provided to the offside using a combined kerb drainage system. Beyond the viaduct there is a linear drainage channel to the offside.

The A12 eastbound carriageway has a kerb and gully system which changes to a kerb outlet system running under the interchange. East of the interchange there is a combined kerb drainage system to the near side which changes to a surface water channel immediately to the west of Wigley Bush Lane Bridge.

The A12 westbound carriageway, east of Wigley Bush Lane Bridge, has a surface water channel to the offside which is replaced by a slotted linear drainage channel. In the vicinity of the A12 westbound off-slip road the crossfall of the carriageway changes with drainage facilitated by a system of kerb outlet drains which continue through the junction and beyond on both sides of the carriageway depending on the crossfall.

The slip roads to Junction 28 are primarily kerb and gully or kerb outlet systems except for the M25 clockwise off-slip road which appears to have “over the edge” drainage into an adjacent filter/carrier drain.

3.7.2 Existing outfalls

There are four relevant outfalls adjacent to the M25 anti-clockwise carriageway. The first is 900m south of Nags Head Lane Bridge, however the discharge point is not obvious from available data. There is a pollution control device which is assumed to be an oil interceptor. This is assumed to be the southern extent of the impermeable catchment area of the anti-clockwise carriageway draining to Junction 28. The next discharge point is adjacent to the M25 anti-clockwise off-slip road near to Junction 28 roundabout. There is a surface water attenuation pond immediately west of the M25 and north of the railway and it is assumed that the run-off from this outfall is attenuated via the pond. The third outfall is 900m north of the junction and is assumed to discharge into Weald Brook via a pollution control device. This is assumed to mark the northern boundary of the impermeable catchment area of the anti-clockwise carriageway discharging to Junction 28. The fourth discharge point is adjacent to the M25 anti-clockwise on-slip road near to the roundabout. It is assumed that this discharges into the watercourse that runs westwards along the northern boundary of the A12 before joining Weald Brook and flowing into Ingrebourne River.

There are three relevant discharge points adjacent to the M25 clockwise carriageway which are 650m and 280m north of the junction and adjacent to the M25 clockwise to Junction 28 slip road. It is assumed that here outfalls discharge to local watercourses which in turn discharges into the watercourse which runs westwards along the northern boundary of the A12 passing under the junction through Grove Culvert.

The A12 west of the junction falls locally towards Junction 28. A 300mm diameter filter drain on the north side of the corridor discharges into Weald Brook/Ingrebourne River at Putwell Bridge on the north side. A 300mm diameter carrier drain on the south side of the corridor also discharges eastwards into the Ingrebourne River. A 525mm diameter carrier drain in the central reserve runs from the east towards Putwell Bridge, crossing the carriageway to the south and is then assumed to also discharge into the Ingrebourne River via a pollution control device.

Surface water from the A12 east is intercepted at the Westbrook Culvert where a 525mm diameter surface water sewer in the central reservation discharges into the culvert. In addition, 225mm diameter filter drains also discharge directly into the culvert. The surface water is then believed to flow along the watercourse which runs westwards along the northern boundary of the A12. A further outfall at the nosing of the Junction 28 east facing slip roads discharges into the same watercourse via a 375mm diameter surface water sewer.

3.7.3 Culverts

There are a number of existing culverts in the immediate vicinity of the junction as identified in Table 3.4. In particular there are a number of significant culverts which carry Weald

Brook, Ingrebourne River and other major watercourses under the various arms of the junction and under the circulatory carriageway.

Table 3-4 Summary of existing culverts

Reference	Name / description	ID	Type	Date	Description
/M25//172.60/Q/3	Anti-clockwise Toe Pipe – MP172/6	30688	Small span structure	Apr-2011	
/A12//18.60/Q/	Grove Culvert	5779	Small span structure	Jan-1965	159m long 6m x 2.9m twin rectangular culvert parallel to north verge of the A12 carrying watercourse through Junction 28
/A12//18.30//	Putwell Bridge	5778	Bridge and large culvert	Jan-1965	50m long carrying Weald Brook/Ingrebourne River under the M25 to the east of the junction
/M25//171.30/Q/5	Anti-clockwise Verge Pipe- MP171/3	30694	Small span structure	Apr-2011	
/M25//171.30/Q/	Weald Brook Culvert No 3	13288	Bridge and large culvert	Jan-1982	44m long 6m x 3.8m rectangular culvert carrying Weald Brook under the M25 900m north of the junction.
28/M25//171.90/Q/	Clockwise Verge Pipe – MP171/9	30696	Small span structure	Apr-2011	
28/M25//172.0/Q/1	Anti-clockwise Verge Pipe – MP172/0	30695	Small span structure	Apr-2011	
/A12//19.30/Q/	Westbrook	5782	Bridge and large culvert	Jan-1965	51m long 4.5m x 2.5m rectangular culvert crossing the A12 to the west of Wigley Bush Road Bridge (Vicarage Bridge)
/A12//19.50/Q/	Eastbrook Culvert	5783	Small span structure	Jan-1965	68m long 6.3m x 2.4m twin rectangular culvert carrying the watercourse under Wigley Bush Road on the south side of the A12.

3.7.4 Drainage assets condition

The Highways Agency Drainage Data Management System (HADDMS) database provides limited information on the condition of the existing drainage assets. Based on the available conditional information parts of the existing drainage networks on the M25 will require defect rectification. The information on life expectancy of the network assets has been requested from Connect Plus Services; a response is awaited. Drainage remedial work was undertaken on the A12 network in 2000.

3.7.5 Flood risk

The corridor defined by Weald Brook and the major watercourse that runs parallel and immediately to the north of the A12 have been assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) over an average width of 75m (Environment Agency Flood Zone 3). The corridor defined by Ingrebourne River south of the A12 has been assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%) over a similar width (Environment Agency Flood Zone 2). Further investigation will need to be undertaken with appropriate mitigation/protection measures developed.

3.7.6 Further information required

The following information is required in order to confirm the suitability of the existing assets:

- Flood risk assessment
- CCTV survey to confirm the condition of drainage assets
- Catchment modelling to facilitate ongoing design.

3.8 Geology

This section of the TAR summarises the existing geological, geotechnical and geo-environmental conditions of relevance to the proposed options.

3.8.1 Baseline information

Baseline information was gathered from the available sources listed below. However, no assurance is given as to their accuracy. As such, it should be noted that the desk based assessment is indicative only at this stage and is pending the findings of a future geotechnical investigation:

- Atkins, Road Investment Strategy, M25 Junction 28 Improvements, PCF Stage 0 Appraisal Specification Report, 8 March 2016
- British Geological Survey (BGS), 'Borehole Scans' (Online) <http://www.bgs.ac.uk/data/boreholescans/home.html> (accessed 19 May 2016)
- BGS, England and Wales Sheet 257, Romford, Solid and Drift Geology, 1:50,000, 1996
- BGS, Essex Mineral Resources Map (Online) <https://www.bgs.ac.uk/downloads/start.cfm?id=2568> (accessed 15 August 2016).
- BGS, 'Geology of Britain Viewer' 1:50,000 (Online) <http://mapapps.bgs.ac.uk/geologyofbritain/home.html> (accessed 19 May 2016)
- BGS, 'Lexicon' (Online) <http://www.bgs.ac.uk/lexicon/> (accessed 19 May 2016)
- BGS, 'Mining Access Portal' (Online) <http://mapapps2.bgs.ac.uk/mineplans/home.html> (accessed 19 May 2016)
- BGS, 'Onshore Geoindex' (Online) <http://mapapps2.bgs.ac.uk/geoindex/home.html> (accessed 19 May 2016)
- Coal Authority & BGS, 'Coal Authority Interactive Map' (Online) <http://mapapps2.bgs.ac.uk/coalauthority/home.html> (accessed 15 August 2016)

- Connect Plus Services (CPS) Sample Approach – Geotechnical Asset, Annex A – Geotechnical Asset Condition Methodology, June 2011
- Envirocheck Report, purchased on 13 June 2016
- Environment Agency, 'What's In Your Backyard' (Online) <http://apps.environment-agency.gov.uk/wiyby/> (accessed 19 May 2016)
- GeoEssex, 'GeoEssex' (Online) <http://www.geoessex.org.uk/> (accessed on 15 August 2016)
- Highways Agency, Design Manual for Roads and Bridges (DMRB), Volume 4 Geotechnics and Drainage, Section 1 Earthworks, Part 3, HD 41/03, Maintenance of Highway Geotechnical Assets 2003
- Highways England, DMRB, Volume 4 Geotechnics and Drainage, Section 1 Earthworks, Part 3, HD 41/15, Maintenance of Highway Geotechnical Assets 2015
- Highways England, Highways Agency Geotechnical Database Management System (HAGDMS) V5.12.0 (Online) <http://www.hagdms.co.uk/> (accessed 15 August 2016)
- Natural England, 'MAGIC Interactive Mapping' (Online) <http://magic.defra.gov.uk/MagicMap.aspx> (accessed 19 May 2016)
- Ordnance Survey, Southend-on-Sea & Basildon, Brent wood & Billericay. Explorer Edition 175, 1:25,000, 2015
- Zetica, 'UXB Risk Maps' (Online) http://www.zetica.com/uxb_downloads.htm (accessed 19 May 2016).

3.8.2 Geology

The proposed scheme is located within the London Basin, to the north of the northeast-southwest trending London Basin Syncline. No faults are mapped within the proposed scheme.

Made ground is expected to be associated with construction of the M25 and A12, in particular, forming the embankments on which the network is built upon. Made ground is also expected to be present within the historical landfill site detailed below, and infilled ponds within the study area.

Alluvium and head deposits, associated with Ingrebourne River and Weald Brook, are mapped directly beneath the A12 in a southwest-northeast orientation, the M25 Junction 28 and south of the M25 Junction 28. Alluvium and head deposits are also mapped in a north-south orientation approximately 200m west of the M25. Alluvium and head deposits are expected to be present across a majority of all the options within the proposed scheme.

Bedrock geology is anticipated to comprise London Clay Formation of the Thames Group. The Claygate Member forms the uppermost beds of the London Clay Formation and is anticipated to be present approximately 300m north of the M25 Junction 28.

A summary of the anticipated geology within the proposed scheme is shown in Table 3-5.

3.8.3 Site history

The historical maps available from Envirocheck dated from 1868 to 2016 and are summarised for the proposed scheme in Table 3.6.

Environmental datasheets, taken from the site specific Envirocheck Report presented as Appendix C, identified the following features and land uses which historical maps did not reveal:

- An unknown heap located 782m to the north-west
- Infilled ponds located 277m east, 302m north-west, 335m north-east and 357m to the north-west
- An historical landfill site located immediately north-west of Junction 28 which ceased receiving waste in 1983
- An historical swimming pool service company operating between Brook Street and the A12 approximately 450m to the northeast of the centre of the Junction 28 roundabout
- An MOT service and repair centre 189m to the south
- Air conditioning and refrigeration contractors 752m to the west
- A gas pipeline which passes through the study area, running approximately parallel to the M25 about 300m to the north-east.

3.8.4 Hydrogeology

The Environment Agency records the geological units within the proposed scheme with the following aquifer classifications:

- Alluvium – Secondary A Aquifer (Superficial)
- Head Deposits – Secondary Undifferentiated Aquifer (Superficial)
- Claygate Member – Secondary A Aquifer (Bedrock)
- London Clay Formation – None (unproductive stratum).

The Environment Agency defines a Secondary A Aquifer as “*permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers*”. A Secondary Undifferentiated Aquifer is defined as “*cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type*”.

There are no groundwater abstractions or groundwater Source Protection Zones (SPZs) located within the proposed scheme.

The site is not subject to tidal influence.

Two exploratory hole records within the proposed scheme have recorded groundwater at 3.2m below ground level (bgl) (TQ59SE138) and 5.2m bgl (TQ59SE363). The depth of groundwater throughout the proposed scheme, particularly in close proximity to the Weald Brook, should be confirmed during the ground investigation and reported on in the GIR.

Table 3-5 *Summary of anticipated geology*

Type	Period	Group	Formation	Member	Thickness (m)	BGS Lexicon and Environment Agency Description
Artificial Ground	-	-	-	Made Ground	0 – 4.2 (unknown for historical landfill site)	Man-made superficial deposit with variable composition on natural ground surface. Made Ground is expected to be associated with the construction of the M25 and A12, historical landfill sites and infilled ground. Anticipated to comprise reworked London Clay Formation, reworked Head Deposits or imported granular material for the M25, A12 and infilled ground. Historical landfill site is likely to comprise inert waste which remains largely unaltered once buried such as concrete, bricks, tiles, soil, stones and glass.
Superficial	Quaternary	Fluvial Deposits	Alluvium	-	0 – 2.7	Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present.
		Mass Movement Deposits	Head Deposits	-	0 – 3	Gravel, sand and clay depending on upslope source and distance from source. Poorly sorted and poorly stratified deposits formed mostly by solifluction and/or hillwash and soil creep. Essentially comprises sand and gravel, locally with lenses of silt, clay or peat and organic material.
Bedrock	Paleogene	Thames Group	London Clay Formation	Claygate Member	0 – 10	Mainly comprises dark grey clays with sand laminae, passing up into thin alternations of clays, silts and finegrained sand, with beds of bioturbated silt. Ferruginous concretions and septarian nodules occur in places.
				-	30+ (base unproven)	Mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. Commonly contains thin courses of carbonate concretions ('cementstone nodules') and disseminated pyrite. It also includes a few thin beds of shells and fine sand partings or pockets of sand, which commonly increase towards the base and towards the top of the formation. At the base, and at some other levels, thin beds of black rounded flint gravel occurs in places. Glauconite is present in some of the sands and in some clay beds, and white mica occurs at some levels.

Table 3-6 *Summary of site history within 250m of the proposed scheme*

Date	Summary of site history (within 250m of the proposed scheme)
1868	An unnamed road which follows a similar alignment to the current day A12 is mapped to the west of the current day M25 Junction 28 only. The site and surrounding land is situated amongst open fields except for the area to the north of the site which is occupied by Alder Wood and Lower Vicarage Wood. Brook Street is a small village approximately 1km to the north-east of the location currently occupied by M25 Junction 28 of the M25. Development within the village includes residential properties, a farm, a public inn and a hospital. The railway line is mapped in its current configuration and is identified as the Great Eastern Railway. There are three large ponds located 800m to the south-east from the location of M25 Junction 28. Boyles Court is a large estate situated approximately 900m south-east from the location of M25 Junction 28 and Boyles Court Farm is located immediately south of the estate. An unnamed road which follows a similar alignment to the current day Colchester Road is mapped.

Date	Summary of site history (within 250m of the proposed scheme)
1872	Weald Brook is mapped in its current alignment, joining Ingrebourne River where the watercourse passes under the current A12. Mapping identifies that Putwell Bridge supports the road over the river. Three ponds are situated within 250m of the centre of M25 Junction 28; two located approximately 200m to the north-west in open fields (one situated within the current extents of the M25 main carriageway) and one located approximately 100m south-east of Putwell Bridge. Putwell Farm is situated immediately south of M25 Junction 28 in its current location. The Poplars is situated immediately south-east of the junction and the Grove (woodland) is situated immediately to the north-west. A windmill is located 100m to the north-east of the Poplars.
1896	No significant change.
1898	Brentwood Sewage Works is located approximately 300m to the south-west from the centre of the current location of M25 Junction 28.
1920	The unnamed road (currently Colchester Road) is mapped as a Roman Road. Old filter beds are located approximately 100m to the south-west from the location of M25 Junction 28; alongside Nag's Head Lane and close to Brentwood sewage works (now named sewage works). The sewage works development has increased in size and now comprises at least 10 tanks and some new filter beds. The aforementioned windmill is no longer shown on the maps.
1938	The railway line is identified as the London and North Eastern Railway. Minor residential development of Harold Park is evident (approximately 1km south-west of M25 Junction 28).
1961	The Roman Road is identified as Brook Street north of M25 Junction 28 location and as Colchester Road to the south. Significant residential development has occurred, namely in and around Brook Street and Harold Park and alongside Nag's Head Lane. A reservoir is present south-east from the current location of M25 Junction 28 and approximately 130m to the east of the location currently occupied by the M25. A coal yard and garage now operate in the village of Brook Street.
1968	A roundabout has been constructed at the current location of M25 Junction 28; significant earthwork construction has been undertaken to develop what appears to be an elevated roundabout. The A12 to the east of the current day M25 Junction 28 has been constructed in a southwest-northeast orientation bordering the north of Brentwood. The Brook Street/Colchester Road follows the current day alignment. The road has seen structural changes and is raised on embankment. An electricity substation is located immediately east of M25 Junction 28.
1973	No significant change.
1978	A hotel has been constructed on the northern side of Brook Street which has an electricity substation within the grounds. This is 300m to the east of the junction.
1984	The M25 has been constructed in its current configuration, with the embankment extents some 60m either side of the motorway and the roundabout has been modified to accommodate the link between the M25 and A12. The two ponds situated approximately 200m north-west of M25 Junction 28 are no longer mapped (the M25 main carriageway has been built over one of them). A garage is located north of Brook Street and close to the Colchester Road roundabout. The M25 has been constructed beneath the railway line south of M25 Junction 28.
1986	A filling station is shown immediately west of Putwell Bridge and on the southern side of Colchester Road.
1999	Drains and hydrological features have been clearly mapped, in particular, the drains and watercourses that cross the A12, M25 and M25 Junction 28.
2006	No significant change.
2016	No significant change.

3.8.5 Historic landfill sites

The Environment Agency 'What's In Your Backyard' website records one historical landfill site within 500m of the proposed scheme. The Brook Street historical landfill site is located approximately 50m northwest of the existing M25 Junction 28 and the extent of the landfill site is coincident with the M25. The historical landfill site last received waste in August 1983 and is likely to comprise inert waste which remains largely unaltered once buried such as glass, concrete, bricks, tiles, soil and stones.

The historical landfill site poses several risks to the scheme including the presence of made ground, contamination and potential instability/subsidence. It should be noted that earthworks in the vicinity of historical landfill sites may be susceptible to leachate infiltration. Works in the areas involving the installation of sheet pile walls or gantry piles could experience excessive corrosion and/or groundwater contamination due to the highly aggressive nature of the historical landfill site. The impact of the historical landfill site on the proposed scheme should be considered in more detail in the Preliminary Sources Study Report during Stage 2.

3.8.6 Maintenance records

A preliminary review of HAGDMS undertaken on 19 May 2016 identified 38 earthworks within the proposed scheme and within close proximity on the M25 and A12. Earthwork records, and therefore any potential existing defects, are not available on HAGDMS for the A12 immediately west of the M25 Junction 28. It is likely that the earthworks are inspected and maintained by the Havering London Borough Council. An assessment of the condition of the earthworks and any potential existing defects cannot be made at this stage, however, they will be assessed during the Preliminary Sources Study.

The condition of the earthworks are classified as "A – As New", "B – More than Satisfactory" or "C – Satisfactory" based on the classification of the worst case feature class. The earthwork condition has been classified in accordance with Schedule 14 of the M25 DBFO contract with Connect Plus Services. No condition classifications have been applied to the earthworks on the A12 east of the M25 Junction 28 in Area 6 as the Schedule 14 only applies to Area 5.

The number of features per class and the feature description recorded within the 38 earthworks on the M25 Junction 28 and A12 are as follows:

- One Feature Class 1A "Major defects", comprising a major soil slip. The major soil slip was first recorded in May 2006 as 20m wide with a 1m high backscarp. Subsequent inspections in May 2010, February 2015 and November 2015 have noted that the major soil slip has not deteriorated
- Seven Feature Class 1D "Minor defects", comprising minor soil slips, tension cracks and slope washout
- One Feature Class 2 "At Risk areas" comprising extensive animal burrowing
- Nil Feature Class 3 "At Risk Repaired areas".

Table 3-7 defines the assessment of the features from Highways England's standards HD 41/15. The defect and at risk features have been recorded in accordance to the former Highways Agency's 2003 standards HD 41/03. Since July 2015, the HD 41/03 document has been superseded by Highways England's standards HD 41/15. The notes shown in Table 6.1 of HD41/15 summarise the changes in feature class classifications between HD 41/03 and HD 41/15.

It may be possible that new features have occurred or existing features have developed since the previous inspections on the M25 and A12 east, in addition to the A12 immediately west of Junction 28, where there are no inspections available on HAGDMS. Therefore, it is

recommended that initial and repeat inspections should be undertaken in accordance with HD 41/15, within the area of the proposed scheme prior to production of the GIR.

3.9 Mining

The proposed scheme is not located in an area affected by mining or quarrying based upon a review of the Coal Authority & BGS Interactive Map, the BGS Mining Access Portal and the BGS Essex Mineral Resources Map.

3.9.1 Geological SSSI

There are no geological SSSI's or Regionally Important Geological Sites (RIGS) / Local Geological Sites located within 500m of the proposed scheme, according to Natural England's MAGIC Interactive Mapping and GeoEssex. The nearest geological SSSI is Thorndon Country Park located approximately 2km southeast of the proposed scheme.

In summary, no further consideration of special geological features is required for any of the options for the proposed scheme.

Table 3-7 *Example of geotechnical feature assessment and classes*

Class	Description of feature	Examples of features
Class 1: Visible defects		
1A	Major defects.	<ul style="list-style-type: none"> • A slip greater than ½ height of a major earthwork. • A rock fall involving large boulder-size* blocks of rock or greater than 1m³ volume of rock debris.
1D	Minor defects.	<ul style="list-style-type: none"> • Defects other than Major defects.
Class 2: Likely defects		
2	At Risk areas. Assessment may be based on available information (maps, historical reports, behaviour of similar assets, etc.) and or visual inspection.	<ul style="list-style-type: none"> • An asset overlying an area of mining activity where no mitigation measures were carried out during construction or where mitigation measures have deteriorated. • An area of sidelong natural or made ground subject to historical slope movement. • Animal burrows.
Class 3: Areas of repair		
3	At Risk Repaired areas. Sections of geotechnical assets where defects have been repaired or where preventative works have been undertaken to prevent deterioration of areas considered to be at risk. This class does not apply to areas that have been reinforced as part of a widening or improvement project.	<ul style="list-style-type: none"> • Granular slope replacement of a failed cutting. • Areas of remedial slope drains. • Areas of remedial mine filling. • Areas of remedial rock bolting. • Areas of bio-engineering.

Notes:

Class 1B and 1C as used in HD 41/03 have been consolidated into Class 1A.

Class 2A and 2B as used in HD 41/03 have been consolidated into Class 2.

Class 3A, 3B and 3C as used in HD 41/03 have been consolidated into Classes 2 and 3.

*Large boulder is particle of diameter greater than 600mm, approx.

3.10 Public utilities

3.10.1 General

Information has been obtained from Statutory Undertakers under the New Roads and Street Works Act 1991 (NRSWA). To date the C2 and C3 procedures have been adhered to, which the Design Manual for Roads and Bridges (DMRB), SA 10/05 defines and articulates the purpose as:

- **C2 – Scheme identification and preliminary inquiries.** During the Scheme Identification Study, the Project Sponsor or the Overseeing Organisation's appointed representative should seek from Undertakers details of their apparatus within the specific section of the maintainable highway or public road which is being considered for alteration or improvement without making any commitment to the scheme. Undertakers should provide such information as they have available from records and draw attention to any likely special problems which could arise from the Overseeing Organisation's proposed scheme.
- **C3 – Budget Estimate.** During preparation of the TAR, the Overseeing Organisation's appointed representative should follow up the preliminary inquiries and submit details of the proposed scheme options to the Undertakers using standard letter NRSWA/C3.1. The Overseeing Organisation's appointed representative should also enclose pro forma NRSWA/C3.2 for completion by the Undertaker. Separate proposals and budget estimates should be requested for each alternative route identified.

Details which have been provided to date regarding the C3 Budget Estimate are articulated in the Statutory Undertakers Estimate product also produced at this Project Control Framework stage. Details which were provided at the C2 stage have been assimilated into one composite utility drawing, which can be found in Appendix D and the known utilities are as geographically located as below.

3.10.2 M25 mainline

The following utilities companies have identified their infrastructure in proximity of the existing M25 motorway corridor:

- Genesys
- Essex & Suffolk Water
- National Grid
- UK Power Networks
- Thames Water
- British Pipeline Agency.

3.10.3 M25 Junction 28 circulatory and slip roads

The following utilities companies have identified their infrastructure in proximity of the Junction 28 roundabout and slip roads:

- Openreach British Telecommunication
- Essex & Suffolk Water
- National Grid

- UK Power Networks
- Thames Water
- Telent
- Virgin Media.

3.10.4 A12 corridor

The following utilities companies have identified their infrastructure along the A12 in the proximity of the scheme:

- Openreach British Telecommunication
- Essex & Suffolk Water
- National Grid
- UK Power Networks
- Telent
- Virgin Media.

3.10.5 Surrounding fields

Public utilities also exist in the nearby fields surrounding Junction 28, away from the main A12 and M25 corridors. These are identified in Table 3-8, and graphically in the composite utility plans in Appendix D.

Table 3-8 Summary of statutory undertaker utilities in surrounding fields

Utility company	Infrastructure	Geographic reference			
		North-eastern quadrant	South-eastern quadrant	South-western quadrant	North-western quadrant
Openreach British Telecommunication	Overhead plant			✓	✓
Essex & Suffolk Water	Water main		✓		✓
National Grid	Overhead transmission cables			✓	✓
	National high pressure gas	✓	✓		
	Local high pressure gas			✓	✓
	Medium pressure gas		✓		
	Low pressure gas		✓		
UK Power Network	Overhead plant				✓
	Underground plant			✓	
British Pipeline Agency	High pressure pipeline			✓	✓
Thames Water	Foul sewage		✓	✓	

3.11 Environmental status

M25 Junction 28 is within a predominantly rural setting in a narrow strip of greenbelt between the edge of the settlement of Brentwood just to the east and Romford further to the west. Brentwood Borough Council have declared two Air Quality Management Areas (AQMAs); for the eastern half of the junction and for the area near Nags Head Lane to the south. London Borough of Havering has declared a borough wide AQMA which covers much of the area to the west. Defra has recorded elevated NO₂ concentrations on the A12. There are a number of Noise Important Areas within the area. The traffic levels on the M25 and A12 give rise to noise and air quality problems in the area. Changes to flows brought about by the scheme could affect noise or air pollution levels.

There is a Grade II Listed Building, The Nags Head Inn just to the east of the junction on Brook Street, along with two Registered Park and Gardens at Warley Place to the south and Weald Park to the north. There are no designations for landscape quality but there are a number of Ancient Woodlands around the junction. There are two Local Nature Reserves (LNR) to the north west of the junction but no national or internally designated ecological sites. The area surrounding the junction is Grade 3 Agricultural Land Classification (ALC) and there is a former landfill site immediately to the north-west. Two waterbodies cross the site, the Ingrebourne and the Weald Brook which both have associated fluvial flood plains.

3.12 Environment

The conditions presented in the sub-sections below have been derived from the Environmental Study Report (ESR) that was carried out during PCF Stage 1.

3.12.1 Noise

Road traffic noise from the M25 and A12 is the dominant source of ambient noise in the study area. The land use within 600m of Junction 28 is generally agricultural and commercial, with the closest business located 55m from the junction on Brook Street. Maylands Golf Course is located approximately 600m Junction 28.

In terms of noise sensitive receptors, the closest residential area is at Nag's Head Lane, approximately 250m south east from Junction 28. Further residential areas are at Brook Street (600m), Harold Park (800m), and Wigley Bush Lane (850m). These areas are of mixed residential and commercial land use.

There are a number of Noise Important Areas within the study located close to the M25 Junction 28 and along the A12 towards Brentwood; five are within the scheme area extent.. The nearest NIA is immediately adjacent to the junction (approx. 12m) with the four other NIAs approximately 300m to the east, 400m to the south, 800 to the east and 1.1km to the northeast. These are shown on the environmental constraints plan, Appendix B to the Environmental Study Report.

3.12.2 Local air quality

M25 Junction 28 is situated on the boundary of London Borough of Havering with Brentwood Borough Council. London Borough of Havering has declared a borough wide AQMA for NO₂ and PM₁₀. Brentwood Borough Council have declared two AQMAs (for NO₂) within the vicinity of the scheme: for the eastern half of Brook Street roundabout (Junction 28); and 200m to the south (Nags Head Lane crossing). Brentwood Borough Council produced an Air Quality Action Plan (AQAP) in 2008, including proposals to work with the Highways England on integrated demand management and Variable Speed Limits (VSL) on the M25 and A12.

Defra's Pollution Concentration Mapping indicates elevated NO₂ concentrations in the vicinity of the scheme of 40-50 µg/m³ along the A12, and 30-40 µg/m³ on Brook Street.

In terms of sensitive residential receptors, there is a residential development on Nags Head Lane, approximately 250m south from. In addition there are isolated residential receptors within 200 m of the junction located on: Roman Road; The Poplars to the south east (accessed off Brook Street); and at Putwell Bridge Farm, off the westbound on-slip to the A12. Larger residential settlements are located in Brook Street, over 600m to the east and in Harold Park, over 800m west.

3.12.3 Landscape

The junction lies within agricultural land between Romford and Brentwood but is not designated for landscape value although there are two registered parks and gardens and several areas of ancient woodland in the study area. This area is located within National Character Area Profile No.111 Northern Thames Basin. Lower Vicarage Wood lies within the study area as is designated as Ancient Woodland. The junction lies in designated Green Belt.

The following key landscape assets have been identified within a study area and could be affected by the proposed scheme:

- The Lower Vicarage Wood (approximate 300m to the north east) and Vicarage Wood (approximate 780m to the north east) have a status of Ancient and Semi Natural Woodland)
- There is a number of copses and woodland blocks of belts within the study area that aren't protected by designations but are valuable landscape resources
- Visual amenity of sensitive visual receptors within the study area as identified within the assessment report
- There is a group of Ancient and Semi Natural Woodlands, located approximately 1.3km to the north-west and 1.3km to the south west of the junction but no potential direct effects have been identified at this stage.

The main receptors in this area include some of the residential properties at the edges of Romford and Brentwood as well as isolated properties and some sections of the Public Rights of Way (PRoW's). The key visual receptors are:

- *Receptor 1* - Views from open access land including Tyler's Common to the south of Tyler's Hall Farm and open access land near Harold Court
- *Receptor 2* - Views of employees within business parks adjacent to Brook Street near Junction 28 (group receptor)
- *Receptor 3* - Views from residential receptors located to the north of the M25 in South Weald (group receptor) including Lake House, Colmar Farm, Colmar, Park Farm and Halfway House
- *Receptor 4* - Views from residential receptors located on Nag's Head Lane linking Brook Street area with Tyler's Common to the south of Junction 28
- *Receptor 5* - Views from residential receptors located along Dark Lane
- *Receptor 6* - Views from bridleway section that follows the crest of the cutting along the existing M25, close to Dark Lane
- *Receptor 7* - Views from residential receptor Grove Farm near M25 Junction 28
- *Receptor 8* - Views from Maylands Golf Course, located to the north west of Junction 28

- *Receptor 9* - Views from Maylands Cottages and Harold Park to the west of Junction 28
- *Receptor 10* - Views from Oak Farm.

3.12.4 Townscape

Not applicable.

3.12.5 Heritage and historic resources

The study area contains 20 designated heritage assets. In summary, these comprise:

- 1 Scheduled monument
- 1 Grade II* listed building
- 15 Grade II listed buildings
- 1 Grade II registered park and garden
- 2 Conservation areas.

The designated assets are largely grouped within three areas. In the north of the study area a number of listed buildings are located within the village of South Weald, adjacent to Weald Park Registered Park and Garden, while both the village of South Weald and Weald Park themselves are designated Conservation Areas. To the east of the parkland, on the north-eastern edge of the study area lies a univallate hillfort which is a Scheduled Monument. A second small group of listed buildings lies along the A1023 Brook Street, including the Nags Head Inn, the sole Grade II* listed building within the study area. A final trio of listed structures is grouped at Boyles Court Farm in the south of the study area. The study area contains 39 non-designated assets. These non-designated assets are of low or negligible value. The non-designated assets are listed in a gazetteer in Appendix E of the ESR and Figure 7.1 in Appendix E of the ESR.

3.12.6 Biodiversity

Designated Sites

There is one statutory designated site located within 2 km of Junction 28. This site is the Manor Local Nature Reserve (LNR), the closest point of which is approximately 1km west of Junction 28 at central grid reference TQ555923.

There are 26 non-statutory designated sites located within 1 km of the proposed scheme options (Table 3-9).

3.12.7 Habitats

A review of the MAGIC website identified two potential Habitats of Principal Importance (HPI) located within 500 m of Junction 28. These are lowland mixed deciduous woodland, hedgerows, rivers and ponds.

The main habitats recorded within the Survey Area during the extended Phase 1 habitat survey undertaken in February 2016, were:

- Broadleaved semi-natural woodland
- Scrub (continuous and scattered)
- Scattered trees

- Semi-improved grassland
- Improved grassland
- Tall ruderal
- Standing water (ponds)
- Running water.

The broadleaved semi-natural woodland habitat recorded within the Survey Area during the extended Phase 1 habitat Survey is in part regarded as HPI.

The London Borough of Havering Biodiversity Action Plan (BAP) priority habitats: woodlands, hedgerows, and ponds and lakes; and Essex BAP priority habitats: hedgerows, ponds and rivers, were also identified within the survey area.

Table 3-9 Summary of non-statutory designated sites within 1 km of the proposed scheme

Site name	Approximate distance and direction from junction	Description	Area (Ha)	Grid reference
Ingrebourne Valley SMI	Immediately adjacent	A riparian corridor that leads down to Rainham Marshes, including extensive reedbeds, lakes, and wet grasslands that support an exceptional wetland invertebrate and bird fauna. The upper reaches are largely wooded. A good population of water voles is present throughout.	263	TQ538842
Dagnam Park and Hatter's Wood SMI	1.3km north-west	An historic landscaped park with ancient woodland, a variety of grassland habitats, and ponds. The ponds support important populations of amphibians, including great crested newt. The site is important for its breeding and wintering birds, including skylark, yellowhammer, hawfinch, jackdaw and various thrushes.	75	TQ550930
Lower Vicarage Wood LWS	400m north-east	A large ancient woodland with overgrown hornbeam coppice and frequent standards of pedunculate oak.	6.1	TQ569929
The Oaks LWS	575m north	Mixed deciduous woodland dominated by pedunculate oak.	14	TQ566930
Vicarage Wood LWS	800m north-east	Ancient woodland with overgrown hornbeam coppice and pedunculate oak standards.	4.2	TQ570932
St Faith's/ Honeypot Lane Meadows LWS	1.9 km north-east	This site comprises extensive grassland, hedgerow and streamside habitat.	15.6	TQ586937
High Wood LWS	2.7 km north-east	The main body of this wood is ancient, although the eastern tip is of more recent origin.	4.9	TQ582950
St Charles Nature Reserve	2.5 km north-east	This site is a remnant of old woodland now in a predominantly urban environment.	0.4	TQ587942
Jackson's Wood and Tyler's Shaw LWS	1.3km south	Ancient woodland formed of hornbeam coppice with scattered ash and pedunculate oak standards.	4.4	TQ574908
Warley Country Park LWS	1.3km east	Lowland mixed deciduous woodland and scrub interspersed by grassy glades. Marshy grassland is present in the north section.	25	TQ584924
Bachelor's Walk Woods LWS	1.5km south-east	Two sections of streamside woodland The northern section has a canopy dominated by hornbeam coppice with pedunculate oak standards, whilst alder	1.4	TQ582916

Site name	Approximate distance and direction from junction	Description	Area (Ha)	Grid reference
		is found in by the stream. Ground flora is typical of ancient woodland.		
Weald Country Park LWS	1.8km north-east	Lowland mixed deciduous woodland, lowland dry acid grassland, wood-pasture and parkland.	139	TQ570947
La Plata Grove LWS	2.1 km east	This woodland close to the centre of Brentwood has a variety of tree species and supports a sizable population of a threatened Essex plant	1.7	TQ587932
Warley Place LWS	1.9km south-east	A former house and gardens with native trees and woodland ground flora, and exotic trees, shrubs and herbs.	10	TQ583909
Foxburrow Wood LWS	2 km south	This large ancient wood has suffered losses to the construction of the M25 and also expansion of the grounds of the adjacent Foxburrow house	6.9	TQ575902
Coombe Wood LWS	2.2 km south-east	The woodland's diverse habitat structure supports important ancient woodland species.	7.9	TQ579901
Tylers Common SBI Grade 1	1.6km south	A large common with a good range of wildlife habitats, with some uncommon plants. Habitats present include acid grassland, hedgerow, lake, scrub, semi-improved neutral grassland, and unimproved neutral grassland. The site supports a range of common butterflies including common blue, Essex skipper and meadow brown, and breeding birds including skylark and meadow pipit.	29	TQ566905
Long Wood and Sage Wood SBI Grade 1	1.8km west	A large area of ancient woodland likely to support a good assemblage of woodland birds and invertebrates.	4.3	TQ544922
Duck Wood SBI Grade 1	1km west	A large ancient woodland, with a series of ponds that are valuable for amphibians. Breeding birds include sparrowhawk, woodpeckers, bullfinch and hawfinch. In addition the wood supports several notable invertebrates.	10	TQ555923
Carter's Brook and Paine's Brook SBI Grade 2	2 km west	Two streams lined with woodland and grassland, forming a valuable green corridor across the north of Havering. Considered to be of use by bats, birds, invertebrates and water voles.	12	TQ541929
Tylers Hall Pond SBI Grade 2	1km south	A large pond with a good range of aquatic plants.	0.9	TQ566913
Jermains Wood SBI Grade 2	1.3km south	An ancient woodland providing invertebrate and breeding bird habitat.	7.3	TQ570908
Bourningwood Fields SBI Grade 2	1.8km south-west	Semi-improved neutral grassland surrounded by mature native hedgerows. Habitats present are of value to breeding birds and invertebrates.	7.0	TQ557906
Romford to Harold Wood Railsides SBI Grade 2	940m south-west	Marsh/swamp, scrub, secondary woodland, semi-improved neutral grassland, and tall herbs alongside a railway that provide a wildlife corridor.	28	TQ531894
Shoulder of Mutton Wood SLI	1.6 km west	A small ancient woodland with a wet ditch running from east to west across the site.	2.2	TQ551919
Folkes Lane Woodland SNCI	2 km south	Ancient woodland.	2.1	TQ573902

There are ten ancient woodlands within 1 km of Junction 28 (Table 3.10).

Table 3-10 Summary of ancient woodland parcels within 1 km of the proposed scheme

Site name	Approximate distance and direction from junction	Area (ha)	Grid reference
Lower Vicarage Wood	400 m north-east	5.8	TQ570928
Vicarage Wood	800 m north-east	4.2	TQ571932
Duck Wood	1 km west	9.5	TQ556923
Jackson's Wood	1.3 km south	4.4	TQ574908
Fir Wood	1.3 km north-west	3.4	TQ556930
Shoulder of Mutton Wood	1.6 km west	1.9	TQ551919
The Osiers	1.6 km north-west	4.2	TQ555935
Folkes Lane Woodland	2 km south	2.1	TQ573902
Coombegreen Wood	2 km south	17	TQ575902
High Wood	2.7 km north-east	4.9	TQ582950

Habitats within the junction

The land central to Junction 28, beneath the M25 overpass, and between the main carriageways of the A12/M25 and their slip roads, is comprised of young broadleaved woodland and scattered scrub. The broadleaved woodland canopy is dominated by ash, with abundant pedunculate oak, frequent silver birch, and hazel. Scrub species are dominated by blackthorn, with frequent bramble, hawthorn, rose and dogwood. The ground flora is mostly dominated by semi-improved (species-poor) grassland and tall ruderal vegetation. Grass species include Yorkshire fog, cock's-foot, common bent, meadow grasses and fescues, interspersed with frequent teasel and common nettle.

A wide band of bare ground is located directly beneath the M25 overpass, between the broadleaved woodland and scrub mosaic. The land surrounding Junction 28 is described below in four quadrants, referring to north-east, south-east, south-west and north-west.

North-east quadrant. The north-east quadrant contains agriculturally improved grassland bordered by ancient woodland further east and broadleaved woodland to the north. A further narrow band of broadleaved woodland is located along the clockwise verge of the M25 north of the junction. A line of mature trees, mainly oak and silver birch follow a wet ditch adjacent to the eastbound carriageway of the A12. The mature trees are fronted by continuous blackthorn scrub and semi-improved grassland interspersed with tall ruderal vegetation.

Further to the north-east, north of the A12 are small fields of improved grassland separated by hedgerows, and a number of dwellings. There are at least four ponds within fields east of Wigley Bush Lane, and a further two (one of which appears to be a newly constructed fishing lake) east of Weald Park Way.

South-east quadrant. The south-east quadrant is intersected by the A1023 Brook Street. Between the A12 carriageway and services on A1023 Brook Street is a large area of dense

bramble scrub. Improved grassland, hedgerow, scattered trees and scrub are also present in this quadrant. Scattered trees surround the buildings that are associated with the services, and include species such as horse chestnut, pedunculate oak, Lombardy poplar and willow. Two disused residential dwellings are present; adjacent to the services and 'The Poplars', located approximately 30 m east from Junction 28. Semi-improved (species-poor) grassland and tall ruderal vegetation occupy the Brook Street roadside verges, which were consistent in distribution and species composition throughout the survey area. South of Brook Street are improved pasture fields with hedgerows.

The Great Eastern Mail Line railway, which runs west to east crosses the M25 south of Junction 28. The railway embankment is mainly wooded, with patches of dense bramble scrub.

Further south of the railway line are houses and gardens on Nags Head Lane and arable fields to the east of the M25. The M25 forms a wide cutting south of Junction 28 which is predominately semi-improved neutral grassland, with scattered-dense scrub and new plantation of broadleaved trees towards the top of the slope.

South-west quadrant. The south-west quadrant is mainly comprised of improved and semi-improved grassland, a wet ditch, hedgerows, continuous scrub, scattered mature trees and two ponds. One pond is surrounded by scattered trees and the other (a balancing pond for the M25, located approximately 35 m west of the motorway) is dominated by common reed.

The A12 is bordered by a continuous line of blackthorn-dominated scrub with frequent mature cherry trees. Between improved and semi-improved grassland and residential housing further west, is a large parcel of broadleaved woodland, scrub and grassland mosaic, which also contains the Ingrebourne River.

South of the junction and west of the M25 are arable and improved grassland fields separated by hedgerows, as well as houses and gardens alongside Nags Head Lane.

North-west quadrant. The north-west quadrant consists primarily of semi-natural habitats: broadleaved woodland, semi-improved grassland, scattered scrub, the Ingrebourne River, and two ponds obscured by the surrounding broadleaved woodland south of Grove Farm. A stream is also present adjacent to the A12, bounded by broadleaved woodland and scrub. North of Grove Farm is improved grassland adjacent to the M25 carriageway.

The Weald Brook flows through the north-west quadrant into Ingrebourne River in the south-west quadrant, beneath the A12 west of Junction 28. The watercourse is shrouded by trees and has a slow flow rate. A narrow stream is present, which flows through the north-west and north-east quadrants adjacent to the A12 via a culvert beneath the north extent of Junction 28. The west extent of the stream is covered by dense broadleaved woodland and scrub. The eastern extent is more open and lined by mature trees, scrub and tall ruderal vegetation.

3.12.8 Notable and protected species

Notable plants

The road verges are predominantly narrow and comprised of rough semi-improved (species-poor) grassland, tall ruderal, and scrub vegetation. It is considered unlikely that notable species or significant assemblages of notable plant species are present within the roadside or disturbed habitats surveyed immediately surrounding Junction 28.

Invertebrates

There are numerous records for notable invertebrates within 500 m of Junction 28; of those notable invertebrates recorded within 500m of the junction, a total of five are Species of Principal Importance (SPI): wall, small heath and white-letter hairstreak (butterflies); and shaded broad-bar and latticed heath (moths).

The habitats immediately surrounding Junction 28 are not particularly suitable to support significant assemblages of invertebrates, due to their disturbed and young successional nature. However, individuals of notable species may be present within adjacent scrub, improved and semi-improved fields. Broadleaved and ancient woodland habitats have potential to support stag beetle and other notable invertebrate species. The tree species on which white-letter hairstreak is known to breed (elm species) was not recorded during the targeted ecological survey. However, it may be present in broadleaved woodland within the survey area.

Weald Brook, Ingrebourne River and an unnamed stream have potential to support white-clawed crayfish.

Amphibians

There are no records of great crested newt within 500m of Junction 28. The nearest record for great crested newt is 680 m to the north within Weald Country Park. The extended Phase 1 habitat survey identified suitable aquatic habitat for breeding great crested newts, including two ponds in the north-west quadrant, two ponds in the south-west quadrant, six ponds in the north-east quadrant, and a number of wet ditches and drains surrounding Junction 28.

Suitable terrestrial habitat is present adjacent to the M25 and A12 carriageways, including unmanaged grassland, tall ruderal and scrub in a mosaic, as well as continuous scrub. The land within each quadrant also contains hedgerows and parcels of broadleaved woodland with standing and fallen dead wood. These terrestrial habitats provide habitat connectivity to nearby ponds and offer suitable foraging and hibernation opportunities for great crested newts.

Suitable habitat, including ponds and terrestrial habitat, is present within the study area for other notable amphibians, in particular common toad, which is an SPI and London BAP priority species, as well as common frog and palmate newt, which are also London BAP priority species.

Reptiles

Grass snake has been recorded within Maylands Golf Club and the Weald Brook, which is within the proposed scheme area boundary. Adders have been recorded at Jermaines Wood approximately 100 m to the south of the proposed scheme. During the extended Phase 1 Habitat Survey it was identified that areas of unmanaged grassland, tall ruderal and scrub mosaic; continuous scrub; and young broadleaved woodland adjacent to the M25 and A12 carriageways offer suitable habitat for reptiles, including slow worm and common lizard, for which no records were identified during the desk study.

Semi-improved grassland and scrub is present within the north-west quadrant between Grove Farm and Maylands Golf Club, and grassland and scrub to the south of the A12 west of Junction 28 is also suitable for common reptiles. Parcels of broadleaved woodland containing fallen trees and dead wood within the north-east, south-west and north-west quadrants also provide suitable hibernacula for reptiles.

Birds

There are three records of notable birds, within 500 km of Junction 28. These are song thrush, kingfisher and willow warbler. The habitats within the study area are also suitable for a number of other notable birds, records of which were not identified within 500m during the desk study. This includes grey partridge and skylark which are SPI, and London BAP, London Borough of Havering BAP, and Essex BAP priority species. Also dunnock, which is an SPI and London BAP priority, and barn owl which is an SPI and London Borough of Havering BAP priority species. The road system on and around Junction 28 provides suitable foraging habitat for raptors, in particular red kite and buzzard. Barn owls typically occupy disused buildings and

may be present in the old dwellings within the south-east quadrant, or farm buildings within the south-west quadrant.

The extended Phase 1 Habitat Survey identified areas of scrub, broadleaved woodland and scattered trees within the survey area that offer highly suitable nesting opportunities for a wide variety of birds.

Bats

There are at least eight bat species within 5 km of Junction 28: Daubenton's, Natterer's, Leisler's, noctule, Nathusius' pipistrelle, common pipistrelle, soprano pipistrelle, and brown long-eared bat. The nearest records were for Natterer's and Daubenton's, recorded approximately 800 m to the north-west of Junction 28.

The extended Phase 1 habitat survey identified two disused residential dwellings and a number of other farm buildings in the north-east, south-west and north-west quadrants that may have potential to support roosting bats. Habitats within the survey area such as hedgerows, broadleaved woodland, scrub, ponds and rivers offer abundant foraging habitat for bats in the immediate area, and provide commuting links across the landscape.

A number of mature and semi-mature scattered trees in all quadrants and broadleaved woodland in the north-east, south-west and north-west quadrants also offer potentially suitable roosting habitat for bats.

Hazel dormouse

There are no records for hazel dormouse within 500 m of Junction 28. The extended Phase 1 habitat survey identified dense and continuous scrub adjacent to the carriageways and between fields, which offer suitable habitat for hazel dormice. These habitats are connected to intact hedgerows and parcels of broadleaved woodland located in the north-east, south-west and north-west quadrants, all of which have potential to support hazel dormice. These habitats are all considered suitable for hazel dormice and provide a continuous corridor for the movement and dispersal of this species across the wider landscape.

Otter and water vole

There are two records of water vole within 500 m of Junction 28. The nearest record for water vole was located approximately 175 m south-west of Junction 28. There are no records were provided for otter within 500 m of Junction 28.

The extended Phase 1 habitat survey identified Weald Brook and the Ingrebourne River, as well as other tributary streams that had potential to support water voles and otters.

Badger

There is one record of badger within 500 m of Junction 28. The extended Phase 1 habitat survey identified extensive suitable foraging habitat for badgers, including; hedgerows, scrub, improved and semi-improved field margins, and broadleaved woodland. Parcels of broadleaved woodland located in the north-east, south-west and north-west quadrants offer potentially suitable habitat for badger setts.

Other Mammals

There are two records hedgehog within 500 m of Junction 28. The extended Phase 1 habitat survey identified suitable foraging habitat for hedgehog.

Brown hare is a species that is an SPI and included as a priority species within the London BAP, London Borough of Havering BAP, and Essex BAP. Although there are no records

identified from within 500 m of Junction 28, the habitats within the proposed scheme boundary are suitable for this species.

3.12.9 Water and environment

There is one Water Framework Directive (WFD) waterbody: the River Ingrebourne (GB106037028130) at Junction 28. This waterbody includes the River Ingrebourne and several tributary watercourses. The River Ingrebourne is a tributary of the River Thames. It rises near Brentwood and flows in a south westerly direction under the M25 near Junction 28, where the first of its tributaries is Weald Brook, followed by Paynes Brook.

The Environment Agency interactive mapping indicates that there are pockets of Secondary A superficial aquifers within the study area. Secondary A aquifers are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. Generally, these were formerly classified as minor aquifers. The alignment of the secondary aquifer reflects the surface hydrology, following the current or historical course of the surface watercourses and is likely to be associated with the presence of river terrace gravels.

There is one surface water abstraction within 1km. It is assumed that Nags Head Lane Wastewater Treatment Works will discharge to the River Ingrebourne within the study area.

Highways Agency Drainage Data Management System (HADDMS) records several outfalls on the A12 around Junction 28 and one outfall on the M25 within the study area. Baseline assessments have been undertaken for these outfalls, with all the outfalls on the A12 assessed as low risk and the outfall on the M25 assessed as high risk.

The Environment Agency's Flooding from Rivers interactive map 2 indicates that the Junction is within areas of Flood Zone 2 and 3. These sources of flood risk include the following:

- River Ingrebourne
- Weald Brook
- Paine's Brook.

3.13 Journey ambience

In terms of views for motorised travellers, the views from the road on the surrounding road network are restricted. There are often intermittent views over the surrounding landscape which comprise of a mixture of agricultural, residential and commercial properties, planted vegetation and engineering structures.

In terms of driver stress for motorised travellers, Junction 28 plays a critical role in providing access between the M25 and the A12, particularly the A12 towards Essex. As such Junction 28 often experiences significant capacity issues as it caters for high levels of demand between the M25 and A12 routes. The north east quadrant of the M25 has high volumes of traffic and often experiences severe congestion, which cause disruption and delays to the surrounding road network when emergency closures and lane closures of the motorway, gyratory and the Dartford Crossing are imposed.

The sections of the M25 in the north east quadrant feature in the top 10 percentile of all UK roads in terms of vehicle hour delay; this includes Junction 28. Junction 28 has limited capacity on the roundabout circulatory section due to the high traffic levels and the capacity of the signalised intersections. In addition, Junction 28 experiences a high number of accidents and incidents. While the majority of these accidents are minor, in many cases these result in significant disruption to traffic and unreliable journey times contributing to further driver stress and frustration for motorised travellers.

In terms of non-motorised users (NMUs), there are several public rights of way (PRoWs) which are located adjacent to, or intersect with, sections of the existing road. There are 4 identified PRoWs within 1km radius of Junction 28 all of which are located within the Borough of Brentwood. These are detailed in the ESR. There is an existing pedestrian footpath and cycleway at Junction 28 which crosses both the M25 south facing slip roads via at grade crossings. The footpath provides access from A1023 Brook Street in the east to the A12 Colchester Road in the west. A separate pedestrian footpath exists on the A12 eastbound carriageway of the A12 Colchester Road following the slip road up to the junction and stopping at the access road to Grove Farm.

Pavements are also contained on the A1023 Brook Street east and west bound carriageway, the east side of Wigley Bush Lane, on both sides of Weald Park Way, a footpath which alternates sides follows Nags Head lane and a pedestrian footbridge crosses the A12 at Spital Lane.

There are roads suitable for use by cyclists. There are currently short sections of share use paths or dedicated cycle ways present which would encourage this use such as at Junction 28 along Brook Street-Colchester Road and Spital Lane footbridge which continues along Brook Road.

3.14 Accessibility

3.14.1 Option values

Option and non-use values should be assessed if the scheme being appraised includes measures that will substantially change the availability of transport services within the study area. As no new transport options will be created by this scheme, option values have not been considered.

3.14.2 Severance

As noted in Section 3.2 of this report several footpaths and shared use paths exist around the Junction 28 roundabout. Further detail of these are reported in the M25 Junction 28 - NMU Audit Context Report⁶.

In terms of the implications of the Junction 28 RIS improvements, any impacts of the options on these routes and crossing points are expected to be minor.

3.14.3 Access to the transport system

There is no major access to the public transport system in this location. M25 Junction 28 is over 3 kms from the nearest mainline rail stations (Brentwood) and therefore any implications of the proposed improvements to Junction 28 are expected to be minor.

Similarly there is no significant opportunity for parking and transfer to pedestrian or cyclist infrastructure directly from the location of Junction 28.

There are two Transport for London bus services that serve the area via Junction 28 and the A1023 Brook Street. These include:

- Route 498 - Romford to Brentwood
- Route 608 - Gallows Corners to Shenfield High School.

⁶ M25 Junction 28 - NMU Audit Context Report. Prepared by Atkins on behalf of Connect Plus (February 2015).

The closest bus stops to Junction 28 are located on the A1023 approach around 300m to the east of the roundabout. There is also a bus stop on the A12 immediately west of the westbound on-slip from Junction 28.

3.15 Integration

3.15.1 Transport interchange

As stated above, the nearest rail station is in Brentwood over 3 kms away from Junction 28. Two bus routes serve Brentwood via the A1023 Brook Street and are served by a couple of bus stops in the vicinity of the junction on Brook Street. These serve local amenities across Brentwood, and the area around Junction 28 does not act as a major transport interchange.

3.15.2 Land use policy

Land use policy in the location of the scheme is governed by the Brentwood Local Plan. Brentwood Borough Council is currently preparing a new Local Plan and once adopted will supersede the policies set out in the current Replacement Local Plan (2005). The Local Plan also conforms to the Essex County Council's Local Transport Plan, which sets out the transport strategy for the county, and incorporates local strategies for each of the districts and boroughs.

In particular the Local Plan focuses on policies for housing, employment and commercial development, as well as issues relating to transport, the green belt and countryside, sustainability and protection of the environment.

The South East Strategic Economic Plan (SEP) published in 2014 by the South East Local Enterprise Partnership (LEP) set out to support the creation of 200,000 private sector jobs and accelerate the rate of housing completions to ultimately complete 100,000 additional homes by 2021. A major focus of the SEP is on *Corridors of Growth* with the A12 and Great Eastern Mainline corridor forming one of those identified. The A12 corridor is identified as a crucial link between international gateways (in particular the ports of Harwich and Felixstowe) and wider strategic networks, as well as a key facilitator for growth in Chelmsford, Colchester, Brentwood and Maldon. Through extensive investment in infrastructure improvement the SEP suggested there is potential to enable the creation of approximately 19,300 jobs and 15,200 homes at key locations along the corridor. Clearly the performance of Junction 28 is key to supporting growth along this corridor.

In developing the Junction 28 improvement scheme consideration will continue to be given to key policies relating to for example:

- The current Green Belt and Special Landscape Area designations will need to be considered with the development and assessment of junction improvement options
- Any change of use to land adjacent to Junction 28 site may impact on longer-distance and local traffic movements, potentially impacting on the performance and operation of Junction 28
- A focus on growth adjacent to the A12 corridor and the provision of additional junctions along the A12 could impact on both the volume of commuter and business traffic on the A12 and also the use of Junction 28
- The impact of future growth within Brentwood and at locations along the A12 corridor on the number of vehicles travelling through Junction 28 will need to be considered to ensure improvements match long-term needs, and that Junction 28 continues to support future growth

- Improvements to the junction should seek to support efficient movement along the M25 and A12 and facilitate local growth in housing and employment.

3.16 Technology

A review of existing infrastructure in the immediate vicinity of Junction 28 has been facilitated by Technology Geographic Layout drawings 4111a and 4111b; these are shown in Appendix E. This information is limited to the M25, further information to cover the full study area including the A12 is required to conclude a detailed assessment.

3.16.1 ITS equipment on A12

Following an outline assessment there appears to be minimal technology equipment on the A12. The equipment of note comprises:

- Loop sites on the A12 either side of the existing junction to provide traffic counting data
- Two strategic MS3s⁷ on cantilevered gantries (with associated CCTV) on the east-bound mainline approach, providing strategic diversion messages.

3.16.2 ITS equipment on M25

Junction 28 is within a Controlled Motorway section of the M25. An outline technology review has identified a number of key technological features around Junction 28, including:

- MIDAS loops sites for traffic counting and queue detection
- Gantry mounted VMS and Advance Motorway Indicators to provide speed limit information
- Ambient Light Monitors which dictate brightness requirements of signage
- Fog detectors which trigger relevant messaging on signage
- PTZ cameras to provide full coverage of the section
- ERTs (type 254) for emergency use
- Distribution Network Operator/Independent Distribution Network Operators (DNO/IDNO) electricity interfaces.

3.16.3 Third party equipment

Due to the limited data being available a detailed assessment of third party equipment has not been undertaken at this stage. However following an outline review it is likely that the following third party equipment will feature in the study area:

- Distribution Network Operator/Independent Distribution Network Operators (DNO/IDNO) electricity interfaces
- Possible traffic counting sites operated by the NTIS.

⁷ Message Sign Type 3 (LED variable messages signs, displaying text information for motorists)

A full assessment of existing ITS infrastructure can be undertaken at the next PCF stage.

3.16.4 Communications network

Highways England motorway communication drawings (as-built) highlights that there are existing longitudinal communications infrastructure comprising composite/optical fibre cable in a ducted network predominantly alongside the M25 anticlockwise carriageway.

A transmission station is located adjacent to the M25 north on-slip ramp. This is within the extent of the proposed improvement.

3.17 Maintenance access – maintenance lay-bys, access paths and steps

3.17.1 M25 corridor

General maintenance is undertaken via the hard shoulder which runs in both directions for the extent of the study area. The hard shoulder has been discontinued at several locations adjacent to structures where retrospective additional lanes have been provided. There are several locations throughout the corridor where specific access for maintenance has been provided (such as to pollution control devices), including the provision of steps up/down embankments/cuttings. Furthermore there are two maintenance lay-bys within the corridor, 1.5km south and 800m north of the existing junction to the anticlockwise verge which include a grasscrete area to park vehicles adjacent to the hard shoulder.

3.17.2 A12 corridor

General maintenance can only be undertaken in lane closures using temporary traffic management systems for the extent of the study area. There are however two specific access arrangements for the two cantilevered MS3 signs which are adjacent to the A12 westbound verge, 2.1km and 1.6km from the existing junction respectively. The furthestmost MS3 is accessed via a concrete path from an adjoining lay-by. The MS3 closest to the existing junction has a specific maintenance lay-by which facilitates access.

It should be noted that there is a pre-constructed crossover point in the central reserve approximately 0.4km east of the existing junction. This could be utilised to facilitate the construction of any proposals in the vicinity.

3.17.3 Circulatory and slip roads

The southern extent of the inside circulatory has a vehicular access opposite the A1023, Brook Street approach. A NMU route which connects Brentwood to Romford can be utilised for non-vehicular access to undertake minor maintenance of infrastructure to the outside of the circulatory from the A1023 approach to the A12 westbound off-slip stop line at the roundabout. Maintenance to any other part of the circulatory, or significant maintenance activities throughout will require temporary traffic management systems.

All slip roads with the exception of the M25 anti-clockwise on-slip road do not feature hard shoulders or any maintenance lay-bys. All major and minor maintenance activities will therefore require temporary traffic management systems. The M25 anti-clockwise on-slip road has a maintenance lay-by which facilitates maintenance of a substation adjacent to the near-side verge. Furthermore during the auxiliary lane of the A12 eastbound on-slip road, a historical lay-by has been discontinued and made redundant by a continuous safety barrier.

3.18 Existing structures

A review of existing structures in the study area has been carried out. The information available is limited to the M25. Information shown has been acquired from Highways England's Structures Management Information System (SMIS).

Existing structures within the Junction 28 study area have been identified as shown in Tables 3-11 and 3-12 for bridges and gantries respectively.

Subsequent work on the Junction 28 improvements beyond Stage 1 will investigate any implication of the scheme on these structures.

3.19 Other relevant factors

No other relevant planning factors are noted at this stage.

Table 3-11 Summary of existing bridge structures

Road	Kilometrage	Reference	Name	Number	Type	Usage	Constructed	Custodian
M25	169.5	13284	Chequers	/M25//169.50//	Bridge And Large Culvert	Highway Overbridge	1982	DBFO
M25	169.9	13285	Wrightsbridge Rd Subway	/M25//169.90//	Bridge And Large Culvert	Pedestrian Subway	1982	DBFO
M25	170	13286	Weald Brook Culvert No 1	/M25//170.00/Q/	Small Span Structure	Culvert under Project Road	1982	DBFO
M25	170.6	13287	Weald Brook Culvert No 2	/M25//170.60/Q/	Small Span Structure	Culvert under Project Road	1982	DBFO
M25	171.3	13288	Weald Brook Culvert No 3	/M25//171.30/Q/	Small Span Structure	Culvert under Project Road	1982	DBFO
M25	172.4	13290	Brook Street Viaduct	/M25//172.40//	Bridge And Large Culvert	Viaduct	1982	DBFO
M25	172.7	13844	Poplars Railway	/M25//172.70//	Bridge and Large Culvert	Railway Overbridge	1980	Network Rail
M25	173	13563	Nags Head Lane	/M25//173.00//	Bridge And Large Culvert	Highway Overbridge	1982	DBFO
M25	173.9	13564	Boyles Court	/M25//173.90//	Bridge And Large Culvert	Cattle Access Overbridge	1982	DBFO
A12	18.8	5781	Poplars East	/A12//18.80//	Bridge And Large Culvert	Under bridge	1965	DBFO
A12	18.6	5780	Poplars West	/A12//18.60//	Bridge And Large Culvert	Highway Overbridge	1965	DBFO
A12	18.6	5779	Grove Culvert	/A12//18.60/Q/	Small Span Structure	-	1965	DBFO
A12	18.6	13748	Grove Culvert Extensions	/A12//18.60/Q/1	Small Span Structure	-	1982	DBFO

Table 3-12 Summary of existing gantries

Road	Kilometrage	Key	Name	Number	Type	Constructed	Custodian
M25	169.6	28642	Sign Gantry GAB16968	/M25//169.60/S/1	Sign/Signal Gantry	2012	DBFO
M25	170.4	28643	Sign Gantry GAB17048	/M25//170.40/S/	Sign/Signal Gantry	2012	DBFO
M25	171.2	28644	Sign Gantry GAB17126	/M25//171.20/S/	Sign/Signal Gantry	2012	DBFO
M25	171.8	28645	Sign Gantry GA17187	/M25//171.20/S/	Sign/Signal Gantry	2012	DBFO
M25	172.6	28646	Sign Gantry GAB17265	28/M25//172.60/S/2	Sign/Signal Gantry	2012	DBFO
M25	173.3	28647	Sign Gantry GA17332	/M25//173.30/S/2	Sign/Signal Gantry	2012	DBFO
M25	172	28652	Sign Gantry GB17207	28/M25//172.0/S/	Sign/Signal Gantry	2012	DBFO
M25	172.9	28653	Sign Gantry GB17207	/M25//172.90/S/1	Sign/Signal Gantry	2012	DBFO
M25	173.7	28654	Sign Gantry GB17371	/M25//173.70/S/	Sign/Signal Gantry	2012	DBFO
M25	174	28658	MS3 Cantilever Gantry GA17402	/M25//174.0/S/1	Sign/Signal Gantry	2012	DBFO
M25	174	23121	VMS Gantry 5740B	/M25//174.00/V/1	Sign/Signal Gantry	2001	DBFO
M25	174	23594	MS3 Variable Message Sign 4T09	/M25//174.0/S/	Sign/Signal Gantry	2002	DBFO
M25	174.3	28648	Sign Gantry GA17432	/M25//174.30/S/	Sign/Signal Gantry	2012	DBFO
M25	174.5	28655	Sign Gantry GB17456	/M25//174.50/S/3	Sign/Signal Gantry	2012	DBFO

4 Planning factors

4.1 Option constraints

A number of planning factors and related constraints exist which will impact on the development and choice of a preferred option. These issues will be assessed and taken into account during on-going scheme development.

4.1.1 Design

All options extend beyond the highway boundary requiring significant amounts of land acquisition. This is dictated by the allowable horizontal alignment geometry for new works and the existing geometry of the current network. In addition the vertical alignment is constrained by achieving:

- The scheme introduces an additional merge for traffic travelling east bound towards Essex. There are already two merges where the dedicated left lane from the M25 clockwise merges with the on-ramp to the A12 east, and where the on-ramp from Junction 28 merges with the A12 eastbound. The constraint relates to the operational feasibility of an additional merge and meeting acceptable standards
- necessary headroom clearances over/under existing highways and the Great Eastern Main Railway line (East Anglia Main Line)
- Minimum sag and crest curve radii
- Constructability considerations
- The vertical profile of the existing network.

The alignment is additionally constrained by:

- The proximity of Maylands Golf club to the north west
- Interaction with Weald Brook and Ingrebourne River to the west
- Proximity of Lower Vicarage Wood to the North East
- Great Eastern Mainline railway to the south. The proximity of the scheme to the main railway line to London to the south of Junction 28 presents a constraint. Options that require works across the rail line would be require development in line with Network Rail discussions and processes that could delay delivery within the RIS1 road plan period
- Residential areas south of the railway and the main conurbation of Brentwood to the east.

Buildability constraints including:

- Minimising excavation of existing highways and works sequencing
- Extension of existing structures, including bridge deck extensions adjacent to live running lanes.
- Diversions of existing nationally/locally significant utilities including British Pipeline Agency plant, National Grid High Pressure Gas Main, National Grid High Voltage overhead cables.

4.1.2 Neighbouring development

Areas of development which may be affected include:

- G&R Skips and recycling and associated businesses to the north west of the junction which is directly affected by most options
- Residential properties and small businesses with frontages onto Nags Head Lane to the south of the junction
- The Poplars, Brentwood Garden Centre and the Holiday Inn which front onto Brook Street to the South East of the junction.

4.1.3 Environment

A number of environmental issues and constraints have been identified around Junction 28 (Appendix F):

- Air quality - Junction 28 is located within the proximity of several AQMAs; Brentwood Borough Council have declared two Air Quality Management Areas (AQMAs); for the eastern half of the junction and for the area near Nags Head Lane to the south. London Borough of Havering has declared a borough wide AQMA which covers much of the area to the west
- A number of Noise Important Areas exist in the vicinity of the scheme. The scheme should be looking to improve noise levels on affected parties
- Several small water courses exist in close proximity of the scheme, namely Weald Brook and Ingrebourne River. It is important that the scheme does not reduce the size of the flood zone around these water courses. Similarly any diversionary works to the watercourses will require Environment Agency approvals
- Vicarage Wood, located 400m north east of the Junction and Lower Vicarage Wood, located 800m north east, are both designated as Ancient Woodland
- Ingrebourne Valley Site of Metropolitan Importance (SMI) for nature conservation, lies immediately adjacent to Junction 28
- Lower Vicarage Wood Local Wildlife Site (LWS), The Oaks LWS and Vicarage Wood LWS lie 400m north-east, 575m north and 800m north of Junction 28 respectively
- There is a Grade II Listed Building, The Nags Head Inn just to the east of the junction on Brook Street and two Registered Park and Gardens at Warley Place to the south and Weald Park to the north
- The villages of South Weald and Weald Park are designated Conservation Areas and contain a number of listed buildings
- The area immediately to the east and south of Junction 28 are designated as Green Belt, which is a land use planning designation
- There are 4 identified public rights of way (PRoWs) within 1km radius of Junction 28 which interest with sections of the existing road.

4.1.4 Operation

Operational constraints during the construction and post-construction operational and maintenance regimes include:

- The need to maximise lane availability during periods of works, particularly during peak travel times
- Limitations of suitable diversion routes for traffic affected by closures and restrictions during construction
- Construction impacts and re-alignment of local authority roads including A1023, Nags Head Lane and Wigley Bush Lane
- Great Eastern Mainline Railway operational constraints, track possessions and construction windows
- Maintaining traffic flows on the A12 and Brook Street roundabout
- Maintenance of provision for non-motorised users including footbridge alterations.

Also integrating the design and programme for implementation with proposed widening works on the A12 between the M25 and Chelmsford is also an important consideration in the development of this project forward.

5 Scheme options

5.1 Introduction

The work undertaken during PCF Stage 0 primarily set out to confirm the need for the improvements. The Stage 0 work also identified four key project specific objectives that are intended to address the identified problems at Junction 28. These are set out in Chapter 2 of this report and include the need:

- to cater for future traffic demands efficiently with minimal delay and to support future development and economic growth
- to improve the network resilience and enable smoother flow of traffic and reliable journey times
- to improve road safety on the approaches to and through Junction 28
- to minimise the impact of high traffic volumes and stopping traffic on local air quality and noise.

The study also confirmed close alignment of the project specific objectives and Highways England's eight key performance indicators (KPIs) comprising:

- Making network safer
- Delivering better environmental outcomes
- Helping cyclists, walkers and other vulnerable users
- Encouraging economic growth
- Keeping the network in good condition
- Supporting the smooth flow of traffic
- Achieving real efficiency
- Improving user satisfaction.

Both the project specific objectives and Highways England's KPIs are critical in guiding the identification and development of a range of options to improve Junction 28 during PCF Stages 1 and 2.

5.2 Option development

5.2.1 PCF Stage 0 – Strategy, Shaping and Prioritisation

PCF Stage 0 was completed in September 2015 which confirmed and prioritised the problems associated with Junction 28 by reviewing available evidence, and examining the suitability and viability of a range of alternative solutions to address these. In doing so it also confirmed and scoped an appropriate improvement scheme for addressing the problems and achieving Highways England's strategic outcomes and KPIs. Stage 0 culminated with the identification of a number of alternative options for Junction 28 to be considered further in PCF Stage 1.

The approach adopted in PCF Stage 0 to develop and assess strategic options and scheme options comprises several key steps including *Identification and assessment of high level Strategic Options* and *Initial development and assessment of Project Options*.

Identification and assessment of high level Strategic Options – a range of strategic options were identified which could potentially be considered to address the key problems at Junction 28. These strategic options give high level consideration to a range of alternatives dealing with supply and demand, and include options for different modes as appropriate (e.g. including a Do-maximum highway option, local access and demand management, enhanced public transport and reviewing the SRN classification). Based on this assessment a strategic option focussing on localised highway improvements at Junction 28 was confirmed as the preferred solution. The key factors in selecting this strategic option include:

- The highway proposal is strongly aligned to addressing the local problems identified for Junction 28
- It can be delivered within the RIS1 period
- The timescales for other options would extend beyond RIS1
- While the Do-maximum junction improvements would perform strongly in terms of impacts against addressing the problems, it will not address short term problems and the cost would significantly exceed the RIS1 budget
- Based on the foregoing, it was also considered that a highway improvement option offered good flexibility and scalability, in that it could be designed to allow incremental improvements to the junction in the future, thus forming the basis of a Do-maximum as and when required.

Initial development and assessment of Project Options – based on the preferred Strategic Option a range of detailed project options were identified as concepts. Seven project options were identified:

- A hamburger through-about
- A northern loop
- A compact northern loop
- A satellite roundabout
- A single cloverleaf
- A southern link
- A Do-maximum (for example a double cloverleaf).

These options were assessed based on the expected impacts of achieving the identified transport objectives, indicative cost ranges, and key issues and risks relating to scheme delivery. This assessment was aligned with the principles of the Department for Transport's (DfT's) Early Assessment Sifting Tool (EAST) approach. In this way the key elements of the five case business case model were included in the assessment as appropriate at this early stage (Strategy, Economy, Managerial, Financial and Commercial) and enabled the assessment to consider deliverability issues.

The key findings of this initial assessment of the scheme options are summarised in Table 5.1.

Table 5-1 PCF Stage 0 initial assessment and short listing of scheme options

Scheme Option	Option 1 Hamburger Through-about	Option 2 Northern Hook	Option 3 Satellite Roundabout	Option 4 Compact Northern Hook	Option 5 Single Cloverleaf	Option 6 Southern Link	Option 7 Do Maximum – Options
A) Impact on problems (Impact scores from 0 – neutral, 1 Very low to 5 Very high)							
Congestion and delay on the Junction 28 disrupts journeys on the strategic road network and local roads	1	3	1	3	3	3	5
Actual and significant perceived safety concerns associated with driver movements on the Junction 28 gyratory	3	4	2	3	4	4	4+
Resilience to incidents or accidents is poor, resulting in significant disruption and unreliable journey times	1	3	2	3	3	3	4-5
Air quality is an issue at the junction, with Air Quality Management areas immediately adjacent	0	3	0	3	3	3	4-5
Overall impact against problems	1	3	1	3	3+	3+	4
B) Timescales (years)	3	5+	3-5	5	3-5	5-10	5-7
C) Indicative cost range (£ million)	20-30	60-100	10-20	50-70	50-70	100-150	150-250
D) DCO Issues?	No	Yes	Maybe	Yes	Yes	Yes	Yes
E) Deliverability issues and risks (■ = Low risk, ■ = Medium risk, ■ = High risk)							
Scale of investment (affordability)							
Cost exceeds RIS1 budget						■	■
Funding availability		■					■
Maintenance - access & increased costs	■	■	■	■	■	■	■
Impacts Area 6 maintenance activities/costs			■				
Statutory undertakings – location and cost	■	■	■	■	■	■	■
Practical feasibility / deliverability							
Overall technical feasibility		■		■	■	■	■
Disruption to local & SRN traffic during construction	■	■	■	■	■	■	■
Ambiguity to A12 through traffic over which roundabout to use			■				
Public / stakeholder acceptability							
Reputation – not being seen to fixing the problems fully	■	■	■	■	■	■	■
Reputation – scheme benefits SRN users at expense to local communities						■	
Acceptance by LAs/LEP	■		■			■	■
Implementation timescales							
Timescales extend beyond RIS1 period		■				■	
Timing with A12 improvements to east		■	■	■	■	■	■
Network Rail issues and protracted process		■	■	■	■	■	■
Legal / planning issues							
Land take required		■	■	■	■	■	■
Environmental issues – ancient woodland; visual intrusion; landfill site; ecology impacts		■	■	■	■	■	■
Potentially impacts on a listed building (farm)						■	
E) Initial Rank as RIS1 scheme		=2		=2	1	4	

Based on this initial assessment, the single cloverleaf option was highlighted as the best performing option. The key factors drawn out from the assessments include:

- The single cloverleaf option (Option 5) best addresses the local problems at Junction 28.
- It was considered that the single cloverleaf loop option could be implemented within the RIS1 timescale
- While the Do-maximum double cloverleaf option (Option 7) offers a better solution for addressing the problems, it would extend beyond the RIS1 timescale and the cost would exceed the RIS1 budget
- The single cloverleaf option offers flexibility and scalability, and importantly could form the first phase of a longer term scheme similar to the Do-maximum
- The single cloverleaf option also presents fewer delivery risks and issues; those that exist are considered to be largely manageable through the design and implementation phases
- The alignment for the single cloverleaf is both technically feasible and minimises issues/risks relating to land-take, disruption to local communities, acceptance by the public and local authorities, network rail issues and processes, and environmental impacts.

Based on the assessment, the hamburger through-about and the satellite roundabout options were discarded and not taken forward to Stage 1. The assessment indicated that the hamburger through-about option would have very little effect on achieving the project objectives, and that any noticeable improvements would only be short term. Also it was felt that there would be severe disruption to local and strategic traffic during the construction of this option. Similarly, it was considered that the satellite roundabout option would have little effect on meeting the objectives; in particular, the improvements would be at the expense of the free movement of traffic on the A12.

Based on the option assessment the following options were recommended to be taken forward for further consideration under PCF Stage 1:

- Option 2 - Northern hook
- Option 4 - Compact northern hook
- Option 5 - Single cloverleaf loop
- Option 6 - Southern link.

Full details of the Stage 0 findings are set out in the PCF Stage 0 Final Report (September 2015).

5.2.2 PCF Stage 1 – Option development

The RIS statement for the 2015 to 2020 road period sets out what Government expects in terms of improvements for Junction 28. This strategy also incorporates the following objectives:

- Improvements to Junction 28 to alleviate and manage current and future congestion through the junction, by the introduction of a new free flow link for right turning traffic between the M25 motorway anticlockwise and the A12 east
- Construction to start by end 2019/2020

- A set budget of £50 million to £100 million.

Stage 1 commenced with a comprehensive review of the four options selected at Stage 0. This involved refining and developing the shortlisted options resulting from a more detailed understanding of the key issues, risks and constraints, as well as significant progress in the design; including, for example, the vertical alignment which was not undertaken during Stage 0. A key focus for the refinement and development of the options was to find an option that would achieve the identified benefits and be affordable.

This process led to the identification of additional options and variants as the scheme options were further developed to avoid implications relating to risks and constraints. The options are introduced in Section 5.6.

5.2.3 Option constraints

During the option refinement and development, consideration of the key issues, risks and constraints was critical. The key issues and constraints are set out in Chapter 4 and in summary include:

- **Design constraints.** The scheme development faces a number of design constraints including:
 - the introduction of an additional merge for traffic travelling east bound on the A12 towards Essex
 - designing the alignment of the scheme with challenging vertical height differences
 - managing the proximity of Maylands Golf Club to the north-west, the Weald Brook and Ingrebourne River to the west, the proximity of nearby ancient woodland, and the Great Eastern Mainline Railway to the south.
- **Buildability constraints.** The development of the scheme considered options for: extending existing structures adjacent to live running traffic lanes, and keeping the M25 and A12 carriageways open and available during construction periods. Diversions of existing nationally significant utilities (for example, British Pipeline Agency (BPA) plant and National Grid high voltage overhead cables) were considered significant issues.
- **Neighbouring development.** Areas of development which may be affected include: the skips hire and recycling business adjacent to the junction; residential properties and small businesses with frontages onto Nags Head Lane; Maylands Golf; as well as the Brentwood Garden Centre and the Holiday Inn which front onto the A1023 Brook Street.
- **Environmentally sensitive areas.** There are a wide range of sensitive areas adjacent to or close to the junction, including: noise and air quality issues; several small water courses in close proximity to the scheme; the ancient woodland on north-east area of junction, ecology risks and habitats; and listed buildings.
- **Operational.** In developing the scheme, consideration has been given to: minimising the implications with Great Eastern Mainline Railway, maintaining the availability and minimising disruption to traffic on the M25 and A12 during construction; and minimising impacts on maintenance activities including winter maintenance; and protecting the provision for non-motorised.

Also, it is important to align the scheme with the proposed widening works on the A12 between the M25 and Chelmsford (a potential RIS2 scheme) so that the design and programme for implementation are integrated across the two projects.

5.3 Interdependencies

The success of the Junction 28 scheme options is partially dependent on the successful implementation of complementary signal enhancements at adjacent traffic signals along the A1023 Brook Street, namely Nags Head Lane/Wigley Bush Lane and Spital Lane junctions. The proposed scheme seeks to divert the right turning traffic between the M25 anticlockwise and the A12 east away from the roundabout. This will in turn involve the optimisation of the traffic signals with different patterns of turning traffic using the Junction 28 roundabout, in terms of cycle times, green times and offsets. Whilst the traffic signalised junctions along the A1023 Brook Street operate independently from Junction 28, it is important that there is some level of coordination in the operation of the two sets of signals.

Whilst not directly dependent, the Junction 28 scheme will also have an important interface with the proposed widening of the A12 between the M25 and Chelmsford. A key interface will be the design of the merge arrangements for the new link on the A12 east.

5.4 Risks

In developing the scheme further, a comprehensive risk log will be maintained to support the preparation of the business case in subsequent stages (in particular, the Management Case element). The successful delivery of the Junction 28 improvement scheme and the associated outcomes will be subject to managing these risks (i.e. so that they either do not occur, or are effectively mitigated).

Details of the Projects Approach to Risk are set out in the PCF Stage 1 Risk Management Plan.

During PCF Stage 1, a risk register has been developed for each option, and subsequently reviewed and updated through a series of workshops held in December 2015, February and June 2016. The risks identified in each of the registers have been subject to qualitative assessment to identify the potential impacts of each risk, both pre-mitigation and post-mitigation. This confirmed the effectiveness of appropriate risk mitigation plans identified for each risk.

The project team has actively considered and managed these risks throughout Stage 1 of the project. The risk register for the preferred option(s) will be carried forward through the subsequent PCF stages of the Junction 28 scheme. As the project is most likely to be procured via ECI, the wider integrated project team will then be used to identify and manage the risks and opportunities.

The risk management process conforms to the guidance given in the HA Risk Manual.

At this early stage a number of key potential risks have been identified. In terms of Junction 28 these typically relate to:

- Strategic issues; such as changes in Government priorities and/or lack of support from local highway and planning authorities, statutory bodies as well as the public
- Traffic patterns and demands, linking to any uncertainty over future growth and traffic patterns, as well as potential changes to the highway and transport network that may affect demands and routing in as yet unforeseen ways

- Technical challenges and complexities that may result in not achieving the project timescales, impacting on the operation and availability of the existing transport infrastructure and its users
- Statutory processes; the time and cost to acquire the land require to implement the scheme
- Acceptance; potential opposition and challenges to the scheme.

5.5 Option descriptions

5.5.1 Overview

As part of the process of option development outlined above, 5 main options have evolved together with a number of variants. All 5 options have been designed to provide a new free flow link for right turning traffic between the M25 motorway anticlockwise and the A12 east.

Based on the PCF Stage 0 findings and initial design work in Stage 1, it was clear that the initial Stage 0 options all achieved the scheme outcomes but would also have significant impacts across the different project constraints. This in turn would contribute to limiting options performance against the project objectives, as well as impacting the deliverability of the scheme within the available budget and timeframe. It was also evident at that stage that the cloverleaf option (Option 4) offered the greatest potential to be refined and developed to best manage the impacts against the identified constraints (Table 5-2). Hence a range of cloverleaf and loop variants has been identified for Option 5.

The options include:

- Option 2 – Northern hook
- Option 4 – Compact northern hook
- Option 5 – Cloverleaf loop (with 6 variants)
- Option 6 – Southern link.

These are described separately in turn in the remainder of this section, with illustrations shown in Figures 5-1 to 5-8.

A key focus in identifying the options and variants was to achieve a balance across achieving the project objectives, capacity of the link and future proofing, deliverability in terms of design and programme, and affordability. Therefore certain design elements such as the number of lanes differs between the options; with some options showing a 1 lane plus hard shoulder arrangement, and others a 2 lane link plus hard shoulder. A single lane link is sufficient to cater 2037 design year flows, though consideration of a two lane link is expected to offer some additional benefits associated with catering future traffic volumes beyond 2037.

5.5.2 Option 2 – Northern hook

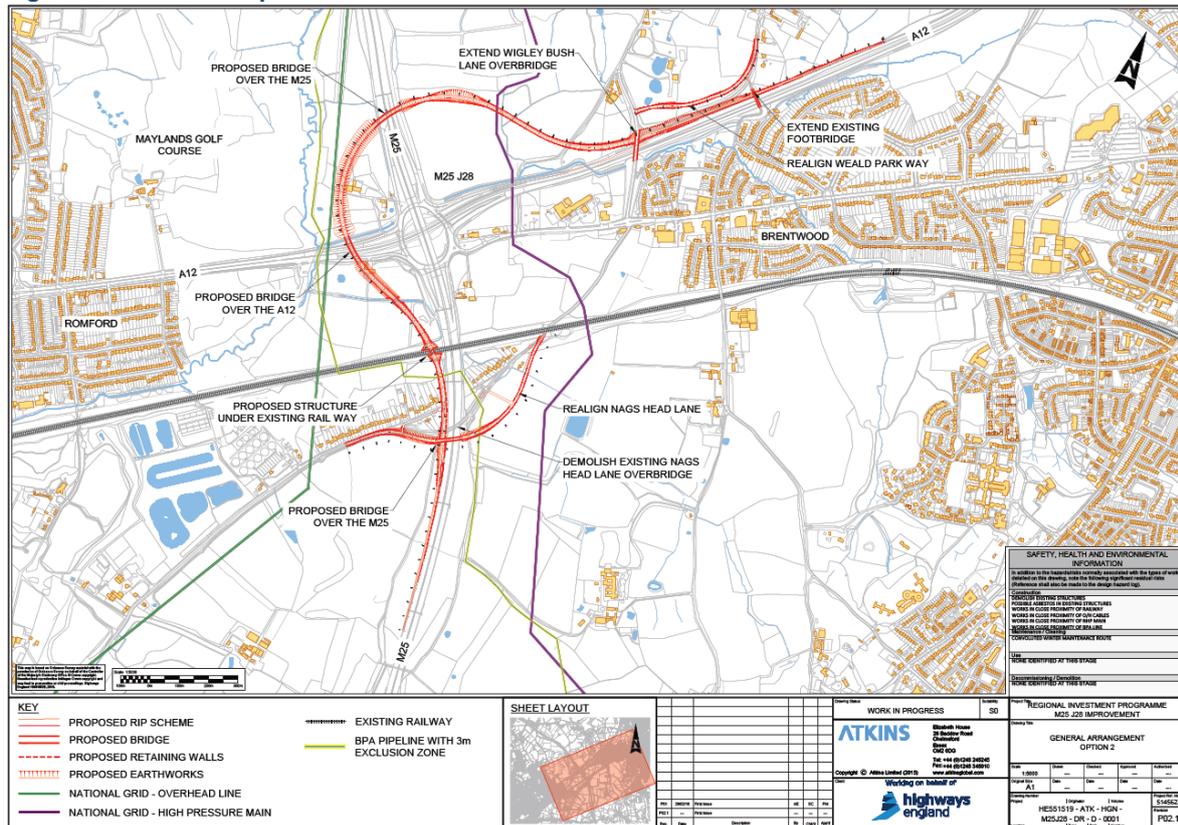
A two lane link with hard shoulder connects the M25 south with the A12 east via a two lane link (plus hard shoulder) that hooks around the north of Junction 28 merging with the A12 to the east of Wigley Bush Lane. The option requires the realignment of Nags Head Lane overbridge, Wigley Bush Lane overbridge, footbridge over the A12 and Weald Park Way, together with new structures under the railway, over the A12 west and the M25 north (Figure 5.1).

Option description

This option requires a diverge from the M25 anticlockwise south of the Nags Head Lane overbridge. This requires the realignment of Nags Head Lane, the demolition of the existing overbridge and the construction of a new bridge and associated embankment. Moving north the diverge passes under the railway and requires a significant retaining wall between the M25 and the new off-slip road carriageway. North of the railway line the link passes to the west of the existing junction, crossing the A12 and slip roads on a proposed overbridge. The alignment then crosses over the adjacent land to the north-west of the junction on an embankment before crossing the M25 on a second overbridge.

Passing to the east of the M25 the alignment of the link transitions into cutting before merging with the A12 at a point east of Wigley Bush Lane overbridge. As a consequence of the horizontal geometry, the ancient woodland north of the A12 is encroached. Wigley Bush Lane overbridge and the footbridge further east will need to be extended. Weald Park Way will be realigned to accommodate the merge.

Figure 5-1 **Option 2 - Northern hook**



Key interactions with existing infrastructure

- Realignment of Nags Head Lane
- Demolition and reconstruction of Nags Head Lane overbridge
- Proposed structure under Great Eastern Main Line (GEML) railway
- Extension to Wigley Bush Lane overbridge

- Realignment of Weald Park Way
- Extension to A12 footbridge Impact to Putwell Bridge Farm buildings
- Impact to G&R Skips and Recycling buildings
- Diversion of British Agency Pipeline
- Diversion of National Grid, National High Pressure gas pipeline.

5.5.3 Option 4 – Compact hook

This options is similar to Option 2 in that it is a two lane link with hard shoulder that hooks around the north of Junction 28 to join the A12 east in the vicinity of Wigley Bush Lane. However, following the diverge from the M25 anti-clockwise the new alignment runs parallel to the M25 through widened structures until it reaches the A12, where a new structure takes it over the M25 north. This option also requires reconfiguration of Nags Head Lane overbridge, Wigley Bush Lane overbridge and Weald Park Way, together with a structure under the railway to the south (Figure 5.2).

Option description

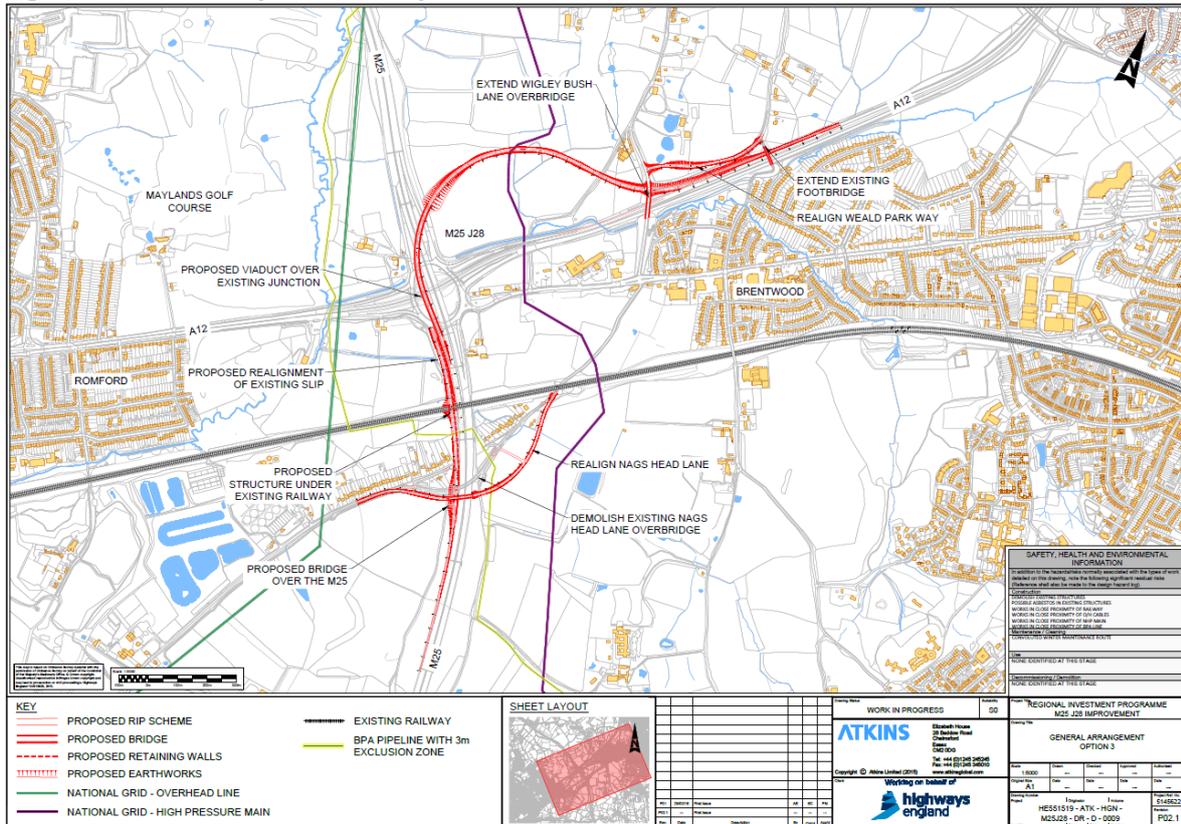
For this option it is necessary to alter the M25 anticlockwise diverge configuration to facilitate the proposed link diverge and to make space for the proposed parallel structure (which will carry the new link over the existing junction). As a consequence the reconfigured diverge to the Junction 28 roundabout starts south of the Nags Head Lane overbridge. This will require the realignment of Nags Head Lane, the demolition of the existing overbridge and the construction of a new bridge and associated embankment. Moving north the realigned diverge slip road to the roundabout passes under the railway and requires a significant retaining wall between it and the M25 anticlockwise carriageway before approaching the roundabout.

A second successive diverge from the M25 anticlockwise to the new link utilises the existing lane-drop configuration from the M25, and follows the vertical profile of the main M25 carriageway. The alignment of the new link then passes over the existing Junction 28 roundabout, the M25 mainline and associated slip roads north of the junction on a multi-span viaduct. To the east of the M25 the link descends before merging on to the A12 east of Wigley Bush Lane overbridge. As a consequence of the horizontal geometry, the ancient woodland north of the A12 is encroached. Wigley Bush Lane overbridge and the footbridge further east will need to be extended. Weald Park Way will be realigned to accommodate the merge.

Key interactions with existing infrastructure

- Realignment of Nags Head Lane
- Demolition and reconstruction of Nags Head Lane overbridge
- Proposed structure under the GEML railway
- Extension to Wigley Bush Lane overbridge
- Realignment of Weald Park Way
- Extension to A12 footbridge
- Diversion of British Agency Pipeline
- Diversion of National Grid, National High Pressure gas pipeline.

Figure 5-2 Option 4 – Compact northern hook



5.5.4 Option 5A – Cloverleaf loop variant 1

A single lane with hard shoulder that connects the M25 anti-clockwise carriageway with the A12 east in the form of a cloverleaf type loop located in the north-west quadrant of Junction 28. It requires a tunnel under the railway line for the realigned diverge from the M25, and the realignment of Nags Head Lane to the south (Figure 5.3).

Option description

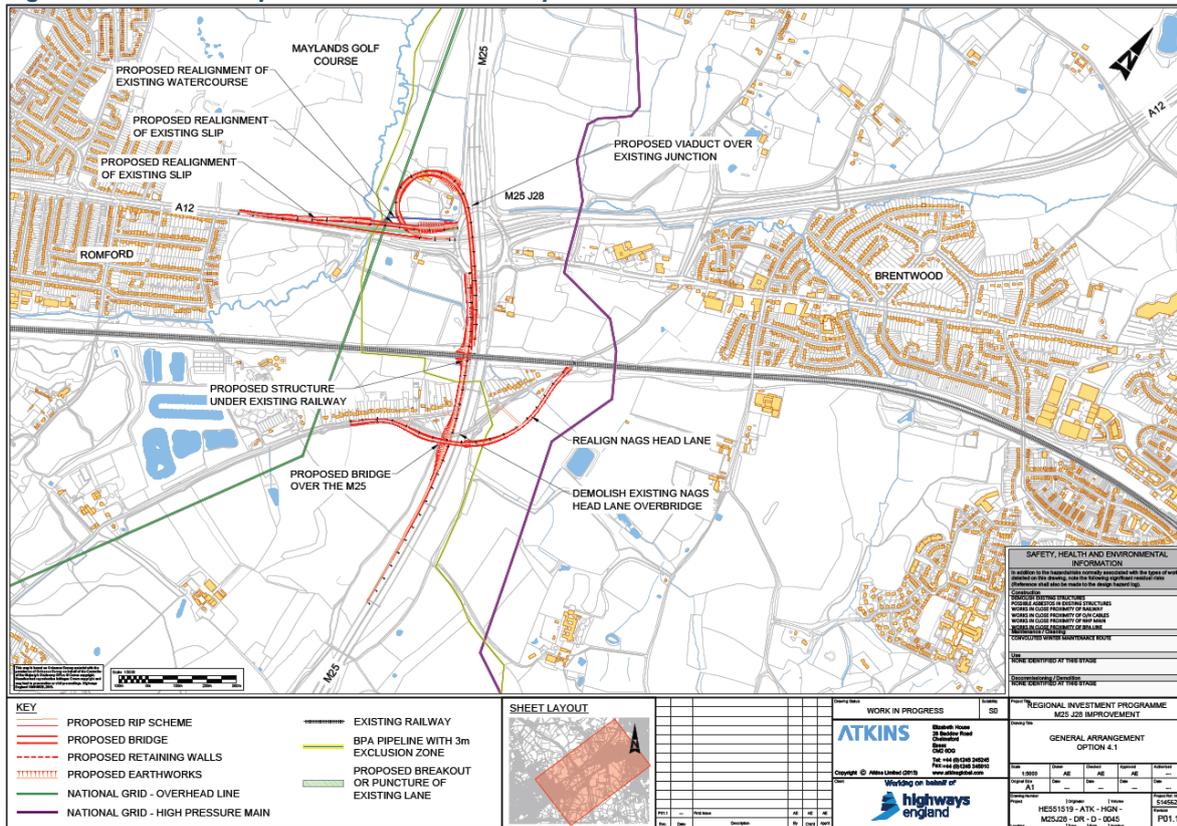
For this option it is necessary to alter the alignment of the M25 south off-slip and the diverge configuration. This is required to enable sufficient space to accommodate both an initial diverge from the M25 to the Junction 28 roundabout and a second diverge to the new link via a proposed parallel structure over the existing junction. As such the reconfigured diverge to the roundabout starts from a point south of the Nags Head Lane overbridge. This requires the realignment of Nags Head Lane, the demolition of the existing overbridge and the construction of a new bridge and associated embankment. Moving north the realigned diverge passes under the railway and requires a significant retaining wall between the M25 carriageway and the off-slip approach to the roundabout.

The second diverge, for the proposed link, utilises the existing lane-drop configuration from the M25. The link then follows the vertical profile of the structure on the M25 mainline carriageway on a parallel structure over the existing roundabout and the M25 north on-slip road from the roundabout merge. The horizontal alignment continues in a loop while the vertical profile starts to descend on a proposed embankment; this would follow the existing topography downhill towards the A12 carriageway. Due to the compact alignment assumed under this option the buildings associated with the skip/recycling centre in this quadrant of the junction are directly impacted.

The proposed link requires the realignment of the existing A12 west off-slip road to facilitate the merging of the new link with the existing A12 west before the existing structure that support the roundabout circulatory carriageway. To achieve this the A12 west off-slip road requires a structure enabling the proposed link to run under the realigned A12 west off-slip road.

Currently the A12 eastbound carriageway has 2 lanes which reduce to a single as the A12 passes under the Junction 28 roundabout (under the structure on the eastern side of the roundabout). The lane reduction is achieved with ghost island road markings. It is proposed to extend the existing single lane section of the A12 westwards in advance of the point where the new link will merge with the A12. This will enable a lane drop arrangement at the A12 west diverge to the off-slip road to the Junction 28 roundabout, followed by a lane gain as the new link merges with the A12. The A12 would then either reduce to a single lane as at present, or continue as two lanes through the junction. It is likely that this will not require widening of the supporting structure of the roundabout circulatory and M25.

Figure 5-3 Option 5A – Cloverleaf loop variant 1



Key interactions with existing infrastructure

- Realignment of Nags Head Lane
- Demolition and reconstruction of Nags Head Lane overbridge
- Proposed structure under the GEML railway
- Reconfiguration of M25 anticlockwise diverge and off-slip road
- Reconfiguration of A12 west off-slip road

- Realignment of existing watercourses
- Impact to G&R Skips and Recycling buildings
- Diversion and protection measures required of/to British Agency Pipeline infrastructure
- Possible diversion of National Grid overhead transmission cables.

5.5.5 Option 5B – Cloverleaf loop variant 2

As in Option 5A this option connects the M25 anticlockwise with the A12 east via a single lane cloverleaf type loop (with hard shoulder) located in the north-west quadrant of Junction 28. However, by moving the layout further north compared to Option 5A, this option avoids impacting on the railway mainline to the south. It does involve the widening of the existing M25 structure to support the proposed new M25 anticlockwise diverge and off-slip road for accessing the new link. It also requires the realignment of the A12 west off-ramp to accommodate the merge with the A12 eastbound carriageway (Figure 5.4).

Option 5B sets out to provide a similar level of connectivity as Option 5A, but its evolution was based on reducing costs and maintain the works programme by eliminating the need to cross the GEML railway line and associated realignment works on Nags Head Lane. This significantly reduces the option costs and risk to programme. This had the added benefit of reducing the option's footprint and hence associated impacts. It does however require a departure from the DMRB standards in terms of successive diverges.

Option description

This option involves a new diverge from the M25 anticlockwise carriageway to the new link immediately after the existing diverge to the Junction 28 roundabout. To accommodate the new diverge the existing M25 viaduct would need to be widened with a new retaining wall required to support associated earthworks. The arrangement of the two diverges in this option does not meet DMRB standards in terms of the required distance between successive diverges.

Beyond the second diverge the proposed link starts to turn towards the adjacent land to the north-west of the existing junction. A new structure is proposed to support the link over the existing roundabout circulatory carriageway and M25 north on-slip roads. The horizontal alignment continues in a loop while the vertical profile starts to descend from the proposed structure on an embankment following the existing topography downhill towards the A12. As Option 5A, the compact alignment of this option impacts directly with the buildings associated with the skip/recycling centre in this quadrant of the junction.

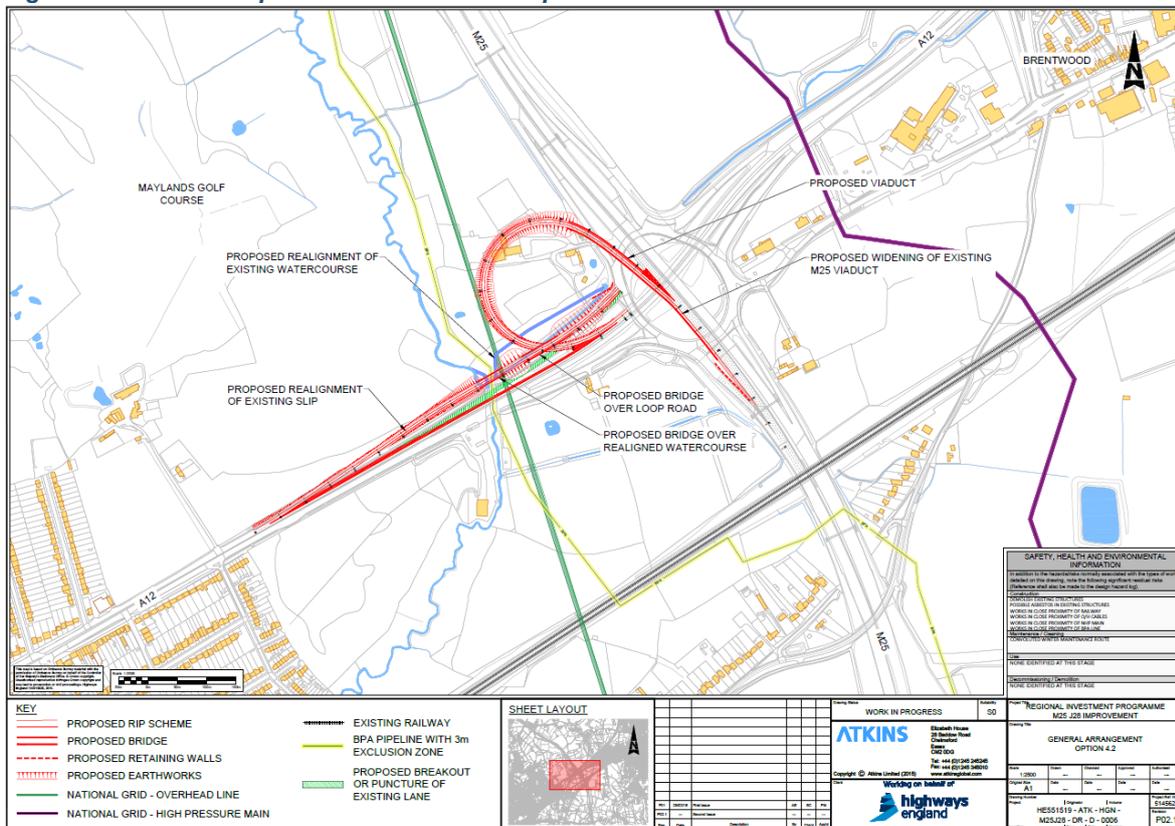
Accommodating the proposed link also involves the realignment of the existing A12 west diverge and off-slip road to facilitate a merge with the existing A12 eastbound carriageway before the existing structures that support the roundabout circulatory carriageway. The realignment of the A12 west off-slip road would involve a new structure that allows the proposed new link to run under the realigned A12 diverge/off-slip road.

In terms of arrangements for the A12 west merge and diverge, this Option 5B would follow that described for Option 5A. That is to extend the existing single lane section of the A12 westwards in advance of the point where the new link will merge with the A12 to enable a lane drop arrangement. This would be followed by a lane gain as the new link merges with the A12. The A12 eastbound carriageway would then either reduce to a single lane as at present, or continue as two lanes through the junction.

Key interactions with existing infrastructure

- Widening of existing M25 viaduct
- Existing hard shoulder utilised as auxiliary lane for proposed diverge
- Reconfiguration of A12 east diverge and off-slip road
- Realignment of existing watercourses
- Protection measures required for British Pipeline Agency infrastructure
- Possible diversion of National Grid overhead transmission cables
- Impact to G&R Skips and Recycling buildings.

Figure 5-4 Option 5B – Cloverleaf loop variant 2



5.5.6 Option 5C – Cloverleaf loop variant 3

As Option 5B this option connects the M25 anticlockwise with the A12 east via a single lane cloverleaf type loop (with hard shoulder) located in the north-west quadrant of Junction 28. Similarly this option avoids impacting on the mainline railway to the south. By moving further north compared to Option 5B, Option 5C avoids the need to widen the existing M25 structures. Locating the diverge from the M25 for the new link to the north of Junction 28 requires realigning the existing M25 north on-slip road to pass under the new loop. It also requires the realignment of the A12 west off-ramp to accommodate the merge with the A12 eastbound (Figure 5.5).

The evolution of Option 5C was based on examining the potential to develop a less complex scheme compared to Option 5B by avoiding the need for widening the existing M25 viaduct. In doing so this gave greater certainty to the construction phasing and the buildability of the scheme. It also looked to address the issue concerned with the successive diverges, and by utilising the exiting hard shoulder over the M25 viaduct for deceleration and diverge looks to comply with the requirements for successive diverge spacing outlined in the DMRB.

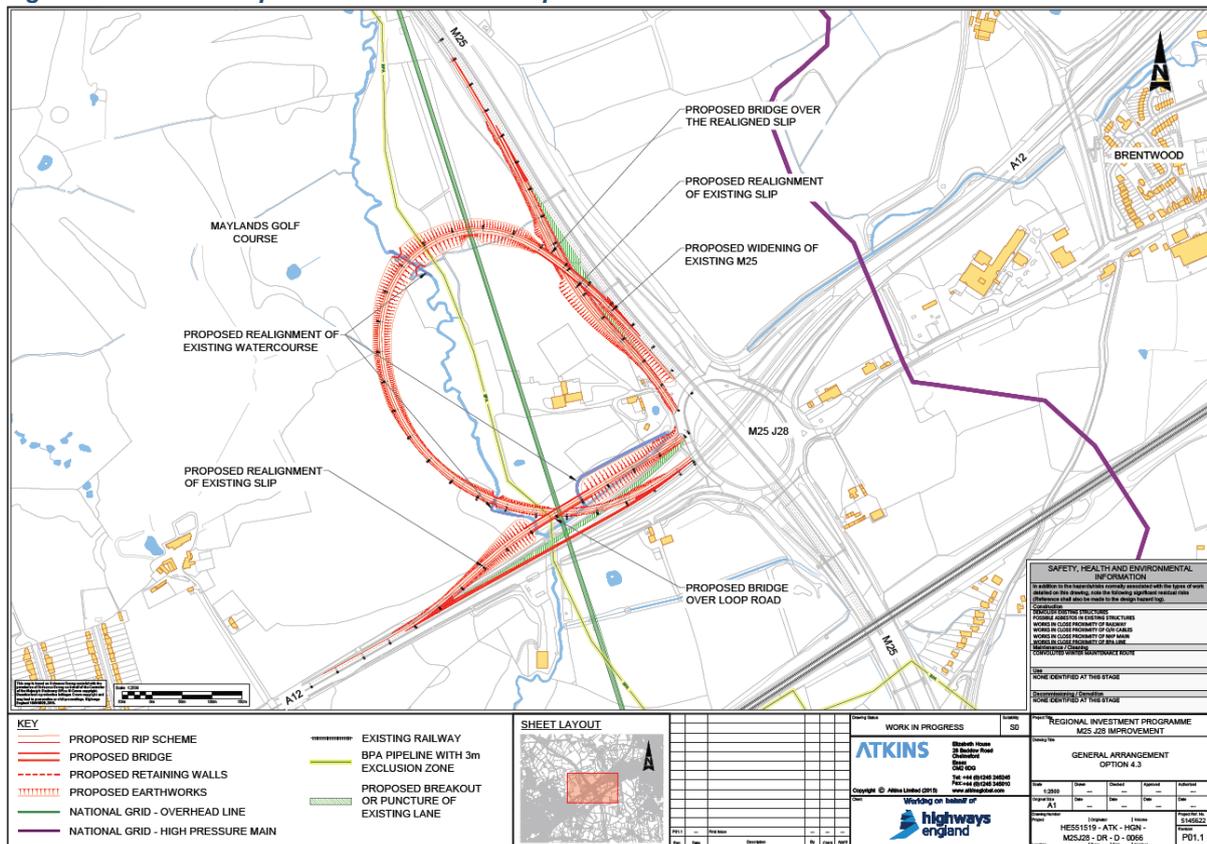
Option description

The option proposes to use of the existing hard shoulder on the M25 viaduct as a deceleration lane and diverge to the new link on the northern side of the junction. BY moving the scheme further north Option 5C involves no works over the existing railway structure or to the existing M25 viaduct.

Following the diverge the alignment of the new link turns into the adjacent land to the north-west of the existing junction. The existing M25 north on-slip road and merge will be realigned to pass under the proposed link. The horizontal alignment continues in a loop while the vertical profile starts to decline from the proposed structure on an embankment following the existing topography downhill towards the A12.

In terms of arrangements for the A12 west merge and diverge, this Option 5B would follow that described for Options 5A and 5B. That is to extend the existing single lane section of the A12 westwards in advance of the point where the new link will merge with the A12 to enable a lane drop arrangement. This would be followed by a lane gain as the new link merges with the A12. The A12 eastbound carriageway would then either reduce to a single lane as at present, or continue as two lanes through the junction.

Figure 5-5 Option 5C – Cloverleaf loop variant 3



Key interactions with existing infrastructure

- Protection measures required for British Pipeline Agency infrastructure
- Realignment of existing watercourse
- Possible diversion of National Grid overhead transmission cables
- Reconfiguration of A12 east diverge and off-slip road
- Reconfiguration of M25 north anticlockwise on-slip road and merge.

5.5.7 Option 5D – Northern loop

This option connects the M25 south with the A12 east via a two lane loop (with hard shoulder) located in the north-west quadrant of Junction 28. However, unlike Options 5A, 5B, and 5C this loop option does not merge with the A12 under the existing Junction 28 circulatory structure. Instead the loop road crosses the M25 to the north of Junction 28 via a bridge structure and merges with the A12 to the east of Junction 28 in the proximity of Wigley Bush Lane. A realignment of the dedicated M25 north to A12 east lane is also required (Figure 5.6).

Option description

As in Options 5C and 5F a diverge from the M25 anticlockwise carriageway to the 2 lane link is provided on the northern side of Junction 28 with some widening of the main carriageway. This results in successive diverges with this diverge following the initial diverge from M25 anticlockwise to the Junction 28 roundabout. The hard shoulder on the M25 carriageway over the existing viaduct between the two successive diverges will be discontinued to avoid potential ambiguity. Following the diverge the proposed link turn into the adjacent land to the north-east of the existing junction, and the existing M25 north on-slip road and merge will be realigned to pass under the proposed link.

The horizontal alignment continues in a loop while the vertical profile starts to rise before passing over the M25 and associated slip roads. East of the M25 the alignment is on embankment which reduces in height to merge to the A12 at appoint east of the Wigley Bush Lane overbridge.

The configuration of the merge with the A12 eastbound to the east of the junction, it is proposed that a new dedicated left turn slip is constructed as part of the scheme connecting the M25 anticlockwise and the A12. The reason for including this dedicated left turn lane is that assuming current arrangements there would be a need for three success merges, i) firstly between the existing dedicated left turn from the M25 north and the exit from the roundabout, ii) followed by the downstream link merging with the new loop road and iii) finally the downstream link merging with the A12 via a tiger tail ghost island configuration. As such there is insufficient space to accommodate three successive merges without widening the A12 corridor and rebuilding/widening structures and realigning Wigley Bush Lane – which would be more costly than providing the new dedicated left turn link.

Therefore assuming a new dedicated left turn link a conventional Type A merge can be provided with the exit from the roundabout, followed by a tiger tail style ghost island merge with the A12. To facilitate the merge to A12 east it will be necessary to extend Wigley Bush Lane overbridge.

Key interactions with existing infrastructure

- Extension to Wigley Bush Lane overbridge
- Realignment of existing watercourse

- Reconfiguration of circulatory/A12 eastbound merge
- Reconfiguration of M25 north anticlockwise on-slip road and merge
- Protection measures required for British Pipeline Agency infrastructure
- Diversion of National Grid, National High Pressure gas pipeline
- Possible diversion of National Grid overhead transmission cables
- Impact to G&R Skips and Recycling infrastructure Impact to Ancient Woodland.

5.5.8 Option 5E – Northern loop variant

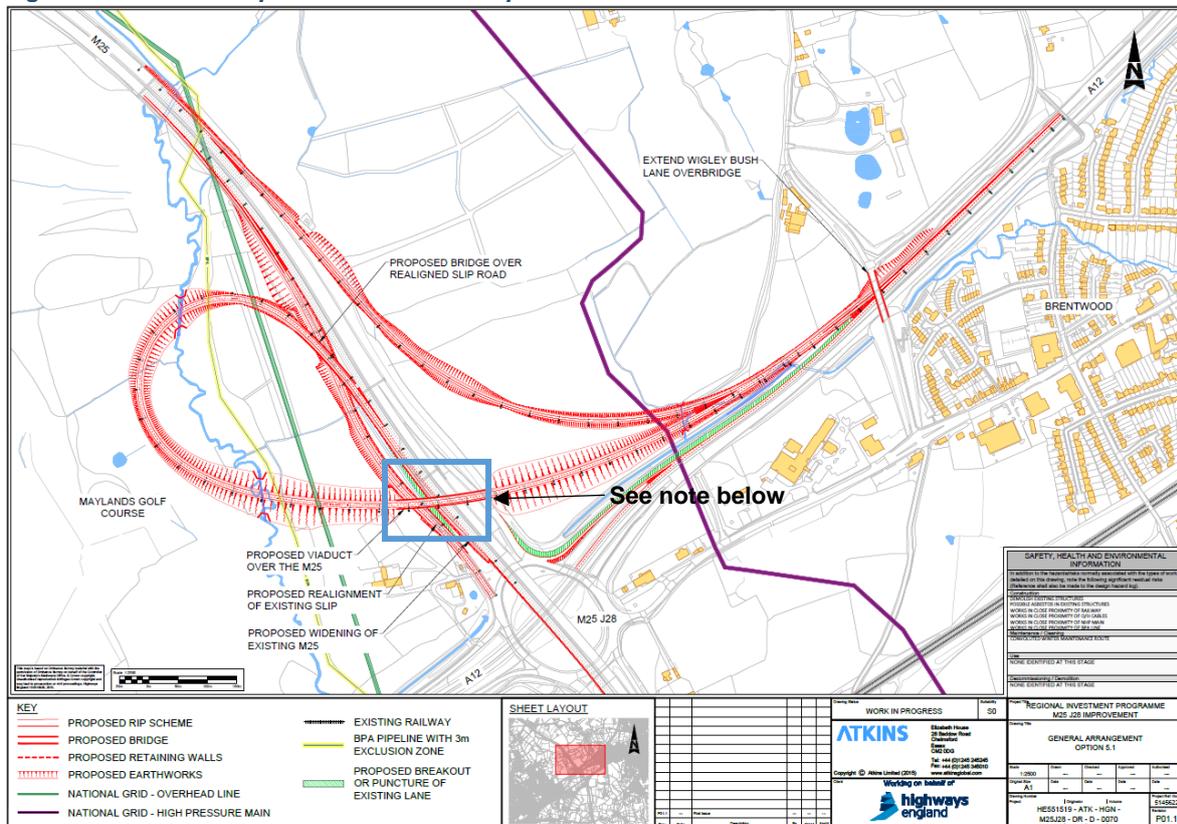
This option assumes the same configuration to Option 5D. The only variation is that the loop road passes under the M25 to the north of Junction 28 before merging with the A12 in proximity of Wigley Bush Lane (Figure 5.6).

Option description

This option is identical to that described above for Option 5D in terms of the diverge from the M25 anticlockwise, the merge arrangements with the new link and the A12 eastbound carriageway, and the need for a realigned dedicated left turn lane form the M25 north.

The only difference relates to the alignment of the loop as it descends towards the proposed M25 underpass (whereas the Option 5D alignment passes over the M25).

Figure 5-6 Option 5D and 5E – Loop variants 4 and 5



Note. Option 5D assumes an overpass across the M25 north, and Option 5E assumes an underpass.

Key interactions with existing infrastructure

- As Option 5D, plus those below
- Positioning of the new structure under M25 has important interactions with the operation of the motorway during construction
- Reconfiguration of M25 north diverge off-slip road towards the roundabout, to create headroom for the underpass.

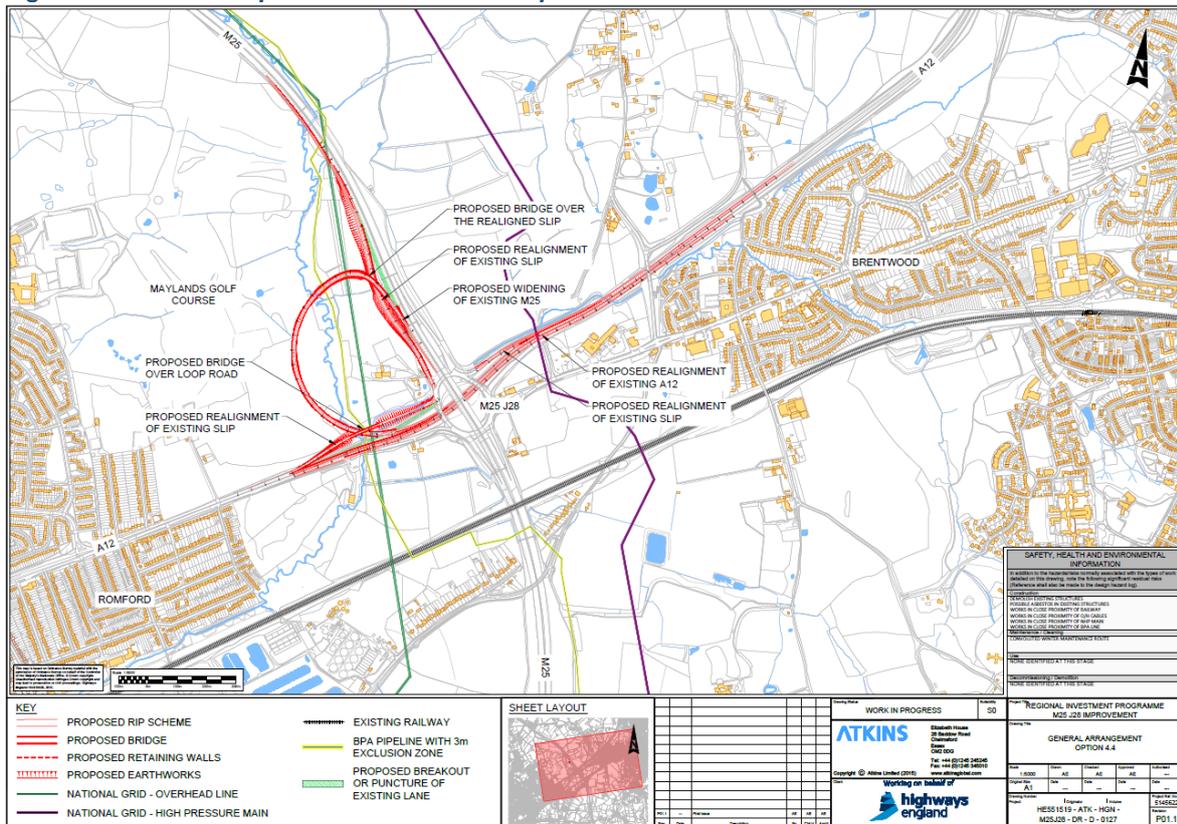
5.5.9 Option 5F – Cloverleaf loop variant 4

Option 5F is essentially a 2 lane (with hard shoulder) variant of Option 5C (Figure 5.7).

Option 5F is a variation of Option 5C and was developed to understand the implications and feasibility of providing a two lane loop road merging with the A12 eastbound carriageway underneath the existing Junction 28 roundabout structure.

To accommodate a diverge to the 2 lane link from the M25 anticlockwise carriageway, the diverge point is further north compared to Option 5C. Similarly a reconfiguration and realignment of the cross section of the A12 is required to accommodate the merging of the two lane loop road so that the proposed alignment doesn't impact the existing structures supporting the circulatory roundabout and the M25.

Figure 5-7 Option 5F – Cloverleaf loop variant 6



Key interactions with existing infrastructure

- Protection measures required for British Pipeline Agency infrastructure

- Realignment of existing watercourse
- Possible diversion of National Grid overhead transmission cables
- Reconfiguration of A12 east diverge and off-slip road
- Reconfiguration of M25 north anticlockwise on-slip road and merge
- Reconfiguration of A12 mainline in vicinity of existing junction.

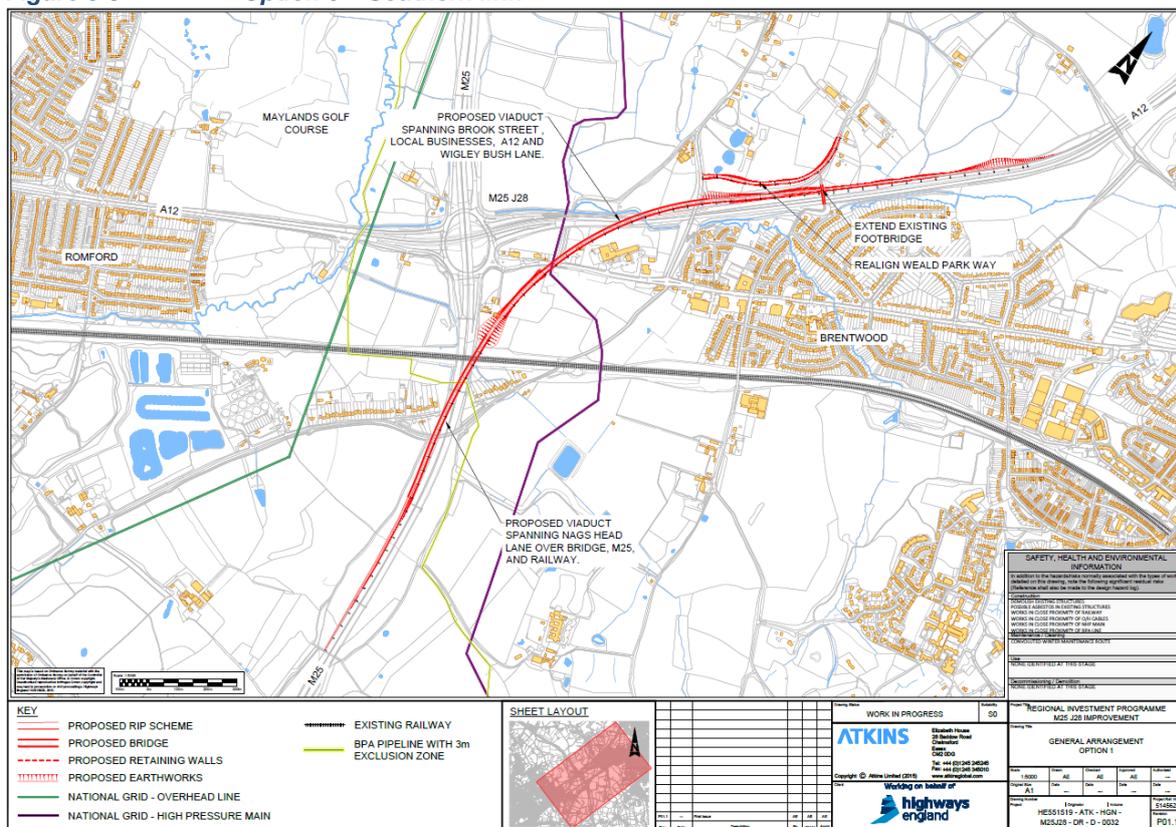
5.5.10 Option 6 – Southern link

A two lane link with hard shoulder that connects the M25 anticlockwise with the A12 east passing directly through the south-east quadrant of the junction with various multi-span viaducts to pass over the M25, Brook Street and the A12. It also requires the realignment of Weald Park Way (Figure 5.8).

Option description

This option requires a diverge from the M25 anticlockwise carriageway south of Nags Head Lane overbridge, before the link climbs over Nags Head Lane, the M25 and the existing mainline railway on a multi-span viaduct. To the south-east of the existing junction the alignment is on a short length of embankment before crossing over Brook Street, Brentwood Garden Centre, the A12 and Wigley Bush Lane overbridge on a second multi-span viaduct before merging with the A12 eastbound carriageway. As a consequence it will be necessary to realign Weald Park Way, and the existing footbridge to the east will need to be extended.

Figure 5-8 Option 6 – Southern link



Key interactions with existing infrastructure

- Impact to The Poplars farm buildings
- Impact to Brentwood Garden Centre
- Impact to Brentwood Holiday Inn
- Realignment of Weald Park Way
- Extension to A12 footbridge to accommodate the alignment of the new link.

5.6 Summary

As discussed in Section 5.2, one of the key focusses of the option identification process was to understand the key issues, risks and constraints surrounding the scheme, and evolve the option development to best manage and/or mitigate these. Table 5.2 illustrates well how the scheme has developed to best avoid the key project and planning constraints, and hence potentially reduce cost and time implications.

Table 5-2 Option interfaces with key project and planning constraints

Key Categories		Options (and variants)								
		Initial options identified in Stage 0				Additional variants developed in Stage 1				
		2	4	5A	6	5B	5C	5D	5E	5F
Time	Network Rail interface and approvals	✓	✓	✓	✓					
	Significant construction complexities	✓	✓	✓	✓			✓	✓	
Physical Environment	British Pipeline Agency diversion	✓	✓							
	National Grid overhead transmission cables diversion					✓	✓	✓		✓
	National Grid, national high pressure pipeline diversion	✓	✓					✓	✓	
	Impact to the Ancient Woodland	✓	✓					✓	✓	
	Watercourse diversion					✓	✓	✓	✓	✓
Stakeholder	Realignment of Local Authority Roads	✓	✓	✓	✓					
	Closure of G&R Skips and Recycling	✓				✓				
	Closure of Brentwood Garden Centre			✓	✓					
	Impact to Holiday Inn Brentwood			✓	✓					
Road User	Works required inside existing circulatory		✓							
	Works required to existing M25 Viaduct					✓				
	Affect to Wigley Bush Lane overbridge	✓	✓	✓	✓					
	Affect to Nags Head Lane overbridge	✓	✓	✓	✓					
	Affect to A12 footbridge	✓	✓	✓	✓					

6 Engineering assessment

6.1 Highway geometry - general

The geometric design standards adopted for this link are in accordance with *DMRB TD 22/06 Layout of Grade Separated Junctions*. Where appropriate, other geometric parameters relating to the design speed of the link are in accordance with *DMRB TD9/93 Highway Link Design*. Highway cross sections and headroom requirements have been designed in accordance with *TD 27/05 Cross Sections and Headrooms*.

The highway design is based on available LiDAR data and has not been optimised at this stage of the design process. Further refinements during the subsequent stages are likely to provide further value management opportunities. All of the options under consideration are designed to provide a grade separated connection between the M25 anti-clockwise carriageway and the A12 eastbound carriageway.

General arrangement drawings for each of the options considered under PCF Stage 1 are shown in Appendix G.

6.1.1 Geometric parameters – design speed

In accordance with Volume 6 of the DMRB, design speeds have been applied to the various types of highways as listed in Table 6-2.

Table 6-1 Typical design speeds (DMRB Volume 6)

Highway type	Design speed (Kph)
Merge and diverges adjoining M25 Mainline	120
Slip roads	70
Link roads	85
Loop roads	Varies*

* Loop roads have been designed on the basis of a 75m minimum radius in accordance with TD 22/06. For the purposes of the concept design an appropriate design speed based on the loop road radius has been used for other key geometric parameters.

6.1.2 Geometric parameters – stopping sight distance

Stopping sight distances on all options have been designed to comply with Table 3 of TD9/93 – Highway Link Design. The required distance to the relevant design speeds can be seen in Table 6.2.

Table 6-2 Standard stopping sight distances

Design speed	Stopping site distance	
	Desirable minimum (m)	One step (m)
120 kph	295	215
70 kph	120	90
85 kph	160	120
60 kph	90	70

6.1.3 Geometric parameters – horizontal and vertical curvature

Horizontal and vertical curvature of the options have been designed to comply with Table 3 of TD 9/93 - Highway Link Design. The desirable minimum values and permissible relaxations from Table 3 of TD 9/93 are listed in Table 6-3. Unless otherwise stated, all horizontal transition curves have been designed with a rate of change of centripetal acceleration of 0.3ms^{-3} .

Table 6-3 Standards for horizontal and vertical highway curvature

Design speed	Horizontal radius	Vertical crest curve		Vertical sag curve (K)		
	Desirable minimum (m)	One Step (m)	Two step (m)	Desirable minimum (K)	One step (m)	Absolute minimum
120 kph	1020	720	510	182	100	37
85 kph	510	360	255	55	30	20
70 kph	360	255	180	30	17	20
60 kph	255	180	127	17	10	13

6.1.4 Geometric parameters – gradient

Gradients on the options have been designed to comply with the parameters outlined in TD 9/93 - Highway Link Design. The desirable maximum and minimum values can be seen in Table 6-4.

Table 6-4 Desirable gradient for highway design

Highway type	Gradient	
	Desirable maximum	Desirable minimum
Motorways – including Merge & Diverges adjoining M25 Mainline	3%	0.05%
All-purpose Dual Carriageways	4%	0.05%
All-purpose Single Carriageways	6%	0.05%

6.1.5 Geometric parameters - cross sections and headrooms

Cross section and headroom parameters have been determined in accordance with TD 27/05 as listed in Table 6-5.

Table 6-5 Standard highway cross sections

Type	Location	Hard shoulder	Lane 1	Lane 2	Hard strip	Verges		Options
						Cutting	Embankment	
IL2A	Interchange links	3.3m	3.65m	3.65m	1.0m	1.5m	2.0m	Options 2, 4, 5D, 5E & 5F
IL1A	Interchange links	3.3m	3.70m	N/A	0.7m	1.5m	2.3m	Options 5A, 5B & 5C

All new overbridges have been designed with a minimum headroom of 5.30m in accordance with TD 27 with sag compensation where appropriate. Verge widths vary where necessary to provide forward visibility and when the carriageway passes through structures.

6.1.6 Option 2 – Northern hook

Option 2 has also been designed as a 2 lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, 3.65m wide lane 1, 3.65m wide lane 2 and 1.0m wide offside hard strip. The connector road design speed is 85kph and is in the basic form of a hook merge (TD 22/06, Figure 4.1).

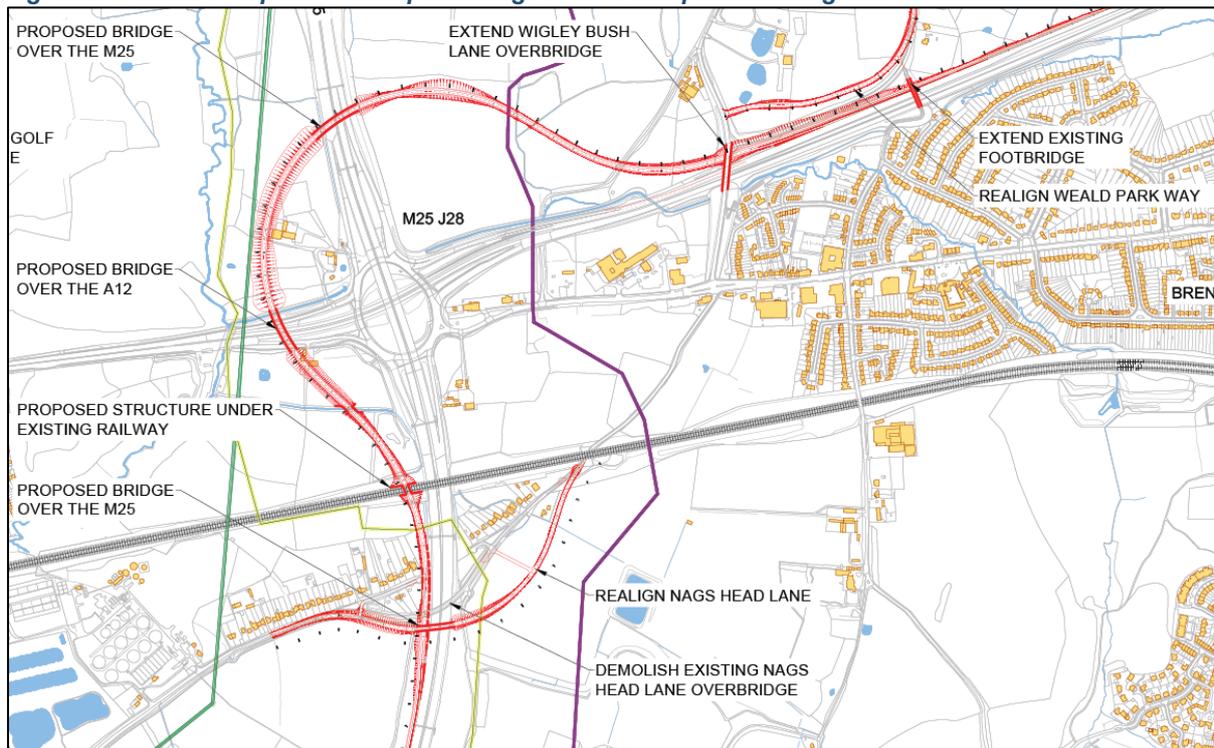
Geometric alignment and specifications (Figure 6-1)

The connector road diverges from the M25 anti-clockwise carriageway approximately 1.0km south of the junction, using a Type B (Option1) ghost island diverge (Figure 2/5 of TD 22/06). The alignment passes under Nags Head Lane requiring a new structure to replace the existing bridge, with Nags Head Lane itself being realigned over it.

Beyond the diverge nosing the link road peels away from the M25 mainline on a 2040m horizontal left hand radius (2 steps above the desirable minimum) passing immediately to the east of the residential property at No 18 Nags Head Lane.

The M25 continues to fall in a northerly direction towards Junction 28, however the link road flattens out using a combination of crest curve with a K value of 55 followed by a sag curve with a K value of 21.5 which takes the alignment under the Great Eastern mainline railway. This necessitates a 200m length of retaining wall adjacent to the M25 as the new link crosses the line of Nags Head Lane. At this point the horizontal alignment tightens with a 510m left hand radius (the desirable minimum to TD9/93 at 85kph), pulling the link road to the west of Junction 28.

Figure 6-1 Option 2 – Proposed alignment and slip road arrangements



To the north of the railway the alignment climbs on a 2.43% gradient into a crest curve (K value 70) to pass over the A12. It then hooks to the right using a 360m right hand radius (relaxation of one step below the desirable minimum) giving the alignment the classis hook configuration. The apex of the crest is in line with the southern boundary of the A12 and the elevation of the link falls towards the north to reduce the embankment height as it traverses fields to the north

west of the junction. Another sag curve with a K value of 21 is then used to elevate the highway again to pass over the M25 and the adjacent slip-roads on a vertical crest curve (K value of 55) approximately 300m to the north of the existing roundabout.

To the east of the M25 the interchange link then drops to tie into the A12 on a 2.6% gradient with a horizontal 360m left hand curve to bring it parallel to the A12. The link road then merges with the A12 using a Type H alternative ghost island merge (Figure 2/3 of TD 22/06), with a short length of auxiliary lane on the trunk road.

Interactions with existing highway infrastructure

This alignment requires alterations to Nags Head Lane. This is an existing 2 lane all-purpose unclassified road. The proposed realignment of Nags Head Lane has been designed to a similar standard to the existing alignment using a 50kph design speed (TD9/93). The minimum radius used in the design is 180m which is the desirable minimum (TD9/93 Table 3). Desirable minimum stopping sight distance has been achieved of 70m. The new alignment also significantly improves the approach to the railway underpass to the east of the M25. The alignment takes land to the south of the exiting Nags Head lane which is currently in agricultural use.

This option also requires local alterations to Weald Park Way which has been designed to be in keeping with the existing geometry of the road using a 60kph design speed (and in consideration of the existing 40mph speed limit) with a horizontal curvature which is no less than 190m (approx. 1 step below desirable). This assumes transition curves with a rate of change of centripetal acceleration of 0.6ms^{-3} . The vertical profile has been designed using absolute minimum sag curves and desirable minimum crest curves.

This option also requires the northern extension of the Wigley Bush Lane overbridge to enable the interchange link to pass under it.

Departures from standards

No departures from current design standards have been identified for this option at this stage.

6.1.7 Option 4 – Compact northern hook

As with Option 2, Option 4 has also been designed as a 2 lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, a 3.65m wide lane 1, 3.65m wide lane 2, and a 1.0m wide offside hard strip (TD 27/05, Figure 4.1b). The connector road design speed is 85kph in accordance (TD 22/06, Table 4/1).

Geometric alignment and specifications (Figure 6-2)

As with Option 2 the link is in the basic form of a hook merge (TD 22/06, Figure 4.1) but passes over the centre of the existing roundabout rather than swinging to the west.

For Option 2 the interchange link diverges before the existing diverge to the Junction 28 circulatory carriageway. However, with Option 4 the existing diverge to the Junction 28 roundabout is moved to a point approximately 500m south of its current location, which is then followed by a new diverge to the interchange link. The new slip road diverge assumes a Type B (Option1) ghost island arrangement (TD 22/06, Figure 2/5).

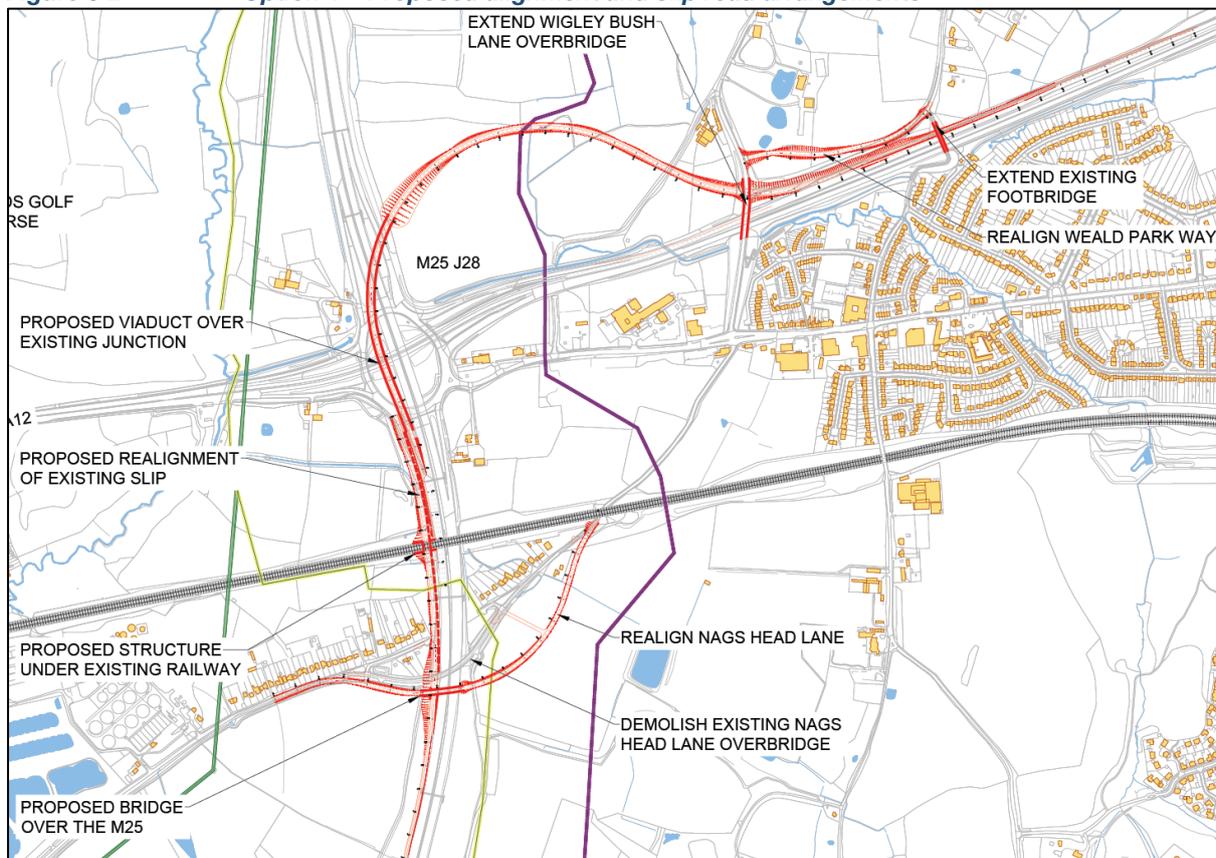
The new slip road to the Junction 28 roundabout passes under Nags Head Lane requiring a new structure to replace the existing bridge (similar to Option 2), with Nags Head Lane itself being realigned over it. Beyond the diverge nosing the slip road peels away from the M25 mainline on a 1440m horizontal left hand radius (1 step above the desirable minimum at 120kph). The M25 continues to fall in a northerly direction towards Junction 28, however the

link road flattens out using a sag curve with a K value of 37 (the absolute minimum at 120kph) taking the alignment under Nags Head Lane rising back up to existing ground level and passing immediately to the east of the residential property at No 18 Nags Head Lane. A subsequent crest curve (K Value 33.6, the desirable minimum for a slip road with 70kph design speed) then takes the alignment back under the Great Eastern mainline railway with a maximum downhill gradient of 5.1%. This configuration is intended to minimise the level differences between the slip road and the adjacent M25 mainline carriageway. This still necessitates a 500m length of retaining wall adjacent to the M25 preceding and receding from the railway underpass. North of the railway the slip road flattens out by means of another sag curve (K Value 20, the absolute minimum at 70kph) to join the Junction 28 roundabout.

Moving the existing slip road diverge to the south enables the new interchange link diverge to be located further north compared to Options 1 and 2, and takes advantage of the existing Junction 28 ancillary lane. This option has been designed with a Type C lane drop at the diverge taper (TD 22/06, Figure 2/5) with the nose approximately 150m south of the existing junction. The Type C diverge is required to achieve the compactness of this option. The spacing between successive diverge nose tips between the Junction 28 slip road and the interchange link diverge is approximately 550m; this exceeds of the minimum permitted distance from TD 22/06 (3.75 times the design speed, which equates to 450m on the M25).

Beyond the diverge nose the link road deviates from the M25 mainline using a short straight viaduct (immediately adjacent to the existing M25 viaduct) crossing over the southern and northern sections of the Junction 28 circulatory carriageway, as well as the A12 main carriageway. The link road then curves to the right using a 360m right hand horizontal curve which is one step below the desirable minimum for the 85kph design speed (TD9/93 table 3).

Figure 6-2 Option 4 – Proposed alignment and slip road arrangements



To provide the elevation to cross over the M25 motorway (north) a vertical sag curve with a K value of 37 (minimum for 120kph) raises the link road immediately beyond the diverge. This will achieve a maximum up gradient of 5.92% followed by a long crest curve with a K value of 55 (desirable for 85kph) which carries the link road over Junction 28 and the M25, at which point the alignment slopes down on a straight gradient of 1.34% to match the A12 levels on the east side of the junction.

Horizontally the alignment beyond the M25 crossing continues to sweep round on the 360m right hand curve, dissecting the ancient woodland to the north of the A12. It then transitions into a 360m left hand curve to facilitate the merge with the A12. As with Option 2 the link road merges with the A12 using a Type H alternative ghost island merge (TD 22/06, Figure 2/3), with a short length of auxiliary lane on the trunk road.

Interactions with existing highway infrastructure

As with Option 2 this option also requires local alterations to Weald Park Way which has been designed to be in keeping with the existing geometry of the road using a 60kph design speed and horizontal curvature which is no less than 190m. This uses transition curves with a rate of change of centripetal acceleration of 0.6ms^{-3} . The vertical profile has been designed using absolute minimum sag curves and the desirable minimum crest curves. This option also requires the northern extension of the Wigley Bush Lane Overbridge to enable the interchange link to pass under it.

Departures from standards

No departures from current design standards have been identified for this option at this stage.

6.1.8 Option 5A – Cloverleaf loop variant 1

Unlike Options 2 and 4, Option 5A has been designed as a single lane rural motorway interchange link (IL1A) comprising a 3.3m wide hard shoulder to the nearside, 3.70m wide lane 1 and a 0.7m wide offside hard strip in accordance with (TD 27/05, Figure 4.1b). As the link passes through an angle in excess of 180° it has been designed as a one-way loop (paragraph 1.21 of TD 22/06) thus allowing a minimum loop radius of 75m. The slip roads have been developed using a design speed of 75kph (TD 22/06).

Geometric alignment and specifications (Figure 6-3)

As with Option 4 the diverge to the Junction 28 circulatory is moved to a point approximately 500m south of its current location and utilises a Type B (Option1) ghost island diverge (TD 22/06, Figure 2/5). The new slip road passes under Nags Head Lane requiring a new structure to replace the existing bridge (similar to Option 2), with Nags Head Lane itself being realigned over it.

Whilst the geometry of the re-aligned slip road is broadly the same as with Option 4 there are some minor variations to accommodate the subsequent interchange link diverge. Beyond the diverge nosing the slip road peels away from the M25 mainline on a 1440m horizontal left hand radius (1 step above the desirable minimum at 120kph). The M25 continues to fall in a northerly direction towards Junction 28 however the slip road flattens out using a sag curve with a K value of 43 which takes the alignment under a realigned Nags Head Lane, rising back up to existing ground level and passing immediately to the east of the residential property at No 18 Nags Head Lane. A subsequent crest curve (K Value 24 less than one step below the desirable) then takes the alignment back under the Great Eastern mainline railway with a maximum downhill gradient of 5.1%. This configuration is intended to minimise the level differences between the slip road and the adjacent M25 mainline carriageway, but still necessitates a 500m length of retaining wall adjacent to the M25 preceding and receding from

the railway underpass. To the north of the railway the slip road flattens out by means of another sag curve (K Value 20) to join the Junction 28 roundabout.

The new interchange link diverges from the M25 taking advantage of the existing Junction 28 ancillary lane and using a 1020m left hand radius followed by a straight and a 2080m left hand radius to take the alignment above the junction.

The distance between successive diverge noses is currently shown as 425m which is marginally less than the minimum value of 450m. However this can be examined further and be engineered out at the next project stage. There is no standard configuration in TD 22/06 comprising a mainline lane drop leading to a single lane connector road, and therefore this would be a non-standard configuration and may represent a departure from standard.

The loop road diverges from the M25 mainline before the existing M25 viaduct before running over the A12 and the circulatory carriageway of the roundabout. This will require a new viaduct running above the junction parallel to the existing M25 viaduct structure. Beyond the end of the "near straight" associated with the diverge, Option 5A loops to the west using a 110m radius left hand curve taking the loop through 270° facilitating a tie in to the eastbound carriageway of the A12 to the west of the existing Junction 28. A stopping sight distance of 120m has been considered for the loop road which is the equivalent to a 60kph design speed and is consistent with the 110m radius.

As the loop road diverges from the M25 a compound vertical sag curve with a minimum K value of 37 carries it over the Junction 28 to M25 clockwise on-slip, increasing the uphill gradient to 2.5%. The increasing gradient is arrested by a 200K crest curve which then changes to a 17k crest curve where the alignment transitions from the 120kph mainline speed to the 60kph loop road design speed. The alignment then falls on 5.62% downhill gradient towards the A12 before another sag with a K value of 30 brings it up to match the A12 vertical profile facilitating the tie-in.

The loop road ties into the A12 eastbound carriageway utilising the nearside lane of the A12 as a lane gain. To facilitate this, the current nearside lane closure on the A12 is extended such that A12 mainline traffic passes the merge point using the offside lane only. There is no standard configuration in TD 22/06 comprising a single lane connector road merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a potential departure from standard. This configuration ensures that the A12 carriageway requires no widening under the existing interchange structures.

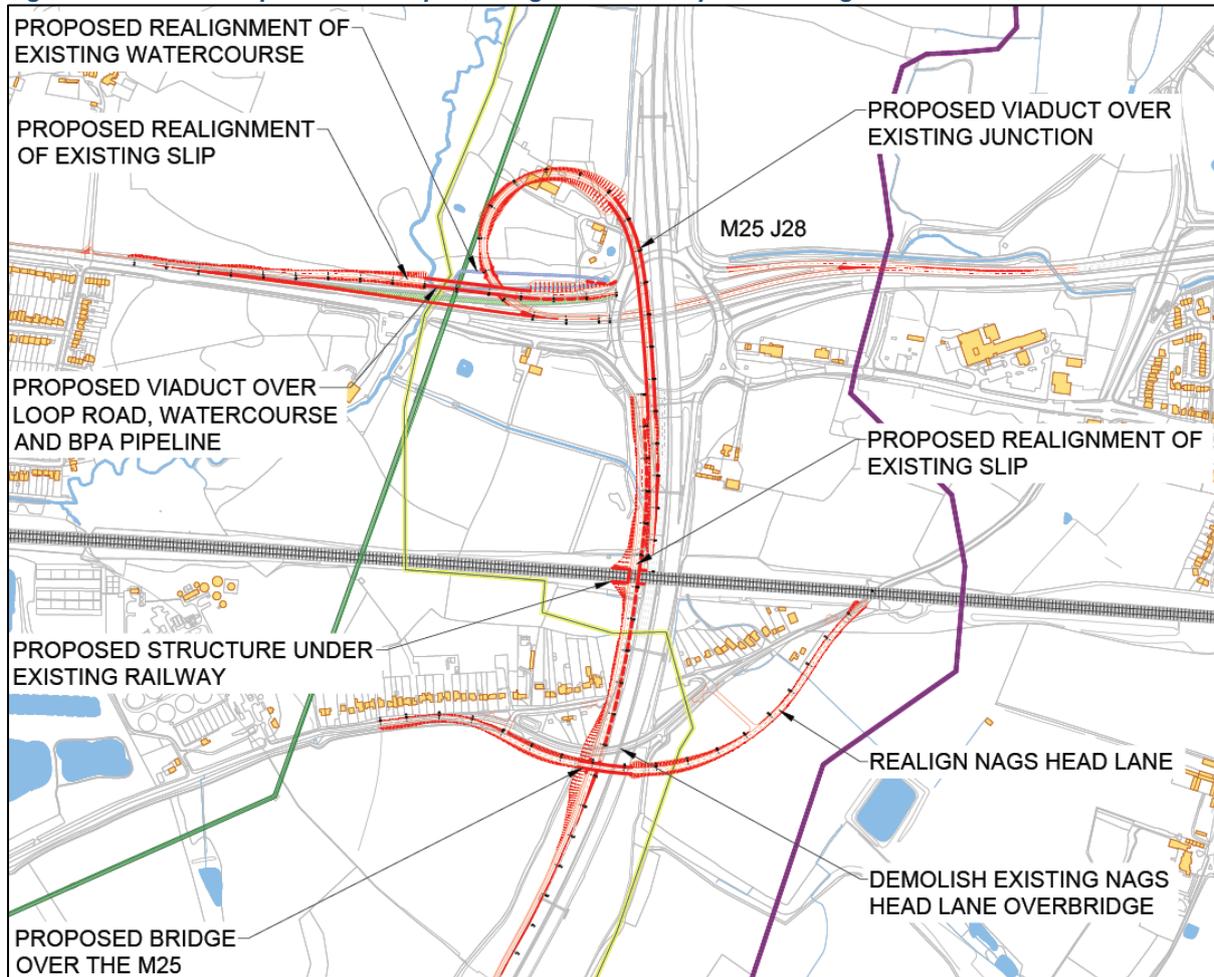
Interactions with existing highway infrastructure

The tie-in of the loop road to the A12 requires the A12 eastbound off-slip road to be realigned to climb over the loop road which then passes under it. In realigning the off-slip road the diverge from the A12 needs to be relocated approximately 350m to the west of the existing diverge. The existing diverge is in the form of a basic Type A – taper diverge (Figure 2/6.1, TD 22/06). The new diverge is proposed to be in the form of Type C – lane drop at taper diverge (Figure 2/6.2 TD 22/06). The A12 comprises two lanes at this location. There is no standard configuration in TD 22/06 comprising a two lane carriageway where the nearside lane is dropped at a taper diverge with the mainline traffic proceeding in the offside lane only; therefore this is a non-standard configuration and may represent a departure from standard.

The horizontal realignment of the slip road is facilitated by a 2040m left hand curve followed by a 1440m right hand curve. This takes the slip road away from the mainline allowing a vertical sag curve to be introduced with a K value of 20 and a subsequent 3.3% uphill gradient taking the alignment over Weald Brook, the BPA pipeline and the proposed loop road.

Other than the loop road, a vertical crest curve with a K value of 30 with a coincident 520m right hand horizontal curve aligns the slip road with the Junction 28 to tie in to the roundabout at a similar point to the existing slip road.

Figure 6-3 Option 5A – Proposed alignment and slip road arrangements



Departures from standards

No definitive departures from current design standards have been identified for this option at this stage. However there are two non-standard configurations which may constitute departures:

- The two lane carriageway with a nearside lane drop at a taper diverge on the A12 east bound diverge to Junction 28 is a non-standard configuration to TD 22/06 and may therefore constitute a departure.
- The single lane connector road merging with a single lane mainline lane utilising a lane gain scenario on the loop road merge to the A12 eastbound is a non-standard configuration to TD 22/06 and may therefore constitute a departure.

6.1.9 Option 5B – Cloverleaf loop variant 2

Option 5B is similar in principal to Option 5A.

In this variant of Option 5A, with the loop road diverge leaving the M25 clockwise carriageway 300m further north. The intentions here is to eliminate the need to re-align the M25 anti-clockwise off-slip road, and by moving the scheme north avoid any implications with the Great Eastern Mainline railway and Nags Head Lane.

Geometric alignment and specifications (Figure 6-4)

As with Option 5A it has been designed as a single lane rural motorway interchange link (IL1A) comprising a 3.3m wide hard shoulder to the nearside, a 3.70m wide lane 1 and a 0.7m wide offside hard strip (TD 27/05, Figure 4.1b). As the link curves more than 180° it has been designed as a one-way loop (TD 22/06, paragraph 1.21), allowing a minimum loop radius of 75m. The slip roads have been developed using a design speed of 75kph (TD 22/06).

In Option 5B, the traffic on the M25 anticlockwise carriageway wishing to head towards the A12 east would be directed on to the hard shoulder of the motorway immediately after diverge for the Junction 28 roundabout. The hard shoulder is converted into an ancillary lane for approximately 220m which then forms a lane drop onto the single lane loop road. The distance between the successive diverge noses of the off-slip road to the Junction 28 roundabout and the loop road is 290m, which is a departure from the minimum permitted distance defined in TD22/06 (i.e. 3.75 times the design speed, which equates to 450m on the M25). Furthermore there is no standard configuration in TD 22/06 comprising a mainline lane drop leading to a single lane connector road, and therefore this is a non-standard configuration and may represent a departure from standard.

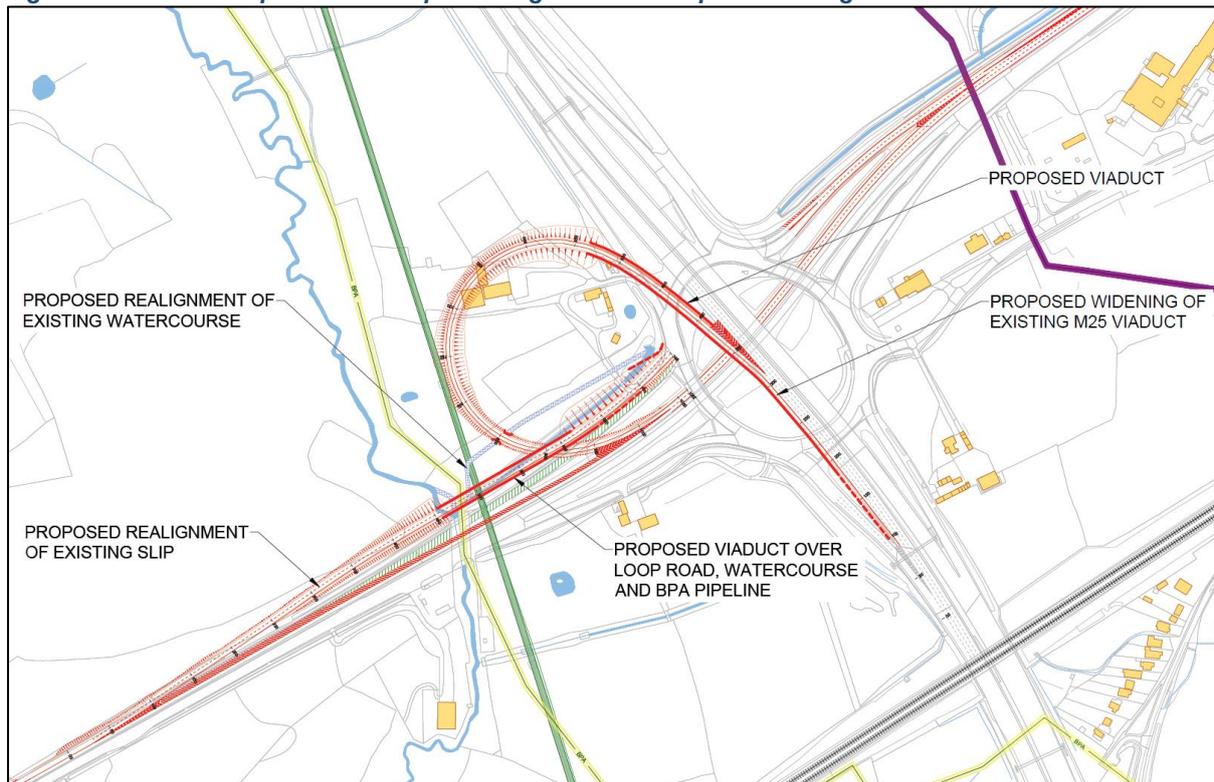
The loop road diverges from the M25 mainline whilst still traversing the viaduct which carries the M25 over the A12 and the circulatory carriageway of the roundabout. This will require widening of the existing structure.

In terms of the horizontal geometry there is a 1020m left hand radius which forms the near straight, transitions directly into a 107m radius left hand curve taking the loop through 270° and facilitating a tie in with the eastbound carriageway of the A12 to the west of the existing Junction 28. A stopping sight distance of 120m has been maintained on the loop road, which is the equivalent to a 60kph design speed and is consistent with the 107m radius.

As the loop road diverges from the M25 a vertical sag curve with a minimum K value of 85 carries the link over the M25 anticlockwise on-slip road from the Junction 28 roundabout, increasing the uphill gradient to 2.88%. The increasing gradient is arrested by a 112K crest curve (one step below desirable for a short length immediately before the drop to the loop road design speed) which then changes to a 30K crest curve where the alignment transitions from the 120kph mainline speed to the 60kph loop road design speed.

The alignment then falls on a 5.62% downhill gradient towards the A12 before another sag curve with a K value of 20 brings it up to match the A12 vertical profile facilitating the tie-in. The loop road ties into the A12 eastbound carriageway utilising the nearside lane of the A12 as a lane gain. To facilitate this, the current nearside lane closure on the A12 is extended westwards such that A12 mainline traffic passes the merge point using the offside lane only. There is no standard configuration in TD 22/06 comprising a single lane connector road merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a departure from standard. This configuration avoids the need to widen the A12 carriageway under the existing interchange structures.

Figure 6-4 **Option 5B – Proposed alignment and slip road arrangements**



Interactions with existing highway infrastructure

As with Option 5A, the tie-in of the loop road to the A12 requires the A12 eastbound off-slip road to be realigned to traverse over the new loop road as it passes towards the A12 eastbound carriageway. However the loop road crosses the off-slip road some 20m closer to Junction 28 (compared to Option 5A) requiring a different vertical profile. Horizontally the slip road alignment is very similar to Option 5A, leaving the A12 approximately 170m west of the existing diverge. The existing diverge is in the form of a basic Type A –Taper Diverge (TD 22/06, Figure 2/6.1), however the new configuration would be Type C – Lane Drop at Taper Diverge (TD 22/06, Figure 2/6.2). The A12 comprises two lanes at this location. There is no standard configuration in TD 22/06 comprising a two lane carriageway where the nearside lane is dropped at a taper diverge with the mainline traffic proceeding in the offside lane only. Therefore this is a non-standard configuration and may represent a departure from standard. The horizontal realignment of the A12 eastbound off-slip road is facilitated by a 3940m left hand curve followed by a 1440m right hand curve. This takes the off-slip road away from the mainline on a 2.3% downhill gradient followed by a vertical sag curve with a K value of 20 and a subsequent uphill gradient takes the alignment over Weald Brook, the BPA pipeline and the proposed loop road. Beyond the loop road a vertical crest curve with a K value of 30 with a coincident 520m right hand horizontal curve aligns the slip road with the Junction 28 roundabout.

Departures from standards

Several departures and non-standard configurations are required for Option 5B which may constitute departures:

- The distance between the successive diverge noses of the slip road and the loop road on the M25 anti-clockwise carriageway is 290m which is a departure from the minimum permitted distance in TD 22/06
- The two lane carriageway with a nearside lane drop at a taper diverge on the A12 east bound diverge to Junction 28 is a non-standard configuration to TD 22/06 and may therefore constitute a departure
- The single lane connector road merging with a single lane mainline lane utilising a lane gain scenario on the loop road merge to the A12 eastbound is a non-standard configuration to TD 22/06 and may therefore constitute a departure.

6.1.10 Option 5C - Cloverleaf loop variant 3

Option 5C is the third variant on the western loop road configuration. However with this option the loop road diverges from the M25 mainline north of the existing M25 mainline viaduct that traverses over the Junction 28 roundabout, thus avoiding any structural alterations within the proximity of the Junction 28 circulatory carriageway.

Geometric alignment and specifications (Figure 6-6)

As with Options 5A and 5B, Option 5C has been designed as a single lane rural motorway interchange link (IL1A) comprising a 3.3m wide hard shoulder to the nearside, a 3.70m wide lane 1 and a 0.7m wide offside hard strip (TD 27/05 Figure 4.1b). As the link curves more than 180° it has been designed as a one-way loop (TD 22/06, paragraph 1.21) thus allowing a minimum loop radius of 75m. The slip roads have been developed using a design speed of 75kph (TD 22/06).

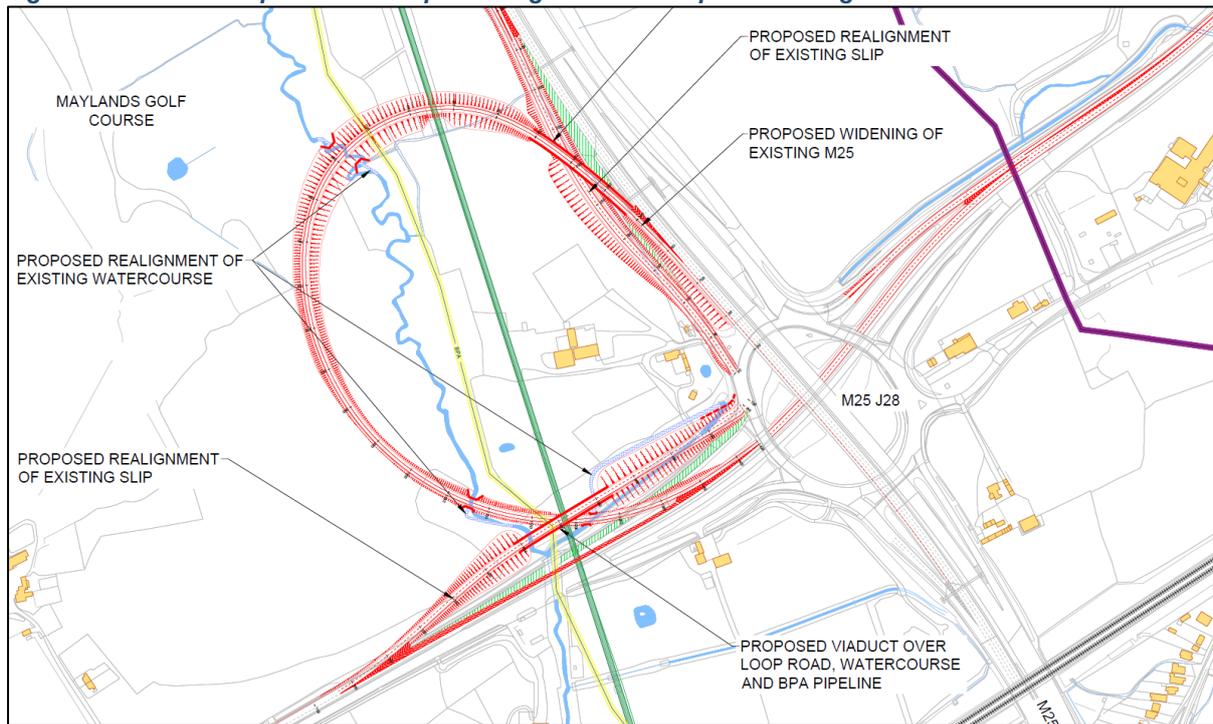
As with Option 5B, traffic destined for the A12 east is directed onto the hard shoulder on the M25 anticlockwise beyond the existing diverge for the Junction 28 roundabout. The hard shoulder would be converted into an ancillary lane for approximately 370m which then forms a lane drop onto the single lane loop road. The conversion of the hard shoulder is a departure from the cross sectional requirements outlined in TD 27/05 – Cross-Sections and Headrooms.

The distance between the successive diverge noses of the slip road and the loop road is increased to 520m which is in excess of the minimum permitted distance from TD 22/06 (i.e. 450m on the M25). There is no standard configuration in TD 22/06 comprising a mainline lane drop leading to a single lane connector road, and therefore this is a non-standard configuration and may be subject to a departure from standard.

The loop road diverges from the M25 anti-clockwise beyond the north abutment of the existing M25 viaduct. This together with the use of the hard-shoulder to provide an ancillary lane means that there is no requirement to widen the M25 over the existing viaduct.

The horizontal geometry for this variant is different to Options 5A and 5B in that it requires a compound horizontal loop radius. A 1020m left hand radius which forms the near straight, transitions directly into a 160m radius left hand curve which in turn transitions into a 295m left hand curve. Together these take the loop through 270°, facilitating a tie in to the A12 eastbound carriageway to the west of Junction 28. A stopping sight distance of 120m has been ensured on the loop road.

Figure 6-5 *Option 5C – Proposed alignment and slip road arrangements*



The loop road diverges from the M25 further north than the other two options, where the M25 mainline is starting to climb. A vertical crest curve with a K value of 173 is used to create a 0.7% downward gradient to minimise the embankment necessary to the west of the M25 carriageway. However the loop road crosses the M25 anti-clockwise on-slip road 250m further north than Options 5A and 5B. The on-slip road is rising to join the M25 mainline carriageway and as a consequence it is necessary to re-align and lower the existing on-slip road so that the loop road can pass over it. The vertical profile of the loop road reflects this so that a second crest curve with a K value of 182 and its apex over the slip road ensures that the elevation is maintained. This is then followed by a downward gradient of 1.5% reducing the height of the embankment and allowing the loop road to pass under the re-aligned A12 east off-slip road (similar to Options 5A and 5B). A sag curve with a K value of 20 and a low point immediately under the A12 off-slip road then elevates the carriageway to run parallel to the A12 eastbound mainline to facilitate the tie in.

As with Options 5A and 5B, the loop road ties into the A12 eastbound carriageway utilising the nearside lane of the A12 as a lane gain. To facilitate this, the current nearside lane closure on the A12 is extended westwards such that A12 mainline traffic passes the merge point using the offside lane only. There is no standard configuration in TD 22/06 comprising a single lane connector road merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a departure from standard. This configuration avoids the need to widen the A12 carriageway under the existing interchange structures.

Interactions with existing highway infrastructure

The loop road crossing of the M25 anti-clockwise on-slip road requires the realignment of the slip road to allow the loop road to pass over it. The realigned slip road leaves the roundabout with a 25m straight which transitions into a 510m radius horizontal left hand curve to provide sufficient clearance from the existing infrastructure to allow it to be lowered to pass under the loop road. This is followed by a 510m right hand curve to bring the alignment back towards the

M25 carriageway followed by a compound left hand curve (1020m and 3871m) to facilitate the merge with the main carriageway.

Vertically the slip road follows the alignment of the existing slip before a vertical crest curve with a K value of 55 lowers the road on 2.2% downhill gradient to pass under the loop road. The slip road passes under the loop road on a vertical sag curve with a K value of 20 raising on a gradient of 3.36% to bring it back to the level of the M25 to facilitate the tie in.

The tie-in of the loop road to the A12 eastbound carriageway west of Junction 28 requires the A12 eastbound off-slip road to be realigned to climb over the loop road which then passes under it. However the crossing point is further west than shown in Options 5A and 5B. Horizontally the slip road alignment is similar to Options 5A and 5B, leaving the A12 approximately 170m to the west of the existing diverge. The existing diverge is in the form of a basic Type A –Taper Diverge TD 22/06, Figure 2/6.1), however the new configuration is in the form of Type C – Lane Drop at Taper Diverge (TD 22/06, Figure 2/6.2). The A12 comprises two lanes at this location. There is no standard configuration in TD 22/06 comprising a two lane carriageway where the nearside lane is dropped at a taper diverge with the mainline traffic proceeding in the offside lane only; therefore this is a non-standard configuration and may represent a departure from standard.

The horizontal realignment of the A12 eastbound off-slip road slip is facilitated by a 3940m left hand curve followed by a 1440m right hand curve. These take the slip road away from the mainline on a 2.3% downhill gradient followed by a vertical sag curve with a K value of 20 and subsequent uphill gradient takes the alignment over Weald Brook, the BPA pipeline and the proposed loop road. Having crossed the new loop road a vertical crest curve with a K value of 30 with a coincident 520m right hand horizontal curve aligns the slip road with the Junction 28 roundabout.

Departures from standards

Several departures and non-standard configurations are required in Option 5C which may constitute departures:

- Use of 380m of hard shoulder as an ancillary lane at the M25 anti-clockwise diverge to the loop road is a departure from the cross sectional requirements outlined in TD 27/05
- The two lane carriageway with a nearside lane drop at a taper diverge on the A12 east bound diverge to Junction 28 is a non-standard configuration to TD 22/06 and may therefore constitute a departure
- The single lane connector road merging with a single lane mainline lane utilising a lane gain scenario on the loop road merge to the A12 eastbound is a non-standard configuration to TD 22/06 and may therefore constitute a departure.

6.1.11 Option 5D – Northern loop

Option 5D has been designed as a 2 lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, a 3.65m wide lane1, a 3.65m wide lane 2, and 1.0m wide offside hard strip (TD 27/05, Figure 4.1b). The connector road design speed is 85kph (TD 22/06, Table 4/1). As the link passes through more than 180° it has been designed as a one-way loop (TD 22/06, paragraph 1.21), thus allowing a minimum loop radius of 75m. The slip roads have been developed using a design speed of 75kph (TD 22/06).

Geometric alignment and specifications (Figure 6-6)

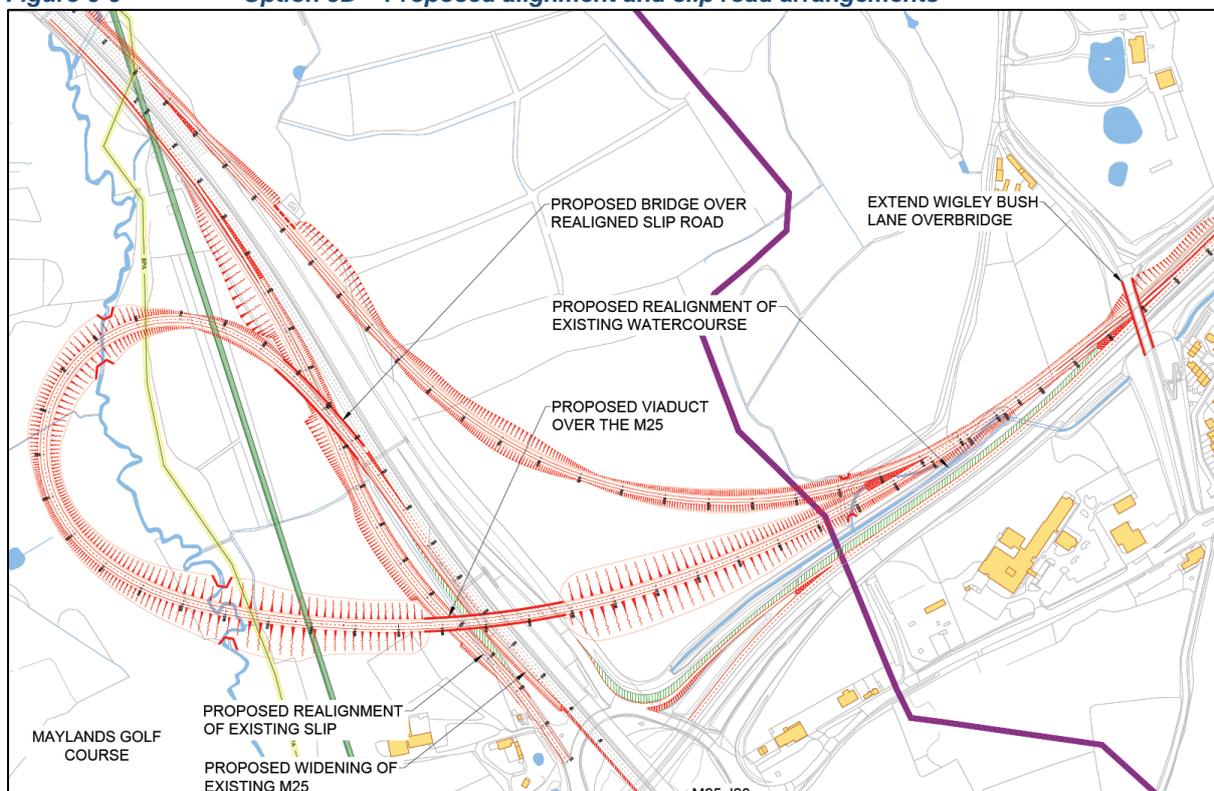
This option has been developed to be fully compliant with the design standards whilst not affecting the existing structures that form the Junction 28 interchange.

It is proposed to widen the M25 anti-clockwise carriageway on the nearside beyond the nosing for the existing M25 anticlockwise off-slip road to Junction 28. This enables the hard shoulder to be maintained while allowing for an auxiliary lane leading into a Type D (Option 2) Lane Drop at Parallel Diverge (TD 22/06, Figure 2/6.3). Although this not the preferred layout a Type D Option 1 would force the alignment too far north making the tie-in to the A12 eastbound carriageway much more problematic.

The loop road leaves the M25 anti-clockwise carriageway on a 1020m left hand radius. Beyond the near straight the alignment tightens into a 150m loop which enables the alignment to pass through the 180° without excessive encroachment into the fields to the east of the junction. The horizontal curvature then eases to a 1014m left hand radius passing over the M25 to the north of Junction 28 before approaching the tie-in with the A12 eastbound carriageway to the east of the M25 using a Type F- Lane Gain with Ghost Island Merge (Option 1 – preferred). This option passes close to the ancient woodland near Wigley Bush Lane and requires the reconstruction of the Wigley Bush Lane overbridge to allow the alignment to pass under it.

As with the other loop options, Option 5D passes over the M25 anti-clockwise off-slip. It remains at similar level to the M25 mainline to pass over the slip-road with a crest curve with a K value of 55 then leading to a downward gradient of 1.4%, reducing the earthworks in the adjacent fields. The alignment then starts to climb again with a sag curve (K value 49) leading to a 5.2% uphill gradient which takes the alignment over the M25. A crest curve with its apex centred over the M25 (K value 55) enables the alignment to drop down towards the A12 eastbound carriageway levels with a gradient of 5.8%. This is followed by another sag curve (K Value 32) to bring the alignment to the same level as the A12 and to facilitate the merge.

Figure 6-6 Option 5D – Proposed alignment and slip road arrangements



Interactions with existing highway infrastructure

As with Option 5B, Option 5D requires the lowering of the Junction 28 to M25 anti-clockwise on-slip to enable the loop road to pass over it. However, in Option 5D the alignment crosses the slip-road twice. To facilitate this it is proposed to move the on-slip road off-line to the west of the existing alignment so the slip road can remain open during construction. From the roundabout the slip road follows the existing alignment before diverting to the west after 100m on a 510m radius left hand curve. A subsequent 510m right hand curve then brings the alignment back towards the M25 with a compound left hand curve (1020 and 4300m radius) facilitating the merge and allowing for the “near straight” at the approach to the merge nosing.

Vertically a 383m long crest curve with a K value of 55, starting approximately 65m from the roundabout, reduces the level of the slip road. This enables a maximum 4.2% downward gradient to take the slip-road under both the two loop road crossing points. This is followed by a sag curve (K value 20) which brings the alignment back up to the level of the M25 with the merge facilitated by another crest curve (K value 102).

The on-slip merges with the M25 anti-clockwise carriageway via a Type F- Lane Gain with Ghost Island Merge (Option 1 – preferred), similar to the existing merge.

A further incremental option considered with this Option 5D is concerned with the provision of an alternative interchange link to take the M25 clockwise to A12 east traffic away from the roundabout and existing dedicated lane. This new link road would merge with the loop road to the east of the M25 before the loop road merges with the A12 eastbound carriageway. The existing M25 clockwise diverge is a Type D (Option 1 preferred) Ghost Island Diverge for Lane Drop, incorporating a tiger tail (TD 22/06 Figure 2/6.3). In the current layout the nearside lane is signed for traffic destined for the A12 east and the A1023 Brook Street. The proposed layout is similar on the approach, however a new interchange link would diverge from the nearside lane using a Type A - Taper Diverge (TD 22/06, Figure 2/6.1). This link road has been designed as a single lane rural motorway interchange link (IL1A) comprising a 3.3m wide hard shoulder to the nearside, a 3.70m wide lane 1, and a 0.7m wide offside hard strip (TD 27/05, Figure 4.1b). The M25 curves to the right at the point of the diverge so the new link road departs from the main carriageway using a 3871m radius right hand curve. This is followed by a 510m radius left hand curve which brings the alignment parallel to the above proposed interchange loop as it approached the A12 east, merging with it via a Type A – Taper Merge (TD 22/06, Figure 2/4.1). The interchange link crosses open fields which slope towards Junction 28. The vertical profile of the link road comprises a crest curve (K value of 80) followed by a 1.82% downhill gradient and a sag curve with a K value of 31 to facilitate the merge with the loop. The current configuration is very close to the maximum 1km length as outlines in paragraph 4.3 of TD 22/06; however it is considered that this length will not be exceeded when the design is refined in future project stages.

Departures from standards

No departures from current design standards have been identified for this option at this stage.

6.1.12 Option 5E – Northern loop variant

Option 5E has been designed with the same configuration and horizontal geometry as Option 5D. The only difference is that in Option 5E the proposed loop road passes under the M25 and the north facing Junction 28 slip-roads. This was intended to reduce the visual and environmental impact of the loop road.

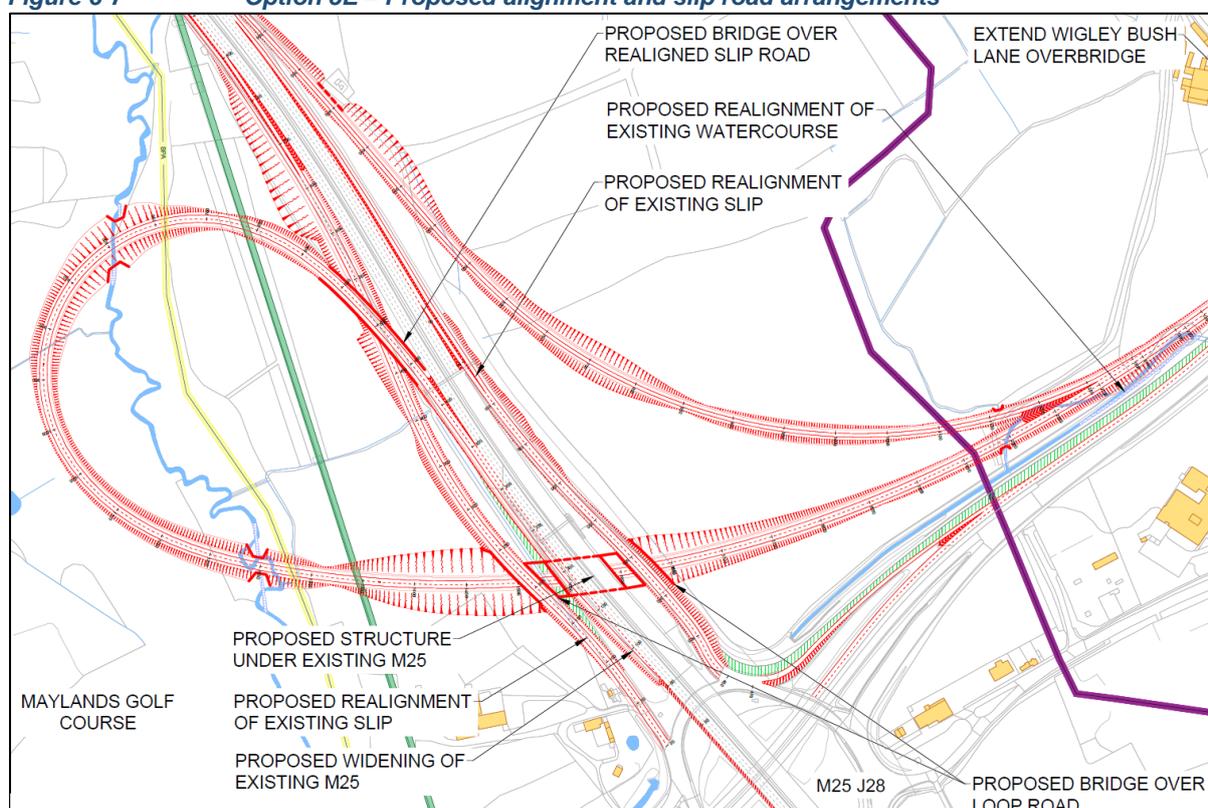
Geometric alignment and specifications (Figure 6-7)

As with Option 5D, Option 5E comprises a 2 lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, a 3.65m wide lane 1, a 3.65m wide lane 2, and a 1.0m wide offside hard strip. The connector road design speed is 85kph.

As noted above the vertical and horizontal alignments for Option 5E are the same as those defined earlier for Option 5D. The following sets out the key exceptions relating to the passing the interchange loop under the M25 carriageway and slip roads.

To facilitate the M25 underpass the vertical profile of Option 5E is substantially different to that shown for Option 5D. As with the other loop options it passes over the M25 anti-clockwise on-slip. It therefore remains at similar level to the M25 mainline to pass over the slip-road with a crest curve with a K value of 60 with a maximum downward gradient of 3.9%. It then levels out with a sag curve (K value 22) leading to a 600m long gradient of 0.65% taking the loop road under the M25. A sag curve (K value 127.6) then raises the carriageway to an uphill gradient of 1.25% bringing the loop road up to the level of the A12 eastbound carriageway. This is followed by another sag curve (K Value 125.5) which facilitates the merge.

Figure 6-7 Option 5E – Proposed alignment and slip road arrangements



Interactions with existing highway infrastructure

As with Option 5D, Option 5E also requires the lowering of the Junction 28 to M25 anti-clockwise on-slip to enable the loop road to pass over it (see Section 6.1.13). However, the vertical profile of the on-slip road is different to Option 5D as it passes over the southern arc of the proposed loop road, and then passes under the loop as it diverges from the M25 anticlockwise carriageway. From the roundabout a sag curve (K value 52.6) raises the slip road with a maximum gradient of 3.2%. This is then followed by a crest curve (K value 31.3) with its apex just north of where the proposed loop road passes under the slip road. A downhill gradient of 4.2% takes the slip under the northern arc of the loop road followed by another sag

curve (K value 141) to bring the slip road back up to the M25 main carriageway levels with a subsequent crest curve to facilitate the merge.

Unlike Option 5D this option also requires the M25 clockwise off-slip road to be raised to allow the loop road to pass under it. To facilitate the construction of this slip road it is proposed to provide a temporary carriageway as it is difficult to obtain a suitable new horizontal alignment for the slip-road. The horizontal geometry for the off-slip road is therefore the same as the existing. The vertical profile is developed by extending the existing 0.5% uphill gradient from the M25 mainline followed by a 259m long crest curve with a K value of 106 which takes the off-slip road over the proposed loop road underpass. This would be followed by a 100m long crest curve with a K value of 55 developing a downhill gradient of 3.2%. A sag curve with a K value of 10 at the immediate would then facilitate the tie in with the roundabout.

As with Option 5D, Option 5E also considers the provision of a second interchange link to take the M25 clockwise to A12 east traffic away from the roundabout and dedicated left turn lane. This is as defined under Option 5D (Section 6.1.13).

Departures from standards

No departures from current design standards have been identified for this option at this stage.

6.1.13 Option 5F - Cloverleaf variant 4

Option 5F is very similar to Option 5C with the loop road diverging from the M25 mainline north of the existing viaduct. The key difference is that has been designed to accommodate two lanes with hard shoulder which significantly changes the diverge and merge configurations, which in turn significantly effects the geometry of the loop road.

Geometric alignment and specifications (Figure 6-8)

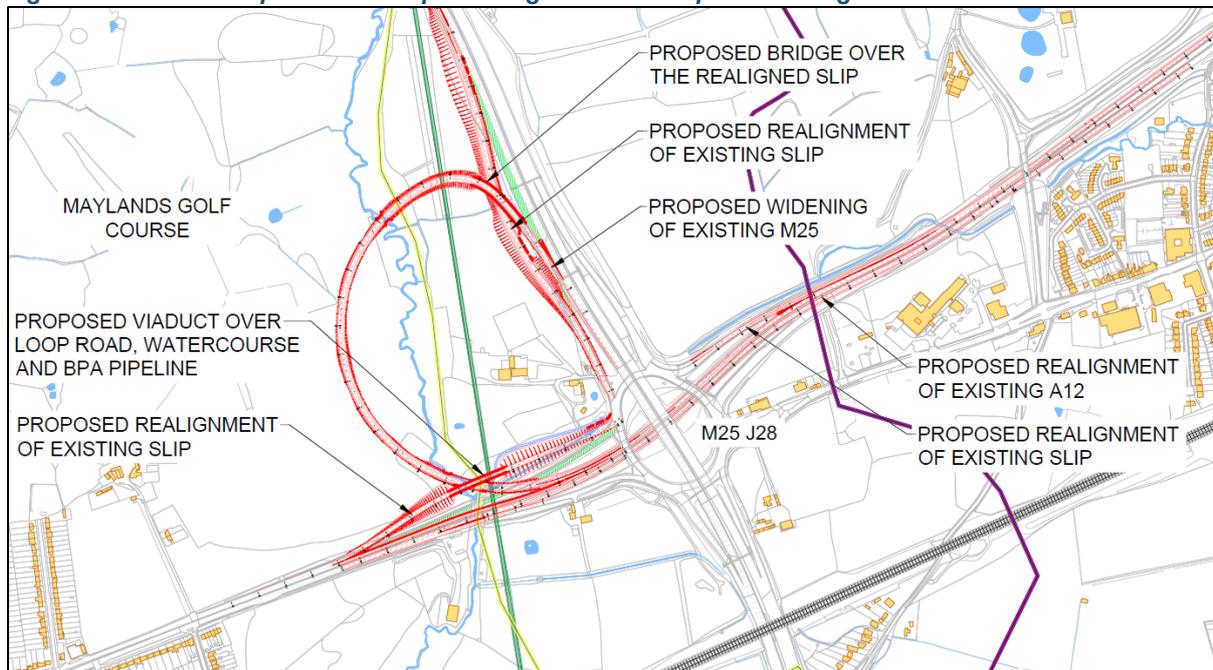
Option 5F has been designed as a two lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, a 3.65m wide lane 1, a 3.65m wide lane 2, and 1.0m wide offside hard strip (TD 27/05, Figure 4.1b). As the link traverses through an angle in excess of 180° it has been designed as a one-way loop (TD 22/06, paragraph 1.21), thus allowing a minimum loop radius of 75m. The layout of the slip roads have been developed using a design speed of 75kph (TD 22/06).

The loop road diverges from the M25 anti-clockwise carriageway using a Type A Taper Diverge (TD 22/06, Figure 2/6.1). Local widening of the M25 at this location enables the continuity of the hard shoulder to be maintained. Leaving the M25 on a 1020m radius left hand curve, the alignment transitions into a 100m left hand loop for 85m beyond the near straight before slackening to a 285m left hand curve taking the loop, road through 270° to run parallel to the A12 eastbound carriageway. The loop road merges with the A12 eastbound carriageway using a Type F - Lane Gain with Ghost Island Merge (Option 2 Alternative). There is no standard configuration in TD 22/06 comprising a two lane connector road merging with a single lane mainline lane utilising a lane gain scenario, and therefore this is a non-standard configuration and may represent a departure from standard.

At the point of the diverge the M25 mainline is on a 1.6% downhill gradient. As the loop road diverges from the M25 a vertical sag curve with a K value of 39 slackens the downhill gradient to 0.51% to carry it over the Junction 28 to M25 clockwise on-slip. Immediately beyond the slip road crossing, a vertical crest curve with a K value of 75 increases the downhill gradient to 4.92% with a sag curve with a K value of 131 taking the loop over its first crossing of Weald Brook before climbing on a 1.6% gradient up the hill side to the west of the brook. A further crest curve with a K value of 218 arrests the climb taking the alignment on a downhill gradient

of 2.35% to take the loop under the realigned A12 west to Junction 28 slip road before tying in to the A12 using a sag curve with a K value of 79.5 and a 0.21% downhill grade.

Figure 6-8 *Option 5F – Proposed alignment and slip road arrangements*



Interactions with existing highway infrastructure

The loop road crossing of the M25 anti-clockwise to Junction 28 slip road requires the realignment of the slip road to allow the loop road to pass over it. The realigned slip road leaves the roundabout with a 55m straight which transitions into a 510m radius horizontal left hand curve to provide sufficient clearance from the existing infrastructure to allow it to be lowered to pass under the loop road. This is followed by a 510m right hand curve to bring the alignment back towards the M25 followed by a compound left hand curve (1020m and 1440m) to facilitate the merge with the main carriageway.

Vertically the slip road follows the alignment of the existing slip before a vertical crest curve with a K value of 30 lowers the road on 4.56% downhill gradient to pass under the loop road. The slip road passes under the loop road on a vertical sag curve with a K value of 20 raising on a gradient of 1.58% to bring it back to the level of the M25 to facilitate the tie in.

The tie-in of the loop road to the A12 requires the A12 eastbound off-slip road to Junction 28 to be realigned to climb over the loop road as it passes underneath. This re-alignment is the same as that defined above for Option 5C (see Section 6.1.11).

The horizontal realignment of the A12 eastbound off-slip road is also the same as that detailed under Option 5C.

With a 2 lane loop under Option 5F the merge of the new loop road with the A12 eastbound carriageway is different. This requires some minor realignment of the channel lines of the existing A12 carriageway as it passes under the interchange. It does not require any alterations to the existing structures but may require reconfiguration of the safety barriers.

Departures from standards

No departures from current design standards have been identified for this option at this stage.

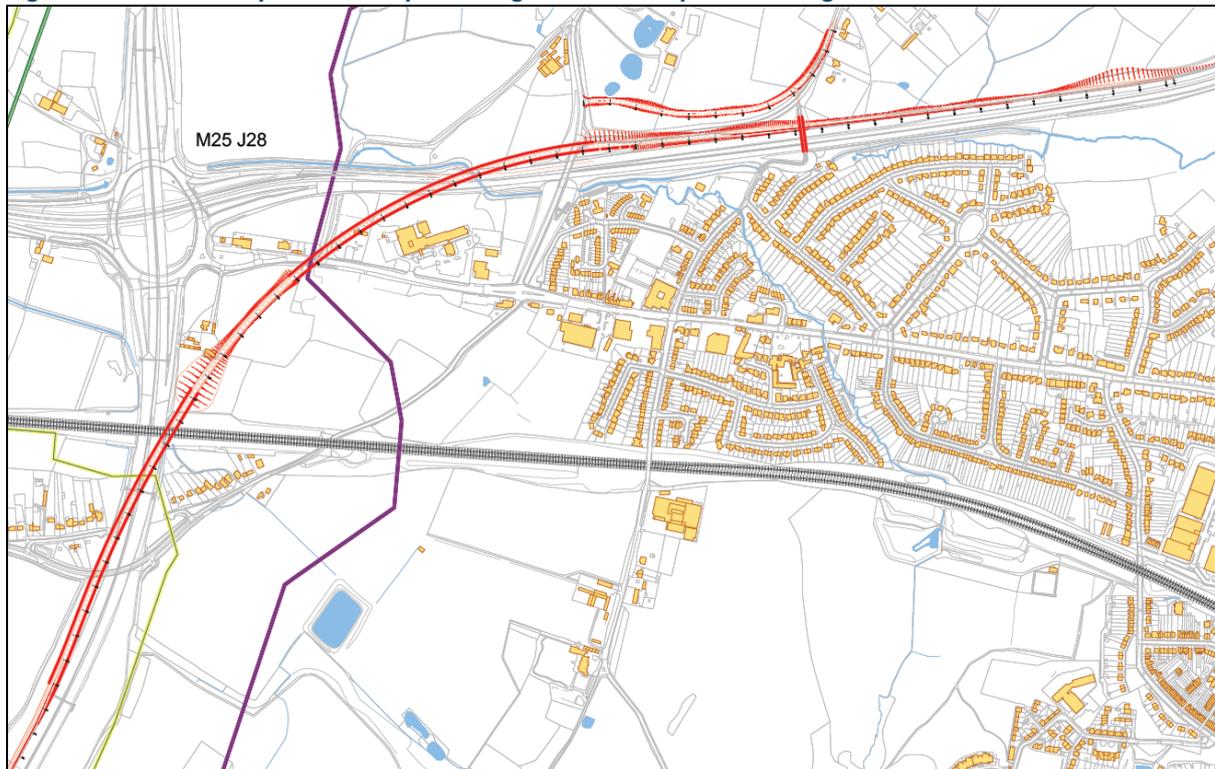
6.1.14 Option 6 – Southern link

Option 6 has been designed as a 2 lane rural motorway interchange link (IL2A) comprising a 3.3m wide hard shoulder to the nearside, a 3.65m wide lane 1, 3.65m wide lane 2 and 1.0m wide offside hard strip (TD 27/05, Figure 4.1b). The connector road design speed is 85 kph (TD 22/06, Table 4/1).

Geometric alignment and specifications (Figure 6-9)

The proposed connector road diverges from the M25 anti-clockwise carriageway approximately 1.2km south of the junction, using a Type B (Option1) ghost island diverge (in accordance with Figure 2/5 of TD 22/06). The vertical profile of the M25 at the point of divergence is on a 1.87% downhill gradient towards Junction 28. The interchange link leaves the M25 on vertical sag curve with a K value⁸ of 37 to match the 120kph main-line design speed. The gradient transitions to a 3.91% uphill gradient over the 214m length of the sag curve, to carry the link over Nags Head Lane and the main line railway.

Figure 6-9 **Option 6 – Proposed alignment and slip road arrangements**



The connector road is approximately 14m above the M25 carriageway as it passes over Nags Head Lane. Horizontally the link curves to the right on a 2040m curve which carries it over the M25 on a long viaduct immediately south of the railway on an acute skew crossing. This is in excess of the horizontal curvature requirements for the 85kph link road and is designed to achieve a desirable corridor as it passes adjacent to commercial properties north of Brook

⁸ The K-value is the horizontal distance required to achieve a 1% change in the slope of the vertical curve (TD 22/06)

Street. A 525m long vertical crest curve with a desirable minimum K value of 55 arrests the gain in height.

With the apex at the railway overbridge, the alignment descends to enable the road to be carried on embankment east of the M25, with a maximum down gradient of 5.6%. A sag curve with an absolute minimum K value of 20 raises the road again to a maximum up-hill gradient of 5.25% to enable it to pass over Brook Street, and then across commercial properties to the north of Brook Street and the A12. A subsequent crest (55 K value) would enable the alignment to descend on a 5.25% downhill gradient north of the A12 to facilitate the tie in. Having passed to the west of the Spirit Health Club at Brook Street, the horizontal curvature is reduced from 2040m to a 1020m right hand radius to bring the alignment parallel to the eastbound carriageway of the A12. The link road then merges with the A12 east using a Type H alternative ghost island merge (Figure 2/3 of TD 22/06) with a short length of auxiliary lane on the trunk road.

Interactions with existing highway infrastructure

This alignment requires local alterations to Weald Park Way which has been designed to be in keeping with the geometry of the existing road (and in consideration of the existing 40mph speed limit). This alignment assumes a 60kph design speed and a horizontal curvature which is no less than 190m (approx. one step below the desirable) using transition curves with a rate of change of centripetal acceleration of 0.6ms^{-3} . The vertical profile has been designed using absolute minimum sag curves and desirable minimum crest curves.

Departures from standards

No departures from current design standards have been identified for this option at this stage.

6.2 Structures

Concept design has been based on the use of standard steel composite construction with open abutments wherever possible. Depth to span ratios of 1:20 have been assumed in most cases to determine surface to surface clearance of crossing highways. All structural details are indicative only. The following provides indicative locations and dimensions of identified structures which may not be exhaustive and are subject to locational/dimensional verification at later design stages.

The general arrangement drawings are available for each option in Appendix G showing location of structures with associated chainages.

6.2.1 Option 2 – Northern hook

The following structures/structural alterations have been identified for Option 2:

Alterations to existing structures

- Demolition of Nags Head Lane Bridge and replacement with a new 4 span, steel composite bridge 75m in length 14m wide to enable the new link road to pass under it
- Partial demolition and reconstruction/extension of Wigley Bush Lane Bridge at chainage 2850 comprising 40m of new construction to enable the new link road to pass under it
- Partial demolition and reconstruction/extension of the existing Spital Lane footbridge to enable the tie in of the link road to the A12 eastbound at chainage 3275 comprising 40m of new construction

- Demolition and replacement of 2 No sign gantries at the M25 anti-clockwise diverge to the new link road at chainages 75 and 455 to facilitate construction of the diverge.

Proposed new structures

- A 15m span railway bridge under the Great Eastern mainline railway to enable the new link road to pass under it at chainage 990 comprising a precast concrete bridge deck founded on contiguous piled abutments approximately 20m wide built in sections under limited track possessions.
- A 100m multi span composite steel bridge 15.1m wide to carry the new link road over the A12 from chainage 1375 to 1475
- A 110m multi span composite steel bridge 15.1m wide to carry the new link road over the M25 and slip roads from chainage 1890 to 2000
- A 200m retaining wall immediately north of the realigned Nags Head Lane on the offside to accommodate the level difference between the link road and the M25 anti-clockwise carriageway from chainage 650 to 850 (average height 2m)
- A 30m retaining wall adjacent to the property at No 18 Nags Head Lane, to accommodate the level difference between the nearside of the link road and the property boundary from chainage 770 to 800 (average height 2m)
- 1 major culvert to carry the link road over the watercourse between the railway and the A12 at chainage 1200
- 2 minor culverts over ditches east of the M25 and north of the A12 at chainages 2350 and 2400.

6.2.2 Option 4 – Compact northern hook

The following structures/structural alterations have been identified for Option 4:

Alterations to existing structures

- Demolition of Nags Head Lane Bridge and replacement with a new 4 span, steel composite bridge 75m in length 14m wide to enable the re-aligned slip road to pass under it
- Partial demolition and reconstruction/extension of Wigley Bush Lane Bridge at chainage 1650 comprising 40m of new construction to enable the new link road to pass under it
- Partial demolition and reconstruction/extension of the existing Spital Lane footbridge to enable the tie in of the link road to the A12 eastbound at chainage 2075 comprising 40m of new construction
- Demolition and replacement of 3 No sign gantries at the M25 anti-clockwise diverge to the re-aligned slip road at SR chainages 5, 395 and IL chainage 22 to facilitate construction of the diverges.

Proposed new structures

- A 15m span railway bridge under the Great Eastern mainline railway to enable the re-aligned slip road to pass under it at SR chainage 910 comprising a precast concrete

bridge deck founded on contiguous piled abutments approximately 20m wide built in sections under limited track possessions

- A 460m multi span composite steel viaduct 16.1m wide to carry the new interchange link road over the circulatory carriageway at Junction 28, over the A12, over the M25 north of the junction and over the M25 clockwise to Junction 28 slip road from IL chainage 340 to 800
- A 260m retaining wall on the offside of the re-aligned slip road between Nags Head Lane and the railway to accommodate the level difference between the slip road and the M25 from SR chainage 650 to 910 (average height 2m)
- A 235m retaining wall on the offside of the re-aligned slip road from the railway to Junction 28 to accommodate the level difference between the slip road and the new interchange link from SR chainage 925 to 1160 (average height 2m).

6.2.3 Option 5A – Cloverleaf loop variant 1

The following structures/structural alterations have been identified for Option 5A:

Alterations to existing structures

- Demolition of Nags Head Lane Bridge and replacement with a new 4 span, steel composite bridge 75m in length 14m wide to enable the re-aligned slip road to pass under it
- Demolition and replacement of 3 No sign gantries at the M25 anti-clockwise diverge to the re-aligned slip road at SR chainages 5, 395 and IL chainage 125 to facilitate construction of the diverges
- Demolition and replacement of 3 No sign gantries at the M25 anti-clockwise diverge to the re-aligned slip road at SR chainages 5, 395 and IL chainage 225 to facilitate construction of the diverges.

Proposed new structures

- A 15m span railway bridge under the Great Eastern mainline railway to enable the re-aligned slip road to pass under it at SR chainage 910 comprising a precast concrete bridge deck founded on contiguous piled abutments approximately 20m wide built in sections under limited track possessions
- A 350m multi span composite steel viaduct 11.5 m wide to carry the new interchange link road over the circulatory carriageway at Junction 28, over the A12, and over the Junction 28 to M25 anti-clockwise slip road from IL chainage 240 to 590
- A 160m multi span composite steel viaduct 12.8 m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 450 to 610
- A 260m retaining wall on the offside of the re-aligned slip road between Nags Head Lane and the railway to accommodate the level difference between the slip road and the M25 from SR chainage 650 to 910 (average height 2m)
- A 235m retaining wall on the offside of the re-aligned slip road from the railway to Junction 28 to accommodate the level difference between the slip road and the new interchange link from SR chainage 925 to 1160 (average height 2m)

- A 28m retaining wall on the offside of the interchange link immediately north of the nosing to facilitate level differences between the link and the M25 main carriageway at IL chainage 150 (average height 2m)
- A 45m retaining wall on the nearside of the realigned A12 west to Junction 28 slip road adjacent to the junction to facilitate the realignment of the water course at A12 SR chainage 1070 to 1115 (average height 2m)
- 1 major culvert to take the new interchange link over the realigned watercourse north of the A12 at IL chainage 900.

6.2.4 Option 5B – Cloverleaf loop variant 2

The following structures/structural alterations have been identified for Option 5B:

Alterations to existing structures

- Widening of the existing M25 viaduct by 9.5m for 300m tapering to 20m over 90m to carry the new interchange link road over the southern segment of the circulatory carriageway at Junction 28 and over the A12 from IL chainage 100 to 390.

Proposed new structures

- A 150m multi span, steel composite viaduct 11.5m wide to carry the new interchange link road over northern segment of the circulatory carriageway at Junction 28 and over the Junction 28 to M25 anti-clockwise slip road from IL chainage 390 to 540
- A 160m multi span composite steel viaduct 12.8 m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 450 to 610
- An 85m retaining wall on the nearside of the interchange link from the back of the nosing to the abutment of the viaduct to accommodate level differences between the link and the M25 anti-clockwise to Junction 28 slip road from IL chainage 100 to 185 (average height 1.5m)
- A 45m retaining wall on the nearside of the realigned A12 west to Junction 28 slip road adjacent to the junction to facilitate the realignment of the water course at A12 SR chainage 1070 to 1115 (average height 2m)
- 1 major culvert to take the new interchange link over the realigned watercourse.

6.2.5 Option 5C – Cloverleaf loop variant 3

The following structures/structural alterations have been identified for Option 5C:

Alterations to existing structures

- Demolition and replacement of 1 No sign gantry at the M25 anti-clockwise diverge to the new loop road at IL chainage 220 to facilitate construction of the diverge.

Proposed new structures

- A 145m multi span, steel composite viaduct 11.5m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip road from IL chainage 210 to 355

- A 125m multi span composite steel viaduct 12.8 m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 440 to 565
- 48m retaining wall on the nearside of the realigned A12 west to Junction 28 slip road adjacent to the junction to facilitate the realignment of the water course at A12 (average height 2m)
- 2 No major culverts to carry the new loop road over Weald Brook at chainages 590 and 1075
- 1 No major culvert to carry the new loop road over the watercourse adjacent to the A12 at SR chainage 1220.

6.2.6 Option 5D – Loop variant 4

The following structures/structural alterations have been identified for Option 5D:

Alterations to existing structures

- Partial demolition and reconstruction/extension of Wigley Bush Lane Bridge at chainage 2400 comprising 40m of new construction to enable the new link road to pass under it
- Demolition and replacement of 2 No sign gantries at the M25 anti-clockwise diverge to the new loop road at IL chainage 245 and 415 to facilitate construction of the diverge
- Demolition and replacement of 2 No sign gantries at the M25 anti-clockwise diverge to the new loop road at IL chainage 245 and 415 to facilitate construction of the diverge.

Proposed new structures

- A 130m multi span, steel composite viaduct 16.1m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip road from IL chainage 440 to 570
- A 170m multi span, steel composite viaduct 16.1 m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip, the M25 and the M25 clockwise to Junction 28 slip from IL chainage 1470 to 1640
- A 35m retaining wall on the offside of the proposed M25 clockwise to A12E interchange link to support the telecoms mast at A12 IL chainage 390 (average height 2m)
- 2 No major culverts to carry the loop road over Weald Brook at IL chainages 800, and 1250
- 1 No major culvert to carry the new loop road and the M25 clockwise to A12E link road over watercourses to the East of the M25 at IL chainage 2000.

6.2.7 Option 5E – Loop variant 5

The following structures/structural alterations have been identified for Option 5E:

Alterations to existing structures

- Partial demolition and reconstruction/extension of Wigley Bush Lane Bridge at chainage 2400 comprising 40m of new construction to enable the new link road to pass under it
- Demolition and replacement of 2 No sign gantries at the M25 anti-clockwise diverge to the new loop road at IL chainage 245 and 415 to facilitate construction of the diverge.

Proposed new structures

- A 130m multi span, steel composite viaduct 16.1m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip road from IL chainage 440 to 570
- A 40m span steel composite bridge 14.8m wide to carry the realigned Junction 28 to M25 anti-clockwise slip road over the new loop road at SR chainage 190 to 230
- A 40m span skewed steel composite bridge 45m wide supporting the M25 to allow the new loop road to pass under it
- A 40m span steel composite bridge 14.8m wide from M25 clockwise to carry the re-constructed M25 clockwise to Junction 28 slip road over the new loop road at SR chainage 300 to 340
- A 35m retaining wall on the offside of the proposed M25 clockwise to A12E interchange link to support the telecoms mast at A12 IL chainage 390 (average height 2m)
- 2 No major culverts to carry the loop road over Weald Brook at IL chainages 800, and 1250
- 1 No major culvert to carry the new loop road and the M25 clockwise to A12E link road over watercourses to the East of the M25 at IL chainage 2000.

6.2.8 Option 5F – Cloverleaf loop variant 6

The following structures/structural alterations have been identified for Option 5F:

Alterations to existing structures

- This option requires no known alterations to existing structures however depending on a more detailed analysis of the geometric alignment of the A12 to accommodate the loop road merge, it may be necessary to undertake pier protection works to enable the road restraint system set-back to be maintained.

Proposed new structures

- A 110m multi span, steel composite viaduct 16.1m wide to carry the new loop road over the realigned Junction 28 to M25 anti-clockwise slip road from IL chainage 195 to 305
- A 115m multi span composite steel viaduct 12.8 m wide to carry the A12 west to Junction 28 slip road over Weald Brook, BPA pipeline and the new interchange link from A12 SR chainage 430 to 545

- A 48m retaining wall on the nearside of the realigned A12 west to Junction 28 slip road adjacent to the junction to facilitate the realignment of the water course at A12 (average height 2m)
- A 100m retaining wall on the nearside of the Junction 28 to M25 anti-clockwise slip road near the M25 merge to accommodate level differences immediately before the back of nosing (average height 1m)
- 2 No major culverts to carry the new loop road over Weald Brook at chainages 495 and 1050
- 1 No major culvert to carry the new loop road over the watercourse adjacent to the A12 at SR chainage 1120.

6.2.9 Option 6 – Southern link

The following structures/structural alterations have been identified for Option 6:

Alterations to existing structures

- Partial demolition and reconstruction/extension of the existing Spital Lane footbridge to enable the tie in of the link road to the A12 eastbound at chainage 2510 comprising 40m of new construction
- Demolition and replacement of 2 No sign gantries at the M25 anti-clockwise diverge to the new link road at chainages 200 and 580 to facilitate construction of the diverge.

Proposed new structures

- Construction of a 600m multi span steel composite viaduct 17.1m wide to carry the new link road over Nags Head Lane, both carriageways of the M25 and the Great Eastern mainline railway from chainage 600 to 1200
- Construction of 630m multi span steel composite viaduct 17.1m wide to carry the new link road over the A0123 Brook Street, the A12 and Wigley Bush Lane from chainage 1495 to 2120
- Construction of 80m of retaining wall on the nearside (extended viaduct parapet) to the east of Wigley Bush lane at chainage 2120 to 2200 to accommodate the level difference between the link road and the A12 eastbound carriageway.

6.3 Earthworks

The underlying geology in the vicinity of Junction 28 is anticipated to comprise a bedrock of London Clay overlain with superficial deposits of gravel. For the purposes of the phase 1 design allowance has been made for cutting slopes of 1:3 and embankment slopes of 1:2.5 which is generally in keeping with the slopes of the existing earthworks at the junction on the A12 and the M25.

Generally all options have an earthworks deficit of varying amounts requiring an overall import of suitable fill. Unsuitable material from cuttings may be used in amenity bunds/landscaping areas or taken to tip off site. Areas of cutting are generally in the vicinity of the tie-in to the A12 eastbound carriageway (Options 2, 4 and 6), the sloping ground to the north east of the existing junction (particularly Option 2 and Option 4 to a lesser extent), and the area in the vicinity of Nags Head Lane and the railway (Options 2, 4 and 5A). Option 5E has significant cutting areas

where it passes under the M25. The other main areas of cut are on the realigned north facing slip roads to the M25 (Options 5D, 5E and 5F)

In the absence of detailed analysis the amount of suitable fill to be sourced within the site is uncertain so a detailed analysis of the earthworks balance is inappropriate at this stage.

Steepened earthworks slopes may be appropriate at some locations, In the vicinity of pylons supporting the National Grid high voltage overhead power lines (Options 5A, 5B and 5C) foundations for more conventional retaining walls may conflict with the foundations for the pylons. On all loop road options (Options 5A to 5F) short lengths of reinforced earth may be required in areas where the approach to interchange link diverge/merges have different vertical profiles to the mainline carriageways. However it may be possible to eliminate these as the designs are refined and the earthwork interfaces are modelled in more detail.

6.4 Drainage

The highway geometry has been designed to avoid flat areas of carriageway with phased horizontal and vertical curvature wherever possible.

Outline drainage design has not been undertaken at this stage. The drainage design should be developed in accordance with the principals set out in DMRB HD33. It is envisaged that surface water channels will be used on link roads with associated fin drains to intercept seepage flows in the road construction. On loop roads with low horizontal radius, it has been assumed that a pipe and gully system will be used for ease of construction.

Linear drainage channels may be necessary in some interchange nosings. Drainage of bridge and viaduct surfaces will be by means of a combined kerb and drainage system.

Filter drains will be used at the bottom of cuttings to reduce ground water levels. Ditches or filter drains will be used at the top of cuttings and the toe of embankments to intercept run-off from existing land drainage systems.

Special provisions may be necessary in the area of historic landfill to the north west of the junction to prevent contamination of surface water and/or induced settlement due to water infiltration into the landfill depending on the nature of the materials deposited and any restoration works undertaken.

The underlying geology at Junction 28 is London Clay and therefore it is unlikely that infiltration methods of disposal will be effective. It has been assumed that balancing ponds or storage tanks will be required at locations to be determined, to limit runoff to current green field rates with appropriate pollution control measures before discharging into Ingrebourne River via upstream watercourses. The impact of some options on the existing balancing pond to the south west of the junction will also need to be considered at the next design stage if they are taken forwards.

6.5 Signing and lining

All road markings and signage will be designed in accordance with the Traffic Signs Regulations and General Directions (TSRGD). The existing signing and road marking arrangements are shown in Appendix H. No changes to road markings are required for the A12W, the A1023 or the M25 clockwise south of the existing junction. No strategic changes to signing are proposed.

6.5.1 M25 anti-clockwise

All options will require alterations to existing gantry signing on the M25 anti-clockwise carriageway with additional/amended directional signing for M25 anti-clockwise to A12E (traffic which would have used Junction 28) now being directed onto the new link/loop road. For

Options 2 and 6 the new link diverges before the Junction 28 off-slip. However for all other options the link diverges after the Junction 28 off-slip. Option 5A presents particular difficulties for directional signing due to the non-standard spacing between the successive diverges on the M25 anti-clockwise. Appropriate road markings will provide advances warning and directions.

6.5.2 M25 clockwise

Options 2, 4, 5A, 5B, 5C, 5F and 6 require no changes to the signing and lining on the M25 clockwise carriageway. Options 5D and 5E have been designed to include for a new dedicated link from the M25 clockwise to A12E as a potential incremental improvement. If included it will require alterations to existing gantry signing on the approach to the diverge and additional directional signing with appropriate road markings. The existing diverge is a ghost island lane drop with the nearside signed for A12 east to Essex and the A1023 to Brentwood and the second element of the diverge signed for A12 west to London.

In the new configuration the Type A taper diverge would be signed for A12 east only. The existing configuration will be retained, however the nearside lane will be for A12 west and A1023 with the offside lane for A1023 only.

6.5.3 A12 eastbound west of Junction 28

Options 2, 4, 5D, 5E and 6 do not require alterations to the existing A12 east road markings and signage on the approach to Junction 28.

Options 5A, 5B, 5C and 5F will require alterations to existing markings and signage on the approach to the A12 eastbound off-slip road. For these options the nearside lane of the A12 east becomes a dedicated lane to Junction 28 with the offside lane being for A12 through traffic only. This is a non-standard configuration and will require advanced "Get in Lane" signing on the approach and associated road markings. For all options the nearside lane remains closed to facilitate the M25 anti-clockwise to A12 east loop road merge.

6.5.4 A12 eastbound east of Junction 28

The current A12 eastbound lane configuration to the east of Junction 28 comprises 3 lanes separated by tiger tail style ghost island road markings (in line with Diagram 1042 of the TSRGD). The nearside lane is for traffic from the M25 clockwise to A12 east dedicated lane, the middle lane is for Junction 28 to A12 east traffic and the offside lane is for A12 eastbound through traffic only. The nearside lane is dropped approximately 1km from the junction.

For Options 2, 4 and 6 the new link road from the M25 anti-clockwise merges with the A12 east of Junction 28. In this arrangement the offside remains for A12 eastbound through traffic, the middle lane remains for the Junction 28 to A12 east traffic. However, traffic travelling from the M25 clockwise (north) to the A12 east merges into the middle lane. This enables the nearside lane to become the lane gain when the new link from the M25 anti-clockwise merges with the A12 east.

For Options 5A, 5B, 5C and 5F the new link merges before the A12 eastbound on-slip road. In this arrangement the offside lane is used for A12 eastbound traffic, the middle lane is used for traffic arriving on the new link from the M25 anti-clockwise, with the exit lane from the Junction 28 roundabout merging with the middle lane. The nearside lane remains for the M25 clockwise to A12 east traffic.

For Options 5D and 5E the offside and middle lane are used for A12 eastbound through traffic. Traffic from the M25 clockwise (north) merges with the new loop road from the M25 anti-clockwise, with the offside lane on new loop road then merging with the middle A12 eastbound lane. The nearside lane then becomes the lane gain for the link road merge.

6.5.5 Junction circulatory

Changes to signage at the junction will be limited to minor alterations to road markings to accommodate the re-aligned approaches of various slip roads depending on the option under consideration.

6.6 Gantries

All options will require alterations to existing gantries on the M25 anti-clockwise and clockwise carriageways including;

- increasing the span of gantries to span widen carriageways
- translocating gantries where the configuration changes make it necessary
- sign changes where existing gantries are unaffected but lane configurations are changed.

The need for additional gantries will need to be reviewed in accordance with the requirements of TD18/85 although none have been identified in PCF Stage 1.

6.7 Lighting

An appraisal in accordance with DMRB standard TA 49/07 Appraisal of New and Replacement Lighting on the Strategic Motorway and All Purpose Trunk Road Network has not been undertaken at PCF Stage 1. However all approaches to Junction 28 (M25, A12 and the A1023) and the circulatory carriageway currently have street lighting. It has therefore been assumed that lighting will be required to avoid dark zones through the interchange and to provide route continuity. This will be examined and designed in accordance with DMRB standard TD 34/07 Design of Road Lighting for the Strategic Motorway and All Purpose Trunk Road Network.

6.8 Statutory undertakers

During PCF Stage 1 the Statutory Undertakes Estimate has been prepared, in which a full breakdown of affected utility infrastructure and the associated cost of diversionary works has been included. An outline summary of the impact the options have to existing utility infrastructure can be seen in Table-6-6.

For full details refer to the PCF1 product for Statutory Undertakes Estimate produced for Junction 28. The composite utility plan can be found in Appendix D.

Table 6-6 Summary impact on statutory undertakers utilities by option

Utility company	Options								
	2	4	5A	5B	5C	5D	5E	5F	6
UK Power Networks	✓	✓	✓	✓	✓	✓	✓	✓	✓
Virgin Media	✓	✓	✓	✓	✓	✓	✓	✓	✓
BT Openreach	✓	✓	✓	✓	✓	✓	✓	✓	✓
Telent	✓	✓	✓	✓	✓	✓	✓	✓	✓
British Pipeline Agency	✓	✓	✓		✓	✓	✓	✓	
National Grid Overhead Transmission Cables	✓		✓	✓	✓	✓	✓	✓	
Essex & Suffolk Water	✓	✓	✓	✓	✓			✓	
National Grid – National Low Pressure Gas			✓	✓	✓	✓	✓	✓	
National Grid – National High Pressure Gas	✓	✓				✓	✓		
Thames Water	✓	✓	✓						✓
National Grid - Medium Pressure or Low Pressure Gas	✓	✓	✓						

7 Traffic analysis

7.1 Overview

The Junction 28 improvement scheme is expected to provide relatively local benefits relating to the improved performance of the roundabout, reduced queuing on the ramps approaching the roundabout as well as along the A12 and M25. It will also be necessary to examine the operational feasibility of the improvement options including the performance of the traffic signals, as well as critically the merge/diverge arrangements on the A12 eastbound section with the introduction of the new dedicated link.

Following modelling approach entails local modelling, comprising a combination of:

- the existing Junction 28/ A1023 roundabout LinSig⁹ model, focusing on the design and performance of the traffic signals on the roundabout
- a new VISSIM based microsimulation model to assess the full journey times savings gained by the scheme options along the ramps and the main M25 and A12 approaches. This model will also be used to complete the operational assessments of the junction including the merge arrangements on the A12 eastbound.

The purpose of the base VISSIM model is to replicate accurately existing conditions so that the base model can be used for the future year assessment including the evaluation of the Junction 28 improvement options. Replicating the operation of the Junction 28 roundabout is relatively complex due to the A1023 Brook Street approach being un-signalised, and blocking of the exit onto Brook Street as a result of queuing from the traffic signals at Nags Head Lane. The traditional transport planning software such as LinSig or TRANSYT are not able to replicate this behaviour accurately, therefore a VISSIM based microsimulation model was developed for Junction 28.

VISSIM modelling provides the ability to evaluate merge / diverge arrangements which will be key features of the proposed design options. In addition, VISSIM modelling also allows the user to produce video clips of the modelled assignments which can be an extremely helpful aid during consultation with stakeholders and the public, to show general traffic conditions for both the 'with' and 'without' scheme arrangements.

Furthermore, the VISSIM model has been used for providing the information required for the economic appraisal and environmental assessments.

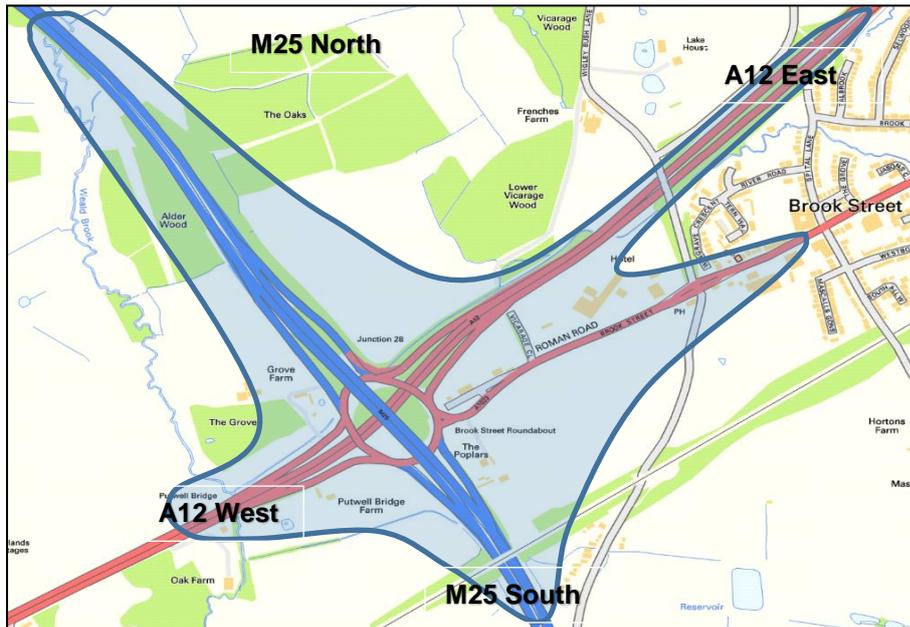
7.2 Area of interest

The area of interest is shown in Figure 7-1. This area was considered sufficient to enable the majority local and wider impacts to be considered (i.e. operational performance, safety, environmental effects and economics).

The roundabout section of Junction 28 comprises a 5 arm signalised roundabout connecting the M25 and A12, as well as the A1023 Brook Street access to Brentwood. The junction between the roundabout and the A1023 Brook Street is currently uncontrolled, and operates as a priority intersection.

⁹ LinSig is a junction modelling software tool which allows traffic signals, and groups of inter-linked signals, to be modelled to evaluate their effect on traffic capacities and queuing. As well as modelling the effects of traffic signals LinSig can also be used to optimise signal timings to reduce delay.

Figure 7-1 M25 Junction 28 Area of Interest



7.3 Traffic analysis

7.3.1 Overview of the transport modelling framework

The transport modelling framework assumed for this study has been described in detail in both the Appraisal Specification Report¹⁰ (ASR) and the Local Model Validation Report¹¹ (LMVR). The following sections provide a summary of the development of the modelling framework used for the assessment of the alternative options for Junction 28.

7.3.2 Data collection

Best use was made of a number of sources of transport related data during the course of this study. The collation of existing and new traffic data for the Junction 28 Improvements project have been reported in full in the Traffic Data Collection Report¹².

7.3.3 Traffic flow data

Traffic surveys were commissioned by Connect Plus Services (CPS) from the 25 to 27 March 2014 (inclusive). The following traffic data was recorded during this survey:

- classified traffic counts on all approaches
- queue length surveys
- origin-destination traffic movements through the roundabout.

¹⁰ M25 Junction 28 Improvements – Appraisal Specification Report, (March 2016).

¹¹ M25 Junction 28 Improvements – Local Model Validation Report, (June 2016).

¹² M25 Junction 28 Improvements – Traffic Data Collection Report, (May 2016).

In addition to above counts, the Highways England's TRADS database was used to obtain M25 and A12 mainline traffic volumes and classifications (Figure 7-2). The 2014 base year demand flows and turning movements are presented in Appendix A.

Figure 7-2 TRADS data sites



7.3.4 Journey time data

Highways England's Journey Time Database (JTDB) has been used for the mainline M25 and A12 through traffic journey time information. In addition new journey time data through the Junction 28 roundabout sections has been collected using TomTom's journey time database.

The JTDB and TomTom journey time section's location plan is shown in Figures 7-3 and 7-4 respectively.

7.3.5 Model calibration and validation

The Junction 28 base model calibration and validation process was undertaken against the observed site conditions such as; journey times, queue data and traffic volume counts. The Junction 28 VISSIM model calibration and validation results are presented in LMVR. The validation results satisfy the DfT's WebTAG¹³ Unit 3.1 criteria for validation of traffic models.

The model validation results confirmed that model is robust and reliable for use in forecasting future year conditions and assessing the alternative projects options for the Junction 28.

¹³ Web-based Transport Analysis Guidance (WebTAG)

Figure 7-3 Journey time database sections

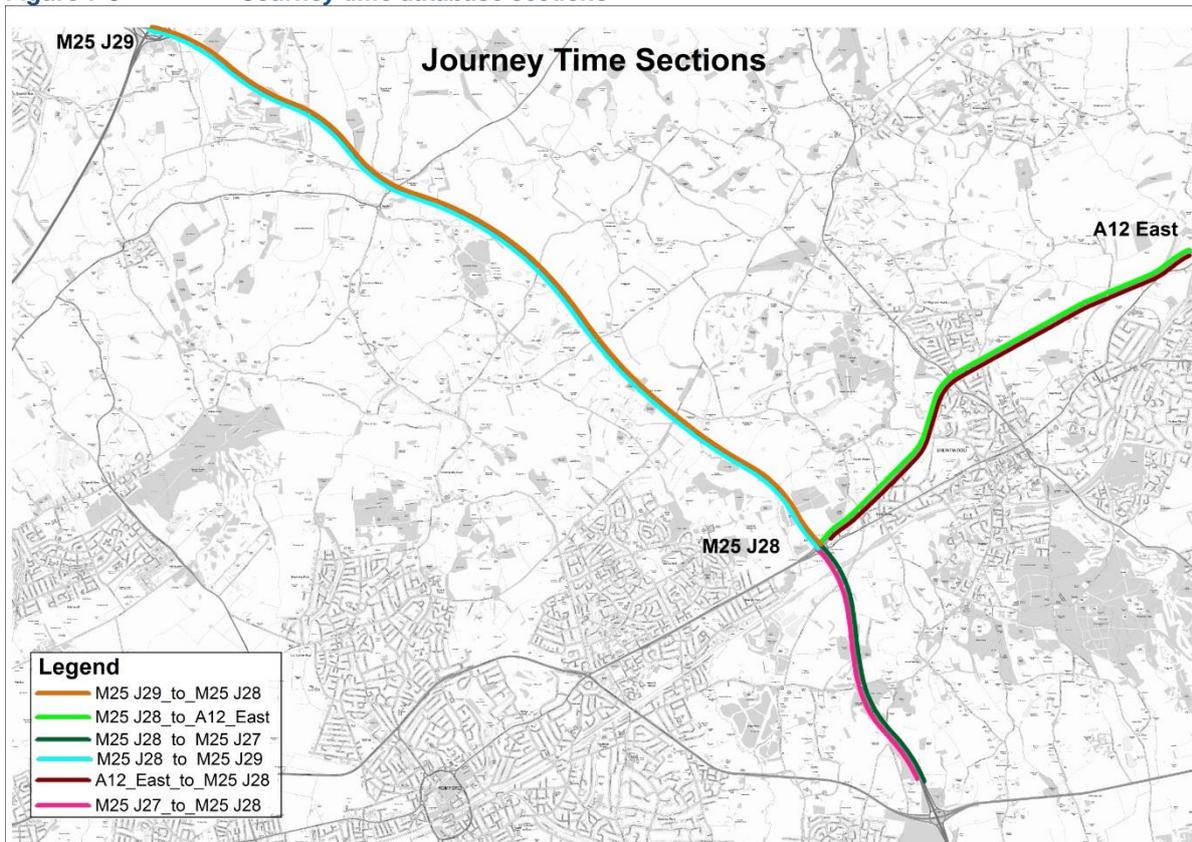
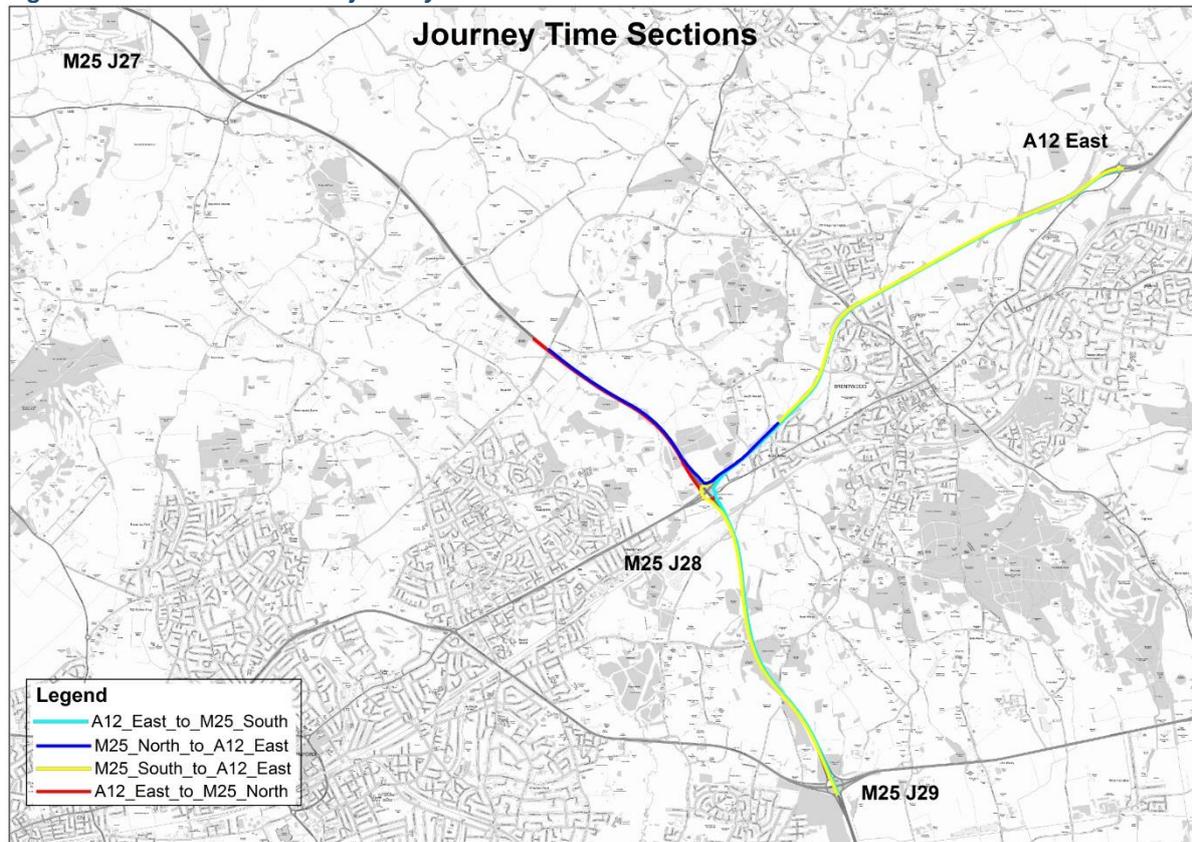


Figure 7-4 TomTom journey time sections



7.4 Traffic forecasting and option testing

7.4.1 Overview of forecasting process

Atkins considered the National Transport Model (NTM) 2015 to obtain the regional level growth predictions for the goods vehicles. Similarly the National Trip End Model (NTEM) has been used for the cars by utilising Temprow (v6.2). The WebTAG Unit M4 guidance has been referred to as required during the development of forecast scenarios. The approach was discussed and agreed with TAME.

NTEM (TEMPRO) growth factors were considered for cars by each time period. Furthermore these factors were updated to account for the influence of changes in fuel and income through time, in line with the WebTAG M4. The NTM growth factors were used for the goods vehicles.

The standard forecast scenarios based on WebTAG Unit M4 guidance are outlined in Table 7-1.

Table 7-1 Standard Forecast scenarios from WebTAG M4

Scenario	Supply	Demand	TEMPRO Constraint
Low Growth	Near Certain and More Than Likely Schemes	Near Certain and More Than Likely Developments	Low Growth TEMPROW
Core	Near Certain and More Than Likely Schemes	Near Certain and More Than Likely Developments	Standard TEMPROW
Optimistic	Near Certain, More Than Likely and Reasonably Foreseeable Schemes	Near Certain, More Than Likely and Reasonably Foreseeable Developments	High Growth TEMPROW

However, due to an unavailability of appropriate strategic model the uncertainty assessment has been undertaken using variants between TEMPROW growth factors.

WebTAG Unit M4 guidance states that the uncertainty in NTEM traffic growth should be considered. It states that an appropriate way to do this would be to look at a range about the central forecast of $\pm 2.5\%$ for forecasts one year ahead, rising with the square root of the number of years to $\pm 15\%$ for forecasts 36 years ahead (i.e. 5% four years ahead, 7.5% nine years ahead, 10% sixteen years ahead, 12.5% twenty five years ahead). It should be noted that is a percentage of the base year demand which is added or subtracted from the forecast matrices.

7.4.2 Years of assessment

For the purposes of evaluating the Junction 28 improvement options traffic forecasts were required for a 2014 base year, an opening year of 2022, and a design year of 2037.

7.4.3 Forecasting requirements

For the purposes of developing and evaluating the options for improvement it was important that the forecasting models were capable of generating the traffic information required by the different study processes. These include the following:

- Options development and designs
- Operational assessment
- Economic evaluation

- Environmental assessments.

The processes above called for 18 hour and 24 hour Annual Average Daily Traffic¹⁴ (AADT) and Annual Average Weekday Traffic flows¹⁵ (AAWT) forecasts. Therefore factors were applied to expand the hourly modelled flows (morning, evening and inter-peak hours) to 24 hour AADT and 18 hour AAWT flows. Details on the derivation of the 24 hour AADT and 18 hour AAWT expansion factors are presented in the M25 Junction 28 Forecasting Report (July 2016).

7.4.4 Do-minimum forecasts

Major transport schemes must be evaluated against an appropriate Do-Minimum base case. The Do-Minimum scenario has been developed to represent the most realistic view of future transport conditions without any improvements to Junction 28. In this scenario only committed transport schemes and land-use proposals that are likely to be completed by each forecast year have been considered. Only those proposals which are likely to have a material effect on travel patterns and/or mode share within the area surrounding Junction 28 have been represented directly within the model. The strategic effects of some smaller measures, such as local traffic management schemes, are likely to be negligible and hence not included. The assumptions underlying the Do-Minimum forecasts are fully documented in the M25 Junction 28 Forecasting Report.

Signal optimisation

The M25 Junction 28 Do-minimum network includes the same highway link structure as the base year VISSIM model, except the signal timings which were optimised for the roundabout. The 2022 and 2037 Do-minimum networks include the optimised signal timings for the Junction 28. No other network improvements have been included in the Do-minimum scenario models.

A12 widening – potential RIS2 scheme

The A12 widening scheme between the M25 Junction 28 and Chelmsford is a potential scheme for inclusion in the Route Investment Strategy 2 (RIS2) period. As this is not a committed scheme it is not included in the Do-minimum network.

Lower Thames Crossing

The project team has liaised with the Lower Thames Crossing (LTC) team to understand the forecast re-routing and redistribution effects of the LTC on traffic patterns at the M25 Junction 28.

The net change in traffic patterns through M25 Junction 28 with the LTC in place are understood to be relatively minor. With LTC in place the overall growth of traffic through Junction 28 is predicted to be similar to the NTEM growth factors.

Furthermore, LTC is not a committed scheme at this stage therefore it is excluded from the Do-minimum assessment.

7.4.5 Forecast Do-minimum traffic growth and flows

By 2022 under the Do-Minimum scenario, (i.e. assuming the M25 Junction 28 improvement scheme is not built), highway demand for cars across the study area is forecast to rise by 8% to 9% compared to the 2014 Base Year. These estimates are based on the “most likely” or

¹⁴ AADT is the total yearly flow on a link divided by 365.

¹⁵ AAWT is the total weekday flow on a link over a year, divided by the number of weekdays in a year

core scenario growth forecasts. Similarly, by 2037 car traffic levels are forecast to increase by 18%.

Forecast matrices (AM, inter-peak and PM peak hours) for the study area are shown in Appendix B. All flows shown relate to a core growth scenario. For comparative reasons 2014 base year flows are also provided.

Importantly, capacity limitations of the A12 between M25 Junction 28 and Chelmsford and A1023 Brook Street would constrain traffic growth in this area, despite more significant growth occurring on upstream and downstream sections of the trunk road network. Therefore, to avoid overestimating delays and subsequent benefits, forecast demand matrices were constrained to capacity for the A12 East and A1023 Brook Street zones.

Under a 2022 Do-minimum conditions significant increases in queues, delays and journey times are expected compared to the 2014 base year. Average delay is expected to increase by 25% and 35% in the AM and PM peak hours respectively, with total delay increasing by 40% (+200 hours) and 50% (+250 hours).

Under a 2037 Do-minimum scenario a significant deterioration in traffic conditions is expected. Average delays could be 2 or 3 times that experienced in 2014 in the AM and PM peak hours respectively. Total delay times across all movements would increase by similar levels. As a result journey times on key movements will also increase, and for example the M25 south to A12 east/Essex movement could see increases in journey times of 30% to 50%.

The key network performance indicators are summarised in Table 7-2.

Table 7-2 M25 Junction 28 network performance summary, Do-minimum

	2014 base year	2022 DM	2037 DM
AM Peak			
Flows	15,262	17,767	20,040
Flows through the roundabout	6,641	7,999	8,484
Total journey time (hours/hour)	5,946	6,292	8,020
Total delay time (hours/hour)	481	680	1,543
Average delays (sec)	94	117	227
Average speed (kph)	84	80	67
PM Peak			
Flows	15,846	18,342	19,644
Flows through the roundabout	7,170	8,264	8,411
Total journey time (hours/hour)	5,922	6,619	9,704
Total delay time (hours/hour)	464	711	1,526
Average delays (sec)	88	119	234
Average speed (kph)	86	81	67
Inter Peak			
Flows	10,868	13,031	15,766
Flows through the roundabout	4,652	5,885	7,144
Total journey time (hours/hour)	5,745	5,794	6,105
Total delay time (hours/hour)	228	303	506
Average delays (sec)	62	71	98
Average speed (kph)	88	86	82

7.4.6 Forecast Do-minimum journey times

Due to the relatively modest growth in the study area by 2037 the journey times are predicted to increase on most of the routes compared to the 2014 base model as a result of the increased demand in the 2037 AM peak (Appendix B). The travel time on several routes could increase by 50% or even double, for example on movements from the A12 west, between A12 east and M25 north, and M25 south to A12 west. The movement between M25 south and A12 east is expected to see a 30% increase in journey time.

The PM peak model predicts journey times to increase under the 2037 Do-minimum conditions compared to the 2014 base model. In particular the A12 west approach is most affected with journey times broadly tripling from between 450 to 700 seconds in 2014 to between 1,200 and 1,800 seconds in the 2037 Do-minimum. Also the M25 south approach shows significant increases in journey times to the A12 east (+40%) and A12 west (+65%).

Average speed is forecast to reduce significantly in the Do-minimum from 84 kph in 2014 to 67 kph in 2037 (-20%).

Table 7-3 Link capacity assessment for M25 Junction 28, 2037 Do-minimum

Link	Lanes	Approximate saturation flow (RR67)	Modelled time period	Signal green time (% cycle time)	Theoretical capacity	Forecast traffic flows	Ratio of flow / capacity
M25 North Off - Slip	3	5,700	AM	37	2,090	2,508	1.20
			IP	22	1,235	1,912	1.55
			PM	40	2,280	2,508	1.10
A12 East Off - Slip	4	7,600	AM	32	2,407	2,642	1.10
			IP	33	2,533	2,170	0.86
			PM	28	2,153	2,330	1.08
M25 South Off - Slip	4	7,600	AM	33	2,533	2,284	0.90
			IP	27	2,027	1,631	0.80
			PM	40	3,040	2,291	0.75
A12 West Off - Slip	3	5,700	AM	20	1,140	1,253	1.10
			IP	20	1,140	1,036	0.91
			PM	22	1,235	1,459	1.18

7.4.7 Do-something forecasts

The traffic forecasts were produced for each of the main Junction 28 improvement options. Where an option has more than one variant, it was considered that the traffic conditions will be very similar and hence for traffic modelling only the most relevant layout was modelled using VISSIM. The Do-Something assessment show that travel conditions can be improved through the introduction of a Junction 28 improvement scheme.

Across the study area highway network the 2037 core growth (with capacity constraint) forecasts (AM peak hour) show that, all the options considered could:

- Deliver a reduction in over-capacity queuing, relative to the Do-Minimum, except A1023 Brook Street approach where the Do-something model predicts an increase in queuing
- All the Do-something options predicts journey time improvements from the M25 south to A12 east
- With each of the Do-something options average speed is expected to improve to around 72 kph compared with 67 kph in the Do-minimum scenario.

The Do-something forecast traffic conditions are summarised in Appendix I, with results compared against the Do-minimum. The Network performance summary is presented in Table 7-5.

The queue lengths for the 2037 were predicted similar results as 2022. The queue length comparison by option for AM, PM and Inter-peak hours can be found in Appendix I.

7.5 Scheme operational performance summary

The operational performance of each scheme is very similar, with little between the forecast journey times along the entire routes. There is however a number of relatively minor differences which, when accumulated over the whole scheme, do enable meaningful comparisons to be made between the various schemes.

In assessing the junction performance at the Junction 28 roundabout the Do-minimum and Do-something modelled queue lengths were compared for each of the improvement option. In summary, the 2022 AM peak modelled queue length is:

- predicted to increase significantly under Do-minimum conditions compared with the 2014 base, particularly on the A12 west and A1023 Brook Street approaches to the roundabout
- expected to reduce by 50% on the M25 south approach to the roundabout in all Do-something options. This is due to the reduction of traffic using this approach as a result of the diversion of A12 east/Essex bound traffic on to the new dedicated link
- forecast to significantly improve in all Do-something options on the A12 west approach as the performance of the roundabout improves with the diverted traffic on the dedicated link
- predicted to increase on the A1023 Brook Street approach under Do-minimum conditions. The queue length is predicted to increase further with the Do-something options. This is mainly due to priority controlled operation at this location for Brook Street traffic combined with the freer movement of traffic using the roundabout, resulting in vehicles struggling to find gaps in circulatory traffic to access the junction from Brook Street.

7.6 Road layout and standards

Highways England's guidelines to determine carriageway capacity are based on AADT flows for the assumed opening year. In this case forecasts relating to a 2022 central growth scenario have been adopted.

Traffic flow ranges for use in the assessment of new rural roads are given in the Design Manual for Roads and Bridges (DMRB) Advice Note TA 46/97. The note gives the economic assessment and recommended flow ranges for new rural road links for opening year AADT flows relating to various carriageway standards. These are set out in Table 7.6 as extracted from the TA 46/97.

Table 7-4 *Link capacity assessment for M25 Junction 28, 2037 Do-something*

Link	Lanes	Approximate saturation flow (RR67)	Modelled time period	Signal green time (% cycle time)	Theoretical capacity	Base year traffic flows	Ratio of flow / capacity
M25 North Off - Slip	3	5,700	AM	43	2,470	2,417	0.98
			IP	40	2,280	1,912	0.84
			PM	45	2,565	2,420	0.94
A12 East Off - Slip	4	7,600	AM	37	2,787	2,581	0.93
			IP	43	3,293	2,170	0.66
			PM	37	2,787	2,291	0.82
M25 South Off - Slip	4	7,600	AM	30	2,280	925	0.41
			IP	12	887	376	0.42
			PM	25	1,900	961	0.51
A12 West Off - Slip	3	5,700	AM	35	1,995	1,222	0.61
			IP	37	2,090	1,036	0.50
			PM	40	2,280	1,412	0.62

Table 7-5 M25 Junction 28 network performance summary, 2037 Do-something

	2037						
	Option 2	Option 4	Option 5B	Option 5C	Option 5D	Option 5F	Option 6
AM Peak							
Flows	20,337	20,381	20,336	20,359	20,344	20,374	20,327
Flows through the roundabout	8,650	8,694	8,649	8,672	8,657	8,687	8,640
JT (total)	6,628	6,521	6,609	6,621	6,604	6,618	6,540
Average Delays (Sec)	198	184	187	184	182	183	188
Total Delays (Hours)	1,344	1,247	1,247	1,254	1,234	1,244	1,279
Avg. Speed (kph)	71	72	72	72	73	73	72
PM Peak							
Flows	20,281	20,254	20,280	20,274	20,297	20,270	20,266
Flows through the roundabout	8,667	8,640	8,666	8,660	8,683	8,656	8,652
JT (total)	6,070	6,069	6,096	6,118	6,113	6,088	6,022
Average Delays (Sec)	129	131	130	130	130	129	129
Total Delays (Hours)	853	861	859	860	861	852	852
Avg. Speed (kph)	80	79	80	80	80	80	80
Inter Peak							
Flows	15,764	15,764	15,765	15,766	15,765	15,766	15,749
Flows through the roundabout	7,142	7,142	7,143	7,144	7,143	7,144	7,127
JT (total)	5,941	5,945	5,949	5,972	5,986	5,963	5,890
Average Delays (Sec)	94	98	95	94	95	93	106
Total Delays (Hours)	483	505	491	486	492	482	549
Avg. Speed (kph)	83	82	83	83	83	83	81

Table 7.6 Opening year economic flow ranges

Carriageway Standard	Opening Year AADT	
	Minimum	Maximum
S2	Up to 13,000	
WS2	6,000	21,000
D2AP	11,000	39,000
D3AP	23,000	54,000
D2M	Up to 41,000	
D3M	25,000	67,000
D4M	52,000	90,000

8 Option estimates

8.1 Introduction

Option estimates have been produced by Highways England Commercial Estimate Team. During PCF Stage 1 estimates were prepared for Options 2, 4, 5B, 5C and 5F. These have been based on the following information provided by the project team:

- General layout & cross section drawings for all options
- Identification of areas/volumes of earthworks cut and fill by options
- High level construction programmes for options
- C3 Statutory undertakers estimates
- Land cost estimates for each option produced by the district valuer
- SGAR dates
- Historic costs
- A risk register for each option.

In order to carry out the economic assessments for all options identified under PCF Stage 1 option estimates were required for all options. Therefore estimates for the other options (Options 5A, 5D, 5E and 6) were derived through extrapolation of the option estimates produced by Highways England Commercial Estimate Team. This entailed the following steps. The commercial estimates received were firstly reviewed (assuming Option 5B as a reference) to identify easily measurable physical parameters that can be used for comparison with the other option design. These included the costs associated with:

- Pavements
- Earthworks
- Land
- Structures.

These 4 key parameters account for around 70% of the method related cost and are those closely associated with the actual works elements of the other options. To extrapolate to the other options the following process was adopted:

- Calculate quantities (volumes/areas) for each of the four parameters for the other options to be estimated
- Calculate the ratio of the quantities between the new options and the reference option and use these ratios to obtain a cost for the key parameter elements
- Based on the new parameter costs for the other options determine costs for all of the other parameters and produce an estimated option estimate for each option.

For the Preparation Cost totals, the commercial figures received to date range from £10.7M to £17.5M. For the purposes of the extrapolation of the option estimates an average figure of £13 million has been assumed.

For land acquisition it was been assumed that:

- Land encircled by the loop road will be purchased at £73,000/Ha
- The skip hire and recycling site (and any associated businesses) would be purchased for a cost of around £3.5 million.

These assumptions have been derived from the commercial estimates and compared to land values in the Brentwood Area.

These ballpark costs are preliminary only to enable the economic assessment in Stage 1 to be completed. New commercial estimates will be required for any of these options that remain of interest in Stage 2.

8.2 Assumptions

In preparing the commercial cost estimates for Options 2, 4, 5B, 5C and 5F assumptions were made on a small number of key items:

- Information was not available at this stage on third party costs and/or fees, and estimates were assumed for the following:
 - Rail Authority costs
 - Environment Agency Costs
 - Local Authority costs
- Statutory Undertakers diversion costs - C3 budget estimates (utility returns) were not available at the time the commercial cost estimates were prepared, therefore diversionary costs were estimated based on the composite drawings provided.

8.3 Cost estimates by option

Table 8-1 provides the estimates for each of the improvement options for Junction 28. These are also shown in shown in Appendix J.

Table 8-1 *Cost Estimates (2010 factor prices, undiscounted)*

Option	Capacity	Preparation costs	Supervision costs	Capital works	Land costs	Total Cost
Option 2	2 lanes	14.3	4.1	100.8	5.8	125.1
Option 4	2 lanes	14.7	4.1	110.5	1.1	130.4
Option 5A (Extrapolated)	1 lane	10.9	3.1	76.8	4.4	95.3
Option 5B	1 lane	8.1	1.3	40.0	4.5	53.9
Option 5C	1 lane	8.3	1.4	48.1	5.6	63.4
Option 5D (Extrapolated)	2 lanes	15.5	4.4	108.8	6.3	135.0
Option 5E (Extrapolated)	2 lanes	11.9	3.4	83.5	4.8	103.6
Option 5F	2 lanes	8.5	1.4	54.8	5.8	70.5
Option 6 (Extrapolated)	2 lanes	17.2	4.9	120.9	7.0	150.0

9 Economic assessment

9.1 Overview

The economic assessments for each improvement option have been carried out in line with Department for Transport (DfT) and Treasury guidance as detailed on the DfT Transport Appraisal website¹⁶ and in the Transport User Benefit Appraisal (TUBA) guidance¹⁷.

The wider economic impacts of the improvement (including its regeneration potential) are not considered in the assessment as they are not considered to be significant in this area, a view supported by Highways England for Stage 1. These impacts will be reconsidered in subsequent PCF Stages 2 and 3.

The economic assessment of the Junction 28 improvement options has been documented in more detail in the Economic Assessment Report (EAR)¹⁸. This chapter provides a summary of the approach adopted for the economic assessments, together with the underlying assumptions and the results.

9.2 Overview of economic assessment process

9.2.1 Costs and benefits considered

The economic assessment of the Junction 28 options was based on the use of outputs from the VISSIM model in conjunction with industry standard appraisal software, focusing on four areas of impact:

- **The impacts of each option on travel times and vehicle operating costs** for trips using the junction. These impacts were estimated on the basis of the forecast change in travel conditions caused by each option compared to a Do-minimum scenario. Conditions in each scenario were forecast using the VISSIM model, with model outputs (travel demand, time and distance matrices) used to calculate user benefits and indirect tax benefits using the DfT's TUBA¹⁹ program, v1.9.6
- **The impacts of each option on road accidents at the junction** were estimated using COBALT v2013.220 (parameters v2016.1) and changes in traffic levels by road link forecast by the VISSIM model
- **The impacts of the construction** on travel times and delay for journeys within and through the study area; indicative estimates of scale were made using QUADRO 4.14²¹, base year traffic flows and early assumptions on likely Traffic Management (TM) measures
- **The costs of construction**, accounting for works, land acquisition, preparation and supervision costs.

¹⁶ <http://webtag.org.uk>

¹⁷ TUBA User Guidance and User Manual, Version 1.9.6, prepared by Atkins on behalf of the DfT, 2015. TUBA is the DfT's bespoke software for carrying out economic assessments of the impacts multi-modal transport schemes.

¹⁸ M25 Junction 28 Improvements, *Economic Assessment Report (Final Draft)*, by Atkins on behalf of the Highways England (August 2016)

¹⁹ Transport User Benefit Appraisal (TUBA)

²⁰ Cost and Benefits to Accidents - Light Touch (COBALT)

²¹ Queues and Delays at Roadworks (QUADRO)

A partial, illustrative estimate of reliability impacts over the appraisal period was also made, on the basis of incident numbers at the junction recorded by Highways England.

9.2.2 Forecast years and appraisal period

For each option, estimates of each element of the scheme's costs and benefits after opening were made for three modelled time periods (AM peak, Inter Peak and PM peak), for two modelled forecast years:

- 2022 opening year
- 2037 design year (15 years after opening).

The TUBA and COBALT analyses provided assessments of impacts over a 60 year appraisal period after scheme opening (2022 to 2081), using outputs from all three time periods and both years provided by the model. No further growth in traffic or benefits was assumed beyond 2037 (apart from an allowance from continued growth in the real value of time, in line with WebTAG).

The assessment of impacts of traffic management during construction on travel times provided a representation of impacts during the construction period, with the relevant duration identified for each anticipated element of management.

9.3 TUBA assessments

9.3.1 Overview of TUBA process

The impacts of the options on travel times and vehicle operating costs for those using the junction after scheme opening were assessed using the DfT's TUBA programme.

TUBA is bespoke software developed on behalf of the DfT to estimate the impacts of transport schemes in terms of the costs and benefits experienced by users and providers of the transport system and the associated indirect taxation impacts. All impacts are considered in monetary terms.

TUBA estimates costs and benefits experienced by users and providers of the transport system by comparing transport conditions in a Do-something scenario against conditions in a Do-minimum scenario. To this end, for highway schemes such as the Junction 28 scheme, TUBA uses information from the transport models to:

- Calculate user benefits by vehicle type and for each element of journey cost. (i.e. travel time and vehicle operating costs - fuel and non-fuel)
- Calculate the changes in the indirect tax income received by the government (for highway schemes this primarily reflects levels of indirect taxation incurred on fuel cost).

For the Junction 28 assessments, the user and provider related costs and benefits in each year produced by TUBA were combined with estimates of costs (as described in Section 8) and accident savings (calculated in a parallel process described below) and discounted to 2010 values (using a discount rate of 3.5% for the first 30 years from the appraisal year and 3.0% thereafter).

9.3.2 Input parameters and assumptions

The EAR sets out the key assumptions and parameters used for running each of the Junction 28 TUBA assessments, along with their sources. Most of the values adopted were based on the guidance given in TUBA, although local data was used where available and relevant, in particular:

- Vehicle Type Proportions: Estimates of the relative proportions of cars, light goods vehicles and heavy goods vehicles were derived from recent observed classified counts at the junction in 2014 (as reported in the LMVR)
- Annualisation Factors: These were used to convert estimates of demand related costs and benefits experienced during the three modelled hours (AM peak hour -07.30-08.30, inter-peak hour -average hour between 10.00 and 16.00 and PM peak hour -16.45-17.45) into estimates of total annual costs and benefits in 12 hour working week days for each modelled year. The factors were based on an assumption of 253 working days per year and comparison of relative levels of demand in the shoulder periods around the main peak hours in the peak periods, identified from Highways England 2014 traffic count data at the junction.

9.3.3 Input matrices

Alongside the parameters files, the key input to each TUBA assessment was a series of matrices representing numbers of trips and travel distance and time for movements across the junction for each vehicle type in each time period, modelled year and scenario.

The matrices were produced by VISSIM by treating each entry/exit as an origin/destination zone. Relevant matrix details and locations were identified in the scheme file for each TUBA assessment to be read in for comparison in the user benefit calculation process.

9.4 Safety assessment

The DfT's COBALT spreadsheet was used to provide a simple assessment of the impact of each of the options on accident costs.

The assessment assumed no change in accident rates on the existing junction between the Do-minimum and Do-something scenarios. Consequently, estimated accident impacts were generated solely by the reallocation of traffic onto dedicated right turns from the M25 northbound to the A12 eastbound which have lower accident rates but involve additional travel distance.

Local accident rates were calculated for the circulatory carriageway around Junction 28 and immediate entry approaches, whilst accident rates for the remainder of the modelled network were based on default national average rates by road type within COBALT. Parameters such as accident values (in monetary terms), changes in the rate of accidents through time and the severity split of casualties were also based on default COBALT values for the relevant link type.

Consistent with the TUBA assessment, the COBALT assessment considered impacts over a 60 year appraisal period, assuming no further growth in traffic or benefits beyond 2037 (apart from an allowance from continued growth in the real value of accidents, in line with WebTAG). The results of the COBALT based safety assessment are summarised in Table 9-1.

Table 9-1 Summary of safety assessment results

Forecast no. of casualties over the 60 year appraisal period (2022 to 2081)	Do-minimum	Option 2	Option 4	Options 5A, 5B, 5C & 5F	Option 5D & 5E	Option 6
Fatal	73.1	73.7	73.4	73.7	73.8	73.2
Serious injury	459.3	463.0	461.2	463.4	463.7	460.2
Slight injury	5650.7	5687.6	5674.8	5692.8	5699.1	5659.5
Casualties saved by option						
Fatal		-0.6	-0.3	-0.7	-0.7	-0.2
Serious injury		-3.7	-1.9	-4.1	-4.4	-0.9
Slight injury		-36.9	-24.1	-42.1	-48.4	-8.8

9.5 Reliability assessment

Journey time reliability is reduced by the existence of journey time variability that drivers are unable to predict. Improving operational resilience and journey time reliability is a key objective of the Junction 28 scheme and the options are expected to improve the junction's resilience, which in turn is expected to lead to improved journey time reliability.

Journey time reliability impacts are currently difficult to represent and quantify. Highways England's MyRIAD tool has been developed to measure the effects of changes in incident related journey time variability on motorways. However MyRIAD is only able to capture reliability variations in relation to motorway widening schemes and technology improvements on links – but is not applicable for junction improvements schemes.

Therefore, to provide a view of the magnitude of the impact for a typical Junction 28 option, a partial appraisal of reliability was undertaken for one of the scheme options (Option 5B) on the basis of:

- observed incident data from Highways England identifying the number and duration of incidents on the gyratory;
- the assumption that the delay impacts of incidents could be represented in simple terms through modelling closure of lanes on the gyratory;
- the use of VISSIM model runs for each time period and modelled year to estimate the impacts of lane closures caused by incidents on traffic delay at the junction in the Do-minimum and Do-something scenarios
- TUBA assessments comparing a Do-minimum scenario with lane closure with the main Do-minimum scenario. Similarly a Do-something scenario with lane closure was compared with the main Do-something to identify the extent to which the Do-something option is forecast to reduce the negative impact of lane closure. Single hour model runs for each time period were expanded to represent the full year. These were then expanded to a 60 year appraisal period on the basis of the number of hours per year and total estimated time period that the gyratory has been observed to be affected by significant incidents over the last three years.

The 'with closure' VISSIM runs were undertaken for two example sections. The sections were selected on the basis of location of incidents over the last three years to provide an indication of the likely range of scale of impact. The selected sections include:

- the southern section between the M25 southbound on-slip and northbound off-slip
- north western section between A12 eastbound off-slip and M25 northbound on-slip.

9.6 Construction and maintenance costs

9.6.1 Capital costs of schemes

As outlined in Section 8, cost estimates for a number of options have been produced by Highways England Commercial Estimate Team. Commercial estimates have been prepared in Stage 1 for Options 2, 4 and 5B. Each estimate covers the costs of works, impacts on utilities, land acquisition, and preparation/ supervision.

Cost estimates for the other options (Options 5A, 5C, 5D, 5E and 5F, including different lane options) were derived for the purposes of economic assessment through extrapolation of the option estimates produced by Highways England Commercial Estimate Team, using the approach outlined in Section 8.

9.6.2 Risk and optimism bias allowances

On the basis of guidance from Highways England, the cost estimates received have been assumed to need no further adjustment to account risk and optimism bias.

9.6.3 Do-minimum costs

All Do Something costs were assumed to be net of Do-minimum costs and therefore no specific Do-minimum costs were assumed for the assessment.

9.6.4 Maintenance costs

Operational and maintenance costs have not been included at this stage as they will be minor in comparison to the main scheme implementation costs. They will be considered further in subsequent stages.

9.6.5 Costs for use in economic assessment

TUBA was used to produce the Present Value of Costs (PVC) for each option for use in the assessment based on the cost forecasts and spend profiles provided by Highways England Commercial Estimate Team (and extrapolated for other options) in 2010 factor costs. TUBA converted the costs to market prices and discounted to a 2010 base year, as required for appraisal.

9.6.6 Impacts of construction and maintenance works on travel times

Construction of each of the scheme options would involve a complex programme of Traffic Management on the live highways, including:

- reduced speed limits
- lane closures
- Contraflow
- overnight closures of the road with diversions.

Outline plans of the current early views of the phases of traffic management likely for each of the options have been developed, identifying the timing and duration of each traffic management measure.

The monetary value of impact of these measures on road users (i.e. the impacts of users experiencing increased journey times) has largely been assessed using QUADRO modelling of each phase of the traffic management, assuming the base year traffic flow levels. Further details of the approach used are provided in the Economic Assessment Report.

It should be noted that the construction delay assessments are necessarily approximate at this stage, reflecting both the relatively early stage of design and the estimation of user impacts using QUADRO. QUADRO is a relatively crude modelling tool, only representing limited diversion options available for drivers affected by construction works.

Overall, the assessment has also focussed on impacts on highway users only. Options 2, 4 5A and 6 will also impact on the rail network and the impacts on passengers have not been estimated at this stage.

As designs develop further there is likely to be scope to refine and optimise traffic management arrangements and their timescales, potentially decreasing their impact. In later PCF stages it will also be possible to model the delay associated with construction in more detail. User delay assessments could include the use of a strategic model rather than QUADRO which would allow a more detailed representation of available route choices and their implications for congestion levels and journey times.

9.7 Economic assessment results

9.7.1 Transport economic efficiency, public accounts & summary analysis tables

Table 9-1 summarises the PVB, PVC and BCR of each of the options assessed. The PVB is presented with and without construction delay impacts, highlighting the significance of the impact, as discussed below.

The PVB excluding construction impacts show that benefits after opening are fairly similar between options (varying by just over 15% between the highest and lowest level). Further analysis of the benefits, presented in more detail in the EAR, shows that the patterns of benefits are also similar between options with the following key characteristics

- Time savings dominate the benefits in each option - vehicle operating costs and accident impacts equate to less than 5% of the total PVB in each case
 - The vehicle operating cost impacts are the net effect of increases in travel distance due to the new turning arrangements and more fuel efficient speeds
 - Accident impacts are slightly negative in each case reflecting the fact that additional travel distance associated with the new turning arrangements more than offsets the improvements in accident rates for those drivers using the new links
- Benefits for business users are significantly greater than those accrued by commuters and other trips, accounting for over 50% of TEE benefits in each option. This reflects a number of influences including the fact that:
 - LGV and HGV benefits are included in the business total
 - Business values of time per car trip are approximately three to four times greater than the values for car trips for commuting and other purpose respectively
- Over 70% of benefits are accrued by car trips. LGV trips account for approximately a further 20% of benefits and HGVs and buses for less than 10% combined. This pattern reflects the net impact of the number of trips made by vehicle type, the value of time per vehicle (including allowances for vehicle occupancy) and the proportions of each vehicle making each of the affected movements
- Benefits during the PM peak are significantly greater than those during the AM peak and Inter Peak in each option
 - PM benefits equate to over 65% of the total net benefit in each case

- AM peak benefits generally equate to just under half those accrued during the PM peak
- Inter Peak benefits are significantly smaller in all options
- This pattern reflects the fact that the scheme is intended to alleviate congestion and delay in peak times and that current and forecast delays are worse in the PM peak than the AM peak, as identified in the Traffic Forecasting Report
- Benefits are focussed on a limited number of movements, particularly between firstly the A12 west and A12 east, M25 J27, M25 J29 and Brook Street and secondly the M25 J29 and the A12 east and west
- Benefits are offset to an extent by disbenefits on some movements. These are more variable between options but focus particularly on movements from Brook Street to M25 J27, M25 J29 and A12 west and from M25 J27 to Brook Street and A12 west.

Construction impacts are significant for all options but vary to a considerably larger extent between options than post opening benefits in both percentage and absolute terms. If the indicative construction delay impacts are included the NPVs for the options range between - £157m and £200m (2010 prices and values) and BCRs range between -0.45 and 4.28. Excluding construction delay leads to NPVs ranging from £205m to £285m and BCRs from 2.97 to 6.27.

Table 9-2 Overall summary of cost, PVC, PVB and BCR by option

Option	Lanes	Cost 2010, factor prices undiscounted	PVC	PVB excluding construction impacts	PVB including construction impacts	BCR excluding construction impacts	BCR including construction impacts
Option 2	2	£125,100	£103,527	£308,132	-£18,377	2.98	-0.18
Option 4	2	£130,400	£107,707	£340,185	-£48,796	3.16	-0.45
Option 5A	1	£95,300	£78,842	£340,387	-£31,649	4.32	-0.40
Option 5B	1	£53,900	£45,154	£339,332	£161,970	7.51	3.59
Option 5C	1	£63,400	£53,029	£329,658	£254,287	6.22	4.80
Option 5D	2	£135,000	£111,686	£348,067	£201,437	3.12	1.80
Option 5E	2	£103,600	£85,710	£348,067	£126,114	4.06	1.47
Option 5F	2	£70,500	£58,877	£341,037	£265,666	5.79	4.51
Option 6	2	£150,000	£124,096	£368,020	£230,951	2.97	1.86

All values in £000s and discounted in 2010 prices and values unless otherwise stated

9.7.2 Reliability

The assessment of the relative impact of lane closures to reflect the impact of incidents in the Do-minimum and Do-something scenarios suggests that the additional capacity provided by the options would significantly reduce the negative impact of a closure (i.e. an incident). The saving estimated varied between £3.6 million (PVB, 2010 prices and values) for the southern section and £8.4 million for the north western section, giving an average of just over £6 million.

These benefits are significant, although they appear relatively minor in comparison to the very significant scale of the TEE benefits associated with the options (approximately 2% of the total). In this context, it is important to note that this assessment of reliability impacts is conservative as a result of a number of factors:

- It has focussed on the impact of delay associated with incidents only (not the impacts of day to day variability, or the additional scheduling allowance made by drivers to cater for unreliable journey times)
- The Highways England record of incidents is not complete, for instance it does not include signal failures which are known to have a significant impact on the junction nor unreported accidents
- No allowance is made for the reduction in accidents and incidents likely as a result of the scheme
- Incident occurrences are assumed to continue to occur at current rates throughout the appraisal period despite forecast traffic growth which would increase incident numbers
- The assessment only covers the impact of incidents during 12 hour weekdays (in line with the TEE assessment) and therefore does not capture impacts overnight or during the weekend.

9.7.3 Noise, air quality and greenhouse gases

Impacts on noise, air quality and greenhouse gases are being appraised but not monetised for PCF Stage 1.

9.8 Sensitivity tests

Sensitivity tests were run comparing Option 6 and Option 2 assuming low and high traffic growth against Do-minimum scenario run using the same traffic growth assumptions (derived as described in the Forecasting Report).

These options were selected to present a range of impacts as they represent the options with the highest and lowest TEE related PVB in the Core scenario respectively. As described in more detail in the Economic Assessment Report, the tests show that growth assumptions have a marked impact on the economic assessment. In both options the low growth scenario reduces the scale of congestion problem in the Do-minimum and the ability of the option to improve the situation, resulting in a reduction in benefits of 30% to 40% compared to those experienced in the Core growth scenario. The high growth scenario increases the scale of benefit in both options, leading to a net increase of PVB which is particularly significant for Option 2.

The variation in results between growth scenarios reflects the fact that the performance of the junction is very sensitive to demand levels. However the differences between scenarios are likely to be accentuated by the fact that it has not been possible to optimise the junction for the patterns of demand experienced in the low and high growth demand scenarios within the timescales available at this stage. Given the sensitivity of the performance of the junction to the balance between flows on different arms, this is potentially leading to overstated delay in the Do-minimum and/or Do-something scenarios in the growth sensitivity tests with associated impacts on the level of benefits estimated.

9.9 Summary

Economic assessment of the impact of the Junction 28 options after opening has been undertaken using information on trip numbers, time and distance through the junction for each vehicle type, time period and modelled year produced by the VISSIM model, in conjunction with the DfT's TUBA and COBALT programmes, assessing transport economic efficiency and accident savings respectively. The resultant estimate of impacts over a 60 year appraisal period shows that each option produces a similar pattern of benefits in terms of distribution

between time period, purpose, vehicle type and movement. The overall scale of benefit is also similar only varying by less than 15% between the options with the greatest and lowest levels of benefits.

The largest differences between options are in terms of construction costs and the impacts of delay during construction, recognising that, as outlined above, current estimates of construction delay are approximate, based on an early understanding of likely TM arrangements and relatively simple assessment of impacts using QUADRO.

Once the current construction cost and delay estimates are included, Option 5C offers the greatest value for money, largely because of relatively low construction costs and delays, in turn largely because it causes the lowest level of disruption to the M25 mainline.

A key area for further analysis in later stages will therefore be improving understanding of construction delays and, if possible, reliability impacts which are intended to be an important part of scheme benefits.

10 Safety assessment

A key transport objective in the Client Scheme Requirements for this project is to “*reduce the "after" accident numbers (per annum) below the "before" accident numbers, including the severity ratio, both on the gyratory and on the M25*”. Removal of significant traffic volume from the conflict areas of the existing circulatory carriageway will improve safety with further improvements potentially being achieved through consequential post construction changes to signal operations at the junction.

All options are similar in terms of the safety assessment and have been determined as being “Type A” following an assessment of the suitable Safety Management System (SMS) undertaken using IAN191/16 as guidance (Table 9-2). A “Type A” SMS means this project requires a basic level of safety management to be applied and is likely to include the completion of a simple hazard analysis to support the production of:

- A Safety plan
- Combined safety and hazard log report
- A more detailed assessment is required in PCF Stage 2.

10.1 Impact on road user – Strategic safety action plan

All options will deliver the safety objectives stated in the Client Scheme Requirements by removing high volumes of traffic from the conflict zones of the circulatory carriageway. This will aim to reduce the occurrence of nose to tail collisions on all approaches and failure to give way accidents on the A1023 approach.

The extra stacking capacity on the interchange links compared to the existing slip roads will eliminate routine queuing on the M25 anti-clockwise main-line carriageway. In turn this will alleviate poor driver behaviour issues such as last minute lane changes to reach the motorway exit, and queue jumping. The use of MIDAS queue detection technology on the loop roads, in conjunction with the existing managed motorway technology on the M25, will also help warn motorists early of any queuing on the link road with associated reductions in speed limits.

The greater network resilience as a consequence of the proposed improvements and the overall safety improvements at the junction will help reduce the number of incidents. In particular this will significantly reduce issues where problems at the interchange affect M25 traffic, reducing the risk of high speed road traffic accidents.

A key feature of Options 5A and 5B is the distance between successive diverges on the M25 anti-clockwise carriageway for traffic travelling via Junction 28 and to A12 east/Essex. A key requirement of the detailed signing strategy will be to ensure these bifurcations are adequately signed as any ambiguity or confusion could lead to unexpected driver behaviour with the potential for accidents or conflicts.

All loop options (Options 5A, 5B, 5C, 5D, 5E and 5F) are designed in accordance with the design standards. However the inherent low horizontal radii of the loop roads have the potential to lead to loss of control accidents. This is mitigated by compliance with visibility requirements including the use of a “near straight” for visibility at the nosing, whole loop visibility at the start of the loop, appropriate fixed signage and the possible addition of vehicle actuated signs if excessive speed is detected.

Table 10-1: Summary safety assessment for Junction 28

Feature	Sub Feature	Type A	Type B			Type C				Comments	
1. Stakeholder Interest²²											
	Number of stakeholders	Single or few	Several	or	Single or few	Many	or	Key	or	Several	<i>There are a limited number of Stakeholders affected by this project with no negative impact envisaged on the safety aspects of their operations.</i>
	Impact	Limited	Limited	or	Significant	Limited	or	Significant	or	Major/critical	
2. Operational Experience											
	Extent	Widespread	Limited	or	Some	None in UK nor overseas				<i>There are no significant features of this project which are significantly different to the operational nature of other interchanges on the M25 network.</i>	
	Where	UK	UK	or	Overseas only						
3. Technology and/or Infrastructure											
	Technology experience (consider degree of innovation and criticality of application)	Widespread	Used in different application	or	Applied in part	Not previously applied				<i>The technology proposed for this project is an extension of the existing managed motorway infrastructure already used on the M25 at this location. The technology is in wide-spread use and there is no current proposal to use novel technology.</i>	
	Level of safety risk that introduced technology affects	Low	Medium			High					
4. Standards and Legislation											
	Design covered by existing standards	All	Mostly			No	or	New standard			<i>The work is covered by existing standards.</i>
	Safety related departures from standard	None/No significant	Some/Few significant			Many Significant	or	Some Critical departures			
	Changes to legislation	None	Minor changes only			Moderate	or	Significant			<i>There are no changes to legislation envisaged.</i>
	Highways England Guidance (in the form of IAN or similar)	Existing/not applicable	Relevant new guidance available			Major development in relevant guidance				<i>Existing guidance has been used where applicable</i>	
5. Impact on Organisation - (consider structure, responsibility, competency, whole life impact)											
		No changes	Minor changes/responsibility transfer			Significant change or responsibility transfer				<i>No changes to the organisational structure or staff number or competencies have been identified.</i>	
6. Project Scale											
	Infrastructure affected	Single/small location	Major location/implications			Widespread/national implications				<i>This project affects a single location but may have a regional impact</i>	
	Extent of roll-out	None/Minimal	Moderate			National potential				<i>The project has no potential for a wider roll-out</i>	

²² Note: Stakeholder interest is related to road safety e.g. operation by stakeholders (e.g. emergency services, recovery organisations or road safety groups) that may be affected by the scheme

10.2 Impact during construction and operation

Safety during the construction period will be ensured by full compliance with Chapter 8 of the traffic signs manual, implementation of a temporary 50mph speed restriction on the A12 and the M25, and making sure planned diversions only make use appropriate roads with a similar standard of provision. Full use of the managed motorway communications infrastructure will enhance the operations of the traffic management systems.

The construction period will require lane closures, carriageway closures with contraflow and full carriageway closures with diversions at various stages and to varying extents depending on the option under consideration. Over-night working where safe and practical for the most intrusive activities will be considered to reduce delays and associated safety issues. Night time working will be restricted by the proximity of residential properties to the works.

Where closures of slip roads and partial closure of the circulatory carriageway of the Junction 28 roundabout are required, suitable alternative routes are available. These will utilise Junction 29, the A127, Gallows Corner and the A12 to/from the south, whilst Junction 27, the M11 and the A414 can facilitate strategic movements to/from the A12 eastbound from the M25 north of the junction.

It is believed that Option 6 is likely to require some full overnight closures of the M25. In this instance advanced warnings utilising the VMS system around the M25 will encourage road users to reverse their direction of travel around the M25 so that they avoid the area.

Where the interchange link comprises a single lane plus hard shoulder configuration on the loop road, it is likely to be necessary to close the link during maintenance interventions. In this event traffic can be diverted to Junction 28 which will still be available to accommodate all traffic movements. Rotating prism traffic signs will help to facilitate this closure with reduced risk to operatives.

Option 5C removes 480m of hard shoulder on the M25 anti-clockwise carriageway between the successive diverges. This will affect the ability to carry out routine maintenance operations which would normally be undertaken from the hard shoulder. It will also impact snow clearance operations, where snow would normally be pushed to the hard shoulder.

10.3 Impact on emergency responders

The reduction in congestion at Junction 28 and the surrounding network together with the additional resilience provided by the alternative options for travelling from the M25 anti-clockwise carriageway to A12 east is likely to reduce delays to emergency services.

The loss of 380m of hard shoulder if Option 5C is implemented is likely to increase difficulties for emergency services, but in particular to breakdown recovery services, traffic control officers and to maintenance vehicles responding to incidents on the network. This will be restricted to the junction area itself however, as access north of the junction will still be available via Junction 28 and the M25 anti-clockwise on-slip road.

During the construction period, general congestion related to the road works will adversely impact emergency responders in the area. Where total closures with diversions are required, access to emergency responders can be accommodated through the closures by the construction teams as the closures are generally for safety purposes.

11 Operational characteristics

11.1 Road characteristics and option design implications

All of the links under consideration have similar operational characteristics in terms of the impact on the existing infrastructure and accommodate similar movements. The impact varies depending under the options under consideration. All options provide linkage to A12 east through the new direct connection utilising the proposed interchange link road, but also via the existing Junction 28 thus increasing network resilience overall.

11.2 Schemes operating regime

The M25 is a part of Highways England's controlled motorway network with variable speed limits and associated supporting technology.

11.2.1 Speed limits

It is envisaged that the management regime will include queue detection on the interchange links to enable the variable speed limit on the M25 to be lowered in the event of queues forming on the link road. These should be considered in regard to all option, and is particularly important for the cloverleaf loop Options 5A, 5B, 5C and 5F due to the shorter length of the new link on these options.

11.2.2 Discontinuous hard shoulder

Option 5C makes use of 380m of hard shoulder as an ancillary lane at the M25 anti-clockwise diverge to the loop road.

11.2.3 Operational responsibilities

The M25 Junction 28 sits at the interface of 4 different asset management operations. The M25 is currently operated and managed on behalf of Highways England by Connect Plus Services in accordance with the 30 year DBFO contract which commenced in 2009. The A12 to the east of Junction 28 is part of the all-purpose trunk road network in Area 6, which falls under the Highways England asset management contract with Amey Highways Limited; this runs until March 2019. West of Junction 28 the A12 is part of the "Red Routes" network managed by Transport for London. The A1023 is part of the county road network managed by Essex County Council.

It is envisaged that regardless of option, the new link road will become part of the M25 network. This will have implications for operational management such as winter maintenance gritting routes and other routine maintenance operations with the nearest turn-around on the A12 eastbound is at exit 12 which is 7km east of Junction 28.

11.2.4 Other provisions

It is anticipated that emergency telephones will be provided on the link road subject to future discussions with the overseeing organisation.

For the single lane loop road Options 5A, 5B and 5C consideration should be given to the installation of rotating prism warning signs on the M25 anti-clockwise approach to facilitate the diversion of traffic to Junction 28 in the event of an incident or for routine maintenance activities which necessitate the temporary closure of the loop road.

11.3 Driver compliance

11.3.1 Construction Phase

The traffic management regimes for the construction of the works are likely to vary significantly depending on the option under consideration. A high level traffic management strategy has been considered to ensure that all works can be constructed using standard traffic management in accordance with Chapter 8 of the traffic signs manual. All works would be undertaken under the protection of temporary 50mph speed restrictions utilising combinations of lane closures and contraflows which should be enforced using average speed camera systems.

At this early stage the following have been considered in terms of high level phasing of construction by option, and some of the potential traffic management restrictions that could be imposed. These are also summarised in Table 11-1.

- Options 2, 4, 5A, 5B and 6 require significant new structures to carry the proposed link road over/under the M25. Options 2, 4 and 5A require the realignment of Nags Head Lane with the demolition of the existing bridge and construction of a new bridge. Construction of supports and decks in the central reserve will require lane closures with carriageway closures and contraflow running on the M25 and associated 50mph temporary speed limits. Nags Head Lane will need to be closed to facilitate this work temporarily requiring associated diversions on appropriate alternative routes.
- Options 2, 5A, 5B and 6 require new structures over the A12 with construction of supports and decks in the central reserve will require lane closures with carriageway closures and contraflow running on the A12 and associated 50mph temporary speed limits.
- Options 4, 5A and 5C will require various closures of elements of the circulatory carriageway at Junction 28 with associated diversions which will require signing and maintenance.
- All options will require temporary closures of the various slip roads at Junction 28.
- Options 2, 4 and 6 will require the partial demolition and extension of the footbridge to the east of Junction 28 requiring carriageway closures and contraflow running.
- Options 2, 4, 5D and 5E will require the partial demolition and reconstruction of Wigley Bush Lane Bridge requiring road closures and temporary diversions.
- Option 6 will require the temporary close of the A1023 requiring diversion through Brentwood however options 4, 5A and 5B which affect the circulatory carriageway of Junction 28 will also necessitate some temporary diversions of the A1023.
- Options 2, 4, 5A and 6 will require temporary closures of the Great Eastern railway line.

11.3.2 Operational phase

To encourage driver compliance all alignments have been designed to be fully compliant with standard road layouts and the design standards wherever possible, however consideration to the following will be required for specific options in future design stages if they are developed further:

- All options require successive diverges to Junction 28 and to the M25 anti-clockwise to A12 loop road. For Options 5A and 5B the distance between the successive diverges

is the minimum (Option 5A) and below the minimum (Option 5B) required in the design standards respectively. Signs and road markings will need to be clear and consistent to ensure that there is no confusion as identified in the outline signage strategy drawings (Appendix K). Drivers that miss the slip road to Junction 28 will need to proceed to Junction 26 to turn around.

- Options 5A, 5B, 5C and 5F have been designed as loop roads with lower radii than other link roads. The layout has been designed such that the loop radii do not decrease as drivers pass around the loop road with visibility available for the whole of the loop. Additional vehicle actuated signage on the loop road to encourage motorists to reduce speed in free flow conditions may be beneficial.
- Options 5A, 5B, 5C and 5F are currently designed with non-standard layouts on the A12 eastbound carriageway. These require A12 eastbound traffic to be segregated with a nearside lane drop taking traffic to Junction 28 and a single offside lane being used for through traffic onto the A12 east. Careful consideration will be required to the signing and lining on the A12 eastbound approach to prevent last minute swooping manoeuvres from traffic in the offside lane wishing to exit to Junction 28. If traffic in the nearside lane wish to continue to the A12 they will still be able to do so via the Junction 28 roundabout. This will need to be reinforced with confirmation signing to avoid unexpected braking manoeuvres and confusion.
- Options 5A, 5B and 5C have non-standard layouts where they merge with the A12 eastbound carriageway where the single lane loop joins the single lane A12 with a lane gain. It is not envisaged that this will generate any issues with driver compliance however additional “Stay in Lane” signage may help to ensure that conflicts are reduced.
- For all options it is envisaged that the M25 variable speed limits will finish at the start of the link road.

Table 11-1 *Summary of potential traffic management during construction*

Construction phase/design feature	Options affected	Closures	Lane closures / Contraflow / Diversion
Construction of new structures to support the proposed link road over/under the M25	2, 4, 5D, 5E and 6	Night closure	Construction of supports and decks in the central reserve will require lane closures with and contraflow running on the M25, with 50mph temporary speed limits
The realignment of Nags Head Lane with the demolition of the existing bridge and construction of a new bridge. Nags	2, 4 and 5A	Head Lane will need to be closed to facilitate this work temporarily, requiring appropriate diversions	
New structures over the A12 with construction of supports and decks in the central reserve	2, 5A, 5B and 6		Will require lane closures with contraflow running on the A12 and 50mph temporary speed limits
Works close to the existing roundabout	4, 5A and 5C		Various section of the existing roundabout circulatory carriageway will need to be temporarily closed, with appropriate diversions and signing and maintenance
Partial demolition and extension of the footbridge on A12 to the east of Junction 28	2, 4 and 6		Carriageway closures on A12 with contraflow running and speed restrictions
Partial demolition and reconstruction of Wigley Bush Lane Bridge	2, 4, 5D and 5E	Temporary closure of A12 during demolition likely, with diversions in place	Lane closures on A12 and speed restriction
Construction of new link and associate structures over A1023	6	Temporary close of the A1023	Diversion through Brentwood
Construction above circulatory carriageway of Junction 28	4, 5A and 5B	Possible night time closures	Possible lane closure on circulatory carriageway, and temporary diversions of the A1023 and other turning movements.
Realignment of slip roads and merges	All	Temporary closure (night time) of the various slip roads at Junction 28	Lanes closure and speed restrictions
Construction of underpass beneath mainline railway	2, 4, 5A and 6	Temporary/night time closures of the GEML	Train speed restriction on GEML

12 Technology assessment

12.1 Introduction

Where possible, the existing technology equipment will be retained. Instances where new infrastructure is required it shall be installed according to Highways England standards and specification and be CHARM (Common Highways Agency Rijkswaterstaat Model) compliant. This section summarises the impact to technology equipment of various options.

Any future design work, which could affect existing communication infrastructure should be undertaken in accordance with the following:

- Motorway Signalling – TD46/05
- NMCS TA 72/97 – System Design
- Infrastructure Design – TA77/97
- MIDAS – TD45/94
- Emergency Telephones – TA73/97
- CCTV – TD17/85 – Criteria for the provision of closed circuit television on motorways
- NRTS Technical Documents – Relevant standards and procedures
- Manual of Contract Documents for Highways Works.

12.2 Motorway incident detection and automatic signalling (MIDAS)

MIDAS is a distributed networks of traffic sensors, mainly loops which are designed to detect incidents or congestion and automatically set appropriate VMS messages to warn drivers of conditions of the road ahead, together with speed limits.

Various gantries are required to be relocated to accommodate carriageway widening. Where these gantries have associated MIDAS infrastructure it will also need to be relocated accordingly. Loops are typically installed in the road surface at nominal 500m intervals and are required to be a maximum distance from the associated gantries.

Additional MIDAS loops should be installed on the proposed link roads for all options to detect queuing. This will enable appropriate speed limit and warning to be set on the M25 mainline in advance of the link road.

Wherever alternations or additional infrastructure are made to the network the site data will need to be updated accordingly.

12.3 Variable message signs

The strategy for VMS installations and modifications will be agreed with the Overseeing Organisation during subsequent PCF stages.

12.4 Signals

Due to the options removing significant volume from the existing junction circulatory a review of the signal timings will be required during subsequent PCF stages.

12.5 Emergency roadside telephones

Emergency roadside telephones will be replaced/relocated wherever affected. It is envisaged that additional emergency roadside telephones will be installed at standard intervals on the proposed link roads.

12.6 CCTV

CCTV infrastructure will be replaced/relocated wherever affected to maintain existing levels of coverage. As the proposed link roads will become part of the M25 network it anticipated that additional CCTV infrastructure will be installed to increase the coverage accordingly.

12.7 National traffic information service (NTIS) assets

Existing NTIS assets will be replaced if affected by the proposals.

12.8 Distribution network operator supplies

It is foreseen that additional Distribution network operator supplies will be required which will be considered during subsequent PCF stages

12.9 Fog detector

Fog detectors will be replaced/relocated and/or added to maintain existing levels of coverage.

12.10 RCC systems and sub systems

The Motorway Communications Systems are controlled from Highways England's Regional Control Centre East (RCC(E)), located at South Mimms (M25 Junction 23), which operates an Highways England National Motorway Communication System Mark 2 (NMCS2) Control Office Base System (COBS) with associated Sub Systems. These systems are required to be updated to accommodate changes to the communications infrastructure. This include additional installations as well as modifications to the data set as a consequence of changes to the MIDAS loops spacing.

12.11 Communications network

In line with the Overseeing Organisation requirements, all technology shall apply IP equipment and adopt NRTS IP services for the outstation to instation communications link. Existing infrastructure will be re-used where practicable.

13 Maintenance assessment

13.1 Maintenance and repair strategy for civils infrastructure

Safe access for maintenance is essential to facilitate the safety of operational workers, motorists and NMUs. Access will be required along the entire length of all options to ensure maintenance works can be carried out while reducing or mitigating associated operational risks. Wherever possible it is highly desirable to synchronise any forecasted maintenance or renewal works planned in the vicinity of the proposals to take full advantage of the construction works and temporary traffic management.

A Maintenance and Repair Strategy Statement is a specific product of PCF Stage 2, however as a principle designers are required by CDM regulations to improve the design in regards to the health and safety of others. As outlined in DMRB 69/15 this process can be demonstrated by following the hierarchy of control, known by the acronym ERIC (Eliminate, reduce, information, control), shown in Table 13-1.

Table 13-1 Overview of ERIC (Eliminate, reduce, information, control)

Action	Example
Eliminate the hazard	<ul style="list-style-type: none"> Avoid maintenance activity through better or alternative design – choice another technique/approach
Reduce the hazard	<ul style="list-style-type: none"> Change detail, proximity, material, use latest technology, design to reduce time of exposure etc. Improve access, provide identification e.g. marker posts, ensure appropriate management systems are in place.
Information	<ul style="list-style-type: none"> Inform others of residual hazards and assumptions after actions above. Assumed diversion routes Traffic management scheme Access to works Drainage access issues (confined space, traffic proximity) etc.
Control	<ul style="list-style-type: none"> Having done the above, the responsibility for producing a 'safe method of work' to ensure it is safe, falls to those in charge of the work itself.

13.1.1 Key maintenance issues – Existing infrastructure

Key infrastructure that has associated maintenance activities at present include:

- routine drainage maintenance – outfalls, pollution control devices, gully and slot drain emptying
- surface course replacement
- road marking and studs replacement
- structure bearing and joint replacement
- routine structural inspections
- safety barrier inspection and replacement
- luminaire replacement
- Traffic signage, signals and technology

- Winter maintenance.

13.1.2 Key maintenance issues – Proposed infrastructure and safety considerations

While not currently detailed as part of the PCF Options Phase (Stages 1 and 2) careful consideration will be given to the following elements of the proposed infrastructure to minimise maintenance intervention and associated operational risk. This will be considered further during the Development Phase of the preferred options.

The following are key consideration relating to potential maintenance activities associated with the options, covering road side features, structures, and drainage.

Road side features

- No vegetation plating in areas which provide visibility splays
- Harden verges close to signs and safety barrier to reduce grass cutting or utilise low growth species
- Locate all none road-user essential features (e.g. feeder pillars) as close to the highway boundary as practically possible
- Locate emergency refuge areas adjacent to features to be maintained
- Locate lighting columns to the nearside verge wherever practical
- Plant trees away from drainage pipes to reduce likelihood of damage caused by root systems.

Structures

- Continuities and integral bridge decks where possible – eliminating joints and bearings
- The possibility of using corrosion resistant rebar
- Removing joints from string courses to remove use of joint sealants over live running lanes
- Inspection galleries built into structures to remove the need for operatives accessing from carriageway.

Drainage

- Wherever possible limit the cross carriageway drains, as these are difficult to maintain and repair and also contribute to pavement failure if damaged
- Avoid proposing manholes and gullies within the wheel track zone
- providing larger pipe diameters to offer additional capacity
- Minimise use of combined kerb/drainage units to reduce the likely hood of blockages and the requirement of intervention.

Inclusive of the above the introduction of any of the proposed options presents several residual maintenance issues.

Winter maintenance operations are affected by all options. When selected, any of the potential options would be added to the existing winter maintenance route, however maintaining

vehicles would have to utilise Junction 12 of the A12 to turn around and re-join the M25. This movement would add approximately 15km to the existing route and therefore a significant additional cost to the winter maintenance budget over the duration of the maintenance contract. Mitigating measures such as specific accesses/turnaround points for winter maintenance should be considered in detail once a preferred option has been selected.

Options 5A, 5B and 5C are single lane loop roads. Any significant maintenance activities to these options will require the closure of the loop road to ensure the safety of the operational workforce. The proposed diversion during the period of works would be to utilise the existing junction.

13.2 Maintenance and repair strategy for road side technology

In the scheme area the Regional Technology Maintenance Contractor (RTMC) are working under the supervision of Connect Plus, who have been appointed as Service Manager for the contract. Through the engagements with Connect Plus, the maintenance requirements of equipment to be maintained by the RTMC shall be captured and agreed.

Where existing access provision for maintenance is in place, this should be preserved along the route. Where this is not possible a suitable alternative should be provided. Any new roadside infrastructure will need suitable access either from the M25 or the A12. Where practicable, positioning of roadside technology should consider access for routine maintenance, preferably away from the roadside. Access for vehicles and other equipment should be provided.

14 Environmental assessment

14.1 Option 2 – Northern hook

14.1.1 Air Quality

The scheme area is located within the Havering AQMA, designated for exceeding the NO₂ annual mean and PM₁₀ 24-hour mean AQS objectives and within Brentwood AQMA Nos. 1 and 2, both designated for exceeding the NO₂ annual mean AQS objective. The scheme is expected to lead to an increase in traffic on the proposed link road at Junction 28. This could potentially lead to an increase in pollutant concentrations at receptors near this link road. The scheme is also expected to lead to a decrease in traffic on the northbound section of the M25 south of Junction 28, and on the eastbound A12, east of Junction 28, which could potentially lead to a decrease in pollutant concentrations at receptors near these roads. There are unlikely to be any significant changes in emissions based on the expected changes in traffic.

14.1.2 Cultural heritage

The construction and operation of Option 2 will not give rise to any direct significant effects on cultural heritage assets. The construction and operation of the option would impact on the setting of the Weald Park Registered Park and Garden, Weald Park Conservation Area, South Weald Conservation Area and the listed buildings within the village of South Weald, which would result in temporary and permanent slight adverse effects. The option would also impact on the setting of a small area of non-designated historic woodland, which would result in a permanent slight adverse effect. There is the potential for impacts on unknown buried archaeology as a result of its truncation or removal.

14.1.3 Landscape

Significant landscape effects are identified for Option 2, both during construction and operational stages. Large scale construction activities would alter the key characteristic of the local landscape character as compounds would be required and construction activities would create a localised new landscape pattern. During the operational stage Option 2 could be partially integrated into the existing landscape, but is assessed as adverse at the local level.

The majority of identified visual receptors would be affected significantly during construction stage due to the scale of operations. Whilst some elements of Option 2 would be blended into the existing landscape in the operational stage, a number of visual receptors would perceive a noticeable deterioration to their views.

14.1.4 Nature conservation

Option 2 will involve direct impacts to Ingrebourne Valley SMI and Lower Vicarage Wood LWS, including loss of habitat. Direct loss of habitat from Ingrebourne Valley SMI would have significant adverse effects on the conservation status of this designated site at the Metropolitan level. Loss of habitat from Lower Vicarage Wood LWS would have a significant adverse effect on the conservation status of at the County level. Effects on notable (non-designated) habitats or species are not considered to have an effect above the Local level and slight adverse.

14.1.5 Geology and soils

The anticipated geology and soils present within the proposed route for Option 2 comprise Landfill Material, Made Ground, superficial Alluvium and Head Deposits and solid geology of London Clay Formation, including Claygate Member in the southern portion of the site. There is potential for impacts to the scheme associated with ground conditions that may be encountered and on human and/or controlled waters receptors associated with potential

sources of contamination within or in close proximity to the proposed route, including localised deposits of Made Ground, the Brook Street Landfill and other potentially contaminative land uses, such as where the option intersects the railway line and an MOT centre.

14.1.6 Materials and waste

At this stage no information on the use of materials or generation of waste associated with the proposed options is currently available. However, it is assumed that proposed options which cover the greatest area (physical extent) will require the greatest amount of demolition works, have the greatest volume of earthworks (excavation works), and will require the greatest volume of construction materials, thus have the potential to produce more waste. A summary of the key effects associated with Option 2 are summarised below:

- Potential excess material use / waste generation if wastes are not reused / recycled where practicable
- Potential for the disposal of large quantities of excavated materials, if the materials are found to be hazardous and thus not suitable for reuse
- Potential for enhanced quantities of demolition waste airings associated with the demolition of the existing Nags Head Lane Overbridge
- Increased excavation waste arising due to the underpass beneath the railway line / M25
- Increased construction waste arisings associated with the construction / extension of bridge(s).

14.1.7 Noise and vibration

The main construction activities that are likely to take place are site preparation, demolition, earthworks, retaining wall construction and road works. Demolition works and piling works (for new viaducts and retaining walls) are likely to cause some of the highest noise levels dependent on the methods chosen. Where it is necessary to close the motorway to undertake the works (e.g. new viaducts passing over live carriageways or railways) the potential for adverse noise impacts at night is very high. This would also be coupled with the wider impacts of re-routed traffic during the night-time. The particular construction activities associated with Option 2 that have the greatest potential to cause disturbance are as follows:

- Construction of a new merge lane to the A12 eastbound (east of Junction 28) which has the potential to adversely affect the residential area to the south of A12 in Brentwood
- Realignment of Nag's Head Lane which has the potential to adversely affect receptors on Nag's Head Lane
- New diverge lane to west of M25N which has the potential to adversely affect properties on Nag's Head Lane, requiring demolition of the existing Nag's Head Lane bridge and construction of a significant retaining wall close to properties
- Extending Wigley Bush Lane overbridge which has the potential to adversely affect a cluster of properties immediately to the southeast
- Construction of a loop to the north-west of the existing junction which has the potential to adversely affect Mayands Golf Course and Grove Farm
- Realignment of Weald Park Way which has the potential to adversely affect properties on Weald Park Way

- Extending the footbridge from Weald Park Way to Spital Lane which has the potential to adversely affect properties in the vicinity.

In the operational phase, Option 2 may give rise to increases in noise at Nag's Head Lane (west of M25), Putwell Bridge Farm and Grove Farm in the Opening Year and the Design Year due to the new diverge from the M25N to the A12 eastbound. A minor decrease in noise is predicted on the east bound on slip from the circulatory to the A12 in the area of Lower Vicarage Wood. Option 2 has the potential to negatively impact on Noise Important Areas (NIA) 5749 adjacent to Nag's Head Lane, NIA 5752 around River Road and NIA 5751 around Selwood Road.

14.1.8 People and communities

The construction and operation of the option would impact on NMUs and residential receptors which would result in temporary and permanent adverse effects ranging from negligible to major adverse. However, NMU are only likely to be negligibly effected on operation. It is likely that some small parts of private property linked to the residential receptors will be required. The impact on motorised travellers' views from the road will depend on the design of the bridges and embankments but is likely to create new visual intrusions.

14.1.9 Road drainage and the water environment

Option 2 would also traverse the flood risk zone for the River Ingrebourne which is a WFD classified river. Providing adherence to best practice mitigation is maintained during the construction period, there should be no significant effects to the water environment. During operation there would be potential impacts to water quality from discharge of polluting runoff and potential direct morphological changes to the River Ingrebourne and the other four watercourse crossings however, these are not likely to be significant.

14.2 Option 4 – Compact hook

14.2.1 Air quality

The scheme area is located within the Havering AQMA, designated for exceeding the NO₂ annual mean and PM₁₀ 24-hour mean AQS objectives and within Brentwood AQMA Nos. 1 and 2, both designated for exceeding the NO₂ annual mean AQS objective. The scheme is expected to lead to an increase in traffic on the proposed link road at Junction 28. This could potentially lead to an increase in pollutant concentrations at receptors near this link road. The scheme is also expected to lead to a decrease in traffic on the northbound section of the M25 south of Junction 28, and on the eastbound A12, east of Junction 28, which could potentially lead to a decrease in pollutant concentrations at receptors near these roads. There are unlikely to be any significant changes in emissions based on the expected changes in traffic.

14.2.2 Cultural heritage

The construction and operation of Option 4 will not give rise to any direct significant effects on cultural heritage assets. The construction and operation of Option 4 would impact on the setting of the Weald Park Registered Park and Garden, Weald Park Conservation Area, South Weald Conservation Area and the listed buildings within the village of South Weald, which would result in temporary and permanent slight adverse effects. The option would also impact on the setting of a small area of non-designated historic woodland, which would result in a permanent slight adverse effect. There is the potential for impacts on unknown buried archaeology as a result of its truncation or removal.

14.2.3 Landscape

Significant landscape effects are expected for Option 4 both in the construction and operational stage. During the construction stage some loss of vegetation is expected where the new route is proposed. Large scale construction operations associated with the proposed viaduct would require introduction of earthworks and compound areas which combined with the construction activity would create a temporary but adverse alteration to the local landscape character. The scheme could be integrated into the existing landscape in the operational stage, however overall significant albeit temporary adverse effects are also expected at this stage due to the scale of change.

Option 4 would require prominent and large scale construction operations. Some of the introduced elements, such as the viaduct over the existing junction, would result in a noticeable deterioration to the existing views also in operational stage. Therefore some visual receptors would be affected significantly both in construction and operational stage.

14.2.4 Nature conservation

Option 4 will involve direct impacts to Lower Vicarage Wood LWS, including loss of habitat which would have a significant adverse effect on its conservation status at the County level. Effects on notable (non-designated) habitats or species are not considered to have an effect above the Local level.

14.2.5 Geology and soils

The anticipated geology and soils present within the proposed route for Option 4 comprise Made Ground, superficial Alluvium and Head Deposits and solid geology of London Clay Formation, including Claygate Member in the southern portion of the site. There is potential for impacts to the scheme associated with ground conditions that may be encountered and human and/or controlled waters receptors associated with potential sources of contamination within or in proximity to the proposed route, such as localised deposits of Made Ground, the railway line (which this option involves tunnelling beneath) and an MOT centre.

14.2.6 Materials and waste

At this stage of the design process no information on the use of materials or generation of waste associated with the proposed options is currently available. However, it is assumed that proposed options which cover the greatest area (physical extent) will require the greatest amount of demolition works, have the greatest volume of earthworks (excavation works), and will require the greatest volume of construction materials, thus have the potential to produce more waste. A summary of the key effects associated with Option 4 are summarised below:

- Potential excess material use / waste generation if wastes are not reused / recycled where practicable
- Potential for the disposal of large quantities of excavated materials, if the materials are found to be hazardous and thus not suitable for reuse
- Potential for enhanced quantities of demolition waste arisings associated with the demolition of the existing Nags Head Lane Overbridge
- Increased waste arisings associated with the construction / widening of viaducts
- Increased excavation waste arising due to the underpass beneath the railway line / M25
- Increased construction waste arisings associated with the construction / extension of bridge(s).

14.2.7 Noise and vibration

The main construction activities that are likely to take place are site preparation, demolition, earthworks, retaining wall construction and road works. Demolition works and piling works (for new viaducts and retaining walls) are likely to cause some of the highest noise levels dependent on the methods chosen. Where it is required to close the motorway to undertake the works (e.g. new viaducts passing over live carriageways or railways) the potential for adverse noise impacts at night is very high. This would also be coupled with the wider impacts of re-routed traffic during the night-time. The particular construction activities associated with Option 4 that have the greatest potential to cause disturbance are as follows:

- Construction of a new merge lane to the A12 eastbound (east of Junction 28) which has the potential to adversely affect the residential area to the south of A12 in Brentwood
- Realignment of Nag's Head Lane which has the potential to adversely affect receptors on Nag's Head Lane
- New diverge lane to west of M25N which has the potential to adversely affect properties on Nag's Head Lane, requiring demolition of the existing Nag's Head Lane bridge and construction of a significant retaining wall close to properties
- Construction of new viaducts over the existing Junction 28 which has the potential to adversely affect isolated properties close to the junction
- Extending Wigley Bush Lane overbridge which has the potential to adversely affect a cluster of properties immediately to the southeast
- Realignment of Weald Park Way which has the potential to adversely affect properties on Weald Park Way
- Extending the footbridge from Weald Park Way to Spital Lane which has the potential to adversely affect properties in the vicinity.

In the operational phase, Option 4 is likely to give rise to noise increases in Lower Vicarage Wood in the Opening Year and the Design Year. A minor decrease in noise on the east bound on slip to the A12 is predicted in the Opening Year. Negligible changes to noise are predicted on the A12 and M25 road links unaltered by Option 4. There is the potential for increases at Nags Head Lane (west of M25) due to the new diverge in this location.

Option 4 has the potential to negatively impact on Noise Important Areas 5749 adjacent to Nag's Head Lane, NIA 5750 at Junction 28, NIA 5752 around River Road and NIA 5751 around Selwood Road.

14.2.8 People and communities

The construction and operation of this option would impact on the NMUs and residential receptors identified which would result in temporary and permanent adverse effects ranging from negligible to major adverse. However, identified NMU are only likely to be negligibly effected on operation. It is likely that some small parts of private property linked to the residential receptors will be needed for the scheme. The impact on motorised travellers' views from the road will depend on the design of the bridges and embankments but is likely to create new visual intrusions.

14.2.9 Road drainage and the water environment

Option 4 would traverse the flood risk zones of the River Ingrebourne which is an EFD classified River. Providing adherence to best practice mitigation during the construction period,

there should be no significant effects to the water environment. During operation there would be potential impacts to water quality from discharge of polluting runoff and potential direct morphological changes to four water course crossings.

14.3 Options 5A, 5B, 5C and 5F – Cloverleaf loop variants

14.3.1 Air quality

The scheme area is located within the Havering AQMA, designated for exceeding the NO₂ annual mean and PM₁₀ 24-hour mean AQS objectives and within Brentwood AQMA Nos. 1 and 2, both designated for exceeding the NO₂ annual mean AQS objective. The scheme is expected to lead to an increase in traffic on the proposed link road at Junction 28. This could potentially lead to an increase in pollutant concentrations at receptors near this link road. The scheme is also expected to lead to a decrease in traffic on the northbound off slip from the M25 south of Junction 28, and on the eastbound on slip onto the A12, east of Junction 28, which could potentially lead to a decrease in pollutant concentrations at receptors near these roads. There are unlikely to be any significant changes in emissions based on the expected changes in traffic.

14.3.2 Cultural heritage

The construction and operation of the Option 5A, 5B, 5C and 5F variants will not give rise to any direct significant effects on the cultural heritage resource. Option 5A would impact on the setting of a small area of non-designated historic woodland, which would result in a permanent slight adverse effect. Option 5B would not impact on any heritage assets. There is the potential for impacts on unknown buried archaeology as a result of its truncation or removal.

14.3.3 Landscape

No significant landscape effects are identified for Option 5A. As relatively small scale construction activities are expected for Option 5A, the landscape effects would not be significant. Option 5A would also not alter significantly local landscape character in the operational stage. Some visual receptors would be significantly affected during construction stage, however only few receptors are predicted to be significantly affected during the operational stage as the proposed planting would mature to integrate the option into the existing landscape.

No significant landscape effects are identified for Option 5B. As relatively small scale construction activities are expected for Option 5B, the landscape effects would not be significant. Option 5B would not significantly alter the local landscape character in the operational stage. In considering visual receptors, only Grove Farm would be affected significantly both in construction and operational stage.

No significant landscape effects are identified for Option 5C and Option 5F. As relatively small scale construction activities are expected for Options 5C and 5F, the landscape effects would not be significant. The elements for Options 5C and 5F would also not significantly alter local landscape character in the operational stage. In considering visual receptors only Grove Farm would be affected significantly both in the construction and operational stage.

14.3.4 Nature conservation

The Option 5A, 5B, 5C and 5F variants will involve direct impacts to Ingrebourne Valley Site of Metropolitan Importance (SMI), including realignment of the stream between Grove Farm and the A12. Direct loss of habitat from Ingrebourne Valley SMI would have significant adverse effects on the conservation status of this designated site at the Metropolitan level. Effects on

notable (non-designated) habitats or species are not considered to have an effect above the Local level.

14.3.5 Geology and soils

The anticipated geology and soils present comprise Landfill Material, Made Ground, superficial Alluvium and Head Deposits and solid geology of London Clay Formation, including Claygate Member in the southern portion of the site. There is potential for impacts to the scheme associated with ground conditions that may be encountered and on human and/or controlled waters receptors associated with potential sources of contamination within or in proximity to the proposed routes, including localised deposits of Made Ground, the Brook Street Landfill and other potentially contaminative land uses such as the sewage treatment works to the south-west of Junction 28 and an MOT centre (Option 5A only).

14.3.6 Materials and waste

At this stage of the design process no information on the use of materials or generation of waste associated with the proposed options is currently available. However, it is assumed that proposed options which cover the greatest area (physical extent) will require the greatest amount of demolition works, have the greatest volume of earthworks (excavation works), and will require the greatest volume of construction materials, thus have the potential to produce more waste. A summary of the key effects associated with the Option 5A, 5B, 5C and 5F designs are summarised below:

- Potential excess material use / waste generation if wastes are not reused / recycled where practicable
- Potential for the disposal of large quantities of excavated materials, if the materials are found to be hazardous and thus not suitable for reuse
- Potential for enhanced quantities of demolition waste airings associated with the demolition of the existing Nags Head Lane Overbridge (Option 5A only)
- Increased waste arisings associated with the construction / widening of viaducts (Option 5A and 5B only)
- Increased excavation waste arising due to the underpass beneath the railway line / M25 (Option 5A only)
- Increased construction waste arisings associated with the construction / extension of bridge(s)
- Increased construction waste arisings associated with the construction of watercourse realignments.

14.3.7 Noise and vibration

The main construction activities that are likely to take place are site preparation, demolition, earthworks, retaining wall construction and road works. Demolition works and piling works (for new viaducts and retaining walls) are likely to cause some of the highest noise levels dependent on the methods chosen. Where it is necessary to close the motorway to undertake the works (e.g. new viaducts passing over live carriageways or railways) the potential for adverse noise impacts at night is very high. This would also be coupled with the wider impacts of re-routed traffic during the night-time. The particular construction activities associated with the Option 5A, 5B, 5C and 5F variants that have the greatest potential to cause disturbance are as follows:

- Realignment of Nag's Head Lane which has the potential to adversely affect receptors on Nag's Head Lane (Option 5A)
- New diverge lane to west of M25N which has the potential to adversely affect properties on Nag's Head Lane, requiring demolition of the existing Nag's Head Lane bridge and construction of a significant retaining wall close to properties (Option 5A)
- Construction of new viaducts over the existing Junction 28 which has the potential to adversely affect isolated properties close to the junction (Options 5A and 5B)
- Construction of a loop to the north-west of the existing junction which has the potential to adversely affect Mayands Golf Course and Grove Farm (Options 5A, 5B, 5C and 5F).

In the operational phase, all sub-options are likely to give rise to noise increases at Grove Farm. Traffic data for Option 5B shows that a moderate increase in basic noise level on the A12 eastbound through the junction is likely in the Opening Year and Design Year; however this is unlikely to have an effect at any receptors

Option 5A would additionally involve the realignment of Nag's Head Lane taking it away from the housing along this route which may cause some reductions in noise levels where not already dominated by noise from the M25

Options 5B, 5C and 5F have the potential to negatively impact on Noise Important Area 5750 at Junction 28 whilst Option 5A has the potential to additionally impact negatively upon noise Important Area 5749 adjacent to Nag's Head Lane.

14.3.8 People and communities

The construction and operation of the option would impact on fewer NMUs and residential receptors than the previous three options which would result in temporary and permanent adverse effects ranging from negligible to major adverse with Option 5A ranging from negligible to moderate. However, NMU are only likely to be negligibly effected during operation. It is likely that some small parts of private property linked to Grove Farm will be required. The impact on motorised travellers' views from the road will depend on the design of the bridges and embankments but is likely to create new visual intrusions, however this should be less than the first three options.

14.3.9 Road drainage and the water environment

Option 5A would cross four new watercourses, including the River Ingrebourne, which is a WFD classified river, and Weald Brook. Option 5B would cross two new watercourses including the River Ingrebourne and Weald Brook and Options 5C and 5F would cross five new watercourses, crossing Weald Brook in three locations.

All the variants would also traverse the flood risk zones of these watercourses. Providing adherence to best practice mitigation is maintained during the construction period, there should be no significant effects to the water environment. During operation there would be potential impacts to water quality from discharge of polluting runoff and potential direct morphological changes to the water course crossings.

14.4 Options 5D and 5E – Loop variants

14.4.1 Air quality

The scheme area is located within the Havering AQMA, designated for exceeding the NO₂ annual mean and PM₁₀ 24-hour mean AQS objectives and within Brentwood AQMA Nos. 1

and 2, both designated for exceeding the NO₂ annual mean AQS objective. The scheme is expected to lead to an increase in traffic on a number of roads in the vicinity of Junction 28. This could potentially lead to an increase in pollutant concentrations at receptors near the affected road network, including those within the Havering AQMA and within Brentwood AQMA Nos. 1 and 2. The scheme is also expected to lead to a decrease in traffic on the northbound off slip from the M25 south of Junction 28, and on the southbound off slip from the M25 north of Junction 28, which could potentially lead to a decrease in pollutant concentrations at receptors near these roads. The scheme is likely to lead to an increase in emissions based on the expected increases in traffic.

14.4.2 Cultural heritage

The construction and operation of Options 5D and 5E will not give rise to any direct significant effects on cultural heritage assets resource. The construction and operation of the option would impact on the setting of the Weald Park Registered Park and Garden, Weald Park Conservation Area, South Weald Conservation Area and the listed buildings within the village of South Weald, which would result in temporary and permanent slight adverse effects. There is the potential for impacts on unknown buried archaeology as a result of its truncation or removal.

14.4.3 Landscape

Significant landscape effects were identified during both construction and operational stage for Option 5D. This is due to partial alteration to the local landscape character as landform, landscape pattern and land use would be altered in the construction stage. Whilst the scheme would partially blend into the existing landscape during operational stage, new features of the Proposed Scheme would become prominent in the operational stage resulting in significant landscape effects. Significant visual effects are expected during construction stage due to their scale of works to be carried out. Fewer visual receptors would be affected significantly in the operational stage as parts of the scheme would be accommodated within the existing landscape through the maturing vegetation.

Significant landscape effects were identified during both construction and operational stage for Option 5E. This is due to partial alteration to the local landscape character as landform, landscape pattern and land use would be changed in the construction stage. Whilst the scheme would partially blend into the existing landscape during operational stage, new features would become prominent in operational stage resulting in significant landscape effects. Significant visual effects are expected during stage construction stage due their scale for some identified receptors. Fewer visual receptors would be affected significantly in operational stage as parts of the scheme would be accommodated within the existing landscape through the maturing vegetation.

14.4.4 Nature conservation

Options 5D and 5E will involve direct impacts to Ingrebourne Valley SMI (including realignment of the river where it is culverted under the new loop road), The Oaks LWS and Lower Vicarage Wood LWS. Direct loss of habitat from Ingrebourne Valley SMI would have a significant effects on the conservation status of this designated site at the Metropolitan level. Loss of habitat from The Oaks LWS and Lower Vicarage Wood LWS would have a significant effect on the conservation status of at the County level. Effects on notable (non-designated) habitats or species are not considered to have an effect above the Local level.

14.4.5 Geology and soils

The anticipated geology and soils present within the proposed routes for Options 5D and 5E comprise Landfill Material, Made Ground, superficial Alluvium and Head Deposits and solid geology of London Clay Formation. There is potential for impacts to the scheme associated

with ground conditions that may be encountered and on human and/or controlled waters receptors associated with potential sources of contamination within or in proximity to the proposed routes, including localised deposits of Made Ground and the Brook Street Landfill.

14.4.6 Materials and waste

At this stage of the design process no information on the use of materials or generation of waste associated with the proposed options is currently available. However, it is assumed that proposed options which cover the greatest area (physical extent) will require the greatest amount of demolition works, have the greatest volume of earthworks (excavation works), and will require the greatest volume of construction materials, thus have the potential to produce more waste. A summary of the key effects associated with Option 5D and 5E designs is set out below:

- Potential excess material use / waste generation if wastes are not reused / recycled where practicable
- Potential for the disposal of large quantities of excavated materials, if the materials are found to be hazardous and thus not suitable for reuse
- Increased waste arisings associated with the construction / widening of viaducts (Option 5D only)
- Increased excavation waste arising due to the underpass beneath the railway line / M25 (Option 5E only)
- Increased construction waste arisings associated with the construction / extension of bridge(s).

14.4.7 Noise and vibration

The main construction activities that are likely to take place are site preparation, demolition, earthworks, retaining wall construction and road works. Demolition works and piling works (for new viaducts and retaining walls) are likely to cause some of the highest noise levels dependent on the methods chosen. Where it is required to close the motorway to undertake the works (e.g. new viaducts passing over live carriageways or railways) the potential for adverse noise impacts at night is very high. This would also be coupled with the wider impacts of re-routed traffic during the night-time. The particular construction activities associated with Options 5D and 5E that have the greatest potential to cause disturbance are as follows:

- Construction of a new merge lane to the A12 eastbound (east of Junction 28), potentially causing an adverse effect at the residential area to the south of A12 in Brentwood
- Extending Wigley Bush Lane overbridge which has the potential to adversely affect a cluster of properties immediately to the southeast
- Construction of a loop to the north-west of the existing junction which has the potential to adversely affect Mayands Golf Course and Grove Farm.

In the operational phase, both sub-options are likely to give rise to noise increases at Alder Wood and Maylands Golf Course as well as at Lower Vicarage Wood. Increases are also possible at Grove Farm. The traffic predictions for Option 5D show that a minor increase in basic noise level is predicted for the A12 in both directions in the Opening Year, with negligible changes to the basic noise level predicted in the Design Year. Both sub-options have the potential to negatively impact on Noise Important Areas 5750 at Junction 28, NIA 5752 around River Road and NIA 5751 around Selwood Road.

14.4.8 People and communities

The construction and operation of these options would impact on the fewest NMUs and residential receptors and would result in temporary and permanent adverse effects ranging from negligible to moderate adverse. However, NMU are only likely to be negligibly affected on operation. It is likely that some small parts of private property linked to Grove Farm and French's Farm will be required to build the scheme. The impact on motorised traveller's views from the road will depend on the design of the bridges or underpass and earthworks but is likely to create new visual intrusions, however this should be less than for Options 2, 4 and 6.

14.4.9 Road drainage and the water environment

Both options 5D and 5E are the most environmentally damaging for the water environment because of the five new watercourse crossings required. Options 5D and 5E variants would also traverse the flood risk zones of Weald Brook and River Ingrebourne, which is a WFD classified river. Providing adherence to best practice mitigation is maintained during the construction period, there should be no significant effects to the water environment. During operation there would be potential impacts to water quality from discharge of polluting runoff and potential direct morphological changes to five water course crossings.

14.5 Option 6 - Southern link

14.5.1 Air quality

The scheme area is located within the Havering AQMA, designated for exceeding the NO₂ annual mean and PM₁₀ 24-hour mean AQS objectives and within Brentwood AQMA Nos. 1 and 2, both designated for exceeding the NO₂ annual mean AQS objective. The scheme is expected to lead to an increase in traffic on a number of roads in the vicinity of Junction 28. This could potentially lead to an increase in pollutant concentrations at receptors near the affected road network, including those within the Havering AQMA and within Brentwood AQMA Nos. 1, 2, 3 and 4. The scheme is also likely to lead to an increase in emissions, based on the expected increases in traffic.

14.5.2 Cultural heritage

The construction and operation of Option 6 will not give rise to any direct significant effects on cultural heritage assets. The construction and operation of the option would impact on the setting of the Grade II listed Nag's Head Inn, which would result in temporary and permanent minor adverse effects. The option would also result in the removal of a small area of non-designated historic woodland, which would result in a neutral effect. There is the potential for impacts on unknown buried archaeology as a result of its truncation or removal.

14.5.3 Landscape

Significant effects have been identified for landscape receptors as a result of Option 6 during the construction stage and for some visual receptors both for both construction and operational stage. During construction stage a considerable loss of vegetation is expected along the A1023 and A12 roads with some alterations to the existing landform as new cuttings and earthworks would be required. During the operational stage implemented environmental measures are likely to integrate the scheme into the existing landscape and introduction of the viaduct is a better option in landscape terms, as the existing landscape pattern, vegetation and land use under the viaduct would only be affected slightly; minor adverse effect.

Some visual receptors would be affected significantly due to the large scale of construction activities at the construction stage. The large scale of the viaduct would result in significant

effects for some visual receptors in the operational stage as existing views would be altered considerably.

14.5.4 Nature conservation

There are no effects on designated sites or ancient woodland. Effects on notable (non-designated) habitats or species are considered to be slight adverse at the local level scale.

14.5.5 Geology and soils

The anticipated geology and soils present within the proposed route of Option 6 comprise Made Ground, superficial Head Deposits and solid geology of London Clay Formation, including Claygate Member in the southern portion of the site. There is potential for impacts to the scheme associated with ground conditions that may be encountered and to human and/or controlled waters receptors associated with potential sources of contamination within or in close proximity to the proposed route, such as localised deposits of Made Ground along the proposed road route and the railway line, and other potentially contaminative land uses, including a service and repair garage, associated tanks, petrol filling stations and electricity sub-stations.

14.5.6 Materials and waste

At this stage of the design process no information on the use of materials or generation of waste associated with the proposed options is currently available. However, it is assumed that proposed options which cover the greatest area (physical extent) will require the greatest amount of demolition works, have the greatest volume of earthworks (excavation works), and will require the greatest volume of construction materials, thus have the potential to produce more waste. A summary of the key effects associated with Option 6 are summarised below:

- Potential excess material use / waste generation if wastes are not reused / recycled where practicable
- Potential for the disposal of large quantities of excavated materials, if the materials are found to be hazardous and thus not suitable for reuse
- Increased waste arisings associated with the construction / widening of viaducts
- Increased construction waste arisings associated with the construction / extension of bridge(s).

14.5.7 Noise and vibration

The main construction activities that are likely to take place are site preparation, demolition, earthworks, retaining wall construction and road works. Demolition works and piling works (for new viaducts and retaining walls) are likely to cause some of the highest noise levels dependent on the methods chosen. Where it is required to close the motorway to undertake the works (e.g. new viaducts passing over live carriageways or railways) the potential for adverse noise impacts at night is very high. This would also be coupled with the wider impacts of re-routed traffic during the night-time. The particular construction activities associated with Option 6 that have the greatest potential to cause disturbance are as follows:

- Construction of a new viaduct spanning Nag's Head Lane, the M25 and the railway which has the potential to have an adverse noise and vibration impact on properties on Nag's Head Lane
- Construction of the new slip road on embankment to the southeast of The Poplars which has the potential to have adverse noise and vibration impacts on this property

- Construction of a new viaduct over the A12 to the east of Junction 28 which has the potential to adversely affect properties to the south of the A12 in Brentwood
- Construction of a new merge lane to the A12 eastbound (east of Junction 28) which has the potential to adversely affect the residential area to the south of A12 in Brentwood
- Realignment of Weald Park Way which has the potential to adversely affect properties on Weald Park Way
- Extending the footbridge from Weald Park Way to Spital Lane which has the potential to adversely affect properties in the vicinity.

In the operational phase, there is the potential for noise increases at properties close to the new slip road, including to the west of the M25 on Nag's Head Lane. At The Poplars there is the potential for an increase affecting the south east façade of the building. Potential increases in these areas were predicted in the Opening Year and the Design Year of Option 6. A minor increase is predicted for the A12 in both directions in the Opening Year and a negligible change is predicted for the same road links in the Design Year.

Option 6 has the potential to negatively impact on Noise Important Areas 5749 adjacent to Nag's Head Lane, 5750 at Junction 28, 5752 around River Road and 5751 around Selwood Road.

14.5.8 People and communities

The construction and operation of this option would impact on the NMUs and residential receptors which would result in temporary and permanent adverse effects ranging from negligible to major adverse.

NMUs are only likely to be negligibly effected during operation. It is likely that some small parts of private property linked to the residential receptors will be required. The option would also require a commercial property (Brentwood Garden Centre) for land take resulting in the loss of that business. The impact on motorised travellers' views from the road will depend on the design of the viaduct structure but is likely to create new visual intrusions.

14.5.9 Road drainage and the water environment

Option 6 is the least environmentally damaging for the water environment based on the limited number of watercourse crossings. However, it would involve a new crossing over the River Ingrebourne, which is a WFD classified river and would traverse the flood risk zone from this river. Providing adherence to best practice mitigation during the construction period, there should be no significant effects to the water environment. During operation there would be potential impacts to water quality from discharge of polluting runoff and potential direct morphological changes to the River Ingrebourne but these are unlikely to be significant.

15 Assessment summary

15.1 Appraisal summary tables (AST)

The Appraisal Summary Tables can be found in Appendix L.

15.2 Summary of consultation with public bodies

Initial engagement with key stakeholders that could influence or have a strong interest in the scheme has been undertaken during PCF Stage 1 in advance of the non-statutory consultation planned for Stage 2 in late 2016. The aim of this initial engagement was to introduce the scheme, and obtain the views of key stakeholders on the key issues and the emerging concepts. The key stakeholder engaged during Stage 1 included:

- Highways England
- Essex County Council
- Brentwood Borough District Council
- London Borough of Havering
- Connect Plus Services
- Transport for London
- Transport for London Bus Operations
- British Pipeline Agency.

The key comments and views discussed at these initial stakeholder events are summarised in Table 15-1.

On balance, there is strong support for the scheme. All stakeholders recognised that current issues being experienced at Junction 28 in terms of congestion and journey time reliability exist and that without intervention will deteriorate considerably in the future as traffic volumes increase. The concepts of providing a free flow link between the M25 anticlockwise and A12 east carriageways was accepted as a good way to address these as part of the RIS1 road plan. There was acknowledgement that the current options offer an affordable solution aligned to the current problems.

The need for appropriate consideration and mitigation of environmental impacts associated with the proposed link options was recognised.

15.3 Comparison of options

This chapter of the TAR summarises and highlights the key findings of the assessment of the options for the Junction 28 improvements. The differences between alternative options are highlighted and discussed in order to present justifications for shortlisting options for further consideration in Stage 2.

Table 15.1 Summary of stakeholders' comments and views

Consultee	Comments / Views
Highways England	Fully supportive of the scheme, in that it meets the scheme objectives, HE's strategic objectives and options have been identified that are currently considered affordable against the original scheme budget. Consideration if the performance of the scheme against environmental KPIs is important particularly in terms of biodiversity, water courses, etc.
Brentwood Borough Council	Brentwood agreed with the overall scheme and the objectives it is designed to meet. The main concern is how this addresses Brook Street problems. Also keen to understand the impact on air quality. Need to engage with members and local residents which they can help facilitate.
Essex County Council	Broadly supportive of the scheme but unclear as to what benefits it will bring Essex, in particular for the regeneration areas. There are concerns over the traffic modelling (capacity constraints) which although will be refined in Stage 2 will need to clearly demonstrate what and where the benefits are. Initial thoughts are that local residents might be more interested in any other improvements that are made to the roundabout.
London Borough of Havering	LB of Havering agreed with the overall problems and objectives and generally supportive of the need for the Junction 28 scheme. Referring to several improvements undertaken at Junction 28 over the years, the Council acknowledged a high level of sensitivity on the area to highway improvements in the area, and that there may be potential concern as to why Junction 28 was being improved again. LBH highlighted some planning sensitivities relating to recent experiences on other projects. For example in terms of landscape there is a ridge of specialist character. They were concerned that the cloverleaf loop options (Options 5A to 5F) impacted on land close to the Maylands golf course, and stressed importance of demonstrating the case for these over alternative options. Havering have a number of key resident groups and local environmental and heritage societies that need to be kept informed.
Connect Plus Services	Fully supportive of the scheme, in that it meets the scheme objectives and addresses issues concerned with congestion, resilience and reliability during events of an accident, breakdown etc. such events often result in traffic queues developing and backing down the slip roads to the M25 and A12 main carriageways. CPS were concerned about the impact of the new loop on maintenance activities, particular of the link itself and winter maintenance, where maintenance vehicles will have lengthy detours to turn round.
Transport for London	Broadly supportive of the scheme and the objectives being sought. The TfL bus operations team are concerned about the buildability of the scheme. In particular this concern relates to any potential closures and the ability to maintain the operation of their buses that run along the A12 from London and pass through Junction 28 to Brook Street and destinations beyond.
British Pipeline Agency	It was noted early on that a high pressure fuel pipeline of strategic national importance ran through the study area. Therefore it was important to understand both the exact location of this pipeline, and work with BPA to achieve a design that follows BPA's processes and requirements, and ultimately could be approved. Therefore BPA had been engaged early in Stage 1 to understand their views, process and standards, and close liaison has been maintained.

15.3.1 Traffic

Under a 2037 Do-minimum scenario a significant deterioration in traffic conditions is expected. Average delays could be 2 or 3 times that experienced in 2014 in the AM and PM peak hours increasing up to 4 minutes in the AM and PM peaks (Table 15-2). Average speeds through the junction (excluding mainline M25 and A12 movements) consequently reduce from around 85 kph in 2014 to 67 kph in 2037. As a result journey times on key movements will also increase, and for example the M25 south to A12 east/Essex movement could see increases of 30% to 50%.

The operational performance of each of the options is very similar, but all show good benefits with little difference shown in terms of forecast journey times, average delays and speed (Table 15-2).

The main difference in traffic terms between the options relate to the operational performance of key design features in each option, for example at the merges, the carriageway standard of the new link, and running speed on the link or loop, etc.

The scheme will improve reliability for commuting and other users through the increased capacity provided by the new free-flow link which will improve the junction's resilience to incidents and reduce the scale of delay associated with incidents and lane closures.

Table 15-2 M25 Junction 28 network performance summary, 2037 Do-something

Criteria	Do-minimum	Forecast difference relative to Do-minimum by option						
		2	4	5B (& 5A*)	5C	5D (& 5E**)	5F	6
2037 AM peak forecasts								
Flows through the roundabout (PCUs/hour)	8,484	2%	2%	2%	2%	2%	2%	2%
Average delays (Sec)	227	-13%	-19%	-18%	-19%	-20%	-19%	-17%
Total delays (Hours)	1,543	-13%	-19%	-19%	-19%	-20%	-19%	-17%
Avg. speed (kph)	67	6%	7%	7%	7%	9%	9%	7%
2037 PM peak forecasts								
Flows through the roundabout (PCUs/hour)	8,411	3%	3%	3%	3%	3%	3%	3%
Average delays (Sec)	243	-47%	-46%	-47%	-47%	-47%	-47%	-47%
Total delays (Hours)	1,526	-44%	-44%	-44%	-44%	-44%	-44%	-44%
Avg. speed (kph)	67	19%	18%	19%	19%	19%	19%	19%

Table notes

* Option 5A assumes same model assignment run as Option 5B

** Option 5E assumes same model assignment run as Option 5D

15.3.2 Safety

It has been established that safety is currently a key issue at Junction 28. However the issue and consequences are concerned with the high occurrence of incidents and the implications on the disruption across the wider highway network as well as harm and injury. Many accidents are damage only, and of the total casualties resulting from the crashes 90% were slight injury. The level of killed and serious injuries (KSIs) is low with on average just under 1 KSI incident each year.

The assessment assumed no change in accident rates between the Do-minimum and Do-something scenarios on the existing junction. Consequently, estimated accident impacts were generated solely by the reallocation of traffic onto dedicated right turns from the M25

northbound to the A12 eastbound which have lower accident rates but involve additional travel distance.

On this basis a slight negative impact on accidents is forecast for each of the options (Table 15-3). This reflects the additional travel distance associated with the new link which leads to an increase in total accidents. This more than offsets the reduction associated with the improvements in accident rates on the new link relative to the existing junction.

Due to the low level of killed and serious injuries recorded at Junction 28, this scheme is not expected to contribute significantly to Highways England's KPI of reducing KSI collisions by 40% by 2020.

Table 15-3 Summary of safety assessment results

Forecast casualties saved over the 60 year appraisal period (2022 to 2081)	Option 2	Option 4	Options 5A, 5B 5C & 5F	Options 5D & 5E	Option 6
Fatal	-0.6	-0.3	-0.7	-0.7	-0.2
Serious injury	-3.7	-1.9	-4.1	-4.4	-0.9
Slight injury	-36.9	-24.1	-42.1	-48.4	-8.8
Safety impacts (PVB, £000s in 2010 prices & values)	-£1,575	-£857	-£1,788	-£1,988	-£336

15.3.3 Economics

Table 15-4 presents a summary of the economic assessment including the cost estimate, net present value (NPV) and benefit cost ratios (BCR) for each of the identified scheme options. Without construction impact all schemes yield substantial positive economic returns with BCRs well in excess of 2 for all options. When considering the impacts of construction on the users of the transport network the BCRs reduce with Options 5B, 5C and 5F showing BCRs of 2 or more.

There is little difference between the benefits (PVB) shown for each option, reflecting that each option essentially does the same thing, and therefore achieve similar outcomes against the scheme objectives. The main difference affecting the BCRs is the estimated scheme costs and to a lesser extent the construction impacts. Options 5C and 5F show the strongest BCRs reflecting the much lower construction costs compared to other options. While Option 5B has the lowest estimated costs, it does have a very high level of impact on users during construction and hence the BCR is not as strong as that shown for Options 5C and 5F.

Table 15-4 Overall summary of economic assessment

Option	Lanes	PVC	PVB excluding construction impacts	PVB including construction impacts	BCR excluding construction impacts	BCR including construction impacts
Option 2	2	£103,527	£308,132	-£18,377	2.98	-0.18
Option 4	2	£107,707	£340,185	-£48,796	3.16	-0.45
Option 5A	1	£78,842	£340,387	-£31,649	4.32	-0.40
Option 5B	1	£45,154	£339,332	£161,970	7.51	3.59
Option 5C	1	£53,029	£329,658	£254,287	6.22	4.80
Option 5D	2	£111,686	£348,067	£201,437	3.12	1.80
Option 5E	2	£85,710	£348,067	£126,114	4.06	1.47
Option 5F	2	£58,877	£341,037	£265,666	5.79	4.51
Option 6	2	£124,096	£368,020	£230,951	2.97	1.86

All values discounted in 2010 prices and values unless otherwise stated

Table 15-4 compares the economics for the assessed options (refer to the ASTs for further information). This shows that Option 6 and the Option 5 variants provide the greatest level of user benefits, closely followed by Option 4. Option 2 does not appear to perform as well comparatively in terms of yielding transport user benefits. The Option 5 variants generally offer the lowest cost solutions particularly Options 5B, 5C and 5F), and hence with the good PVB show the higher BCRs comparatively.

The economic assessment considered the impacts the construction works would have on users of the existing transport network. This was based on early views on the likely arrangements for traffic management required during different phases of construction for each option. Critically the requirement for constructing new structures, or modifying existing structures over the M25 motorway necessitates the need to operate the M25 under two lane contraflow conditions with a 50 mph speed restriction for several months. The construction impacts associated with Options 5B and 5E are expected to effect the M25 mainline flow considerably more than other options. As such the construction impacts for these options reduce the PVB for the options significantly. Options 5C and 5F offer strong PVBs, and with relatively low costs a high BCR is shown for each.

15.3.4 Environment

Table 15-5 compares the environmental impacts of the options, these are based on the ASTs.

Table 15-5 Comparison of options – potential environment impacts

	Option 2	Option 4	Options 5A, 5B, 5C & 5F	Options 5D & 5E	Option 6
Noise	Potential local noise increases close to Nags Head Lane, Putwell Bridge Farm and Grove Farm	Minor increase on east bound on-slip road to the A12. Potential increase near Nags Head Lane by new M25 diverge	Moderate increases at Grove Farm in all variants. Some reduction in Option 5A by Nags Head Lane to south of scheme.	potential to negatively impact on Noise Important Areas 5750 at Junction 28, 5752 around River Road and 5751 around Selwood Road	Potential local noise increases close to slips roads west of the M25 near to Nags Head Lane
Air quality	Potential increase in pollutant concentrations near to link road	Potential increase in pollutant concentrations near to link road	Potential increase in pollutant concentrations near to link road.	Potential increase in pollutant concentrations near the scheme	Potential increase in pollutant concentrations
Landscape	Moderate adverse	Moderate adverse	Slight adverse	Moderate adverse	Slight adverse
Historic environment	Slight adverse	Slight adverse	No impacts on designated heritage assets. Option 5A would result in an a setting impact on a non-designated area of woodland	Slight adverse	Slight adverse
Biodiversity	Moderate adverse	Moderate adverse	Moderate adverse	Moderate adverse	Slight adverse
Water environment	Large adverse	Slight adverse	Large adverse	Large adverse	Large adverse

15.3.5 Non-motorised users

The study area is served by a number of footways, crossing and shared use paths, which would be traversed or impacted by all route options. These PRowS are important public amenity resources, and in all options the availability and continuity of these would be maintained.

16 Programme

An outline programme has been produced for the Junction 28 improvements scheme from Stage 1 through to the start of works.

In particular a review was undertaken looking at the Options and Development Phases, where the programme was updated based on the following inputs:

- Highways England Regional Investment Programme DCO Process Map – Planning Act 2008 (Version 1.11)
- An review of the initial programme with Highways England’s Programme Management Team and DCO specialist, and
- A number of collaborative programme planning sessions with the integrated project team and programme management team.

Table 16-1 provides a summary of key milestones within the updated programme for Junction 28.

Table 16-1 *Proposed timeframe for options, development and construction phases*

Milestone	From	To
PCF Stage 1		October 2016
PCF Stage 2	November 2016	June 2017
PCF Stage 3	July 2017	June 2018
PCF Stage 4	July 2018	December 2019
PCF Stage 5	January 2020	March 2020
PCF Stage 6	March 2020	July 2022
PCF Stage 7	July 2022	July 2023

17 Conclusions and recommendations

17.1 Need for the junction improvement

The existing Junction 28 suffers from significant congestion, poor journey time reliability and a high accident rate. Future economic growth and development is expected across Essex and locally in Brentwood and Havering. Existing plans for housing, employment and commercial growth implies a period of traffic growth. Whilst some modal shift and rerouting is anticipated, the car will continue to be a dominant mode and that traffic conditions will deteriorate considerably.

Without the intervention to improve Junction 28, congestion on the approaches to, and through the junction will continue and conditions will deteriorate further with future traffic growth. This would serve to discourage new development and economic growth in the immediate surrounding areas within London and Essex, and along the A12 corridor.

Specifically, without intervention the likely outcomes would include:

- The network constraint on the wider SNR caused by the inadequate capacity of Junction 28 and the increasingly high traffic demands will act as an inhibitor to economic growth and attractiveness of the local areas and the A12 corridor for new businesses and residents. Without intervention average delays across all movements on Junction 28 will be at least five times that experienced at present (and could be more); average delays could increase to at least 10 to 15 minutes per movement in peak periods
- The ability of the junction gyratory to remain open and available in the event of an accident or incident will diminish significantly. In such event local commuters, residents and businesses will suffer with increasingly longer and unreliable journey times.

The ongoing local air quality issues will continue and be exacerbated without both the reduction in traffic levels and the smoothing of traffic (fewer stopping vehicles).

17.2 Recommendation of options for progression to Stage 2

This TAR sets out the current conditions and performance of M25 Junction 28 highlighting the need for improving the junction. The TAR summarises the traffic and safety issues with the current highway arrangement and confirms the case for improvements at this junction with a set of project specific objectives. The surrounding environment and key issues and constraints have also been identified, including environmental, technical and operational issues.

A number of options have been identified to address the problems and achieve the project specific objectives. The extent to which these achieve the objectives, and offer value for money has been discussed earlier in previous chapters, based on the traffic, environmental and economic assessments. In addition to these assessments a value management review has also commenced under PCF Stage 1. This entailed a value management workshop to review the options against delivering the M25 Junction 28 scheme objectives, providing an initial assessment to assist the short-listing of options to be taken forward to Stage 2 - Option Selection. In considering the value offered to the project, each option was subject to a qualitative assessed in turn during the workshop. To achieve this the following questions were considered in relation to each of the identified options using the 7 point scoring system (Table 17-1):

- How technically feasible is the option when compared to the other options being considered?

- How well does the option deliver the benefits (outcomes) required of the project when compared to the other options being considered?
- How easy would the implementation of this option be when compared to the other options being considered?

This value assessment forms a good basis to identify the strongest options in terms of value against the desired objectives and outcomes, for taking forward to PCF Stage 2. In addition, it is important to consider the affordability of each option alongside value to confirm the selected options for Stage 2.

Options 5B, 5C, 5D and 5F are shown to offer the greatest value in achieving the project objectives, and in terms of deliverability (Table 17-1). This aligns well with the economic assessment which shows Options 5C and 5F with the highest economic cases at this stage (both showing very high value for money BCRs) and clearly these are recommended for progression into Stage 2.

In the economic assessment Option 5B also shows a strong level of user benefits (PVB) but the BCR was effected by a higher level of impact on users during construction, reducing the option to a high value for money BCR. As discussed earlier, the construction impacts in PCF Stage 1 has been based on a relatively crude methodology using the level of information available at this time. Refinements to the methodology will be pursued during Stage 2 and the construction phasing and traffic management arrangements can be examined in more detail. This could result in less disruption during construction being assessed and hence might improve the BCR for Option 5B. Therefore it is recommended that Option 5B is also taken forward as an affordable option.

In summary, it is recommended that the following options are taken forward to the PCF Stage 2 Option Selection:

- Option 5B – Cloverleaf loop variant 2
- Option 5C – Cloverleaf loop variant 3
- Option 5F – Cloverleaf loop variant 4.

17.3 Consideration of options for Stage 2 public consultation

A total of four core options (together with 6 variants of Option 5) have been identified and assessed during PCF Stage 1. It is recommended that the three options identified above for Stage 2 are taken forward to Public Consultation. It is important that the other options are also considered for inclusion in the consultation events, with justification as to why they have been discounted at this stage.

Table 17-1 Summary of the overall performance of Junction 28 RIS1 options

Option	Technical Feasibility	Benefits	Ease of Implementation	Overall Score	Costs within RIS1 budget
Option 2 - Northern hook (2 lanes)	4	3	2	9	Significantly over
Option 4 – Compact northern hook (2 lanes)	4	3	2	9	Significantly over
Option 5A - Cloverleaf loop variant 1 (1 lane)	4	4	4	12	Slightly over
Option 5B - Cloverleaf loop variant 2 (1 lane)	5	6	6	17	Within budget
Option 5C - Cloverleaf loop variant 3 (1 lane)	5	4	6	15	Within budget
Option 5D - Loop variant 1 (2 lanes)	6	6	3	15	Slightly over
Option 5E- Loop variant 2 (2 lanes)	5	4	2	11	Significantly over
Option 5F – Cloverleaf loop variant 4 (2 lanes)	As 5C	As 5C	As 5C	15	Within budget
Option 6 - Southern link (2 lanes)	4	4	0	8	Significantly over

Key to value management based assessment scoring:

- 6 = Delivers the best of the options
- 5 = Not quite the best
- 4 = Nearer best than worst
- 3 = Between best and worst
- 2 = Nearer worst than best
- 1 = Not quite the worst
- 0 = Does not deliver

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