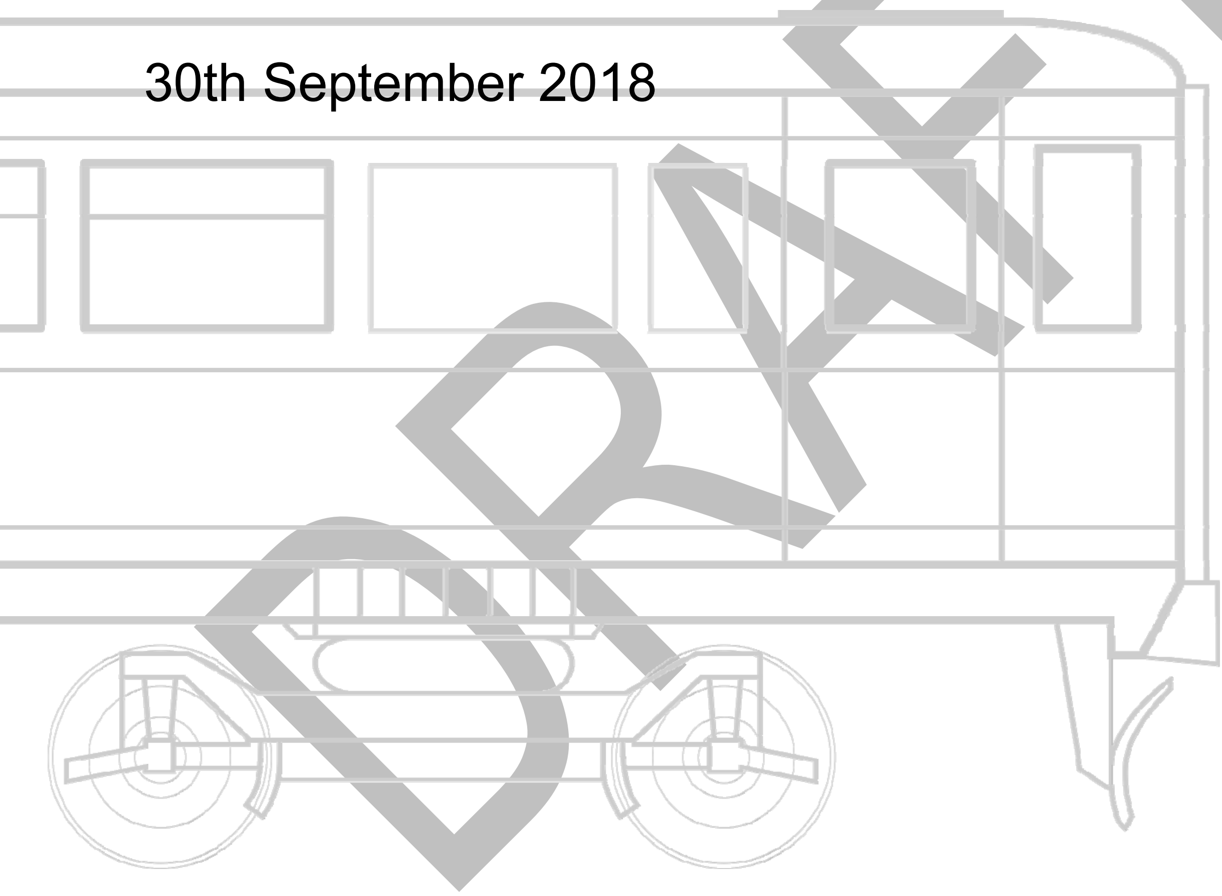
East West Rail Central Section

Phase 2e Report

DRAFT

30th September 2018



Authorised by:

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Preface

Important Notice – This document and its appendices have been produced by Network Rail (NR) in response to a direct output requested from the Department for Transport (DfT) in accordance with Variation No.2 to the Grant Funding Agreement dated 6th June 2018 (the Agreement). The purpose of this document and its appendices is to share with DfT and the East West Railway Company (EWR Co) the output of the option development activity carried out by NR on behalf of DfT and EWR Co for the East West Rail Central Section in the period between 1st October 2017 and 30th September 2018 (known as Phase 2e). This document and its appendices only represent a report on the output of NR's evaluation in this phase 2e of route options and have been prepared only for the purpose of providing EWR Co with further assessment evidence, for use, by EWR Co, in identifying and developing a preferred route with a supporting Strategic Outline Business Case. This document and its appendices should be used exclusively for the purposes of informing this further development activity to be carried out by EWR Co.

Should any other person other than DfT or EWR Co obtain access to this document and its appendices, that person accepts and agrees that this document and its appendices have been produced by NR in accordance with the instructions provided in the Agreement and was produced exclusively for the benefit and use of DfT and EWR Co for the purposes set out above. This document and its appendices may therefore not include all matters relevant to any such person or the further development of options for East West Rail Central Section undertaken by EWR Co following the production of this document and its appendices.

Version	Date	Comments	Author	Checker
Draft	30/09/2018	Issued to EWR Co/ DfT for comment	Various	Various
Draft	30/10/2018	Addressed comments from EWR Co	Various	Various
Final	03/01/2019	Insert Economic Appraisal tables	Various	Various

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Executive Summary

Background

This report covers the development activity carried out by Network Rail, on behalf of the Department for Transport (DfT) and the East West Railway Company (EWR Co) on East West Rail Central Section (EWRCS) between 1st October 2017 and 30th September 2018, referred to as Phase 2e. It continues analysis undertaken in Phase 2d on route options within the preferred geographic corridor between Bedford, Sandy and Cambridge. The focus of Network Rail's output in this phase is to continue to evaluate route options to provide EWR Co with further assessment evidence, for use, by them, in identifying a preferred route with a supporting Strategic Outline Business Case (SOBC). An announcement on a preferred route is expected to be made by EWR Co in Spring 2019.

The East West Rail (EWR) project is intended to provide a strategic rail corridor connecting East Anglia with central, southern and western England. In December 2016, the Secretary of State announced his intention to set up a separate company to lead the development, delivery and operation of EWR. This company, EWR Co, is now formally established and has delegated authorities from DfT. Network Rail is providing a development service through a Grant Funding Agreement signed with DfT.

The National Infrastructure Commission published its final report, 'Partnering for Prosperity: a new deal for the Cambridge-Milton Keynes-Oxford Arc' in November 2017. This made a number of recommendations, supporting the need for EWRCS, but with an emphasis on it being a more interurban, commuter railway, providing connectivity between where people will live and where they will work. In response to this, EWR Co have consulted stakeholders in this phase, on a number of changes to both the strategic objectives and conditional outputs for EWRCS, improving alignment with East West Rail Western Section (EWRWS), and focusing more on connectivity than journey time.

The key activities undertaken by Network Rail in Phase 2e have been to assess the scope, cost and value for route options, through further engineering analysis, journey time analysis, estimating and economic appraisal. The key areas were:

- Linespeed
- Capacity and capability for freight services
- Opportunities to align route options with emerging views on new housing/jobs
- A new intermediate station between Sandy and Cambridge

- Indicative Train Service Specification (ITSS) options with rolling stock assumptions.

The analysis carried out in this phase, as it applies to the route options, is detailed below.

Table X1: Estimate matrix

Estimate Matrix

		Sensitivities						VE			
Route	VE Summary	Freight	Linespeed	Cambourne	Bassingbourne	E of Bedford	Wixams	Sandy	Flood	BM	Shepreth
A1	✓	✓	✓		✓	✓	✓	●	●		●
A3	✓			✓					●		●
C1	✓								●	●	●
C3	✓	✓	✓	✓					●	●	●
E1	✓				✓				●		●
E3	✓	✓	✓		✓	✓	✓		●		●
SN4	✓								✓	✓	✓
SN5	✓								✓	✓	✓

✓	Estimate and Economic Assessment required
●	Estimate update to reflect

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To respond to emerging views on the location of potential new settlements within the Oxford – Milton Keynes-Cambridge corridor, two new route options were also considered during this phase, focusing on the south St Neots/Tempsford area and Bassingbourn. The potential locations for new developments is having an increasing impact on the development work being carried out; and reflects the importance of this new railway to support economic growth in the Oxford – Cambridge corridor.

The route options assessed in this phase are shown below, route options A1 to E3 being the options which emerged from the previous Phase 2c and Phase 2d assessment undertaken by Network Rail, and route options SN4 and SN5 being the 2 new options referred to above.

N.B. Additional route options have been identified in the later stages of Phase 2e which will be subject to more detailed analysis in the next phase of development

Figure X1: East West Rail Central Section schematic of route options

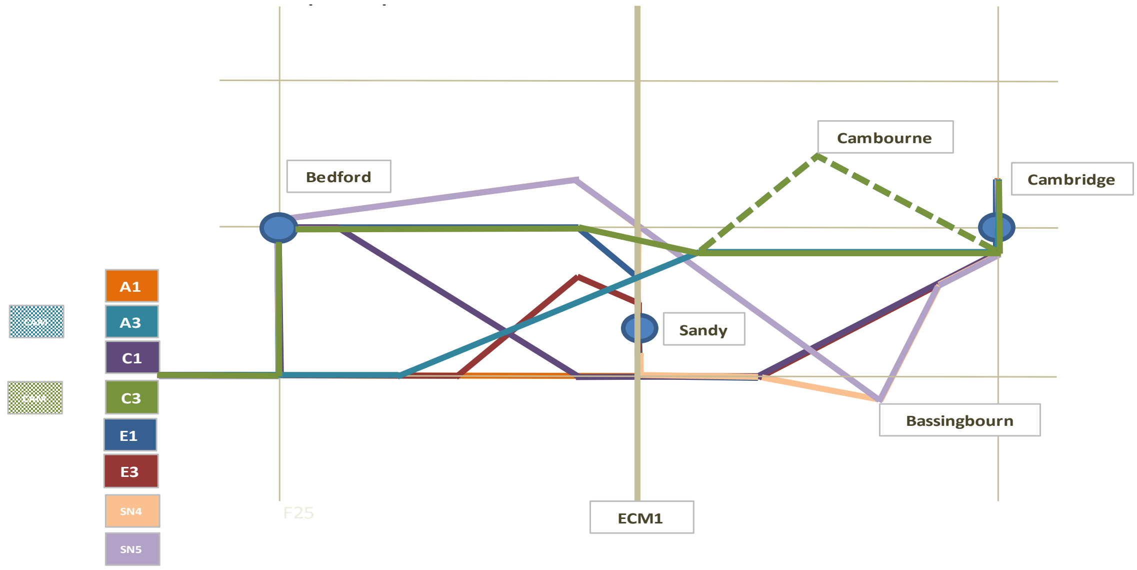


Table X2: East West Rail Central Section route option nodes and indicative alignments

Reference	Bedford Node	Sandy Node	Cambridge Node
A1	New Bedford South Station	New Sandy South Station	Shepreth Branch Junction (south of Wimpole Estate)
A3	New Bedford South Station	New Sandy North Station	Shepreth Branch Junction (north of Wimpole Estate)
E1	Existing Bedford Midland Station	Existing Sandy Station	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
E3	New Bedford South Station	Existing Sandy Station	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
C1	Existing Bedford Midland Station	New Sandy South Station	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
C3	Existing Bedford Midland Station	New St Neots South Station	Shepreth Branch Junction (north of Wimpole Estate)

SN4	Existing Bedford Midland Station	New St Neots South Station/ Existing Sandy Station	Shepreth Branch Junction (via ECML and Bassingbourn)
SN5	Existing Bedford Midland Station	New St Neots South Station	Shepreth Branch Junction (direct via Bassingbourn)

The development of the ITSS in this phase, recognising the need for an 'end-to-end' approach across all Network Rail Routes impacted by EWR, involved representatives from four Network Rail System Operator Route Strategic Planning Teams, the EWRWS Network Rail team and the Network Rail Freight and National Passenger Operator Team. The development of EWRCS has to be considered in relation to the interfaces it has with the existing infrastructure, and also how it interfaces with the wider strategic rail network. This will require on-going consultation with the System Operator Strategic Planning teams, within the relevant Network Rail Routes, as EWRCS develops further.

EWR Co have stated their aspirations for a service frequency level of up to 6tph between Bedford and Cambridge but this has not been addressed in the engineering development undertaken in this phase to maintain consistency of analysis across route options and to maintain programme. Within the economic appraisal undertaken in this phase, a high-level sensitivity to illustrate the potential marginal value of 4tph was undertaken although no work has been undertaken to assess whether this is deliverable on EWRCS and a separate study is being progressed on the ability of the Marson Vale Line (MVL) to accommodate up to 4 trains per hour (tph).

Engineering analysis

The key findings from the engineering analysis undertaken are:

Linespeed

A reduction in the infrastructure footprint width and earthworks quantities, through reducing linespeed from 125mph to 100/90mph, potentially offers opportunities for cost savings. However, existing ground condition, material classification, combined with cut and fill slope angles will have the most significant impact on this, and will need to be considered further in future development phases. Due to the topographical constraints, route option C3 benefits more than route option A1 in this respect.

Freight Capacity and Capability

As with the linespeed analysis, increasing the maximum gradient from 1:125 to 1:80 offers the potential to reduce the infrastructure footprint and earthworks quantities. This has a higher impact on route options where the ground is steeper e.g. C3. This reduced gradient would still allow for intermodal freight but would be a constraint for heavy haul freight, however, current forecasts indicate little demand for heavy haul freight on this route.

This opportunity needs to be considered further in relation to the strategic requirements for EWRCS if it is to be considered as part of the strategic freight network.

Intermediate stations

Two sites were considered for a new intermediate station between Sandy and Cambridge. One aligned to the existing town at Cambourne, and one aligned to the Ministry of Defence (MoD) site at Bassingbourn. Both locations are viable for the purposes of a new station. For Cambourne, route C3 would need to deviate further north, increasing route length by 3.7km, however, this reduces cost as it passes through lower lying ground. The alignment could also impact on the Mullard Radio Astronomy Observatory site and travelling telescope which would require consultation with Cambridge University.

Whether the MoD site at Bassingbourn is a viable site for development is currently unclear although the MoD has indicated it has proposals to develop it for its own purposes. This option, SN4, also increases mileage from the original A1 route option by 0.7km and continues to affect multiple roads, although only one additional road to the original A1 route option.

Sandy South Station

Being located on a flood plain, the opportunity to reduce cost for a new South Sandy Station is through using embankments rather than viaducts. However, this invokes additional design risks such as attenuation compensation. Proposals to reroute the A1 highway away from Sandy to the west could change the indicative layout for a new station at this location considerably, therefore, further consultation with Highways England is required when clarity on their proposals in this location are known. Hydraulic modelling would help to further refine the assessment of the level of flood risk and the impact on options, as it would define the limits of the structures required to cross the flood plain. This will be considered in a future stage of development at an appropriate point in the process.

Bedford Midland Station

The key issue identified in this phase is the impact of the ITSS on a level crossing that serves Bedford Maintenance depot and Thameslink rolling stock moves. With the Marston Vale Line (MVL) running through the centre of the depot, there would need to be significant remodelling of the depot to maintain an acceptable level of risk for both use of the level crossing, and depot operations, due to the increased number of trains that would be passing over it. Solutions to address this are being considered as part of a separate study being progressed by Network Rail, due for completion in March 2019.

Wixams Station

A number of options to align EWRCS with a new station at Wixams on the Midland Mainline (MML) were considered, including a split-level station, with EWRCS passing over the MML, and an at grade station i.e. all platforms at ground level on the MML. The split-level options, i.e. where EWRCS platforms would be on bridges/embankments above the MML, bring additional construction and maintenance costs. The key variable is the interface with the former land fill site at Elstow. Further engineering could identify significant cost savings through adjusting the alignment to impact less on this site. If a new railway station at Wixams were to be built in advance of EWRCS, this would likely determine the location of a new Bedford South Station.

The interface between the grade separated junction and Wixams station proposals are being considered as a holistic design, taking account of multi-disciplinary issues.

Flood Plain Strategy

The route options are significantly affected by crossing numerous watercourses and/or flood plain areas. Consideration was given to reducing the length of viaduct structures and replacing with earthworks embankment, thus reducing costs through more cost-efficient construction methods and this approach has been applied to the cost estimates at this stage of development. The benefits of this were noticeable on route options passing through low lying flood plains. However, reducing viaduct lengths and increasing embankments alters the risk profile as flood attenuation and compensation areas need to be evaluated, provided and maintained to a level that would be acceptable to the Environment Agency.

Shepreth Branch Junction

A new grade separated junction will not easily fit within the current Network Rail boundary and, therefore, land acquisition would be required. A further influencing factor is the location for a new station proposed to the south of Cambridge, to serve the biomedical campus, is critical to the junction layout for EWRCS. Locating the station further north than currently proposed would be preferable but impacts on its interface with the Guided busway and walking/cycling routes. Development for the junction and the station needs to be integrated so that the optimum design can be identified. Cost estimates across all route options include an allowance for permanent and temporary land take based on footprint and an average rate for different land types.

East of Bedford options

This looked at options to provide direct train connectivity into and out of Bedford Midland station from a south-easterly direction from Cambridge. This would enable southern route options to offer the same connectivity at Bedford Midland as northerly route options. All options considered are viable at this stage of development but require issues with the Bedford Maintenance depot to be resolved as referenced earlier.

Economic Analysis

A recalibrated model, procured by DfT from Leigh Fisher to use on EWRWS, has been used for consistency. This led to an error being identified with the previous model used by Atkins in Phases 2a and 2b for the corridor analysis, and subsequently transferred to Network Rail for route option analysis in Phases 2c and 2d. This error has had a significant adverse impact on the Business Case Ratio (BCR) for EWRCS reducing the best performing BCR (E3) in Phase 2d from 1.7 to 0.7. Combined with other impacts from using the Leigh Fisher model, the best performing route option now in Phase 2e, based on transport benefits alone, is A1 with a BCR of 0.35. This suggests that EWRCS does not represent value for money, nor has the potential, from a transport benefits perspective, to develop into a viable scheme. However, a review of the preferred choice of corridor, identified in previous phases against the corrected Atkins model, confirms that this output remains unaffected by the error, and the Bedford, Sandy, Cambridge corridor is still the best performing option, although with a lower Business BCR than previously reported.

Since they were established in December 2016, EWR Co have sought to establish a methodology that enables EWRCS to be evaluated both for transport benefits and economic growth benefits. However, the scale of development/growth that the National Infrastructure Commission (NIC) recommends, is in excess of current Local Development

Plans and, there are only emerging views as to where additional housing/settlements may be. This also comes with a significant risk that such locations may not be feasible, or acceptable, when progressed through the planning process. In support of this, and in responding to the error in the transport analysis deriving from the Atkins model, EWR Co asked Network Rail to undertake some high growth sensitivity tests that were intended to align with the transformational growth scenarios outlined by the NIC. This assumes that housing growth would increase within the corridor from c13,000 dwellings per annum to c30,000 dwellings per annum. This resulted in the best performing route option A1 having a BCR of 1.45. This analysis, however, falls outside the WebTAG guidance although it is intended to align with the transformational growth scenarios outlined by the NIC in its November 2017 report, and could be used to support the strategic case for EWRCS.

EWR Co procured some Land Usage Transport Interaction Modelling from KPMG to consider alongside the transport benefit analysis undertaken by Network Rail. The output from this has not yet been shared with Network Rail therefore no commentary is included in this report.

Throughout this phase, consultation has continued with internal NR stakeholders, external rail industry stakeholders and statutory consultees. EWR Co are now taking the lead with stakeholder management in their role as now in leading the development work; and being the future promoter for the rail elements of the Development Consent Order (DCO) required to authorise EWRCS. The Land and Consents Strategy, attached as Appendix E1 to this report, was written on the assumption that Network Rail would be the promoter for the rail elements of a DCO submission. As this is no longer the case, this document will need to be reviewed and updated by EWR Co to reflect latest position. See also Part E of this report

EWRCS has a significant interface with Network Rail as the Infrastructure Manager for existing, interfacing infrastructure, in addition to its System Operator role. This is an important aspect for the stakeholder management of EWRCS that must continue to be recognised as the project develops further, irrespective of who is leading the development work.

With regards to safety, the Construction Design and Management (CDM) strategy for EWRCS will also need to be updated as EWR Co take on the Client role from Network Rail in the future.

In summary, therefore, development work has continued in this phase on route options, but because of an error in previous transport economic analysis and utilisation of a recalibrated model from Leigh Fisher, the best performing route option A1 does not represent value for money from a transport benefit perspective. However, the strategic case for the scheme emphasises the point that transport infrastructure is just one element in supporting economic growth in the Oxford – Milton Keynes – Cambridge corridor and needs to be supplemented with other benefits arising from an ambitious housing strategy to align with route options. This is currently being discussed with key stakeholders by EWR Co/DfT to determine the strategy going forward for this project.

Part A: **Introduction**

A.01 **Introduction**

This report covers the development activity carried out by Network Rail on behalf of the Department for Transport (DfT) and the East West Railway Company (EWR Co) during the period of 1st October 2017 to 30th September 2018, referred to as Phase 2e. It continues analysis commenced in Phases 2c and 2d which focused on route options within the preferred geographic corridor (identified in Phases 2a and 2b) between Bedford, Sandy and Cambridge, referred to as East West Rail Central Section (EWRCS). Phase 1 was commissioned by EWR Consortium and sought to establish that there was a case to progress further development of this project.

The East West Rail (EWR) project is intended to provide a strategic rail corridor connecting East Anglia with central, southern and western England. It is a project that has strong support from the Department for Transport (DfT) and has long been championed by the EWR Consortium, a group of local authorities and business representatives with an interest in improving access to and from East Anglia and the Milton Keynes South Midlands growth area. In December 2016, the Secretary of State announced his intention to set up a separate company to lead the development, delivery and operation of EWR. This company, which is currently in shadow mode, is the EWR Co. The DfT and EWR Co are currently acting as joint Client for this project until EWR Co is formally established, with Network Rail providing a service for the development of route options for EWRCS.

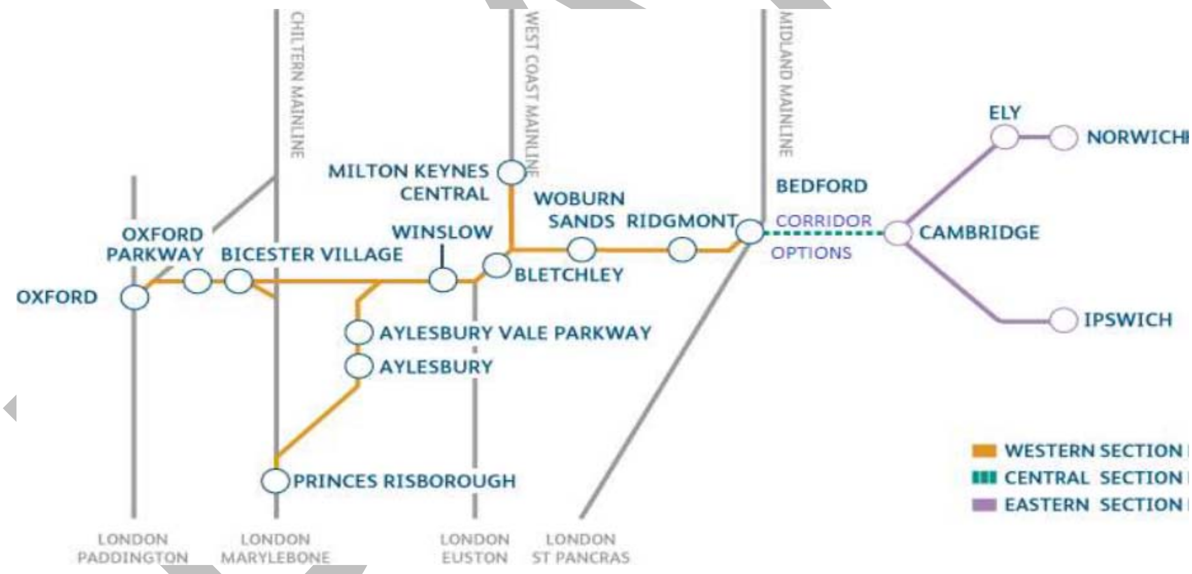
EWR encompasses a corridor shown in Figure A1 between Oxford and Norwich/Ipswich, with connections to Aylesbury, Milton Keynes, Bedford, and Cambridge. This is divided into three sections, which are in different states of development:

- The Western Section (EWRWS) between Oxford and Bedford and Aylesbury. Upgrading this route is a committed scheme and train operations have begun from Oxford Parkway to London Marylebone via Bicester Village, to be followed later with connections to Bedford.

- The Central Section (EWRCS) between the Western section and Cambridge, where there is now little, or no, existing rail infrastructure following the closure of the former Varsity Line in 1967.
- The Eastern Section (EWRES) between Cambridge and Norwich and Ipswich, where an operational railway already exists.

EWRWS is being progressed by EWR Co with development, design and delivery activities being undertaken via an Alliance between Network Rail and a number of suppliers. EWRCS is being progressed by EWR Co, with development activities being led by Network Rail System Operator, with project management support from IP Scotland & North East. EWRES is currently being considered as part of the Cambridge Corridor Study being progressed by Network Rail's System Operator Strategic Planning Team in the Anglia Route, and falls outside the current remit for EWR Co.

Figure A1: East West Rail Western, Central and Eastern Sections



N.B. Figure A1 implies no preference for a route option for EWRCS.

A.02 National Infrastructure Commission

During this phase, the National Infrastructure Commission (NIC) published its final report in November 2017, 'Partnering for Prosperity: a new deal for the Cambridge-Milton Keynes-Oxford Arc'. This made a number of recommendations, supporting the need for EWRCS but with an emerging emphasis on it being a more interurban, commuter railway, providing connectivity between where people will live and where they will work. This required consideration to be given to the strategic objectives and conditional outputs for EWRCS, and EWR Co commissioned Network Rail to undertake a review of available evidence. This considered whether there is sufficient emphasis being given to the level of service provided for shorter journeys pairs compared to the more high profile, Oxford - Cambridge, long-distance, high-speed output, as well as the level of service frequency required to support the economic, housing and employment growth forecast in the Oxford – Cambridge corridor.

As a result of this analysis, a proposal to amend both the strategic objectives and conditional outputs for EWRCS was shared with key industry stakeholders by EWR Co. These changes seek to improve alignment between EWRCS and EWRWS; and have been approved by the EWR Consortium. They are currently awaiting formal approval from DfT and have not yet been formally instructed to Network Rail. However, some of the development work in this phase has sought to respond to emerging views on the location of potential new settlements and the revised focus on an inter-urban, commuter railway, rather than long distance/high speed, in the anticipation that the DfT's approval will follow shortly. See Section A. 03 below for more details.

It will be necessary once these revised strategic objectives and conditional outputs are fully approved, to undertake an impact assessment on previous development activity to provide assurance that decisions have been taken which are consistent with these revised requirements.

A.03 Strategic Objectives and Conditional Outputs

In March 2016, in order to define and document the purpose for EWRCS, a set of strategic objectives, for EWRCS, were endorsed by the Rail Industry Steering Group (RISG)[1] as being:

- improve east west public transport connectivity
- increase economic growth, prosperity and employment within the South-East of England through improvements to east west rail links
- provide faster, more reliable and additional rail links from the west to Cambridge, Norwich and Ipswich
- improve journey times and reliability of inter-regional and commuter journeys
- increase capacity for inter-regional and commuter journeys
- maintain and enhance capacity for rail freight; and
- contribute to tackling climate change.

These were taken from the Phase 1 Conditional Output Study, commissioned from Atkins by the EWR Consortium, and were consistent with the strategic objectives of Network Rail's Long Term Planning Process (LTPP) shown in Table A1 below:

Table A1: Network Rail's Long Term Planning Process Strategic Objectives

Enabling Economic Growth	- By providing sufficient capacity for people to take part in economically productive activities - By improving business to business connectivity - By improving connectivity to/from the retail, tourism and

[1] Rail Industry Steering Group consists of a small number of rail industry representatives from DfT, EWR Consortium, Train Operators and Network Rail to review output and endorse recommendations at key milestones in the development of EWRCS.

	leisure sectors of the economy
Reducing Carbon and the Transport Sector's Impact on the Environment	- By directly reducing the environmental impact of rail - By reducing the use of less carbon efficient modes of transport
Improving the Quality of Life for Communities and Individuals	- By connecting communities - By providing access to social infrastructure such as educational establishments and major - leisure venues - By reducing road congestion
Improving Affordability and VfM	- By meeting other outputs in a VfM and affordable way - By directly reducing whole industry subsidy

Using evidence within the Phase 1 Conditional Output Study undertaken by the EWR Consortium, and the relevant LTPP Market Studies, the conditional outputs, that were endorsed for EWRCS, are shown in Table A2 below.

Table A2: EWRCS Conditional Outputs

Longer distance connectivity for business to business connectivity	- Target of 60 mins or less between Cambridge and Oxford - 1-2 tph between Cambridge and Oxford - Passenger connectivity for longer distance services onto the MML, ECML, WCML and West / South West of Oxford
Shorter distance connectivity to support commuting travel into Cambridge and Oxford	- 1-2 tph between Cambridge and Bedford, Oxford and Bedford - Target of 24 mins or less between Cambridge and Bedford - Average end to end journey speed of 80mph Oxford to Cambridge
Freight capacity	- Provision for one freight tph - Passive provision for potential intermodal terminals on the EWRCS route

These were based on the “<50 miles, best possible future” characteristics identified in the relevant Market Study as part of the Network Rail LTPP.

It should be noted that achievement of all these conditional outputs was not solely within the control of EWRCS. Whilst an additional study has been commissioned by EWR Co into capacity and journey time issues between Bletchley and Bedford, technically, this section currently falls outside the boundaries for EWRCS.

Following the publication of the NIC report in November 2017, consideration had to be given as to whether the strategic objectives and conditional outputs for EWRCS are still appropriate, given the emerging emphasis on a more interurban, commuter railway, providing connectivity between where people will live and where they will work. As a result of this, EWR Co commissioned Network Rail to undertake a review of the NIC report (Appendix A1), and its recommendations, to assess whether the existing strategic objectives and conditional outputs remained appropriate for the development of EWRCS in this, and future, phases. In particular, the Network Rail review focused on whether there is sufficient emphasis being given to the level of service provided for shorter journeys compared to the more high-profile Oxford - Cambridge journey time output.

The output from this review is included in Appendices A2, A3 and A4. However, in summary, the review sought to summarise the evidence base to date that led to the existing strategic objectives and conditional outputs for EWRCS being established. Given the changing nature of the language around EWRCS, and the high level of judgement required in setting conditional outputs, the report highlighted some of the potential evidence that could inform a reassessment of the existing conditional outputs, including:

- an emerging focus on EWR as a 'commuter railway' implies catering for short distance pairs – this might correspond to Generalised Journey Time (GJT) below around 80 minutes
- a significant proportion of the estimated economic benefits of the scheme come from shorter distance pairs which could lead to questioning the focus on Oxford-Cambridge journey time in the conditional outputs.
- for flows under 50 miles, the EWRCS journey time conditional outputs significantly exceed the Market Study aspirations for such flows
- the current service frequency conditional outputs align only with 'good current provision' for new services, with 'best current' defined as 3-4tph
- the conditional outputs around accommodating future demand are weak in comparison to those for EWRWS

It was recommended, therefore, that the output from this analysis should be consulted with key industry stakeholders to ascertain whether there was support to amend the strategic objectives and conditional outputs for EWRCS at this stage of development. EWR Co has taken the lead in the consultation and the proposed amendments to the strategic objectives and conditional outputs, as outlined below, which were shared with key industry stakeholders at both the Rail Industry Combined Working Group on 12th March 2018 and at the EWR Consortium Strategic Board on 14th June 2018, with the revisions being accepted in principle at both meetings.

<u>Proposed amendments to Strategic Objectives for EWRCS and EWRWS</u>

- Improve east west public transport connectivity by providing rail links between key conurbations (current and anticipated) in the Oxford – Milton Keynes – Cambridge corridor;

- Stimulate economic growth, housing and employment through the provision of new, reliable and attractive interurban passenger train services in the Oxford – Milton Keynes – Cambridge corridor;
- Meet initial forecast passenger demand;
- Consider and plan for future passenger demand, making provision, where affordable;
- Contribute to improved inter-regional passenger connectivity and journey times;
- Maintain current capacity for rail freight and make appropriate provision for anticipated future growth;
- Provide a sustainable transport solution to support economic growth in the area.

<u>Proposed amendments to Conditional Outputs for EWRCS</u>

- Shorter distance connectivity to support commuting travel into key employment hubs
    - Capability for up to 6 trains per hour (tph) between Cambridge, Bedford and 4 tph between Bedford and Milton Keynes/Bletchley
    - Target of 30 minutes or less between Cambridge and Bedford
- Longer distance connectivity for business to business connectivity
    - At least 2 tph between Cambridge and Oxford
    - Target of 80 minutes or less between Cambridge and Oxford
- Passenger interchange facilities at all node points to facilitate longer distance journeys.
- Average end to end journey speed of 60mph Oxford to Cambridge
- Freight capability to support anticipated growth, where affordable

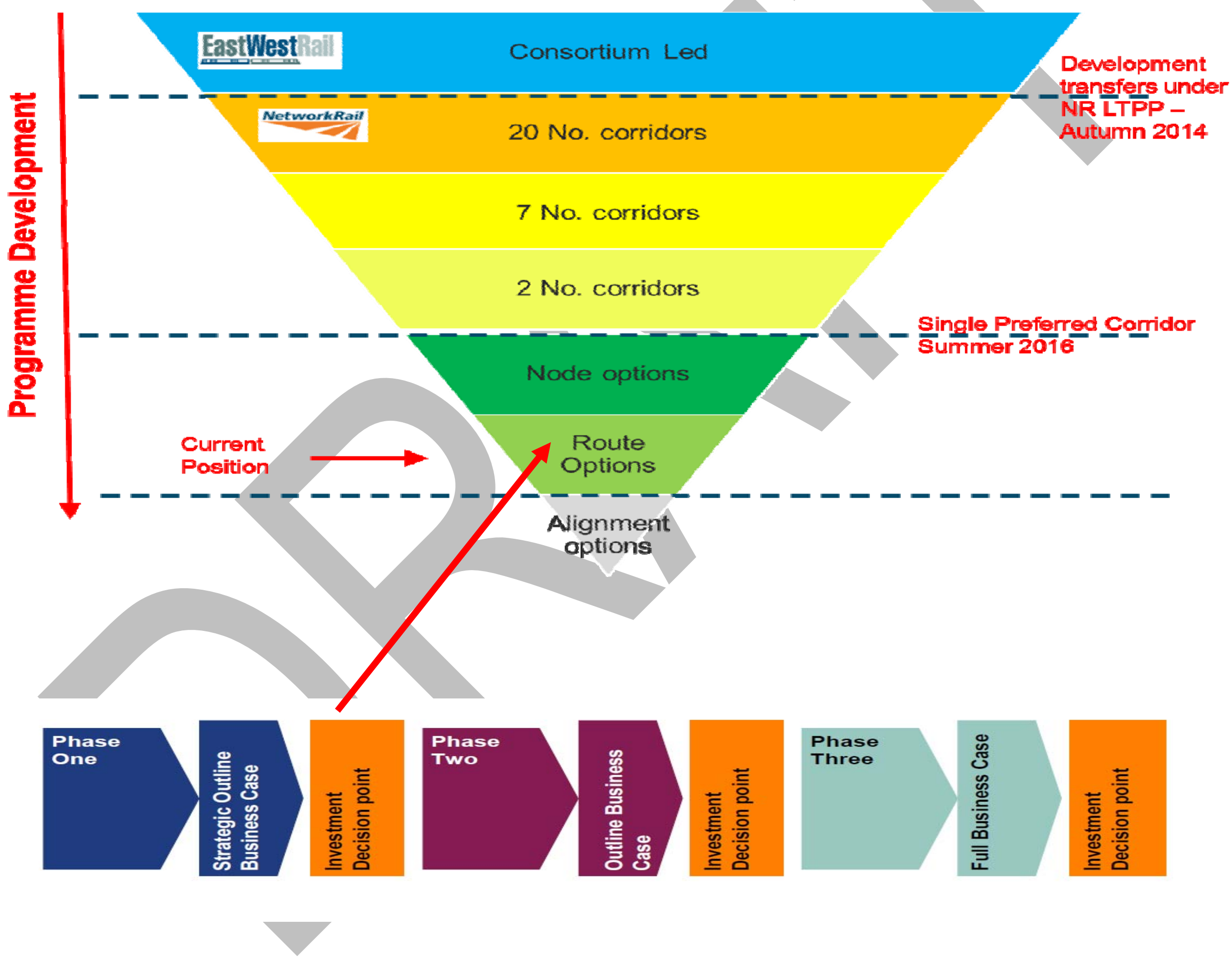
However, it will be necessary to undertake an impact assessment on the development activity carried out to date and whether previous decisions on corridor and route options remain valid. This has been planned to be undertaken in the next phase of development.

These changes have also led to the proposed changes to the evaluation criteria for EWRCS which are covered in Part E of this report.

A.04 Project Phase/History

Development work for EWRCS has adopted a filtering strategy, focusing resources on the options which represent best value for money, and agreeing the pausing of some options with key industry stakeholders based on the evidence provided. Figure A2 below outlines that strategy and where the development work is currently up to and how this relates to the production of a Strategic Outline Business Case.

Figure A2: Development Strategy for EWRCS



EWR Co will take the lead on the production of the SOBC, with the output produced by Network Rail in this phase forming part of the evidence to be used by EWR Co in finalising the SOBC.

This phase is a continuation of early development activity, aiming to identify the single preferred route within the preferred corridor for EWRCS, with a supporting SOBC. Work on route options was carried out in Phases 2c and 2d (see Appendix A5) and this report should be read in conjunction with that analysis and output.

The strategy for both corridor and route analysis has been to progressively filter options to focus time and resources on the options which represent best value for money.

As explained above, the publication of the NIC's report in November 2017 has resulted in a review being undertaken of the strategic objectives and conditional outputs for EWRCS, and some of the development work in this phase has sought to respond to emerging views on the location of potential new settlements and a revised focus on an inter-urban, commuter railway rather than long distance/high speed.

EWR Co anticipate being in a position to confirm a preferred single route in Spring 2019, subject to SOBC and a decision to develop being agreed with DfT.

A.05 **Requirements Documents/Remits**

The output from this phase continues to respond in part, or in full, to 2 key requirements documents which determine what EWRCS is seeking to achieve. These are:

1. Client Requirement Document (CRD), version 1.0, dated August 2015. This is included in Appendix A6. This is a Network Rail GRIP product, produced by the LNE&EM Strategic Planning team within the System Operator function.

N.B. It is the intention to update this when the revised strategic objectives and conditional outputs have been fully consulted, agreed and instructed by EWR Co.

The key outputs specified in this CRD are:

- A Safety and Sustainability Strategy
- A Benefits Realisation Strategy
- A Consultation Strategy
- Route Selection Report (this report provides this output)

- Service Options Report
- Value for Money Assessment (also included in this report)
- Constraint and Risk Register
- A Governance Framework
- A Funding Strategy (N.B. this will now be the accountability of EWR Co)
- Outline Development Programme

2. Phase 2e Grant Funding Agreement (GFA). This is included in Appendix A7, which identifies the scope of work to cover all development activity relating to EWRCS in this phase. The main elements of work in this stage of development were (not necessarily sequential):

For all route options identified in the previous phase, assess the scope, cost and value through engineering analysis, journey time analysis, estimating and economic appraisal of:

- The scope and cost of linespeed up to 125mph and opportunities to align route options with economic benefits associated with new housing/jobs
- Capacity and capability for freight services
- A possible new intermediate station between Sandy and Cambridge
- Indicative train service specification options, with rolling stock assumptions

In addition, activities included:

- overlay all identified route options, where possible, with Highways England proposals to enhance the road network in the Oxford - Cambridge corridor and the A1 corridor, to give visibility of interface/alignment between road and rail proposals
- align all development work on route options with the Cambridge Corridor Study being progressed by Network Rail's System Operator Strategic Planning Team (Anglia Route) and any development work that may be progressed on the Marston Vale Line between Bletchley and Bedford either by the EWRWS Alliance or other parties
- continue consultation with key industry stakeholders, with rail industry Working Group meetings to be arranged as appropriate, providing opportunity to input, comment and challenge the output, or provide additional supporting information, prior to finalisation
- where possible, gain key stakeholder acceptance of preferred route option(s)

- support the DfT and EWR Co in the development of a revised governance structure to support effective and timely decision making on preferred route option(s)
- based on emerging economic appraisal output, including that undertaken by Leigh Fisher on behalf of the DfT, make recommendations to filter route options, through identifying those that offer best value for money in accordance with WebTAG analysis guidance as agreed with the DfT/EWR Co to include land value capture, and to support the development of a strategic outline business case for a single preferred route
- commence drafting of a Statement of Community Consultation (SoCC)
- produce an initial Route Requirements Document (RRD) to determine what is required of EWRCS to translate the operational and performance outcomes into engineering and system output statements and what functional outputs are required of the infrastructure and the wider railway system
- utilise the output from the HazID (hazard identification) exercise undertaken in the last phase to develop a hazard record
- provide any necessary progress reports to the DfT/EWR Co and attend meetings as requested
- produce a report collating and summarising all development activity in this phase to support the consents process
- arrange and/or attend any relevant meetings with stakeholders/ statutory consultees
- review and update all existing and new risks and opportunities identified during this phase of development
- undertake all necessary activities to support the transition to the next phase of development.

During this phase, EWR Co requested Network Rail to consider two new route options (SN4 and SN5) which were identified as a result of emerging views on the location of potential new settlements. The potential locations for possible new developments is having an increasing impact on the development work being carried out, and reflects the importance of this new railway to support economic growth in the Oxford – Cambridge corridor as outlined by the NIC.

A.06 Content and Format

This report summarises the scope and methodology used for the on-going development of route options undertaken in this phase, collates a volume of technical notes and drawings carried out during this study period, includes the economic analysis undertaken on transport benefits and summarises the key findings, output and recommendations from this phase to be considered for the next phase of development activity. Table A3 below shows which elements were considered for which route options within this report.

Table A3: Estimate matrix

Estimate Matrix

		Sensitivities						VE			
Route	VE Summary	Freight	Linespeed	Cambourne	Bassingbourne	E of Bedford	Wixams	Sandy	Flood	BM	Shepreth
A1	✓	✓	✓		✓	✓	✓	●	●		●
A3	✓			✓					●		●
C1	✓								●	●	●
C3	✓	✓	✓	✓					●	●	●
E1	✓				✓				●		●
E3	✓	✓	✓		✓	✓	✓		●		●
SN4	✓								✓	✓	✓
SN5	✓								✓	✓	✓

✓	Estimate and Economic Assessment required
●	Estimate update to reflect

23 Reports

A.07 Change Control

There were a number of change controls applied during this phase as a result of additional requests from EWR Co to include in the development work agreed in the GFA. These were:

- review the evidence and recommendations within the NIC's report published in November 2017 and consider the implications for the current conditional outputs for EWRCS and EWRWS, and provide advice on any changes required (as covered in Section A.02 above)
- undertake a study to assess options for the provision of services to provide direct connectivity to Bedford Midland from a south easterly direction to and from Cambridge
- facilitate passive provision for 10 car platform lengths
- to consider two new route options (SN4 and SN5) which were identified as a result of emerging views on the location of potential new settlements

The relevant variations to the GFA are included in Appendices A8 and A9. These changes were accommodated within the development work in this phase and output is included in this report. (see Appendix A10 for the Project Change Log)

A.08 Indicative Train Service Specification

During Phase 2e, there was a need to further develop the ITSS from previous phases, particularly to take account of emerging changes to EWRWS and work that had started on the Cambridge Corridor Study. An internal Network Rail workshop was convened to develop an 'end to end' service specification that could be used as the basis for any development work being carried out whether on EWRWS, EWRCS or EWRES/Cambridge Corridor Study. Representation included the System Operator Strategic Planning Teams from the relevant Routes which EWR directly affects, namely LNW, LNE&EM, Anglia and Western, as well as from the Freight and National Passenger Operator Team. Where representatives were unable to attend, input was sought in advance of the workshop and the outputs subsequently shared. The EWRWS project team was also represented.

The output from this workshop was a report (see Appendix A11), which was shared with EWR Co and DfT. This provided a number of options for service specifications that could be used in this phase of development to test scope, cost and value. The starting point for the identification of options for EWRCS was the (at that time) approved version of EWRWS's output specification which was used to identify services that could be extended on to Cambridge, as well as new services that could be introduced on EWRCS, and how services may be extended beyond Cambridge to Ipswich and Norwich to accommodate forecast growth.

EWRWS has recently undertaken an end to end analysis of a Concept Train Plan which has highlighted some concerns regarding the current scope of the project. Alternative options are currently being evaluated. Further increments to train services, including the wider EWR programme train service specification options (e.g. interface with EWRCS ITSS), may drive further changes. Options would include integration with other enhancement programmes such as Oxford Remodelling Phase 2, West Coast Main Line released capacity, and rolling stock, franchise strategy and associated specifications.

The impact of this is being considered and will be included in analysis for future phases of development for EWRCS following discussion with EWR Co.

EWR Co have also indicated during this phase that they have an aspiration to test up to 6 tph between Bedford and Cambridge, however, to maintain consistency of analysis between route options and to maintain programme in this phase, this has not been included in this phase of development and needs to be considered further in future phases.

There is also a need to recognise the mutual dependency between EWRCS and EWRWS in delivering an end to end service specification and conditional outputs, and whether increasing train services has an impact on infrastructure outside the scope of EWRCS.

A.09 Interfaces

The key infrastructure enhancement interfaces for EWRCS at this stage of development have currently been identified as follows (see Appendices A12 to A15):

- EWRWS - the interface being between Bletchley and Bedford on the Marston Vale Line, and the continuation of services from Oxford to Cambridge
- Oxford Corridor Capacity Improvements Phase 2 – in development within the Rail Network Enhancements Pipeline, potentially could deliver capacity for the full EWR train service specification in the Oxford area
- West Coast Main Line released capacity analysis – associated with the commencement of HS2 services from 2026/7
- EWRES – scope still to be determined but the interface being at Cambridge Station, and whether EWR services will extend beyond Cambridge
- The ECML Route Study – the interface being passenger connectivity with north-south services on the East Coast Main Line (ECML)
- Wixams new station – the interface being whether this new station will be built and how this may impact on the location of a new Bedford South Station
- Sharnbrook – the interface being a proposal for a new station to the north of Bedford Midland, to align with proposed housing development, and provide a potential alternative turnback facility for Govia Thameslink Railway (GTR) services to release capacity in Bedford Midland
- The Cambridge Corridor Study – the interface being the need for this study to take account of EWRCS proposals and consider the options for services being extended beyond Cambridge Station to Norwich and Ipswich. Also, the EWR Consortium commissioned a Conditional Output report for EWRES which has now been published (see Appendix A14)

- Development work for a new station to the south of Cambridge (nominally referred to as Cambridge South) – the interface being the development of a holistic infrastructure solution, that includes Shepreth Junction, that caters for the outputs of that project, the Cambridge Corridor Study and EWRCS
- MVL study – this is an additional study, which has been commissioned from Network Rail by EWR Co, to consider capacity and journey time improvements between Bletchley and Bedford which may be necessary to support the maximisation of services between Oxford and Cambridge, as highlighted through the ITSS workshop held by Network Rail (Section A.08)
- Oxford to Cambridge Expressway, including A428 Black Cat to Caxton Gibbet Improvement Scheme – the interface being the need to consult with similar stakeholders within the same geographic area, the business case for both schemes, and the consents process
- A1 East of England strategic study – the interface being whether improvements to the section between London and Peterborough, particularly within the EWRCS corridor area, will be progressed and the impact this could have on route options
- Network Rail's Digital Signalling Programme – the interface being the assumption that EWRCS will be digitally signalled

Regular discussions have taken place with relevant Network Rail teams regarding the interfaces in the Bedford area and at Cambridge. This is to communicate the scope of work being carried out, the outputs seeking to be achieved and to align the development work for EWRCS with the development work being carried out to the west and east of EWRCS. This is intended to provide greater assurance of the consistency and alignment of all development work, as well as avoid duplication of effort and resources that could result from any overlaps in scope and geographic area. Track and platform capacity at Bedford Midland is a known constraint that requires further analysis to refine/value engineer solutions in a future phase to identify the optimum solution to integrate EWR services with existing services.

Other interfaces going forward will exist in relation to franchise arrangements, rolling stock procurement and entry into service, and depot requirements, whether for rolling stock or maintenance activities. These are currently excluded from the scope of any development activity being undertaken by Network Rail.

A.10 Route Options

The development work in this phase has continued to look at route options identified in Phases 2c and 2d, as well as new route options (SN4 and SN5) identified in this phase to take account of emerging views on the location of possible new settlements. Following further discussions with EWR Co, a high-level assessment of a potential route serving Bedford South, St Neots/ Tempsford and Cambourne was also carried out to provide indicative costs and journey times to inform discussions with stakeholders (Appendix B11).

Figure A3 and Table A4 below clarify the differences between those route options and should be used as a reference for this report.

Figure A3: Schematic of route options

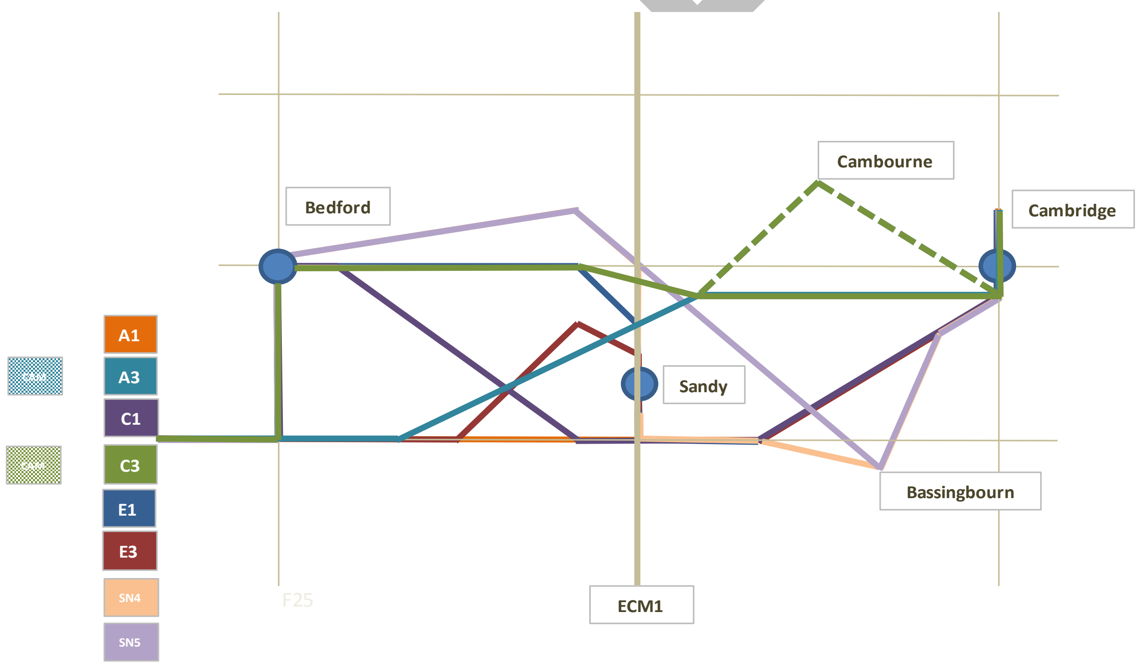


Table A4: Nodes for route options

Reference	Bedford Node	Sandy Node	Cambridge Node
A1	New Bedford South Station	New Sandy South Station	Shepreth Branch Junction (south of Wimpole Estate)
A3	New Bedford South Station	New Sandy North Station	Shepreth Branch Junction (north of Wimpole Estate))
E1	Existing Bedford Midland Station	Existing Sandy Station	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
E3	New Bedford South Station	Existing Sandy Station	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
C1	Existing Bedford Midland Station	New Sandy South Station	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
C3	Existing Bedford Midland Station	New St Neots South Station	Shepreth Branch Junction (north of Wimpole Estate)
SN4	Existing Bedford Midland Station	New St Neots South Station/ Existing Sandy Station	Shepreth Branch Junction (via ECML and Bassingbourn)
SN5	Existing Bedford Midland Station	New St Neots South Station	Shepreth Branch Junction (direct via Bassingbourn)

Part B: **Engineering**

This section provides an update on the engineering development activity covered during this phase.

B.01 **Scope**

The Phase 2e study has considered a number of output sensitivity issues around the assumed design parameters, as well as testing the scope, cost and value of a number of aspects of the route options already identified on Phase 2d. These included:

- Linespeed up to 125mph
- Opportunities to align route options with economic benefits associated with new housing/jobs
- Capacity and capability for freight services
- A possible new intermediate station between Sandy and Cambridge
- ITSS options, with rolling stock assumptions

It was also proposed that the output sensitivities were to be tested on 3 different route options which were identified as being representative of all route options still being considered:

- A1
- C3
- E3

The output from this analysis is summarised in this section in relation to the engineering activities.

B.02 **Source Data**

The development work in this phase was based on a collation of topographical, environmental and other geographical information collected during Phases 2c and 2d. These are presented in Appendix 6 of the Phase 2c and 2d report (Appendix A5) and include:

- Ordnance Survey mapping (OS MasterMap and VectorMap).
- Ordnance Survey topographical data (Terrain 5).
- Environment Agency LiDAR Composite Digital Terrain Models (https://data.gov.uk.publisher/environment-agency).
- Magic Environmental Database (www.magic.gov.uk).
- Private developer development plans and local authority Local Plans.
- Highways England website for information on their future proposals.
- Stakeholder consultation meetings. See appendices in Section D for more details of these.
- Sustrans website (www.sustrans.org.uk) for details of existing cycle routes.

B.03 **Key Assumptions**

A number of key assumptions have been made in developing the route options during previous phases and these have been reviewed and updated in Phase 2e. These are included within Appendix B1 and summarised in Table B1.

Table B1: Key Assumptions for EWRCS

No.	Assumption
1	All new railway to be designed with an aspirational 125mph line speed except the junctions connecting to existing lines, which have been designed to match the existing line speeds. Sub 100mph is to be considered, as remitted, and lower line speeds where geometry and geography dictate
2	All new railway to have an equivalent gradient no steeper than 1:125. Where geographic constraints prevent this the achieved gradients are to be noted for further consideration. NB in this phase 1:80 was considered as a freight sensitivity
3	All new railway is expected to be designed to be compliant with the Technical Standards for Interoperability (TSI).

No.	Assumption
4	All highway works are expected to be designed to be compliant with the Design Manual for Roads and Bridges.
5	All new railway to be designed to provide passive provision for free running 25kV OLE.
6	All new stations to be designed to provide platform standage for 244m* with passive provision for 290m. (*Station provision has been based upon (EWR) Oxford Parkway Station in the absence of patronage figures)
7	Optimisation of alignments continue to be driven by engineering constraints with regard given to environmentally sensitive sites and the impact they could have on cost, programme and risk.
8	Infrastructure to be designed to provide capacity for 3 passenger trains per hour and 1 freight train per hour in each direction between Bedford and Cambridge between the hours of 4am and midnight. It is assumed that infrastructure west of Lidlington and east of Cambridge can accommodate this service frequency without imposing timetabling or journey time constraints on the Central Section. (N.B. During this phase, EWR Co requested that consideration be given to up to 6tph between Bedford and Cambridge, however, to assess all route options against these revised requirements would have resulted in an extension to programme, therefore, it was agreed with EWR Co that this would be tested in future phases).
9	Journey times to be calculated assuming all passenger services stop at Bedford, Sandy and Cambridge. It is noted that there is an aspiration for EWR services to call at the proposed Cambridge South station (Addenbrookes); however, this is not a fact that will determine route selection. It can be assumed that the Cambridge South stop will add 2 minutes to all journey times.
10	Journey times to be calculated assuming the passenger services are a 5-car hybrid Class 80X IEP operating in diesel mode.
11	Railway infrastructure to be designed to accommodate a 775m long multi-modal freight train operating within W12 gauge and RA10 loading, hauled by a single Class 66 locomotive.

No.	Assumption
12	700mm wide cess walkways/continuous position of safety to be provided on both sides of the new railway and 3m wide maintenance access road along one side, where practical. The schematic detail of cut and fill cross-sections is included.
13	Digital signalling Level 2 with ERTMS will be provided for EWRCS infrastructure
14	Additional rolling stock stabling and maintenance sidings for EWR are outside the current scope of EWRCS.
15	A flood plain sensitivity assessment tests the benefit of replacing viaducts with earthwork embankments and the output has been applied in all evaluations.
16	EWRCS shall not provide any infrastructure for the proposed new Cambridge South station but shall not preclude a third party providing this infrastructure.
17	Any new station(s) constructed between Biggleswade and St Neots on the ECML could involve the closure of the existing Sandy station, dependent on option selection.

No.	Assumption
18	Current assumptions regarding growth in Thameslink services and HS2, which inform the analysis undertaken by Network Rail's Capability & Capacity Analysis team, will be delivered.
19	No alterations will be made to the existing railway infrastructure along the route other than those known or defined in the Route Requirements Document[2]. The railway infrastructure alterations resulting from the interfacing projects documented in Section B.09 are excluded from this the scope of EWRCS.
20	Any new station at Bedford South would be in addition to the existing Bedford Midland and St Johns stations would be aligned to or constructed instead of a proposed new Wixams station.
21	Capacity exists on the MML slow lines north of Bedford Midland station to accommodate EWRCS services.
22	Capacity exists on the SBR lines to accommodate EWR services where EWRCS would connect up to the Shepreth Branch Junction.
23	The difference between the Earthworks material excavated from cuttings and the material deposited in embankments is to achieve a balance to within +/- 500,000m3.

[2] The Route Requirements Document is a GRIP product and an initial version has been produced for EWRCS in Phase 2e and is included as an Appendix to this report.

B.04 Key Dependencies

All route options being considered have a number of key dependencies. The approach from the west is proposed to be along the Bletchley to Bedford Midland (BBM) lines (N.B. analysis of this section of infrastructure is covered by a separate remit from EWR Co to Network Rail and the report is due to be completed by Mar 2019) and the connection to Cambridge is proposed to be in the Shepreth Branch Junction area.

B.05 Journey Times

All journey time estimates in this phase have been derived using the Network Rail tool – RouteRunner. This tool allows simple networks of track, gradients and stops to be modelled, and journey times to be estimated, based on a database of rolling stock and is considered suitable for early feasibility studies and has, therefore, been used to undertake the analysis in this phase. Journey times have been calculated using the characteristics of a 5 car Class 80X bi-mode, running in diesel mode. Journey times, however, are sensitive to the type of rolling stock to be assessed although this is not considered to be a significant factor in relation to route option selection.

B.06 Order of Magnitude Cost Estimates

Order of Magnitude Cost Estimates (OMCEs) have been provided as 4Q15 estimates (to provide consistency with estimates produced in previous phases) with a range provided to reflect a range of probability in line with a mid-GRIP 2 level of accuracy. At this stage of development, with multiple route options still being considered, route specific risk registers have not been produced, nor quantified or modelled. The full list of assumptions and exclusions upon which the estimates are based can be found in the Network Rail Cost Plan report which is included in Appendix B2.

B.07 Linespeed and Freight Capacity and Capability

This analysis sought to identify whether there were any significant cost savings from reducing linespeed from125mph to 90mph in line with emerging views that EWRCS should be an interurban, commuter railway rather than long distance, high speed railway. The same question was raised in relation to providing capacity and capability for freight services. Due to the overlap in data responding to these two issues, the output from the linespeed analysis has been combined with the output from the freight analysis and combined into a single report (Appendix B3).

For simplicity, the engineering summary below considers route option A1 to illustrate the outputs, however, for the three route options identified for testing, all combinations and considerations are included in the report Appendix B3. It should be noted that, at this stage of development, the earthworks assumptions have no site data to draw upon. A proposal for further geotechnical studies in the next phase has been discussed and agreed with EWR Co to progress the collection of data and this should prove informative to support future development activity and cost estimating.

Work activities consisted of replicating the Phase 2d route option alignments in Bentley Rail-track (a computer design package for track), including tie-ins to the existing rail network and confirming agreement to cut and fill volumes. N.B. In Phase 2d, AutoCAD Civils 3D report was generated to assess cut and fill volumes, but this has been upgraded to Bentley Rail-Track for Phase 2e to improve accuracy.

Linespeed Analysis

The application of a reduced cess width, due to a reduced linespeed, from 11.2m in Phase 2d, to 10.44m in this phase (chosen as it is the minimum permissible for the proposed speed of 125mph), has resulted in an overall reduction in earthwork volumes and footprint area. For a comparison of the Phase 2d A1 route figures, and the reassessed routes' earthwork figures undertaken in this phase, please refer to Appendix B3.

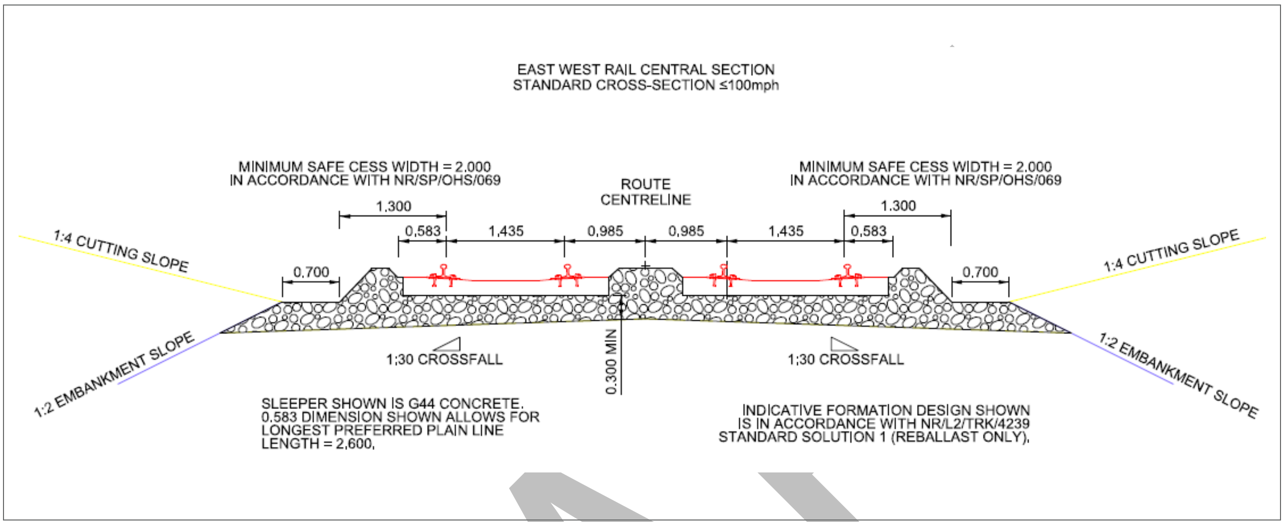
Cross-sections

The following should be noted in relation to the analysis in this section and is an extract from the Sensitivity Assessment Report for Linespeed and Freight Capacity and Capability which is included in the Appendix B3.

In order to undertake the analysis of the three routes options, namely A1, C3 and E3, standard cross-sections were created to model the different linespeeds, and these form the scope of the linespeed analysis undertaken in this study. Two different cross-sections were created in accordance with the requirements of NR/SP/OHS/069 Lineside Facilities for Personal Safety. Clause 2.0 of this standard provides the specification for cess walkways and positions of safety for linespeeds of ≤100mph and >100mph.

For linespeeds ≤100mph, the cross-section shown in Figure B1 below has been used to assess the scope of earthworks required for each of the route options.

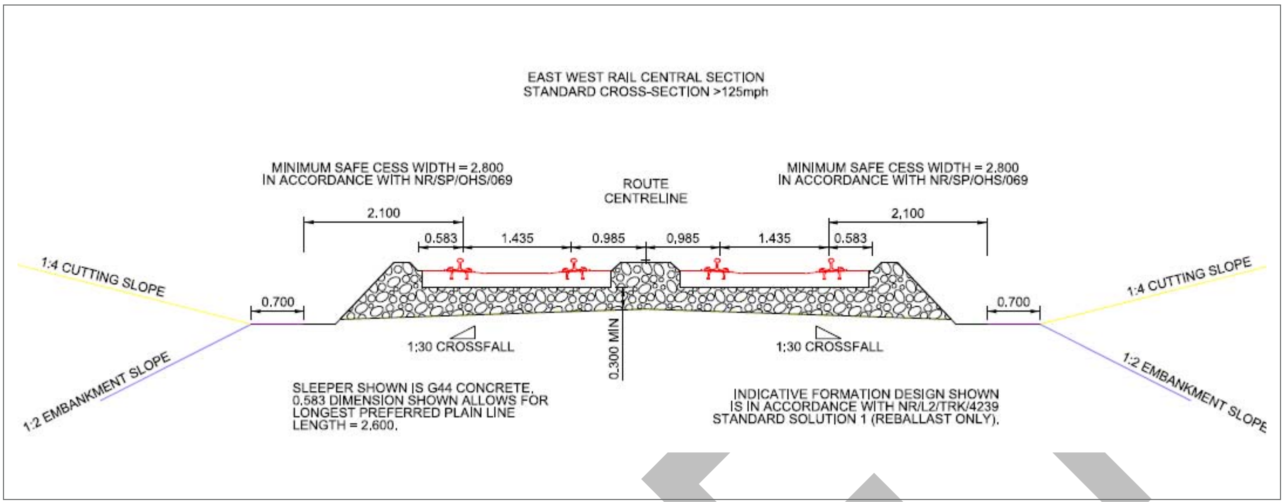
Figure B1: Proposed Cross-Section ≤100mph



This cross-section is based on a 2-track railway with a standard 1970mm six-foot interval, CEN56 rail and G44 concrete sleepers. Ballast shoulders are specified in accordance with NR/L2/TRK/2102 Design and Construction of Track, and the cross-falls are specified in accordance with NR/L2/TRK/4239 Track Bed Investigation, Design and Installation. The dimension from the proposed rail running edge to the edge of the cess walkway is 2000mm, which is the minimum dimension specified in NR/SP/OHS/069. The cutting and embankment slopes have been specified by the Network Rail Geotechnical Design Engineer.

For linespeeds >100mph, the cross-section in Figure B2 below has been used.

Figure B2: Proposed Cross-Section >100mph



The difference between this cross-section and that shown in Figure B1 is the distance from the proposed rail running edge to the far edge of the cess walkway. For linespeeds >100mph, this is 2800mm. Track layout and materials, ballast shoulders and crossfalls are specified to the same requirements as for linespeeds ≤100mph namely: a 2-track railway with a standard 1970mm six-foot interval, CEN56 rail and G44 concrete sleepers. Ballast shoulders in accordance with NR/L2/TRK/2102, Design and Construction of Track and the cross-falls are specified in accordance with NR/L2/TRK/4239 Track Bed Investigation, Design and Installation.

The standard cross-sectional widths above may not be the agreed sections that are used in future detailed design. Consideration will need to be given to the maintenance strategy agreed with the appropriate Route Asset Manager and/or new Infrastructure Manager for EWRCS. This might result in the clearance between tracks, referred to as the six-foot interval, being increased to, for example, 3.0m. Space will also be required to install and maintain formation drainage and cable routes, including passive provision for OLE. Location cabinets, signal equipment, and other lineside equipment, will also require additional safe working areas, as well as access. This might translate into additional widths being required, however, they may be localised and may not be for the full length of the route.

One of the high-level assumptions that has been used, that might influence the outcome of the analysis, is the earthworks balance principle which proposes that the material excavated should be used within the works. In places, this has produced alignments that use the material generated in cuttings but increases the embankments' height as a result.

Alternative alignments could be developed that would be closer to the existing ground if material can be disposed of off-site in an economical manner. A total cost for import /export values should be derived as a benchmark for the worst-case scenario and should be addressed in future phases of development.

N.B. The earthworks balance principle is one of several options to minimise environmental impact and maximise the use of material on site. However, other options are viable, and, in the next phase of development, soil classification optimum usage will be considered further.

Track classification

The track classification is Category 1 for less than 95mph, and Category 1A for above 95mph, in accordance with standard NR/L2/TRK/2102. This determines the track bed construction depth, as outlined below, and the variance is only localised in the S&C areas which would have a limited influence on the material volumes.

Calculation of the Equivalent Million Gross Tonnes per Annum (EMGTPA) has been undertaken in this phase and is estimated to be 39.9 EMGTPA.

Category 1 and 1A lines both require the plain line specification of CEN60 CWR, with concrete sleepers at 650mm spacing, and with a minimum ballast depth of 300mm. Category 1 and 1A lines also require the same S&C specification of NR60 layouts on concrete bearers, with a minimum 300mm ballast depth.

The safe walking route reductions, in relation to width requirements, are as identified below, but are subject to confirmation of the maintenance strategy and policy which is yet to be confirmed for EWRCS. For the purposes of this phase of assessment, analysis has been undertaken on the assumption that Network Rail is the Infrastructure Manager and, therefore, Network Rail's current maintenance strategy and policy have been taken into consideration.

NR/SP/OHS/069 Lineside Facilities for Personnel Safety requires different widths of safe cess (including an allowance for a 700mm wide safe cess walkway) for both 90mph and 125mph line speeds. A combined width of 2000mm (clearance and walkway) is specified for line speeds of ≤100mph and 2800mm for line speeds of >100mph. Higher cants would require the safe cess width to be increased, which would result in additional width being needed for a 125mph linespeed. Appendix B3 - the Sensitivity Assessment Report for Linespeed and Freight Capacity and Capability, included in the appendices, provides an explanation of the track section geometry applied in the Phase 2d and Phase 2e calculations. These sections have been used as the basis for producing corridor footprint areas and earthwork volumes.

Linespeed - Key Findings

The quality of the material, and its classification, will depend on site and ground investigation to be carried out at a later phase in the design programme. The variance between the routes, however, does suggest that, unless the A1 route strata is found to be significantly poor, it has the least volume of earthworks of the three options.

As described above, the infrastructure footprint width (i.e. excluding any earthwork slopes) could be reduced from 10.44m, as used in the phase 2d report analysis, to 8.84m, which is the minimum permissible for linespeeds equal to, or below, 100mph. A comparison of the assessed earthwork impact is presented in Table B2 below. Alternative embankment construction techniques and materials may offer better value for money and a reduced footprint. This can be considered in a later design stage.

The change in earthwork volume, and overall footprint, is attributable to the following changes between Phases 2d and 2e: -

- Infrastructure corridor width reduction (11.20m to 10.44m, edge to edge of safe cess)
- Reduction of assembly volume assumed
- Reduction in route length
- Exclusion of track bed formation and ballast area in cutting volume
- Inclusion of ballast volume in fill (embankment) volume
- Minor geometrical changes to original alignment

Table B2 below shows that for route option A1, a reduction in linespeed will reduce the material from cuttings, but will increase the fill volumes, and material will need to be imported to address the shortfall. There is a risk that volumes of imported material will increase due to this route being on low lying ground, requiring remediation prior to embankment construction. This will need evaluation when site investigation data is available. Land acquisition decreases due to the reduction in footprint width.

Table B2: Route A1 Linespeed Earthworks Comparison

	Phase 2e 125mph (1:125)	Phase 2e 90mph
Route length (km) (ELR:BBM divergence to ELR:SBR connection)	40.70	40.70
Cut (m^3)	1,012,552	908,548
Fill (m^3)	1,724,885	1,788,422
Surplus (+) / deficit (-) (m^3)	-712,333	-879,874
Footprint (m^2)	944,175	910,475

The results below In Table B3 show that for route option C3, a reduction in linespeed could deliver significant reductions in cutting volumes, however, this increases the shortfall in material required for the embankment construction, which consequently would need to be imported to site. Land acquisition decreases due to the reduction in footprint width.

Table B3: Route C3 Linespeed Earthwork Comparison

	Phase 2e 125mph (1:125)	Phase 2e 90mph (1:125)
Route length (km) (ELR:SPC2 divergence to ELR:SBR connection)	45.4	45.4
Cut (m^3)	6,378,589	5,919,757
Fill (m^3)	7,013,136	7,035,101
Surplus (+) / deficit (-) (m^3)	-634,546	-1,115,344
Footprint (m^2)	2,106,747	2,051,217

The results below in Table B4 for route option E3, show that the reduction in excavation is comparable to the volume increase for embankment construction and, therefore, there is a shortfall in material generated on site and that would need to be imported. Land acquisition is increased marginally due to footprint width.

Table B4: Route E3 Linespeed Earthworks Comparison

	Phase 2e 125mph	Phase 2e 90mph
Route length (km) (ELR:BBM divergence to ELR:SBR connection)	47.9	47.9
Cut (m^3)	1,533,183	1,362,050
Fill (m^3)	1,918,762	1,985,723
Surplus (+) / deficit (-) (m^3)	-385,580	-623,673
Footprint (m^2)	1,194,771	1,205,286

As a result of this analysis, the change in earthwork volumes, and infrastructure footprint, can be attributed to the following: -

- Infrastructure footprint reduction (10.44 to 8.84m, edge to edge of safe cess)
- Variation in assembly geometry applied; level of cess walkway has been lowered.

Further commentary is in the report contained within Appendix B3 - Sensitivity Assessment Report for Linespeed and Freight Capacity and Capability.

It should also be noted that a reduction in linespeed could increase the flexibility of possible alignments to navigate areas of sensitivity. This will need to be explored further when a preferred route is identified, and assessment of the optimum alignment is progressed.

Linespeed Earthworks Conclusion

In summary, therefore, both the infrastructure footprint width, and linespeed reduction, offer opportunities to reduce earthwork quantities but these cannot be accurately assessed until there is data obtained from the site. Factors, such as cess to cess width, will be influential but the existing ground condition and material classifications, combined with cut and fill slope angles, will be of greater influence. In addition, the track category has offered some potential for alignment flexibility, however, this is not considered to be significant. One of the reasons the difference is likely to be marginal is, in part, due to the earthworks balance assumption to minimise landfill and import requirements. However, at this stage of development (Phase 2e), based on the data available, a reduction in linespeed would potentially permit a reduced infrastructure footprint width which reduces land take and material quantities.

Signalling

The impact of a reduced linespeed, and increased maximum gradient, on signal spacing for conventional signalling, and the impact on Digital Signalling (ETCS), was also considered in this phase. The current assumption for EWRCS is that it will be ETCS Level 2 as it is a new strategic rail link, therefore, conventional signalling would not be appropriate given the strategy to introduce ETCS across the existing network. However, at this stage of development, the full scope of the infrastructure requirements for ETCS are not yet known, therefore, an initial assessment of what would be required for conventional signalling was carried out to inform the scope in this phase.

In terms of conventional signalling, therefore, the use of both 3- and 4-aspect signalling was considered and quantified, with 3-aspect being deemed sufficient for the current ITSS. This is based on a three-minute headway but still allowing some capacity for future increases in services on the new infrastructure; however, the impact of additional services on the existing infrastructure and conventional signalling would need to be assessed to confirm this. The use of 4-aspect signalling is generally more suitable for higher capacity routes such as high speed main lines e.g. ECML. Signalling Equivalent Units (SEU) are specified based on route length and linespeed.

A comparison of signalling requirements for the Phase 2d, Phase 2e, linespeed and freight capability alignments is presented in Tables B5, B6 and B7 below. Appendix B3 - Sensitivity Assessment Report for Linespeed and Freight Capacity and Capability provides details of the signalling calculations undertaken for route options A1, C3 and E3. For the purposes of this report, the Up Line is in the direction of Lidlington and the Down Line is in the direction of Cambridge.

Table B5: Signalling Requirements for Route Option A1

Signalling Elements	Phase 2d 125mph		Phase 2e 125mph		Phase 2e Linespeed – 90mph		Phase 2e Freight Capability	
	No.	SEUs	No.	SEUs	No.	SEUs	No.	SEUs
3 aspect signals Up Line	-	16	-	16	-	21	-	16
3 aspect signals Down Line	-	16	-	16	-	21	-	16
Emergency crossovers	3	12	3	12	3	12	3	12
Double Junction	2	12	2	12	2	12	2	12
Staff protection systems (LOWS, TOWS)	-	2	-	2	-	2	-	2
Total SEUs		58		58		68		58

Table B6: Signalling Requirements for Route Option C3

Signalling Elements	Phase 2d 125mph		Phase 2e 125mph		Phase 2e Linespeed – 90mph		Phase 2e Freight Capability	
	No.	SEUs	No.	SEUs	No.	SEUs	No.	SEUs
3 aspect signals Up Line	-	18	-	18	-	23	-	18
3 aspect signals Down Line	-	18	-	18	-	23	-	18
Emergency crossovers	3	12	3	12	3	12	3	12
Double Junction	2	12	2	12	2	12	2	12
Staff protection systems (LOWs, TOWS)	-	2	-	2	-	2	-	2
Total SEUs		62		62		72		62

Table B7: Signalling Requirements for Route Option E3

Signalling Elements	Phase 2d 125mph		Phase 2e 125mph		Phase 2e Line Speed – 90mph		Phase 2e Freight Capability	
	No.	SEUs	No.	SEUs	No.	SEUs	No.	SEUs
3 aspect signals Up Line	-	19	-	19	-	25	-	19
3 aspect signals Down Line	-	19	-	19	-	25	-	19
Emergency crossovers	3	12	3	12	3	12	3	12
Double Junction	2	12	2	12	2	12	2	12
Staff protection systems (LOWs, TOWS)	-	2	-	2	-	2	-	2
Total SEUs		64		64		76		64

From the tables above, the only significant variant between the options is the difference in linespeed which equates to circa 10 to 12 additional SEUs across the route options assessed. This is likely to be the case for an equivalent ETCS assessment.

At 125mph, circa 3.3km is travelled every minute (approx. 2 miles) whilst, at 90mph, this reduces to circa 2.4km (approx. 1.5 miles). Signal spacing has been based on maximising capacity based on a three-minute headway. With a lower linespeed, more signals are required, however, derogations to relevant standards may be sought to limit the optimum capacity considered in this study.

This logic is not altered with the introduction of ETCS Level 2 versions currently being considered for implementation on sections of the existing infrastructure.

Signalling Conclusion

To support the analysis of linespeed sensitivity in this phase, it was also necessary to review and update the Bills of Quantity (BoQ) for the new horizontal alignments, utilising the same assumptions as used for Phase 2d e.g. Headway etc.

The variance in SEU count generated by a linespeed reduction is notable; there are increases in the signalling assets required but these would not be considered significant in the context of the overall programme cost. Gradients are not influential on the signalling assets required.

It is likely that the SEU count would reduce when the working headway assumption is replaced with the capacity requirement. This would typically be in later stages of feasibility/option development.

Order of Magnitude Cost Estimates - Linespeed

In the scenarios tested, where the new infrastructure provided was designed to allow for 100mph in lieu of the base assumption of 125mph, the potential cost impact (saving) varied from £6m to £147m.

This reflects the fact that scope reduction (and thus cost savings) is generally only realised on routes requiring high volumes of cut and fill.

The cost estimate for providing a 125mph railway over a 90mph railway is, therefore, considered to be unlikely as a determining factor in route selection. However, should a route requiring significant volumes of cut and fill be chosen, then further evaluation should be undertaken prior to specifying 125mph as a requirement. For some routes, the additional cost of providing 125mph is a small percentage of the overall route cost, therefore it should be considered as a future proofing opportunity, even if current rolling stock cannot take advantage of it. For other routes, the cost of future proofing may not be considered to offer value for money.

It should be noted that the potential freight capability and linespeed savings share significant elements of scope and that the savings outlined above cannot, therefore, simply be combined with the freight capability/capacity savings which are detailed later in this report.

Freight Capacity and Capability Analysis

The development work in this section considered the 3 route options, namely A1, C3 and E3, to determine whether the capital costs could be reduced by increasing the maximum gradient of the new route from that assumed in Phase 2d. This was based on the assumption that steeper gradients would reduce the volume of excavated material and the analysis considered an increase in the maximum gradient from 1:125 to 1:80. This is likely to still allow multi-modal freight (up to 1800 tonnes) to operate but not heavy haul freight (up to >2,600 tonnes+). Opportunities to improve both the horizontal and vertical alignment were explored.

Increasing the maximum gradient allows the vertical alignment to be adjusted to better fit the ground profile. This enables reduced embankment heights and cutting depths, minimising the route's footprint area and reducing the height of any overbridge crossings. However, the final earthwork volume impact is dependent upon how the sensitivity vertical alignment design is applied. A comparison of the assessed impact is presented in Tables B8, B9 and B10 below.

Table B8 below shows that for route option A1, an increase in the steepness of the gradient will increase the cutting material quantities, and decrease the fill required for embankments and improve the earthworks balance to neutral. Land acquisition also reduces due to the reduction in footprint width. The cost estimates at this stage of development assume a worst case of 100% import and disposal in the absence of specific details, but these will be refined further as the project develops further.

Table B8: Route A1 Freight Gradient Results

	Phase 2e 1:125	Phase 2e 1:80
Route length (km) (ELR:BBM divergence to ELR:SBR connection)	40.70	40.70
Cut (m^3)	1,012,552	1,227,004

	Phase 2e 1:125	Phase 2e 1:80
Fill (m³)	1,724,885	1,205,481
Surplus (+) / deficit (-) (m³)	-712,333	21,524
Footprint (m²)	944,318	918,375

Table B9 below shows that for route option C3, the cutting quantities are similar in volume, however, the fill requirements have reduced significantly such that there is now a surplus of material to dispose of. This is a significant volume to be removed from site. The land acquisition area has been reduced due to the reduction in footprint width.

Table B9: Route C3 Freight Gradient Results

	Phase 2e 1:125	Phase 2e 1:80
Route length (from ELR:SPC2 divergence to ELR:SBR connection (km)	45.4	45.4
Cut (m³)	6,378,589	6,433,687
Fill (m³)	7,013,136	4,760,948
Surplus (+) / deficit (-) (m³)	-634,546	+1,672,739

Footprint (m²)	2,106,747	1,993,830

Table B10 below shows that for route option E3, there is little change in the cut volumes but a reduction in fill volumes, resulting in a significant reduction of imported material to compensate for the deficit identified. There is a decrease in land acquisition due to the reduction in footprint width.

Table B10: Route E3 Freight Gradient Results

	Phase 2e 1:125	Phase 2e 1:80
Route length (km) (ELR:BBM divergence to ELR:SBR connection)	47.9	47.9
Cut (m³)	1,533,183	1,488,159
Fill (m³)	1,918,762	1,660,059
Surplus (+) / deficit (-) (m³)	-385,580	-211,900
Footprint (m²)	1,194,771	1,120,601

Freight Capability & Capacity – Key Findings

The quality of the material, and its classification, will depend on site and ground investigations to be carried out at a later phase in the design programme. The variance between the routes, however, does suggest that unless the A1 route strata is found to be significantly poor, it has the least earthworks volumes and footprint of the three options.

Cut volume increase is a function of vertical alignment adjustment to reduce total earthworks. Appendix B3 - Sensitivity Assessment Report for Linespeed and Freight Capacity and Capability provides further information. Route A1, between ch25km to ch28.5km, and ch31.2 to ch32.2km, is where there are the greatest changes in level. This is due to the proposed A1 alignment passing through topographical features that other proposed option alignments would not. This, in turn, increases the volume of material excavated from site and reduces the surplus. Therefore, the assumption, that steeper gradients reduces the volume of material excavated in cuttings, is more complex than originally envisaged because the anticipated cut and fill balance has not been evidenced through the analysis. Therefore, to confirm whether a steeper gradient would offer a cost saving requires further development and analysis.

Order of Magnitude Cost Estimates - Freight Capacity and Capability

In the scenarios tested, where the new infrastructure was designed to allow for intermodal freight only (i.e. heavy haul capability was specifically excluded from requirements), the potential cost impact (saving) varied across the three route options tested from £3.3m to £132.3m. This reflects the fact that scope reduction (and thus cost savings) is generally only realised in routes requiring high volumes of cut and fill.

The cost and benefits of providing for heavy haul freight are, therefore, unlikely to be a determining factor in route selection. However, should a route requiring significant volumes of cut and fill be chosen, then further evaluation should be undertaken prior to specifying heavy haul provision as a requirement.

Conclusion - Linespeed and Freight Capacity and Capability Analysis Combined

A reduction in linespeed, and an increase in maximum gradient, mainly affects earthwork volumes and footprint, or land acquisition areas, as a function of minimum allowable cess width, or an increase in gradient to 1:80. There is little comparative impact on local constraints such as properties and historic and environmental sites. 'Major' engineering elements, such as track and signalling, also remain largely unchanged.

The benefit of a steeper gradient (1:80) has a higher impact on those route options where the ground is steeper than the Phase 2d (1:125) assumed gradient, or where underbridge crossings are required, for example for an 'at grade' major road intersection. Therefore, comparatively, the more 'northerly' route option i.e. C3 would benefit by the greatest degree.

At this stage of development, there is no change in electrification and plant provision, due to either linespeed or gradient changes, due to these being based on a linear length of new

route. There may be a requirement for a wider cess to meet the needs of passive provision for OLE, and its installation and maintenance, that will require the Phase 2d infrastructure footprint width of 11.2m to be implemented.
Detailed design may require other railway infrastructure considerations resulting in an increase in cess to cess width such as OLE passive provision to accommodate electrical clearances, drainage, toughing, track fixity measures etc.

In the interests of futureproofing, an infrastructure designed for a linespeed of 125mph would not disproportionately increase the asset quantities. The case for gradients being limited to 1:125 could be challenged, however, as 1:80 is, in principle, suitable for both passenger and intermodal freight traffic and this may offer a saving. It should be noted that the exclusion of heavy haul freight, between 1800 tonnes and 2600 tonnes+, through steeper gradients, may need to be considered on a strategic basis and may be subject to the regulatory network change processes.

Signalling provision has been based on linespeed and linear length of new route. Decreasing the linespeed has increased signalling provision by around 16 – 20% which in terms of direct costs and is not considered to be significant at this stage of evaluation or development. There is no impact on signalling provision from increasing gradients.

The more 'northerly' route options, e.g. C3, which have greater undulations and earthwork requirements, would benefit from further assessment which could reduce the comparative gap in earthwork requirements with more southerly route options, e.g. A1. For the A1 route option, no significant reductions in quantities have been identified in earthwork volumes in this phase, either from reducing the linespeed, or increasing the gradient. Although the percentages in Table B8 indicate otherwise, the earthworks quantities show that the A1 route has significantly less volume of material to be moved than other route options. However, there is a significant change in volumes for C3 given the applied parameters.

B.08 Intermediate Stations

In this phase, Network Rail were asked by EWR Co to consider options for the introduction of a new intermediate station between Sandy and Cambridge, in response to emerging views on potential new settlements within the Oxford – Cambridge corridor as determined by the NICs report published in November 2017. In considering viable station locations, and areas of population growth and potential development, Cambourne (for 'northerly' route options) and the Ministry of Defence site at Bassingbourn (for 'southerly' route options) were identified as potential locations for a new station. The route options in Phase 2d, described as A1 and E3, were identified as having the potential to be diverted to serve Bassingbourn and route option C3 to serve Cambourne. These route options developed in Phase 2d were, therefore, selected for evaluation in this phase, but other locations and route options could also be assessed in future design phases.

A linespeed of 125mph was assumed, to be consistent with the development of other route options. The design of horizontal and vertical diversions from the 3 route options assessed, to the new intermediate stations, were progressed, including a recalculation of the end-to-end bill of quantities for the route options, utilising the same assumptions as used for Phase 2d.

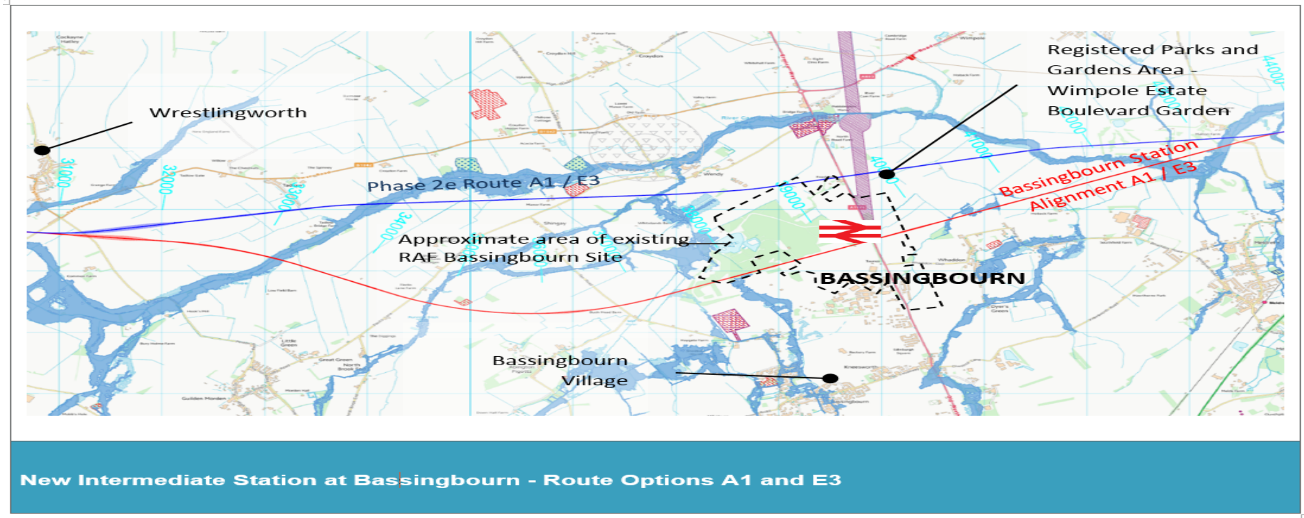
The indicative design of the proposed station infrastructure has been progressed to a similar level of detail to the Phase 2d proposals – platforms, station buildings, car parking, access roads etc. A brief narrative, and plan/profile, for each of the alignments has also been prepared. For full details are please refer to Appendix B4 for further details on the Sensitivity Assessment Report for Intermediate Stations.

Option 1: Intermediate Station at Bassingbourn (route options A1 and E3)

The route alignment for this option has been based on design principles applied in Phase 2d. A straight-line alignment was considered with the benefit of geometrical design input. Figure B3 below shows the indicative alignment, applicable to route A1, to a proposed new station at Bassingbourn. The alignment passes through the former RAF airfield, which is now a Ministry of Defence site, and could be considered as a potential location for redevelopment as proposed within the 5th Studio report, which was commissioned by the NIC to make recommendations on the Built Environment of the Oxford – Milton Keynes – Cambridge corridor to support their report published in November 2017.

No further alignment iteration, or development, was undertaken due to the minimal level of impact identified.

Figure B3: Proposed alignment for Route Option A1 via a new intermediate station at Bassingbourn



A linespeed of 125mph, and a maximum gradient of 1:125, has been assumed for consistency with other route options. Track design element lengths have been maximized, as far as possible, to promote good track quality, adhering to the requirements outlined in NR/L2/TRK/2102. This means that the track design is in optimised sections between identified constraints.

The Bassingbourn route option avoids any direct physical impact on the National Trust property, Wimpole Estate, which would be a positive outcome from a land and consents strategy perspective.

Comparison of Earthworks for Intermediate Station at Bassingbourn

Tables B11 and B12 show earthworks comparisons for the whole route from Bedford.

Table B11 below shows that the alignment for route option A1 is 0.7km longer to accommodate the diversion to an intermediate station at Bassingbourn. Additionally, it increases the volume of material to be excavated and gives a reduction in the material required for fill. However, the quantities assume that the soil's classification will be favourable, and the quality of material excavated will meet the specifications for fill material within railway embankments. There is an increase in land acquisition due to increased length of route option alignment and station footprint.

Table B11: Bassingbourn Earthworks Comparison – Route Option A1

Route		Phase 2e 125mph (1:125)	Phase 2e Bassingbourn
A1	Route length (km) (ELR:BBM divergence to ELR:SBR connection)	40.7	41.4
	Cut (m^3)	1,012,552	1,115,682
	Fill (m^3)	1,724,885	1,688,727
	Surplus (+) / deficit (-) (m^3)	-712,333	-573,045
	Footprint (m^2)	938,832	978,364

Table B12 below shows that the alignment for route option E3 is 0.7km longer, to accommodate a diversion to an intermediate station at Bassingbourn. Additionally, it shows an increase in the volumes excavated and the quantities required for fill. The surplus material has increased but the risks around classification are the same as for those in the A1 option. There is an increase in land acquisition required as with A1.

Table B12: Bassingbourn Earthworks Comparison – Route Option E3

Route		Phase 2e 125mph (1:125)	Phase 2e Bassingbourn
E3	Route length (km) (ELR:BBM divergence to ELR:SBR connection)	47.9	48.6
	Cut (m³)	1,533,183	1,687,852
	Fill (m³)	1,918,762	1,980,252
	Surplus (+) / deficit (-) (m³)	-385,580	-292,400
	Footprint (m²)	1,194,771	1,230,967

Summary

An alignment, to accommodate a new intermediate station at Bassingbourn, would add an additional 0.7km of route length over similar topography compared to the Phase 2d alignment for the route options tested, However, this would have minimal impact on earthwork volumes. The route is estimated to impact on a similar number of properties than the Phase 2d alignment and would not require any further viaducts. There is no additional impact on designated environmental, or heritage, sites identified but it would notably reduce impact, as a result of passing south of the Registered Parks and Gardens area relating to the National Trust property, Wimpole Estate. It should also be noted that the route is aligned to pass through the MoD site at Bassingbourn, where there is a risk that Unexploded Ordnance (UXO) may be present. This would need to be considered in more detail if this route option is developed further. A full comparison between Phase 2d and Phase 2e analysis is shown in Table B13 below which shows the impact of further design refinement in Phase 2e and then diverting route option A1 to accommodate an intermediate station at Bassingbourn, which was not considered in previous phases.

Order of Magnitude Cost Estimates - Bassingbourn option

In the scenarios tested, where route options A1, and E3 were deviated from the base (Phase 2d) alignment to serve a new station at Bassingbourn, the potential cost impact (increase) is £120m for all route options. This is predominantly based on the cost of an additional station, plus an increase in route length of 700m, and one additional overbridge, as a result of the alignment deviation.

Conclusion – Intermediate Station at Bassingbourn

The status, and potential for re-development, of the MoD site at Bassingbourn (e.g. for housing) is currently unclear, as the MoD has indicated its intention to develop the site for its own purposes. Further consultation is also recommended with the MoD to confirm, where possible, its historic, current and proposed future usage as a functioning military base. In addition, gaining general information on site hazards would be advisable i.e. munitions used in training exercises may still be present on the site. Information should also be sought from a specialist regarding the UXO risk in the area.

Earthwork balancing has not been undertaken for the Phase 2e design and should be investigated further, once a suitable earthwork strategy has been produced, and ground and groundwater evaluated as it leads to a variation in footprint quantities.

The route continues to affect multiple roads, but only one additional road to the original A1 route and will require consultation with Highways England to determine the actual crossing type, to enable future collaboration with future highways works.

Signalling variation between the options is deemed to be minimal, however, in relation to track, there would be additional infrastructure required due to the additional mileage increase. No other assets are altered in quantity, at this stage of development, as a result of this proposal.

Table B13: Bassingbourn Intermediate Station – Comparison Table for A1

Item Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Bassingbourn
Buildings and Civils			
Route Length Comparison (km)			
[1]Route length from (ELR:BBM) divergence to ELR:SBR connection	41.0	40.7	41.4
Route Plan Areas (m²)			
Plan area / footprint of alignment corridor to extent of earthworks	981,845	944.175	978,364
[2,3]Earthworks (m³)			
Earthwork cut	1,186,659	1,012,552	1,115,682
Earthwork fill	1,993,056	1,724,885	1,688,727
Deficit (-) / surplus (+)	-806,466	-712,333	-573,045
Other Earthworks (m³)			

Item Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Bassingbourn
[4]Volume of landfill material to be relocated from the former Elstow authorised landfill site/former pit to facilitate embankment construction	919,908		
Private Building Demolition/Purchase/Relocation (no.)			
Buildings directly impacted	20	20	20
Road, Rail and Watercourse Bridge Infrastructure Requirements, and Related Earthworks			
[5]Railway Viaducts (no.)	**1**		
Total length (m)	860		
Total bridge area (m²)	9,632		
Road - Rail bridges (no.)	**21**	**20**	**21**
Overbridges (no.)	13	13	14
Underbridges (no.)	8	7	7
Road Bridge Earthworks (m³)			

Item Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Bassingbourn
Road bridge construction cut volume	58,518		58,518
Road bridge construction fill volume	317,055		338,210
Deficit (-) / surplus (+)	-258,537		-279,692
Total new road construction length (m²)	**5,523**		**5,820**
Total new road construction area (m²)	**65,744**		**67,823**
Watercourse Channel Underbridges	**-**	**7**	**7**
Track and Footpath Bridges			
Track bridges (no.)	**18**		**21**
Overbridges	10		13
Underbridges	8		8
Additional vehicular track bridges	**10**		**8**

Item Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Bassingbourn
(for land access - min. 1 per 1600m) (no.)			
Overbridge (no.)	4		4
Underbridges (no.)	6		4
Track Earthwork (m³)			
Track bridge construction cut volume	292,590		234,072
Track bridge construction fill volume	253,860		317,325
Deficit (-) / surplus (+)	+38,730		-83,253
[6]Footbridges (no.)	**18**		**13**
Overbridges	11		7
Underbridges	7		6
Track			

Item Description	Phase 2d 125mph		Phase 2e 125mph		Phase 2e 125mph Bassingbourn	
SGVs 21-18.5-15-13 Double Junction	1		1		1	
HVs 32.365-28-21.829-18.5 Double Junction (nr)	1		1		1	
Length of twin track plain line (km)	41.0		40.7		41.4	
3no SGVs 28 Emergency Crossovers	3		3		3	
3no EVs 21 Emergency Crossovers	-		-		-	
Signalling						
	No.	SEUs	No.	SEUs	No.	SEUs
Total SEUs (3-aspect or ETCS)		58		58		58
Electrification & Plant						
Principal Supply Points (per 7km)	6					

Full details of the analysis are included in Appendix B4 -Sensitivity Assessment Report for Intermediate Stations.

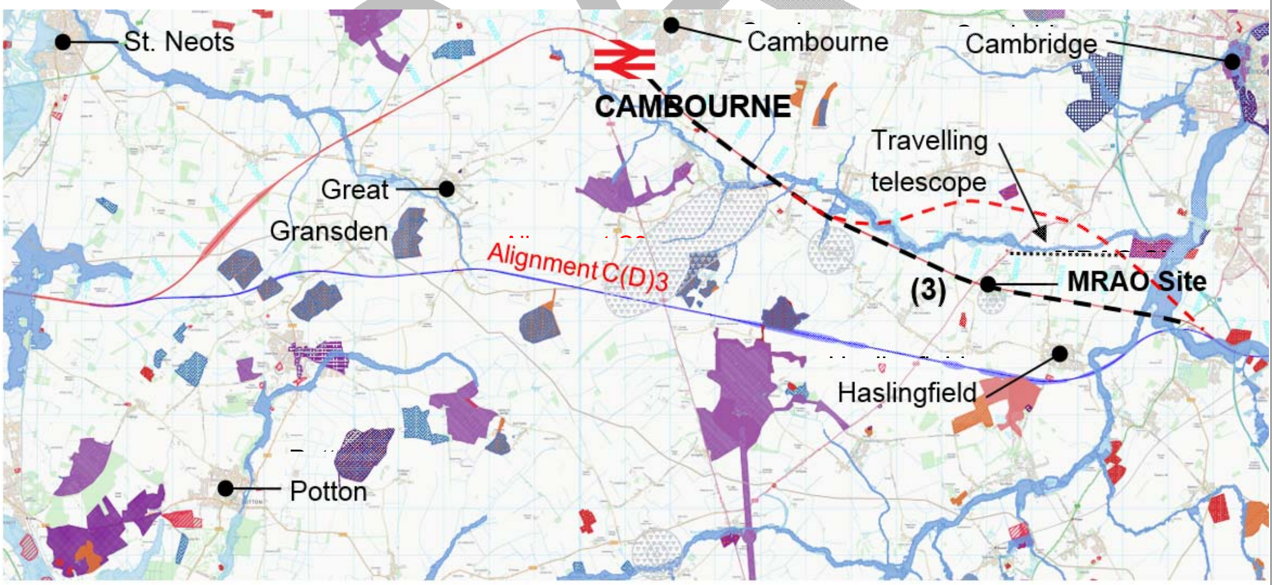
Option 2: Intermediate Station at Cambourne (route option C3)

The route alignment for this option has been based on design principles applied in Phase 2d. A straight-line alignment was considered with the benefit of geometrical design input. Figure B4 below shows the proposed alignment, applicable to route C3, to a proposed new station at Cambourne. The alignment focuses on a point south of the village, between Cambourne and Caldecote, a site considered as having potential for housing development under South Cambridgeshire District Council's Local Plan.

A linespeed of 125mph, and a maximum gradient of 1:125, have been assumed for consistency with other route options developed.

No further alignment iteration, or development, was undertaken due to the minimal level of impact on existing infrastructure or residential areas identified by this option.

Figure B4: Route Development Alignment - East of Cambourne



It can be seen from Table B14 below that comparison of the C3 route option with alignment diverting to serve Cambourne offers an 11% reduction in excavated material and requires 40% less fill, to the extent that a surplus would be generated that would need to be disposed of. As with the other route options, the risks against the classification of soils are similar, however, in this instance the risk is amplified due to the greater volumes of material.

Table B14: Comparison of Earthworks for Intermediate Station at Cambourne

Route		Phase 2e 125mph	Phase 2e Cambourne
C3	Route length (km) (ELR:SPC2 divergence to ELR:SBR connection)	45.4	49.1
	Cut (m^3)	6,393,920	5,644,107
	Fill (m^3)	6,877,161	4,319,910
	Surplus (+) / deficit (-) (m^3)	-483,241	+1,324,855
	Footprint (m^2)	2,194,275	2,008,537

Summary

A Cambourne alignment would add an additional 3.7km of route length over similar topography compared to the original alignment in Phase 2d. This decreases the volume of cut and fill but increases the volume of material for disposal, where previously there was a need for material to be imported. The land acquisition footprint has reduced due to the reduction in earthworks quantities and footprint. A small number of properties could be affected by an alignment in this area, however, the impact of this is yet to be determined and this will be investigated in a future stage of development is this route is selected.

A full comparison between Phase 2d and Phase 2e analysis is shown in Table B15 below.

Costings – Cambourne option

In the scenarios tested, where route C3, was deviated from the base alignment to serve a new station, the potential cost impact (saving) was £101m.

This saving is as a result of the alignment deviation to the north requiring significantly smaller volumes of cut and fill. (Cut reduces from 6.4m3 to 5.6m3. Fill reduces from 6.9m3 to 4.3m3.)

The saving of £101m includes additional scope items associated with the scenario i.e. 3.7km of increased route length, 4 additional road bridges, and the additional station.

Conclusion – Intermediate Station at Cambourne

For route option C3, a Cambourne alignment, despite being 3.7km longer in length, would result in a cost saving due to a reduction in cut and fill volumes as a result of passing through less challenging topography. It would, however, benefit from further earthwork balancing once an earthwork strategy has been determined. This would determine geology, excavated material type, and would assess the suitability as fill material and provide a more accurate estimation of cutting slope angles following classification. An assessment of cutting slope angles would disproportionally benefit the northerly route options through the Sandy Hills and likely bring the capital costs closer to southerly route options.

Consultation with Cambridge University, regarding the Mullard Radio Astronomy Observatory (MRAO) site and travelling telescope, would be beneficial to help determine the impact of passing a railway in close proximity to the equipment on this site. This may include issues such as noise, vibration, electromagnetic compatibility etc. Although the alignment has been positioned to avoid the MRAO site, it still passes immediately to the east of the travelling telescope and, therefore, still requires consideration.

The route would affect multiple roads, and will require consultation with Highways England, to determine the actual crossing type and to enable future collaboration with future highways works.

Signalling variation is minimal, however, with regards to track, there would be additional infrastructure required due to the additional mileage increase. No other assets are altered in quantity.

Table B15: Cambourne Intermediate Station – Comparison Table for C3

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Cambourne
Buildings and Civils			
Route Length Comparison (km)			
[1]Route length from (ELR:BBM) divergence to ELR:SBR connection	45.6	45.4	49.1
Route Plan Areas (m²)			
Plan area / footprint of alignment corridor to extent of earthworks	2,205,191	2,164,259	2,008,537
[2,3]Earthworks (m³)			
Earthwork cut	6,702,458	6,393,920	5,644,107
Earthwork fill	6,887,168	6,877,161	4,319,910
Deficit (-) / surplus (+)	-184,710	-483,241	+1,324,855
Other Earthworks			

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Cambourne
Private Building Demolition/Purchase/Relocation (no.)			
	11	11	18
Road and Rail Bridge Infrastructure Requirements and Related Earthworks			
Rail Viaducts (no.)	**4**		
Total length (m)	2,680		
Total bridge area (m²)	30,016		
[4]**Road Viaducts (no.)**	**1**		
Total length (m)	530		
Total area (m²)	12,720		
Road - Rail Bridges (no.)	**18**		**22**
Underbridges (no.)	9		15

<table>
<tr><th></th><th>Phase 2d
125mph</th><th>Phase 2e
125mph</th><th>Phase 2e
125mph
Cambourne</th></tr>
<tr><td>Overbridges (no.)</td><td colspan="2">9</td><td>7</td></tr>
<tr><td colspan="4">Road/Rail Bridge Earthworks (m³)</td></tr>
<tr><td>Bridge construction cut volume</td><td colspan="2">29,259</td><td>29,259</td></tr>
<tr><td>Bridge construction fill volume</td><td colspan="2">262,744</td><td>343,444</td></tr>
<tr><td>Deficit (-) / Surplus (+)</td><td colspan="2">-233,485</td><td>-314,185</td></tr>
<tr><td>Total New Road Construction Length (m²)</td><td colspan="2">5,629</td><td>5,538</td></tr>
<tr><td>Total New Road Construction Area (m²)</td><td colspan="2">55,559</td><td>61,771</td></tr>
<tr><td>Watercourse Channel Underbridges</td><td>-</td><td>2</td><td>5</td></tr>
<tr><td colspan="4">Track and Footpath Bridges</td></tr>
<tr><td>Track bridges (no.)</td><td colspan="2">14</td><td>24</td></tr>
<tr><td>Overbridges</td><td colspan="2">5</td><td>10</td></tr>
</table>

<table>
<tr><th></th><th>Phase 2d
125mph</th><th>Phase 2e
125mph</th><th>Phase 2e
125mph
Cambourne</th></tr>
<tr><td>Underbridges</td><td colspan="2">9</td><td>14</td></tr>
<tr><td>Additional vehicular track bridges (for land access - min. 1 per 1600m) (no.)</td><td colspan="2">14</td><td>10</td></tr>
<tr><td>Overbridges</td><td colspan="2">9</td><td>3</td></tr>
<tr><td>Underbridges</td><td colspan="2">5</td><td>7</td></tr>
<tr><td colspan="4">Track Earthwork (m³)</td></tr>
<tr><td>Bridge construction cut volume (m³)</td><td colspan="2">87,777</td><td>234,072</td></tr>
<tr><td>Bridge construction fill volume (m³)</td><td colspan="2">190,395</td><td>211,550</td></tr>
<tr><td>Deficit (-) / surplus (+) (m³)</td><td colspan="2">-102,618</td><td>+22,522</td></tr>
<tr><td>Footbridges (no.)</td><td colspan="2">18</td><td>20</td></tr>
<tr><td>Overbridges</td><td>4</td><td>5</td><td>9</td></tr>
<tr><td>Underbridges</td><td>14</td><td>14</td><td>11</td></tr>
</table>

	Phase 2d 125mph		Phase 2e 125mph		Phase 2e 125mph Cambourne	
Track						
FVs 18.5-16-12.75-10.75 Double Junction (no.)	1		1		1	
HVs 32.365-28-21.829-18.5 Double Junction (no.)	1		1		1	
Length of twin track plain line (km)	45.6		45.4		49.1	
SGVs 28 Emergency Crossovers (no.)	3		3		3	
EVs 21 Emergency Crossovers (no.)	-		-		-	
Signalling						
	No.	SEUs	No.	SEUs	No.	SEUs
Total SEUs (3-aspect or ETCS)		62		62		64
Electrification & Plant						
Principal Supply Points (per 7km)	7					

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e 125mph Cambourne

Full details of the analysis are included in the Sensitivity Assessment Report for Intermediate Stations within the Appendices. Please also refer to Appendix B10 for St Neots to Bassingbourn Route Option Development Report and Appendix B11 for the Tempsford assessment

B.09 Sandy South Station

The analysis in this section was to further evaluate the viability and capital cost for infrastructure required for a new station located to the south of the existing Sandy station at the point where route option A1 would intersect with the ECML.

Initial steps were to undertake a data collection exercise and correlate the various outputs. A desk top study was undertaken using data drawn from a variety of sources which are itemised in Appendix B5 - Value Engineering Report for Sandy South Station.

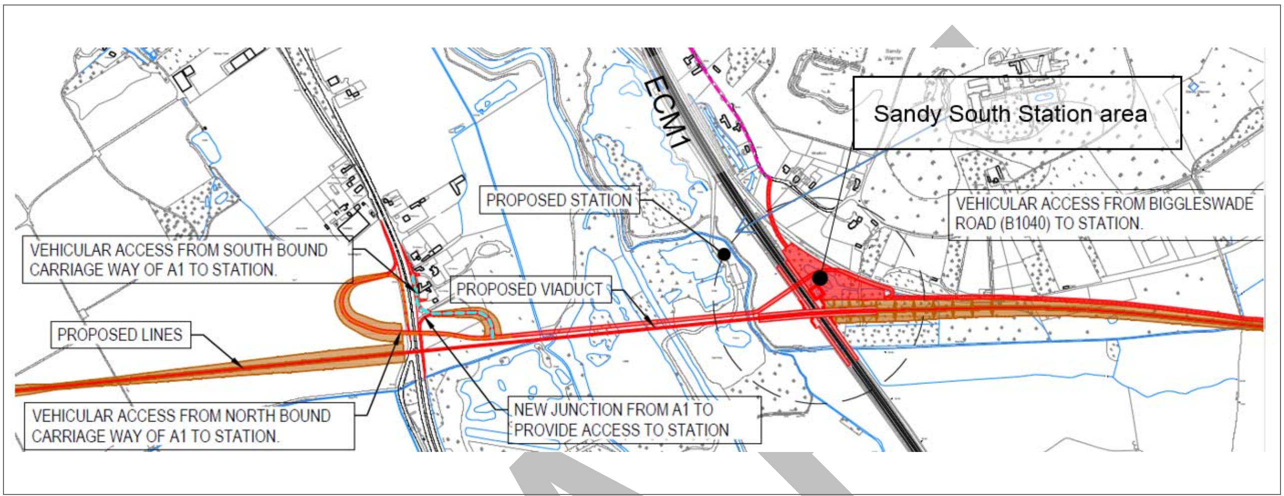
B.09.01 Key Findings

The analysis undertaken in previous phases has indicated that it is feasible to locate a station to the south of Sandy, providing an interchange for passengers to ECML services, via a grade separated station, with platforms sited on both the Up and Down Slow lines of the ECML and on the new EWRCS lines. However, the location of that station on the flood plain required further assessment. It is assumed that the compulsory purchase of land, or purchase of land by agreement with affected landowners, can be reached to enable this. Platforms can be constructed for the range of rolling stock currently proposed.

Sandy South station is also currently proposed to be have links to the A1 and providing parking spaces for up to c.460 cars based on passenger forecast numbers and indicative car parking requirements identified in Phase 2d. This compares to an existing figure of 142 parking spaces at this station. Current footfall assessments assume that the existing Sandy station patronage levels will be retained but it is anticipated that this will be bettered if the proposed station and parking provision is made on the basis that people will be able to access this station, by road or other means of transport, from the surrounding area.

The proposed location for the new station, as identified in Phase 2d, does not conflict with the position of any existing signals, S&C or level crossings and a schematic is shown below in Figure B5.

Figure B5: Phase 2d Proposed A1 Road Junction to Sandy South Station



Preliminary consultation has been undertaken with Highways England and the Environment Agency on these proposals. General observations were made by both parties, none of which are deemed significant enough to prevent the proposal from being developed further at this stage, however, the following considerations will need to be considered further in future development activity:

- It is considered that the proposed site is appropriate for the location in terms of flood risk and it will be possible to manage the flood risk on site through appropriate design of the station. This will ensure the proposed development is fit for purpose and has no negative impact on flood risk to areas outside of the site boundary.

- Flood mitigation measures will need to be defined; maintenance and liabilities for compensation measures determined when an impact assessment is undertaken based on a draft Approval in Principle (AiP) integrated design.

From the consultation carried out, a logic was developed that gave rise to three options to be investigated further to consider whether it would be possible to reduce the level of high cost viaduct and the introduction of earthworks within the flood plain making, an allowance for the inclusion of attenuation to compensate for the loss of flood plain capacity.

- **Option 1** considered a minimal compensation attenuation volume
- **Option 2** considered an approximate 50/50 split in the compensation attenuation volume

- **Option 3** considered a maximum compensation attenuation volume

These resulted in variations of embankment lengths against viaduct lengths, at different locations, seeking an improvement in the cost estimate.

Table B16 below is extracted from tables in the Sandy South report, and includes a comparison to Phase 2d which did not include any consideration of floodplain compensatory storage which was not identified as required at that stage of development.

Table B16: Variations of Embankment Lengths compared to Viaduct Lengths

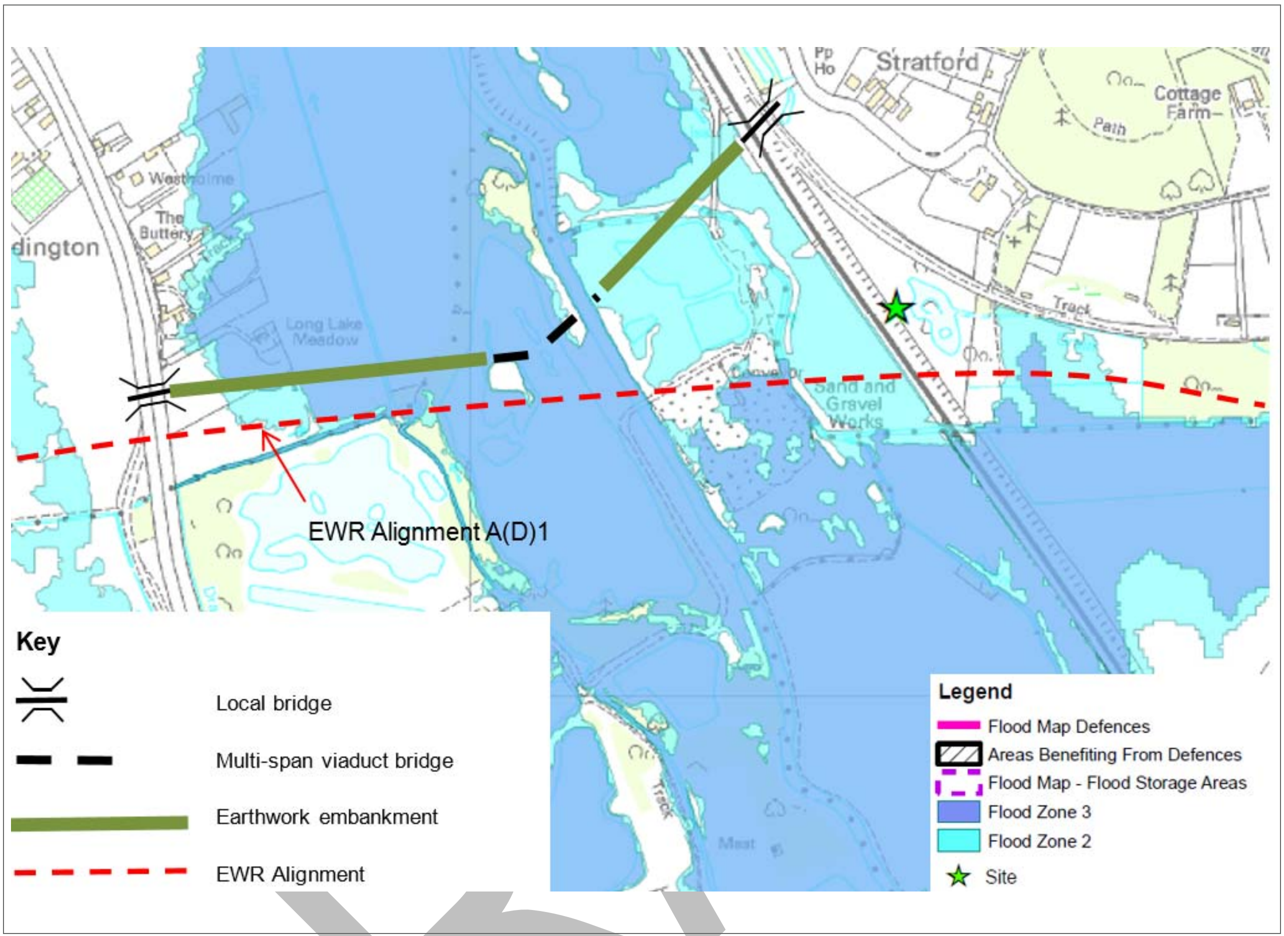
Item Description	Phase 2d	Phase 2e		
		Option 1	Option 2	Option 3
Floodplain compensatory storage				
Highways volume (m³)	0	0	365	907
Railways volume (m³)	0	107	722	1,292
Infrastructure				
Highways Viaduct length (m)	860	310	100	0
Railway Viaduct length (m)	860	228	136	0

For the purposes of this phase of study, the mid-range Option 2 was progressed and is shown in Figure B6 below.

It should be noted that the establishment of an embankment within the flood risk areas will occupy volumes of flood plain that will need to be replaced by other means. It is assumed that suitable land can be acquired for compensatory flood storage to the south of the site, immediately to the periphery, or within, the flood zone 2 area. This will carry a liability for the maintenance and upkeep of such compensation attenuation areas, as well as potentially for any further upgrade that may be required in future years due to increased flood levels as a response to climate change pressures.

Note: Box girders have been proposed at this site to maximise span lengths which should be considered further in future stages; as with other structures over roads, the construction depth of the structure will need to be minimised to retain control of the impact on land take for embankments as the footprint is based on a 1:2 ratio, overall height to width plus infrastructure corridor.

Figure B6: Road Floodplain Crossing - Option 2



Option 2 would reduce viaduct length by 760m, with provision of a 100m long low-level multi-span viaduct partially crossing the Flood Zone 2 area and River Ivel channel. Two underbridges would be required to cross the A1 (road) and ECML (rail) locally, with an additional underbridge where the A1 highway junction within Option 2 is considered. Compensatory storage would be required due to flood plain encroachment.

Table B17 below shows the maximum/intermediate/minimum options with respect to the flood plain crossings by variations of the limits of embankments, viaduct or bridge. The longer the viaduct the fewer overbridges are needed, which is indicated in Table B17 below for Options 1 and 2. Further details are in Appendix B5 Value Engineering Report for Sandy South Station.

Table B17: Comparison of flood plain crossings by variations of the limits of embankments, viaduct or bridge

Item Description	Phase 2d	Phase 2e		
		Option 1	Option 2	Option 3
Infrastructure				
Viaduct length (m)	860	310	100	0
Viaduct area (m²)	9,632	3,472	1,120	0
[1]Local overbridges (no.) (Junction option under-bridges included in rail crossing figures)	0	2	2	3
Earthworks				
Embankment length (m)	0	390	600	640
Embankment earthwork volume (m³)	0	92,613	36,102	37,472
Footprint (m²)	0	7,289	12,587	13,948
[2]Culverts (no.)	0	8	12	13

Floodplain Compensatory storage volume (m^3)	0	0	365	907
[3]*Road Length (m)* *(From west of A1 to east of ECM1)*		780	780	780
Sand and gravel pit/lake infill (m^3) *(Placed fill volume)*	-	[4]Allow 100,000m^3		

Route Option A1 crossing A1 Highway and ECML

Option 2, as shown in Figure B7 below, would entail a local A1 overbridge with embankment earthworks east of the A1 road crossing, encroaching 100m into the Flood Zone 2 area. East of the River Ivel, embankment earthworks would be constructed where Flood Zone 2 is indicated. The 100m encroachment into the flood plain is an arbitrary length to enable cost comparison and presents an option which would not constrict the river channel but would encroach the floodplain.

Figure B7: Railway Floodplain Crossing – Option 2

Option 2 would reduce viaduct length by 724m, increasing the corridor footprint and earthwork volume. Viaduct length has been reduced on the assumption it could be replaced with earthwork embankment, subject to hydraulic modelling. An arbitrary length of 100m of Flood Zone encroachment has been applied for the purposes of enabling cost comparison.

Table B18 below shows the comparison of analysis for the 3 options considered in this phase.

Table B18: Option Comparison

Item Description	Phase 2d	Phase 2e		
		[6]Option 1	[6]Option 2	[6]Option 3
Infrastructure				
Viaduct length (m)	860	228	136	0
[1]Viaduct area (m²)	9,632	2,554	1,523	0
[2]Local underbridges (no.) (-) Applicable Where road junction option 2 is considered	0	2(3)	2(3)	3(4)
[3]Culverts (no.)	0	11	13	15
Earthworks				
[4]Embankment length (m)	0	537	629	718
Embankment earthwork volume (m³)	0	124,143	146,850	171,039
Footprint (m²)	0	24,005	28,030	32,683

Total Corridor Footprint *(west of A1 to east of ECM1)*	9,632	27,611	30,606	34,262
Floodplain compensatory storage volume (m^3)	n/a	107	722	1,292
Sand and gravel pit/lake infill (m^3) *(Placed fill volume)*	-	[5]Allow 100,000m^3		

Order of Magnitude Costings - Sandy South option

The assumptions made in support of previous scope cost assumptions regarding a new station at Sandy South station (Routes A1 and C1) were challenged and updated. This has resulted in the cost estimate for A1 dropping from £1.9b to £1.6b and the cost estimate for C1 increasing from £2.4b to £2.45b.

For A1, the key area to note is that the Phase 2d design allowance for the Sandy South Station was deemed sufficient and was not significantly changed. The area where costs were reduced was as a result of the change in assumptions regarding what proportion of the route would require viaducts and what proportion would be built on embankments. For A1, this change accounts for the £300m reduction.

For C1, there was less beneficial (a saving of £190m), and this saving was overtaken by the increases in costs associated with Bedford Midland (+£240m) detailed elsewhere in this report.

Conclusion – Sandy South Station

The assumptions and assessment regarding Sandy South Station, that informed the relevant route evaluation in previous phases, appear to be appropriate. Any significant savings for routes, utilising a station at this location, would seem to come from establishing a cost-effective way of dealing with flood mitigation measures.

As with the flood plain strategy, there is a reduction in capital cost by using earthworks in place of structures. This benefit has been taken into account in the cost estimates as it is considered to be a reasonable assumption for future development studies.

It is recommended that hydraulic modelling should be undertaken to refine the assessment of the level of flooding risk and the impact of options proposed as it will define the limits of the structures required to cross the flood plain.

The design of the highway junctions is to inform this development study only at this stage and a more detailed design will be required in future phases. However, proposals are currently being considered by Highways England to possibly reroute the A1 away from Sandy to the west and this would change the indicative layout considerably if a Sandy South Station and link road is to be progressed. It is recommended that the interfaces between the highways and the railway are developed further to confirm the viability of the proposals and define high level constraints.

There is a potential risk that some landfill has occurred in the extraction pits and will require further examination when ground investigation works are progressed in future stages of development. Additional earthworks, beyond those assumed, may be required to remediate extraction sites prior to embankment construction. No allowance has been made for land parcels that are required for construction or that may be locked in by the new infrastructure.

Station design is based on a replication of the Oxford Parkway station footprint, however, this will need a greater level of consideration in future stages, including the impact of dynamic pedestrian flow modelling.

Sandy South Station, and the A1 and E3 route options are close to the Sandy Warren SSSI Area of Impact for planning purposes. Suitable engineering, and the provision of alternative land, appropriate for use as new habitat, will be required as there is the potential presence of protected species and habitat under the Wildlife and Countryside Act 1981. Further discussions are advised to establish the validity of the constraints that this would generate which could result in the need to realign the A1 or E3 route options.

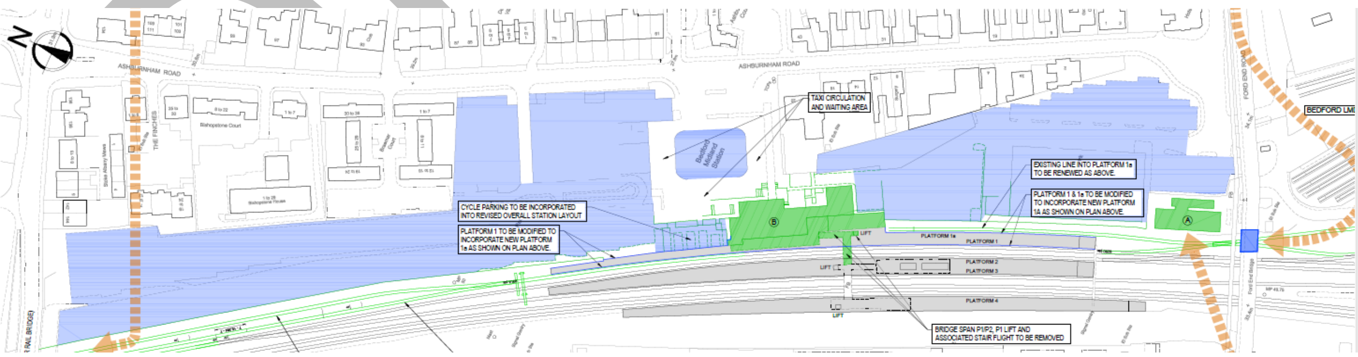
B.10 Bedford Midland Station and connection to the Midland Main Line

The analysis in this section was focused on giving further consideration to the scope and cost of infrastructure interventions that may be required for EWRCS services to access Bedford Midland Station. This included the full range of rolling stock configurations, up to 9 car sets, catering for a provisional platform length of 239m as requested by EWR Co during this phase, and future indicative train service specification (ITSS) for through services. For further details on this section, please refer to Appendix B6 - Value Engineering Report for Bedford Midland Station.

From the site walkout undertaken by the Network Rail project team, and the desk top enquires carried out, Network Rail investigated how to accommodate the level of outputs being sought at this stage of development. The constraint on platform capacity is due, in part, to the difficulty of gaining/timing paths in and out of the EMU Carriage Washer and Jowett Sidings, within the Bedford Maintenance depot, and their current layout, Previous studies undertaken for EWRWS, looked at a proposal for a new platform 6 on the back of the existing platform 5 and a proposal to introduce 3 and 4 car sets for the Bletchley services, as well as considered the need for an extended platform 1A. For 4 car sets on the current timetable and linespeed profile, an extension of Platform 1A would deliver a service capability if the frequency was not altered. However, for longer trains, and/or a more frequent regional stopping service, this would not be sufficient. It is anticipated that risk assessment of the level crossing at Bedford Maintenance depot would prevent a safe system of work and the station changes, to accommodate the longer trains, would impede the paths in and out of the sidings.

There is also a requirement to provide passenger connectivity for EWR services to services on the Midland Main Line (MML) which can be satisfied by passengers changing platforms in the usual manner. For traffic continuing north through Bedford Midland Station, the current Platform 1A would need to be changed from a bay platform to a through platform, with Platform 0 being added to the Bedford town (east) side of the station, and also providing passenger connectivity to services on the MML (SPC1) to the north. Figure B8 below shows the existing layout for Bedford Midland and the layout in Figure B9 below was developed to demonstrate a possible solution for this.

Figure B8: Bedford Midland Station – Existing Layout and Platform Arrangements

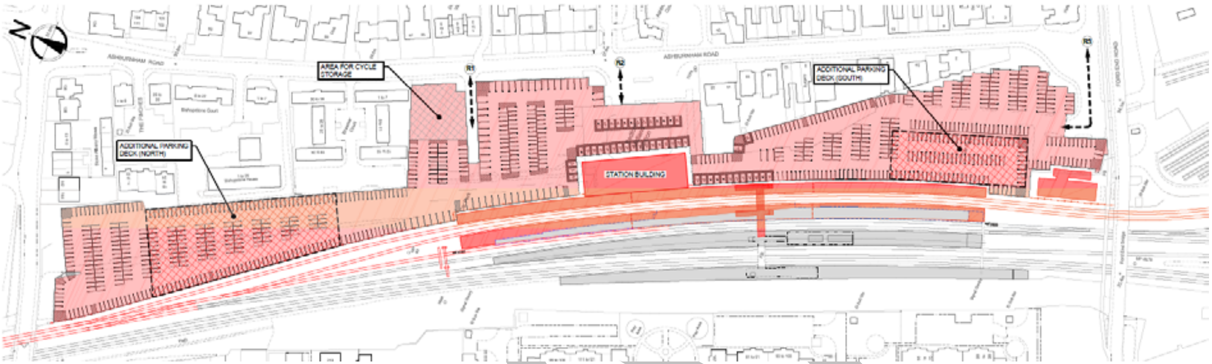


Note: *The Up Fast line lies between the Down Fast and Up & Down Loop and services do not stop at the station.*

Platform number/Platform type/Lines served/Operational platform length - taken from the National Electronic Section Appendix – NESA:

- 1A Bay Platform - Bedford Depot – length 81m
- 1 Through Platform - Up Slow – length 261m
- 2 Through Platform - Down Slow - length 261m
- 3 Through Platform - Up & Down Loop – length 261m
- 4 Through Platform - Down Fast – length 240m

Figure B9: Bedford Midland Station – Proposed Layout and Platform Arrangement



Platform number/Platform type/Lines served/Operational Platform length:

- 0 Through Platform - new - length 290m
- 1A Through Platform – modified - length 290m
- 1 Through Platform - Up Slow modified – length 290m
- 2 Through Platform - Down Slow – length 261m
- 3 Through Platforms - Up & Down Loop - length 261m
- 4 Through Platform - Down Fast - length 240m

Notes: *Refer to Appendix A for 'Bedford Midland Station East West Rail Central Section – Phase 2E' (item ref2) document ref: NR-IP-EN-IDG-DDL-145674-EWRCS-P2e_005 in Appendices*

One of the consequences of this proposed arrangement is that the current station buildings would need to be removed, and some of the at grade carpark spaces would be lost, to provide space for a new station building, level access facilities and a replacement multi story carpark. In addition, there are railway infrastructure and power distribution buildings that would also be impacted along with the engineering sidings. Consideration as to how to relocate these would need to be discussed with relevant stakeholders. The layout will need further work when pedestrian flow analysis is undertaken and the platform train interface (PTI) has been rationalised, in particular, when it has been risk assessed for curvature i.e. straighter platforms may result in additional infrastructure alterations and loss of parking.

The assumed approach path for services to Bedford Midland station from the south would have to come via Bedford St. Johns on the Marston Vale Line (BBM). This approach route is currently a 15mph single track railway, with a limited number of paths due to Thameslink services needing to access Jowett Sidings via the run round sidings, and the EMU sidings. There are multiple crossovers and turnouts to facilitate the access to the depots in the area. The site is further complicated by a level crossing in the Jowett Sidings area (approx. 110m long) carrying personnel, and vehicles, to and from the EMU and Washer areas within the depot.

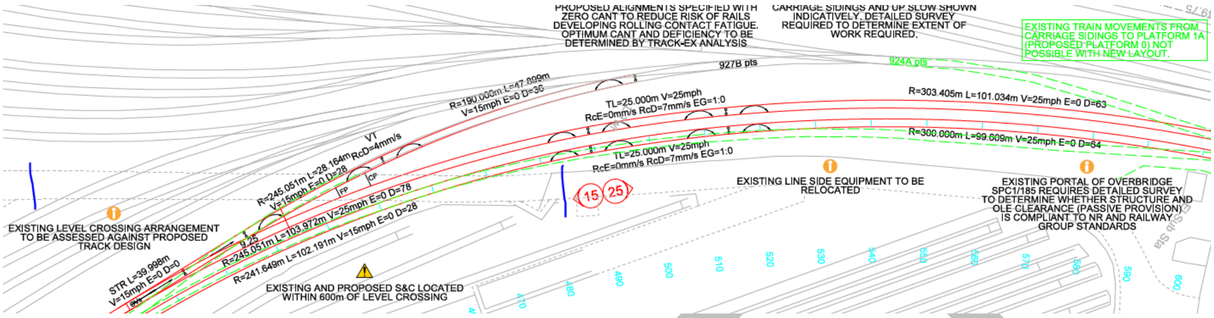
An All Level Crossing Risk Assessment Model (ALCRAM) assessment, of the depot crossing including stock movements over the MVL line, has not yet been undertaken as part of this analysis. However, it is assumed that the proposed increase in services, coupled with the current Thameslink operations, that have not been considered in other phases, will also have an adverse impact on path availability for EWRCS services. This has the potential to result in an increase in the Fatality Weighted Index (FWI). The continued use of the level crossing is considered to be in conflict with the ITSS currently being considered for EWRCS. On that basis, it has, therefore, been concluded that the depot will need to be significantly modified* or, and for the basis of this report, relocated to another site to maintain a safe system of operation. In addition, an EMU siding to the north of the existing Bedford Midland station will also be impacted.

**A constraint was identified in the Inter Disciplinary Check (IDC), when considering the operational requirements of the depot, for the section from Bedford St Johns to Bedford Midland station. This is being considered further as part of a separate study on the MVL being progressed by Network Rail, given the impact on the level crossing, the Thameslink trains and empty coaching stock movements.*

From the analysis undertaken to date, gauge and electrical clearances to Ford End Road Bridge are deemed to be sufficient, however, the bridge constrains the S&C layouts making the throat to the station, and adjacent depots, less than ideal from an operational and performance perspective

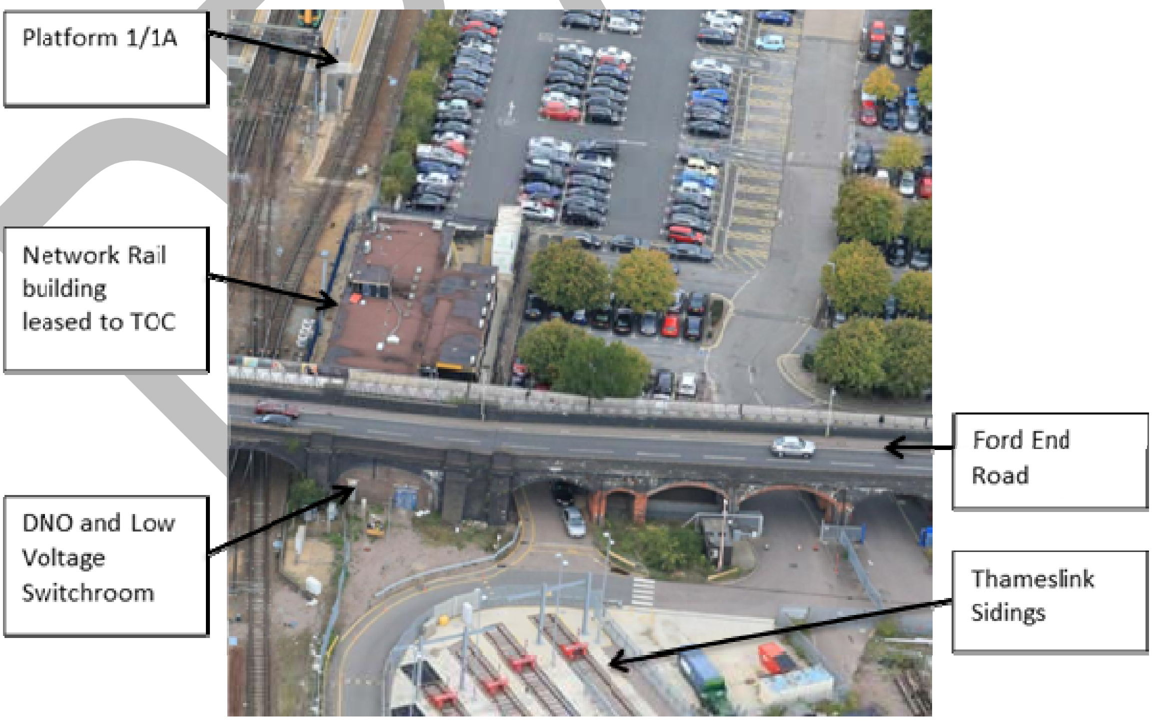
The signalling design that has been considered is for the layout proposed in Figure B10 below. It should be noted that there are future signalling projects planned in the area such as ETCS and that it would be strongly recommended from an efficiency and planning perspective, for projects to be planned, designed and delivered together; however, there will be significant interlocking and control changes to be considered as a result. Signal sighting will also need to be addressed in future stages of development and there is risk that this will generate further alignment alterations.

Figure B10: Signalling design for proposed layout at Bedford Maintenance depot



The loss of parking spaces for the station could be replaced with a new multi-storey car park and, indeed, options already exist to incorporate this within the station facilities complex. The Distribution Network Operator (DNO) connections, and other railway infrastructure and property, will need to be rationalised and relocated where necessary (see figure B11).

Figure B11: Bedford Midland Station area features



Any changes to the station will require consultation through the network and station change processes, it should be recognised that this process is likely to recommend that the station area would require electrification of the new infrastructure to permit flexibility of the operational timetable and during perturbation.

Regarding the highways to the north of the station building, a new single carriageway road has been constructed, the Great Ouse Way, running east-west across the Great Ouse river flood plain and its elevation is not known at the time of writing this report. It is envisaged, however, that the vertical alignment of the railway will have little flexibility for amendment due to the gradients and difference in elevation required to pass through topography near the Bedford and County Golf Course. This will require modifications to the highways, including any impact on Paula Radcliffe Way, however, this will require further analysis and design in the future and with stakeholder consultation being carried out on the options. Alternatively, EWRCS could run on the MML for a greater distance to the north and the eastern turnout could be provided further to the north which has the potential to reduce the impact on the road network.

There are complex interfaces between the operational railway, the local urban areas and the railway industry's light maintenance facilities that will require significant infrastructure interventions to achieve the service levels and maintain safe station functionality. The station modifications can be achieved through the reconfiguration of other railway infrastructure.

The Thameslink run-round used to access the depot has been identified as one of the main issue locations of the existing infrastructure that would need to be addressed. This has been consideration as part of the East of Bedford connectivity option, included within this report; and within a separate MVL study that is due for completion by March 2019.

The industry rules for the safe working of the Bedford Maintenance depot, and the required rolling stock moves, require further assessment and assimilation into a pathing structure to verify the flexibility and capacity of the current layout and stress test it to a failure point. It is important to undertake early consultation with relevant stakeholders to ascertain their input and views on any alterations to the existing layout and arrangements that are likely to be required for EWRCS options via Bedford Midland station.

Costings – Bedford Midland Station

The assumptions made in support of previous scope cost assumptions regarding necessary works at Bedford Midland Station (Routes C1 and C3) were challenged and updated.

The key areas of cost sensitivity to note is that the previous 2d assumptions and allowances regarding the scope (and thus cost) of the station alterations were found to be reasonable and representative of the envisaged requirements.

The one area where existing assumptions were found to be significantly deficient was it the belief that EWR WS would deliver the necessary upgrades as far as Bedford Midland. This appear to be incorrect and the assumption is now that significant modifications, up to and including relocation of depot facilities, may be required to deliver the envisaged ITSS to Bedford Midland. An allowance of £240m has therefore been made for the route through Bedford Midland and the cost estimates for C1 and C3 have increased accordingly.

Conclusion – Bedford Midland Station

The purpose of the study was to determine if the assumptions made within Phase 2d with regards to the station layout and cost allowances for the purposes of route evaluation were reasonable. This study has concluded so far that they were.

However, the Phase 2d assessment assumed that EWRWS would provide all necessary infrastructure solutions to get the ITSS service to Bedford Midland. Since then, it has been confirmed that this will not be the case and, the level of service specification, including EWRCS services, will have an adverse impact on a level crossing and operation of Jowett and EMU sidings to the south of Bedford Midland station. A cost allowance for addressing this has, therefore, been incorporated into the route evaluation. Work has been instructed to Network Rail by EWR Co within Phase 2f to investigate solutions to accommodate the assumed ITSS in the south of Bedford area.

B.11 Wixams Station

The analysis carried out in this section is to inform the option selection process in relation to how a potential new station at Wixams, on the MML, and associated alignments, could impact on the capital cost for EWRCS route options. A design to Approval in Principle (AiP) level, was previously prepared for the current preferred station proposal by local developers.

For the purposes of this analysis, 3 options to connect EWRCS with a new station at Wixams were considered shown in Figure B12 below. These are:

- A1 – a split level station passing over the MML

- A2 – a split level station passing over the MML

- A3 – an at grade station running parallel to the MML

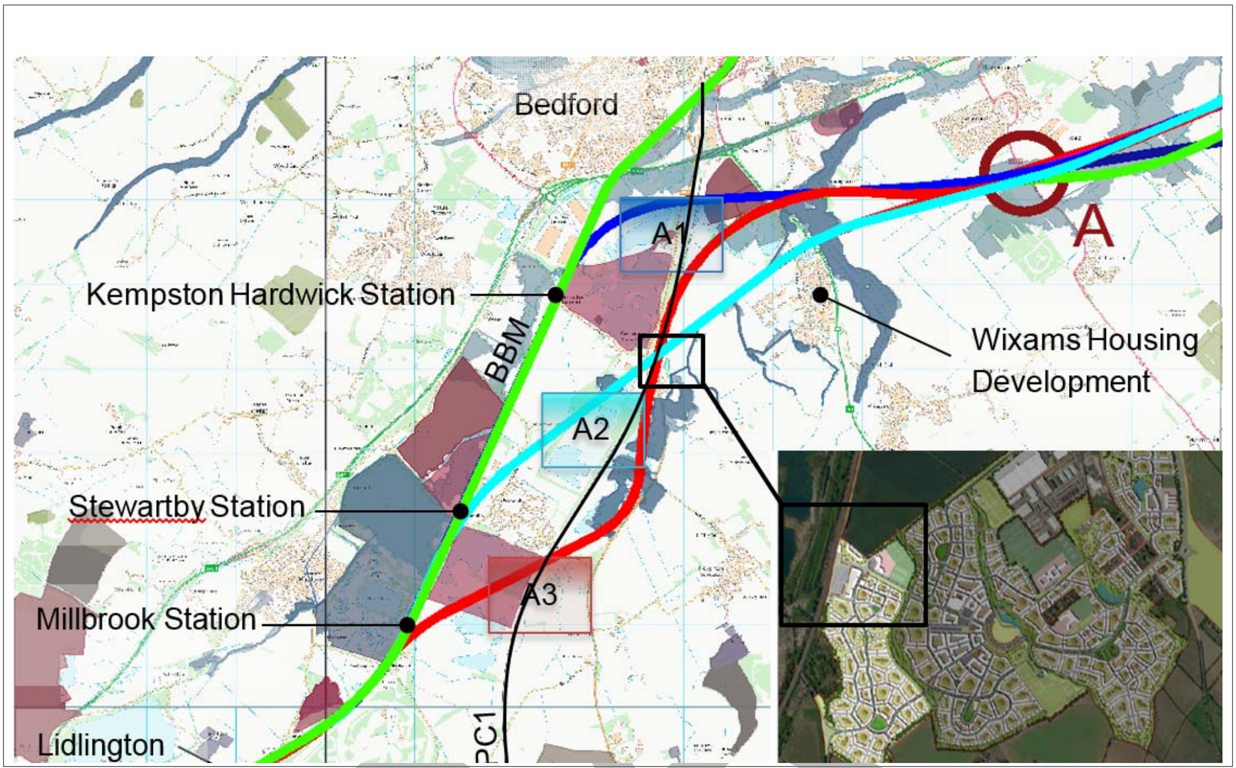
N.B. These references are different to the route option references.

However, as this new station was not being progressed at the time this phase of study commenced, the A2 route option is based on Bedford Borough Council's Bedford Master Plan which is in the public domain.

N.B. Network Rail has recently learned that the funding shortfall to build a new station at Wixams has been resolved and, therefore, work to progress the design and implementation of this is likely to progress over the next couple of years.

Figure B12 below is from the Phase 2d report and was taken as the starting point for the analysis carried out. The three alignments to/from the MVL to a station to the south of Bedford, and connecting to EWRCS are shown were then considered further using additional data, such as local bore holes. The A1 alignment is consistent with the concept for a Bedford South Station, and alignments A2 and A3 are consistent with a new Wixams station, but all are within the same geographic area in transport assessment terms. For further details on this section please refer to Appendix B7 - Wixams Route Option Sensitivity Report.

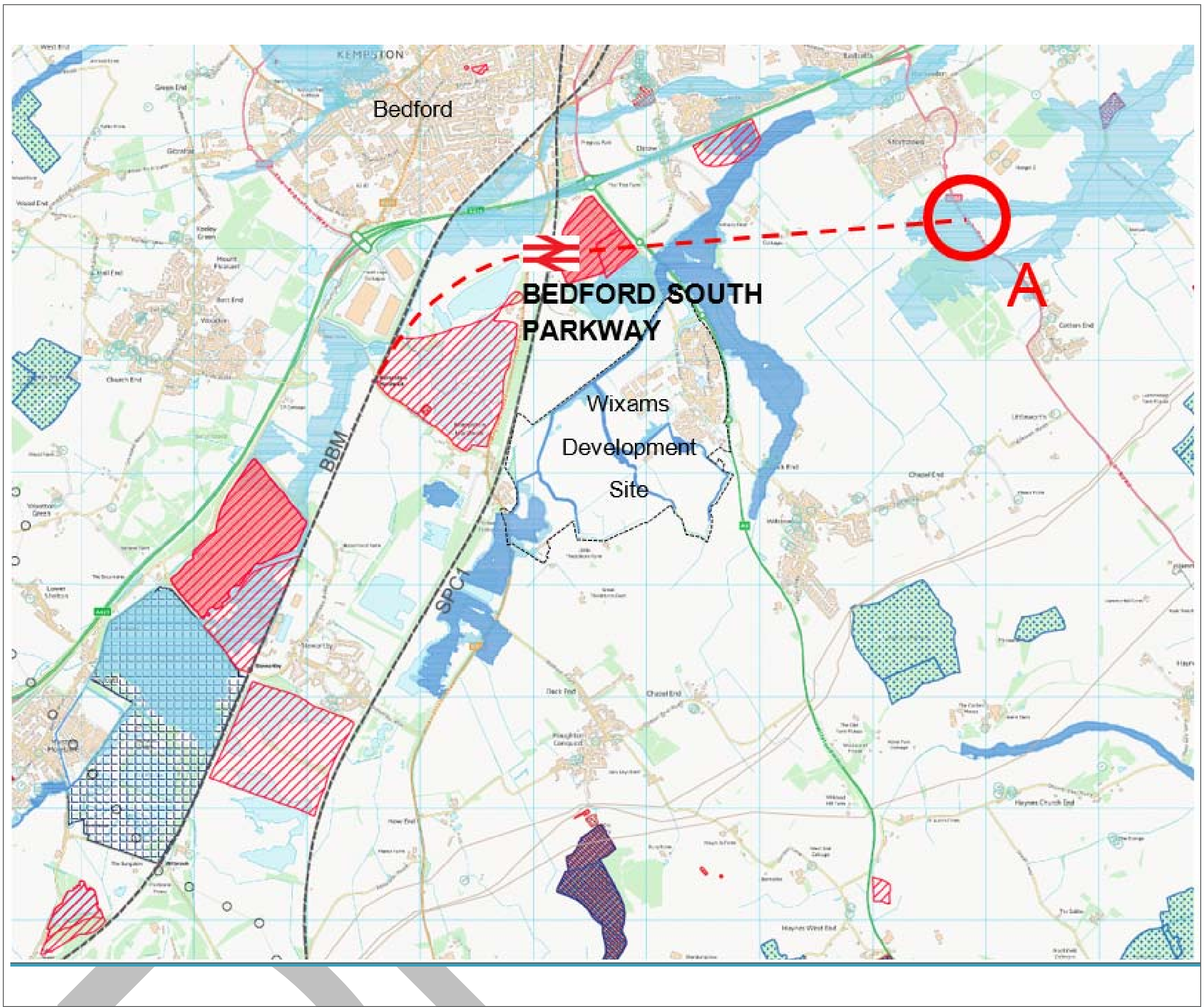
Figure B12: Phase 2c Routes: MVL Divergence to Point A



Based on the possible Phase 2d route option alignments, the routes selected for development are based on certain criteria as shown below:

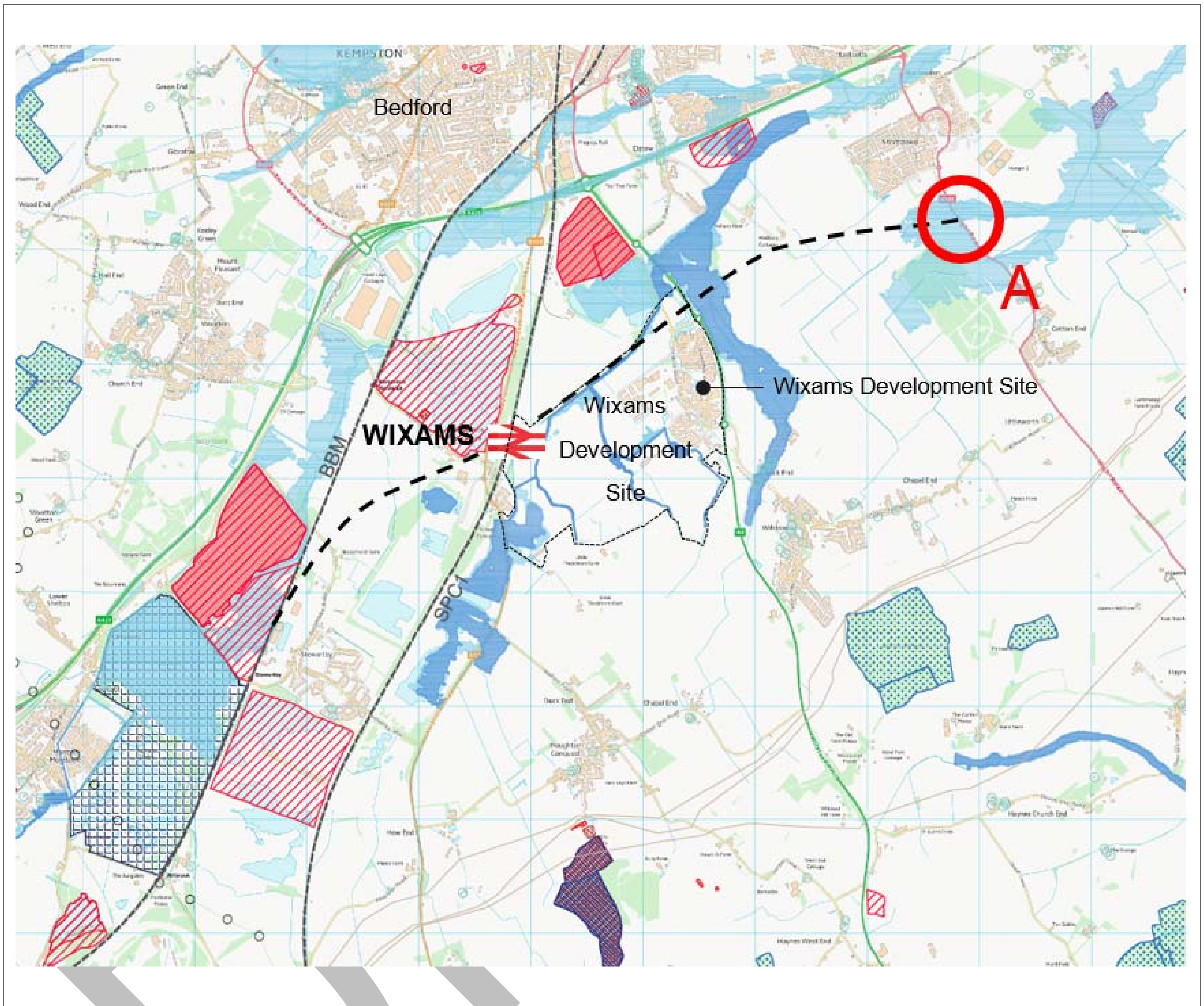
1. Route option A1, shown in Figure B13 below, appears to provide the optimum interface with the MVL, and any further infrastructure enhancements that may be made to this route in the future (currently being considered as part of a separate study by Network Rail). A1 is also the shortest new route alignment, however, as a result, it goes through the adjacent former land fill site resulting in the potential requirement to undertake significant works to mitigate this at a considerable cost. The East of Bedford options, which have also been considered as part of this report, assume a connection to this alignment.

Figure B13: Possible Alignment for Route Option A1 for a new Bedford South Station



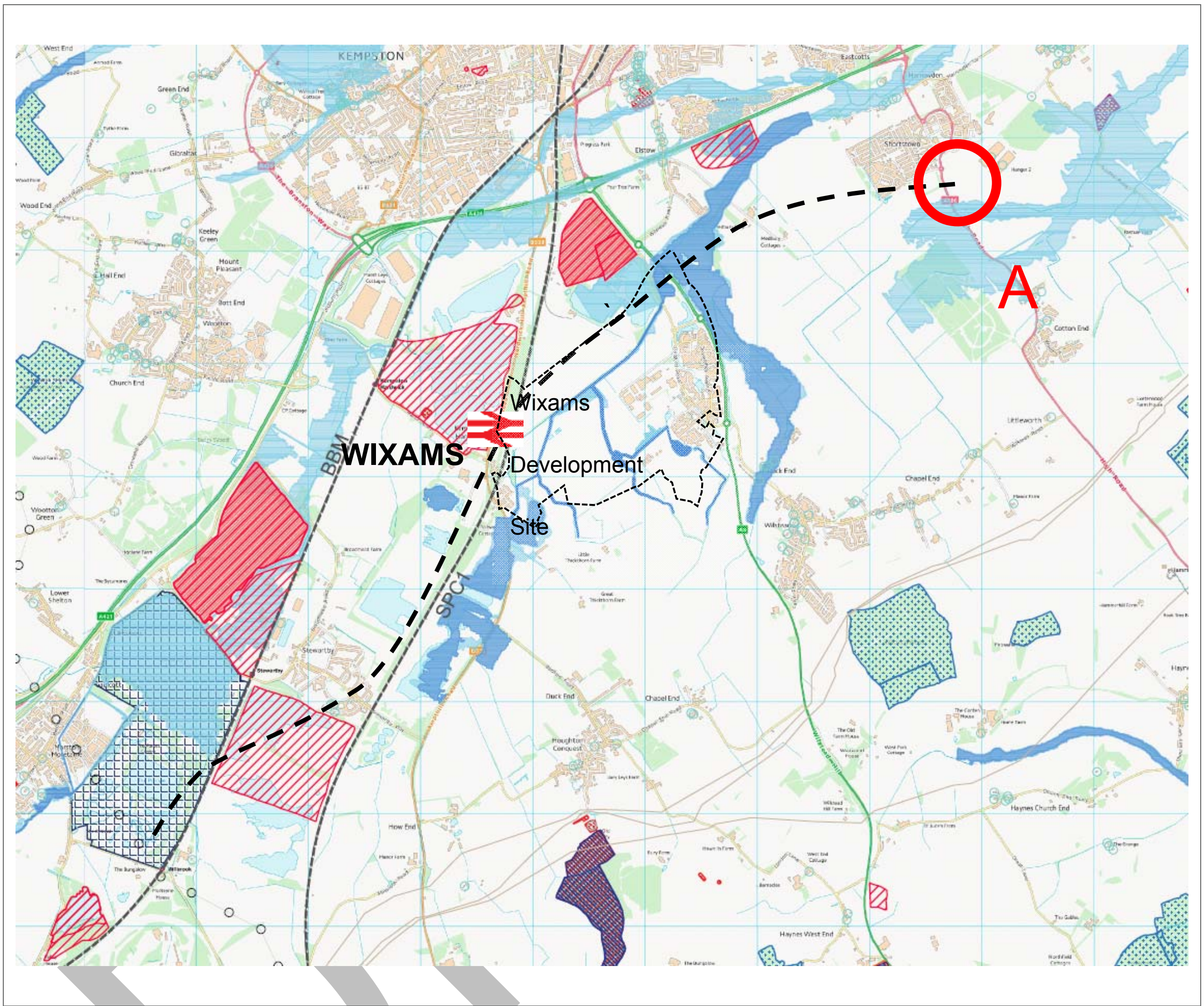
2. Route option A2, as shown in Figure B14 below, has the benefit of avoiding the former land fill site at Elstow but requires an increase in route miles to do so. This option is not sympathetic to the relatively recent Wixams residential housing development as it would require some properties to be demolished.

Figure B14: Possible alignment for Route A2 at a new Bedford South Station at Wixams



3. Route option A3, shown in Figure B15 below, has the greatest increase in route miles for EWRCS in this assessment, and also has the greatest impact on existing, and proposed, developments in this area, However, it has the benefit of a simpler station configuration which could be built and operated from ground level, rather than on an overbridge, as with the other options. This option provides a grade separated crossing over the MML, and then 2 dedicated tracks for EWR services run in parallel along the eastern side of the MML, before diverging off to the east, after the new station. .

Figure B15: Possible alignment for Route A3 for a new Bedford South Station at Wixams



Full station schematics for each location are included within the report in the Wixams Route Option Sensitivity Report (Appendix B7).

Key Findings

From the perspective of constructability, route options A1 and A2 both offer split level stations with EWRCS passing over the MML. This brings additional costs to the construction and maintenance of the facilities, particularly with respect to access requirements to the operational railway and may benefit from further development with regards to optimising the position of the new infrastructure.

A1 is the shortest route, proposing a route between gravel pits and former land fill sites to minimise impact, but it does have a significant impact on the former land fill site at Elstow, as discussed.

A2 avoids the capital cost of remediation of the former land fill site at Elstow but this might pass over land that has permission for extraction or land fill in the future or land that has been worked in the past and not recorded. This option also has the potential to negatively impact new housing developments in the area.

A3 has a simpler station layout, being an at grade station, however, it requires repositioning of the existing track and other infrastructure on the Slow lines of the MML, for which multiple possessions for access would be required. These details are contained within the Wixams Route Option Sensitivity Report (Appendix B7).

All the routes are sensitive to an increase in land remediation costs. It is known, for example, that this area was previously used for industrial output during the war and it is not known what measures were adopted on decommissioning.

The comparison below in Table B19 shows that the A1 route option has the least construction scope of the options.

In terms of the analysis undertaken in this phase, if the priority is to minimise the linear length of the infrastructure, then route option A1 would be preferable. Route options A2 and A3 would allow building of a new station at Wixams, providing passenger connectivity between MML and EWRCS services.

Table B19 below provides a comparison of the buildings/civils requirements for the different options outlined above.

Table B19: Comparison Table for a new Bedford South Station at Wixams

	A1	A2	A3
Buildings and Civils			
Route Length Comparison (km)			
[1]Route length from (ELR:BBM) divergence to Point A.	5.4	7.2	9.8
Route Plan Areas (m²)			
Plan area / footprint of alignment corridor to extent of earthworks	106,080	194,460	317,177
Maintenance track area	19,710	26,280	35,770
[2,3]Earthworks (m³)			
Earthwork cut	9,747	7,932	18,135
Earthwork fill	356,660	665,095	1,553,795
Deficit (-) / surplus (+)	-346,913	-657,163	-1,535,660
Track Formation (imported fill/Ballast)	19,440	25,848	35,172
Volume of material to be relocated from the former Elstow authorised	919,908	-	-

	A1	A2	A3
landfill site/former pit relocation (Applies to A1 only)			
Private Building Demolition/Purchase/Relocation (no.)			
Buildings directly impacted	5	3	4
Road and Rail Bridge Infrastructure Requirements and Related Earthworks			
Road - Rail bridges (no.)	**4**	**6**	**7**
Overbridges (no.)	1	2	1
Underbridges (no.)	3	3	5
Other Viaduct / Multispan/ long span bridges	-	-	1
SPC1 flyover single long span bridge (m/m^2)	-	-	60/672
SPC1 split level interchange station (m/m^2)	50/560	50/560	-
Road Bridge Earthworks (m^3)			
Road bridge construction cut volume	0	0	0
Road bridge construction fill volume	26,900	53,800	26,900

	A1	A2	A3
Deficit (-) / surplus (+)	-26,900	-53,800	-26,900
Total new road construction length (m²)	**325**	**650**	**325**
Total new road construction area (m²)	**3,997.5**	**7,995**	**3,997.5**
Track and Footpath Bridges			
Track bridges (no.)	**0**	**1**	**2**
Overbridges	0	0	1
Underbridges	0	1	1
Additional vehicular track bridges (for land access - min. 1 per 1600m) (no.)	**1**	**1**	**1**
Overbridge (no.)	1	1	1
Underbridges (no.)	0	0	0
Track Earthwork (m³)			
Track bridge construction cut volume	0	0	0

	A1	A2	A3
Track bridge construction fill volume	21,155	21,155	42,310
Deficit (-) / surplus (+)	-21,155	-21,155	-42,310
Footbridges (no.)	**2**	**3**	**2**
Overbridges	2	3	2
Underbridges	0	0	0
Track (Full route)			
SGVs 21-18.5-15-13 Double Junction	1	-	-
SGVs 28 Transitioned Crossover	-	1	1
SGVs 28 Transitioned Turnout	-	2	2
HVs 32.365-28-21.829-18.5 Double Junction (nr)	-	-	-
Length of twin track plain line (km)	5.4	7.2	9.8
3no SGVs 28 Emergency Crossovers	-	-	-

	A1		A2		A3	
Signalling (based on 90mph) Refer to Appendices in the technical report for signalling calculations						
Signalling Asset	No.	SEUs	No.	SEUs	No.	SEUs
3 aspect signals Up Line	-	3	-	4	-	5
3 aspect signals Down Line	-	3	-	4	-	5
Emergency crossovers	1	4	1	4	1	4
Double Junction	1	6	1	6	1	6
Staff protection systems (LOWs, TOWS)	-	1	-	1	-	1
[4]Total SEUs		17		19		21
Electrification and Plant						
Principal Supply Points (per 7km)	1		1		2	
Station						

	A1	A2	A3
Total Platform, car and cycle parking area	Refer to technical report appendices for quantities		

Costings – Wixams

In the scenarios tested wherein routes A1, and E3 were deviated from the base alignment to serve a potential new station in the area of the Wixams development. The potential cost impact (saving) was £161m, when compared to those routes serving a station at the site identified in the Phase 2d study as Bedford South Station location.

However, it should be noted that the station infrastructure costs for both location (Wixams and Bedford South) are actually very similar. The cost saving is almost entirely attributable to the fact that Wixams alignments avoid the former landfill site, and thus the significant cost currently assumed for dealing with that. It is entirely possible that more efficient ways of passing through the former land fill at Elstow could be found and it is recommended that further work is undertaken to understand this before a final decision on station location is made.

Any option via Wixams would result in a shorter length of the MVL being upgraded and this will need to be taken into account in any cost comparison between options.

Conclusion-Wixams

A number of options exist for a station proposed to the south of Bedford. The construction of the station and infrastructure would appear to be similar for all three options that have been assessed. The major variable is work included for crossing the former landfill site at Elstow. It is possible that there could be significant cost savings through further engineering development, investigating the contaminated land, or by adjusting the alignment. It is recommended that fulfilling the conditional outputs and strategic fit should determine the exact location of a new station should this option be progressed further.

The options considered as part of the East of Bedford analysis in this report should also be assimilated with the options for a new Bedford South Station at Wixams. It is recognised that any Wixams option results in a shorter length of the MVL requiring to be upgraded which will need to be taken into account in cost comparisons.

B.12 Flood Plain Strategy

Across the 8 route options covered by this assessment, there are a total of 29 sites where the possible route alignments cross watercourses or flood plain areas. The watercourse crossings vary in size, from minor watercourses regulated by Bedford Borough Council in their role of Lead Local Flood Authority, to more extensive flood plain areas regulated by Bedford Group of IDBs as the Internal Drainage Board. The main rivers passing through the study area are regulated by the Environment Agency.

The Phase 2d assessment proposed five viaduct crossings across the 8 identified routes options. These viaduct crossings spanned the entire width of the flood plain, presenting a ‘worst case’ scenario in terms of required viaduct lengths. This approach avoided the introduction of any flood risk impacts such as the loss of flood plain areas, or restriction of flood flow paths.

As part of this phase of development work, further assessment of the possible solutions, at each of the main river crossings, has been undertaken. Full details are provided in Appendix B8 - Value Engineering Report for Flood Plain Strategy. This sought to identify alternative viaduct options, which would require a shorter length of structure, with the intent of verifying that the cost allowance was appropriate and proportionate. These alternative options will still have an impact on flood risk, however, these issues are common in relation to all new infrastructure river crossings and there are recognised methods available to mitigate the impacts to a level that should be considered acceptable to the Environment Agency (EA).

The output from this analysis provides several alternative solutions that offer a reduction in the total viaduct length across each route option and should represent a likely ‘best case’ scenario in terms of proposed viaduct length. Also proposed, where applicable, is a potential mid-range solution which offers a reduced viaduct length from the Phase 2d proposal, but that has less impact on flood risk than the minimum viaduct length options identified.

Consultation with the EA has continued in this phase and EA river modelling data has been obtained to inform this assessment.

These revised solutions have been determined by desktop assessment and have not yet been subject to detailed assessment. However, it is envisaged that they will provide a basis for further assessment to be carried out using hydraulic modelling. Drawing 145674-NRD-UB-EWR-DRG-C-CV-400005, provided in Appendix A of the Value Engineering Report for Flood Plain Strategy (Appendix B8), illustrates the location and length of each of the crossings.

By reducing viaduct lengths from those proposed in Phase 2d, there will be a requirement to mitigate the flood risk impacts as a result of the flood plain loss, associated with construction of embankments in the flood plain, and restriction of the width of the flood plain. These impacts will require mitigation to prevent an increase in water levels upstream of the infrastructure.

To accurately determine the level of mitigation required, hydraulic modelling will be required, however, a preliminary assessment in this analysis has estimated indicative volumes of flood plain storage that could be lost across each of the 8 routes if viaduct lengths are minimised as far as possible. To offset this loss, it will be necessary to provide compensatory flood plain storage of an equivalent volume. This could be provided in the form of the creation of new drainage channels as well as third party land that could be used for the purposes of flood plain storage, although such land would probably have to be compulsorily acquired, or purchased, to do so.

These flood plain interface sites will require further assessment at subsequent design stages to determine the required form of each crossing (i.e. culvert, bridge, viaduct) and dependent on the strategy for the future Infrastructure Manager or as detailed in legislation.

The assessment related to the 6 route options from Phase 2d of EWRCS, listed as A1, A3, C1, C3, E1, E3, plus the 2 new route options of SN4 and SN5.

The analysis carried out identifies all locations where there is a potential impact on existing flood plains from any of the 6 route options identified in Phase 2d plus the 2 further route options identified for assessment in this phase (SN4 and SN5). No hydraulic modelling of the crossings has been undertaken at this stage of development. The assessment has been via desktop analysis with a view to providing a starting point for a hydraulic assessment to be carried out in the future.

This desk top assessment has been undertaken based on flood plain information requested from the EA in the form of the Flood Map for Planning and additional EA modelling data. Where alternative or reduced viaduct lengths are identified, it will be necessary to cross areas of flood plain with an engineered embankment. In these instances, the volume of the embankment will displace any flood plain attenuation capacity or volume used for the storage of water during times of flood. In these instances, it will be necessary to compensate for this loss of volume with provision of an equivalent area termed compensatory storage.

Three main rivers are crossed by the route options:

- the Great Ouse which flows from Bedford in a north easterly direction
- the River Ivel which flows north, mid-way between Bedford and Cambridge and converges with the Great Ouse
- the River Cam which flows north east from Cambridge.

All three rivers have a significant corresponding flood plain area adjacent to the main river channel and each presents a significant crossing for EWRCS. The crossing of each river is discussed further in Appendix B8 - Value Engineering Report for Flood Plain Strategy.

Where there is an interaction with a watercourse crossing, or flood plain, it will be necessary for the EWRCS proposals to be designed and constructed to accommodate the following:

- remaining operational and safe for users during flood conditions
- providing no net loss of floodplain storage
- not restricting water flows
- not increasing flood risk elsewhere as a result of the above points under various test scenarios.

These measures have been considered more fully in the option development report (Appendix B8) Value Engineering Report for Flood Plain Strategy but will need further development to be incorporated into the design and documented as part of a Flood Risk Assessment in the Environmental Assessment for EWRCS provided at later design stages.

Output from Analysis

A variety of options are available to mitigate impact on the flood plain and, for the purposes of this analysis, a mid-way solution has been adopted. The Phase 2d report applied the principle of a full viaduct in flood areas. Option 1 reduces this to the minimum and option 2 was developed to take due regard of realising the reduction, but still providing a realistic view pending the outcome of future hydrology studies. Therefore, option 2 has been used as the basis for the assessments. Table B20 below shows the values considered.

Table B20: Comparison of Phase 2d report viaduct assumptions against the outputs of Phase 2e report for Option 2 mid-range interventions

Crossing ID	Maximum viaduct length from 2D report	2E Option 2 'mid-range' Alternative viaduct length (metres)		2E Option 2 Embankment volume increase (Cubic Metres)	2E Option 2 Attenuation compensation (Cubic Metres)
		Proposed	Reduction		
4	860	230	630	124,143	720
13	1000	550	450	132,616	NA
17A & 17B	700	390	310	113,611	4,880
17C	300	NA	NA	NA	NA
18	880	NA	NA	NA	NA
19	650	500	150	17,490	3,720
21	800	650	150	21,404	4,730
29	600	260	340	73,814	3,180

Key findings

Due to the difference in construction costs between embankments and viaducts or bridge structures, there is a cost reduction benefit anticipated for the installation of earthworks within the identified floodplain areas. The exploration of this has resulted in the assessment of the various route options, and the reasonable opportunities that may exist as a result. However, future studies will need to take a move informed view on the position outlined in this analysis. Some of the areas for consideration and discussion are identified below, but there will be other issues to emerge once data is available for analysis in later phases.

From an initial view of the flooding data, it is apparent that much of the floodplain area is susceptible to limited inundation depths of approximately 1m, in the areas where embankments are proposed, and the probability of flooding events is low. By applying the option 2 solutions, it is possible to mitigate the worst effects of the flooding by using viaducts and still take advantage of the cost benefits of using earthwork structures.

Within floodplain areas, it is common for there to be soft ground. Engineering in soft ground requires some caution as excessive, or uncontrolled, settlement, will result in a poor track quality and loss of route resilience. Settlement can be achieved through consolidation over time with surcharged embankments. A reduction in the time that the consolidation takes can be achieved through measures such as wick drains (Prefabricated Vertical Drains (PVD)), and incorporating monitoring systems, as designed by geotechnical engineers once the conditions are understood.

The consolidation achieved is due to equalising pore water pressures through the migration of water in the soils. This will reduce the porosity of the land in the vicinity of the embankment and has the potential to change ground water movement and levels. Further studies will be needed to understand these properties in the strata affected. Other techniques are worth consideration, such as soil mixing, stone columns or ground replacement, or indeed a combination of some, or all, options.

In addition to the embankments, the railway drainage strategies will need to comply with run-off, and pollutant level, management. The visual impact of the embankments can be softened through sympathetic vegetation and landscaping designs. Controls will need to be in place to prevent the migration of invasive species such as Japanese Knot Weed or Himalayan Balsam, both of which are prone to populate railway corridors. In addition, scour protection and flood proof, maintenance access routes will need to be above the prevailing levels so that inspections and maintenance works can be taken without interruption, making the railway more resilient.

The embankments will have a greater impact on the neighbouring land owners than the viaducts and those who may require livestock and farm vehicle movement through, and between, fields, may place demands on routes to be retained. This will need to be investigated further as part of the land and consents strategy consultation activities.

Costings – Flood Plain Strategy

As previously described all 8 route options were assessed for their sensitivity to a change in assumptions as to what would be needed to mitigate the impact of the railway in flood plain areas.

One route, C3, was not affected by the change. All other 7 routes were affected and potential cost savings from between £37m (E1) to £315m (A1) identified. These savings have been incorporated into the updated AFC for the phase.

This remains an area of uncertainty, where cost is driven by not only by engineering requirements but also consents, particularly the EIA process.

Conclusion – Flood Plain Strategy

The study looked at the opportunity to reduce the length of viaduct structure and replace it with an earthworks embankment. This was anticipated to reduce costs through the use of cheaper construction methods. The benefits were significant where there were more flood plain crossings on routes which are through low lying floodplains, and less significant on the routes which cross the hills.

The approach has been to consider the use of an embankment solution, in place of viaducts. In addition, crossing rivers and surface water run off channels have been addressed through using traditional bridge structures and culverts. This change in approach alters the risk profile as the flood attenuation and compensation areas need to be evaluated, provided and maintained.

B.13 Shepreth Branch Junction

There is a need to optimise a solution for the interface between EWRCS and the existing rail links into Cambridge from the south on the WAML – see Figure B16 below. The current proposal for this is where the lines from Liverpool Street Station to Cambridge (BGK) and Hitchin to Cambridge (SBR) converge at Shepreth Branch Junction. For further details on this section please refer to Appendix B9 - Value Engineering Report for Shepreth Branch Junction

Figure B16: Diagram showing the geographical layout of Shepreth Branch Junction

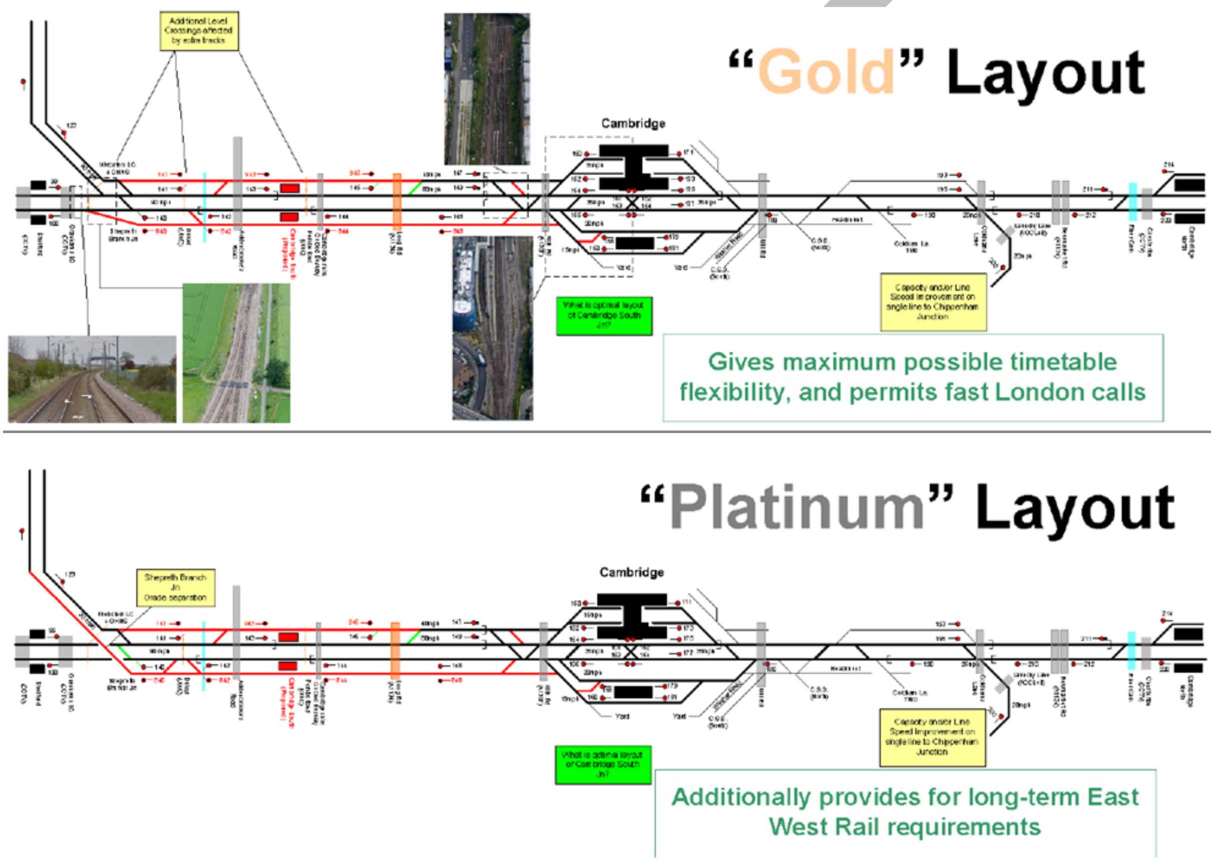
EWRCS will potentially merge with the SBR at grade somewhere between Foxton and Harston. Further analysis in the next phase of development will be undertaken to confirm the optimum junction layout.

Shepreth Branch Junction will also be affected. This is a heavily utilised junction and previous development work, undertaken by the Network Rail Anglia System Operator Strategic Planning Team, proposed a grade separated junction as shown in the Platinum option in Figure C17 below.

This envisages a four-track railway from Shepreth Branch Junction to Cambridge station, with EWRCS joining the SBR before the proposed grade junction. However, the infrastructure required for a new compliant grade separated junction will not easily fit within the existing Network Rail boundaries and, therefore, it is anticipated that land will need to be compulsorily acquired, or purchased, to facilitate this proposal.

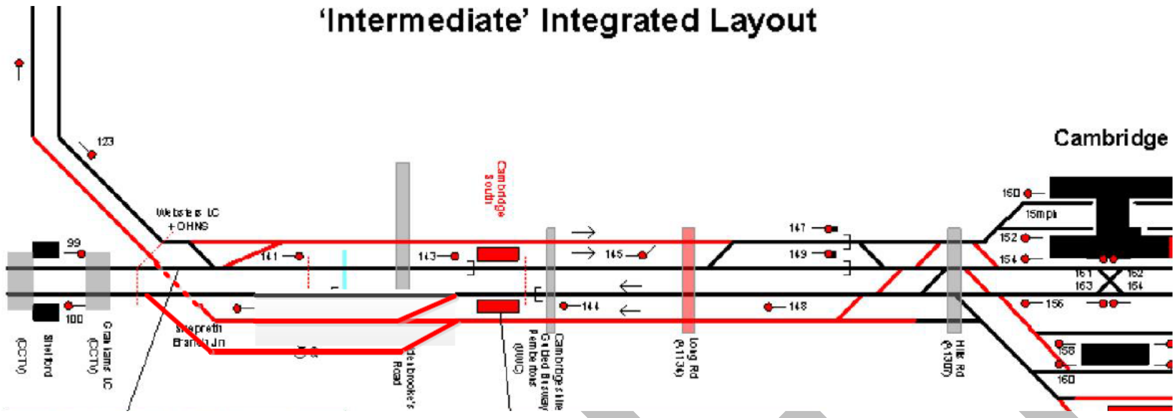
The gold option shown in Figure B17 below shows the Phase 2d layout for an at grade junction, however, the Network Rail Anglia report (see Appendix B12) concluded that this will not provide the capacity required to accommodate EWRCS services, and the platinum solution was progressed for further development.

Figure B17: Possible solutions for interface between EWRCS/SBR and WAML at Shepreth Branch Junction (extract from Appendix B12)



Phase 2d considered how the Platinum layout might be achieved by developing options based on alternative track layouts and identifying conflicts and constraints. Following further input (see Appendix B12) from the Network Rail Anglia team, Phase 2e considered the intermediate integrated layout shown in Figure B18 below. This added a loop to ease perturbation and traffic capacity constraints, during and post construction, and an additional turnout on the Down Slow.

Figure B18: Shepreth Branch Junction intermediate integrated layout



Note: In previous development work it was considered whether it would be possible to use part of the former route known as the Varsity Line, however, this has been utilised for the Guided Busway that serves Cambridge and surrounding areas and is managed by Cambridgeshire County Council.

Key Findings

The selected site for the grade separated junction identified in the Phase 2d Platinum option has several significant constraints. Generally, these are urban areas, topography, flood plain and former clay pits, designated environmental and heritage sites, including SSSIs, SACs, SPA's, Nature Reserves, Listed Buildings and Scheduled Ancient Monuments (SAMs), all of which have been identified as relevant in this area. These remain the same for the 'intermediate' integrated layout of Phase 2e.

Unless specifically stated, designated environmental and heritage sites, such as SSSI's, SAC's SPA's, Nature Reserves, and Listed Buildings have not been used to drive route alignment at this stage of design, however, they have been noted and are reflected in the risk register. One specific designated site that the analysis recommends should be avoided is the SAM site located between Addenbrooke's Road and Great Shelford, based on the complexity of the consents process and other viable options being available. The area is also listed on the Historic England Sites at Risk Register for 2016.

Changes to Shepreth Branch Junction are, therefore, significantly constrained by existing housing developments and transport infrastructure, as well as the preference to avoid the designated SAM site.

In the previous analysis undertaken in Phase 2d, the location of a proposed new station to the south of Cambridge was not defined and, therefore, it is shown just south of the A1134, or Long Road, where it can easily be linked to the Guided Busway. Given that the location of the proposed new station has not yet been finalised, on the Platinum layout it is shown further south, between the Guided Busway on the spur route to Addenbrooke's Hospital and Addenbrooke's Road which was opened in 2010. This is currently the preferred solution for the project that is being led by Network Rail Anglia Route to consider the new station and capacity requirements between Cambridge Station and Shepreth Branch Junction. The location of a new Cambridge South station has a significant impact on the design outputs as it reduces the site's length and forces compromises to be made on gradients, reducing them to 1:30 in some scenarios. Though this is permissible, it is undesirable and would be prohibitive to freight traffic and this is being considered further in the next phase of development to review the optimum solution for all known aspirations for enhanced infrastructure in the area to the south of Cambridge.

Due to location constraints, any grade separation would be achieved at a tight angle (high skew), with electrical clearances required on WAML and SBR. This requires a deep structural construction depth resulting in rail to rail separation of up to 10.0 metres. At 1:125 (0.8%), an end to end site layout of circa 3.2km (allowing for S&C and traversing WAML) is necessary, or at 1:80 (1.25%), circa 2.3km would be required, with an additional 250 metres dependant on the S&C configuration to Cambridge station throat. The existing distance from the Cambridge point ends of the Shepreth Branch Junction to Addenbrooke's Road is 1.2km and to the A1134 Long Road is 2.4km. The location of a new station is, therefore, critical to this junction layout and its development should be integrated with the junction design with all associated constraints and design parameters considered.

As the location of the station is not yet fixed, it should continue to be assessed on the assumption that a new grade separated junction will need to be implemented for EWRCS. Based on the discussion above this would indicate that a location near Long Road is preferable for the new Cambridge South Station.

Options to address Platinum and 'Intermediate' Integrated layouts

In all cases, the Down Royston Slow lines to Cambridge will be at grade. For the Up Slow lines, the options, are as follows, assuming a rail to rail separation of 8.0m:

- **Option 1** – starting at the new (c.2010) Addenbrooke's Road bridge, railway to dive under the BGK lines and A1301 Cambridge Road and connect to the SBR Up Slow lines

- **Option 2** – following the same alignment of Option 1, but, in addition, construct a flyover starting to the south of Addenbrooke's Road bridge and rising over the BGK lines and A1301 Cambridge Road and connect to the SBR Up Slow lines

- **Option 3** – starting to the south of Addenbrooke's Road bridge, railway to rise over the BGK lines at a rising 1:91 gradient and reconnect to the SBR Up Slow lines at the A1301 Cambridge Road bridge with a descending 1:30* gradient. (Note: some lowering and realignment of the BGK lines is required for this option)

- **Option 4** - as option 3, but with an approach gradient of 1:31* and a decent of 1:53*. This is a derivative of the option outlined in Phase 2d but with the proposed new station 500m further south. (Note: some lowering and realignment of the BGK lines is required for this option).

*Though technically permissible, gradients exceeding 1:80 are non-preferred and unlikely to gain Network Rail Route Asset Manager (RAM) or freight operator support.

Note: incorporating the grade separation and the station (i.e. split level) was not considered but could be investigated in future studies

These options are shown in more detail in Figures B19, B20 and B21 below.

Option 1 - EWRCS/SBR Up line dive under

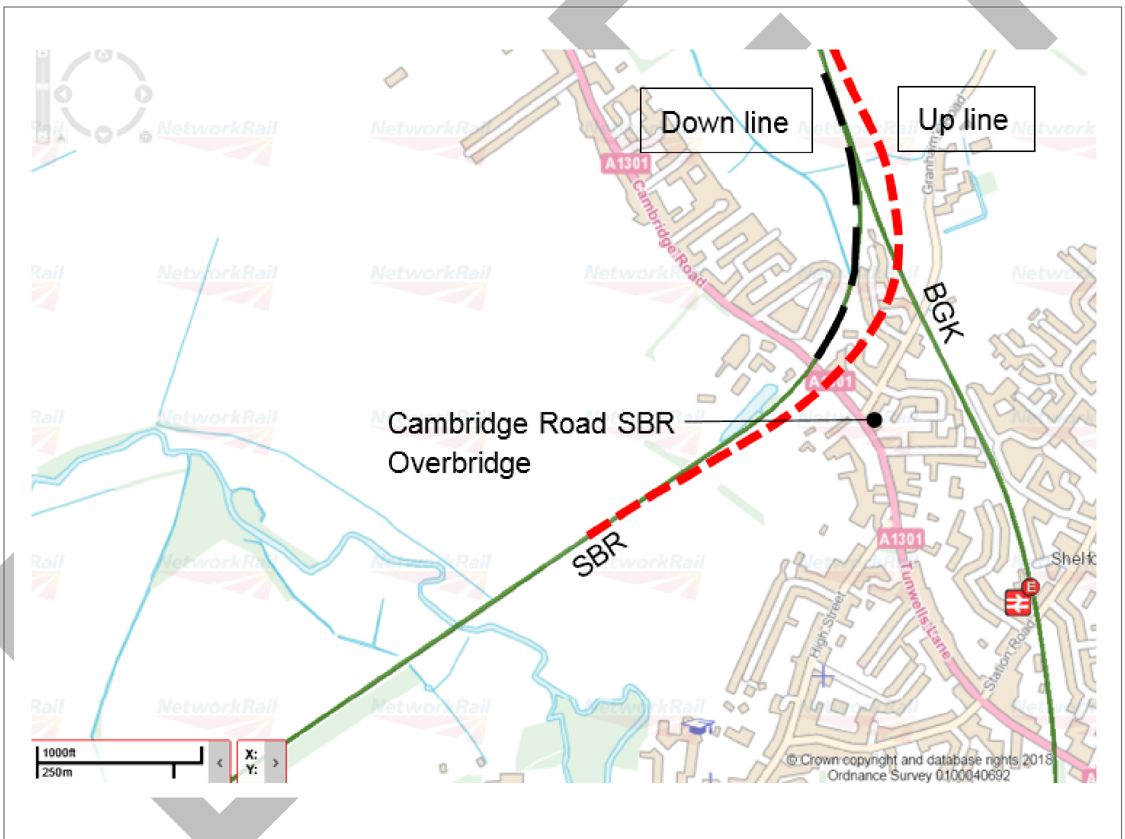
A new EWRCS/SBR Up line could be constructed in fields passing beneath Cambridge Road embankment, east of the existing SBR lines. This would significantly impact residential housing between the SBR and BGK, with multiple dwellings requiring removal.

A dive under could be constructed using cut and cover construction and box jacking under Cambridge Road embankment and the BGK lines, subject to ground conditions. The approach cutting length, and transition to ground retention (and type), would depend on ground water level in the area. If ground water exclusion was required, the box would need to be 'tanked' against ingress and positive drainage potentially provided to remove surface water.

Option 2 – EWRCS/SBR fly-over

A new EWRCS/SBR Up line overland solution could be constructed to provide a new flyover above Cambridge Road embankment and BGK crossing. Cambridge Road has an approximate 1:25 gradient from the junction with Hinton Way, to its south-eastern approach to the bridge position, limiting options to adjust the road’s vertical alignment. Therefore, a 10 - 11m high bridge crossing would be required to account for embankment height and road clearance. This would have a substantial visual impact on the area and may affect road user sighting.

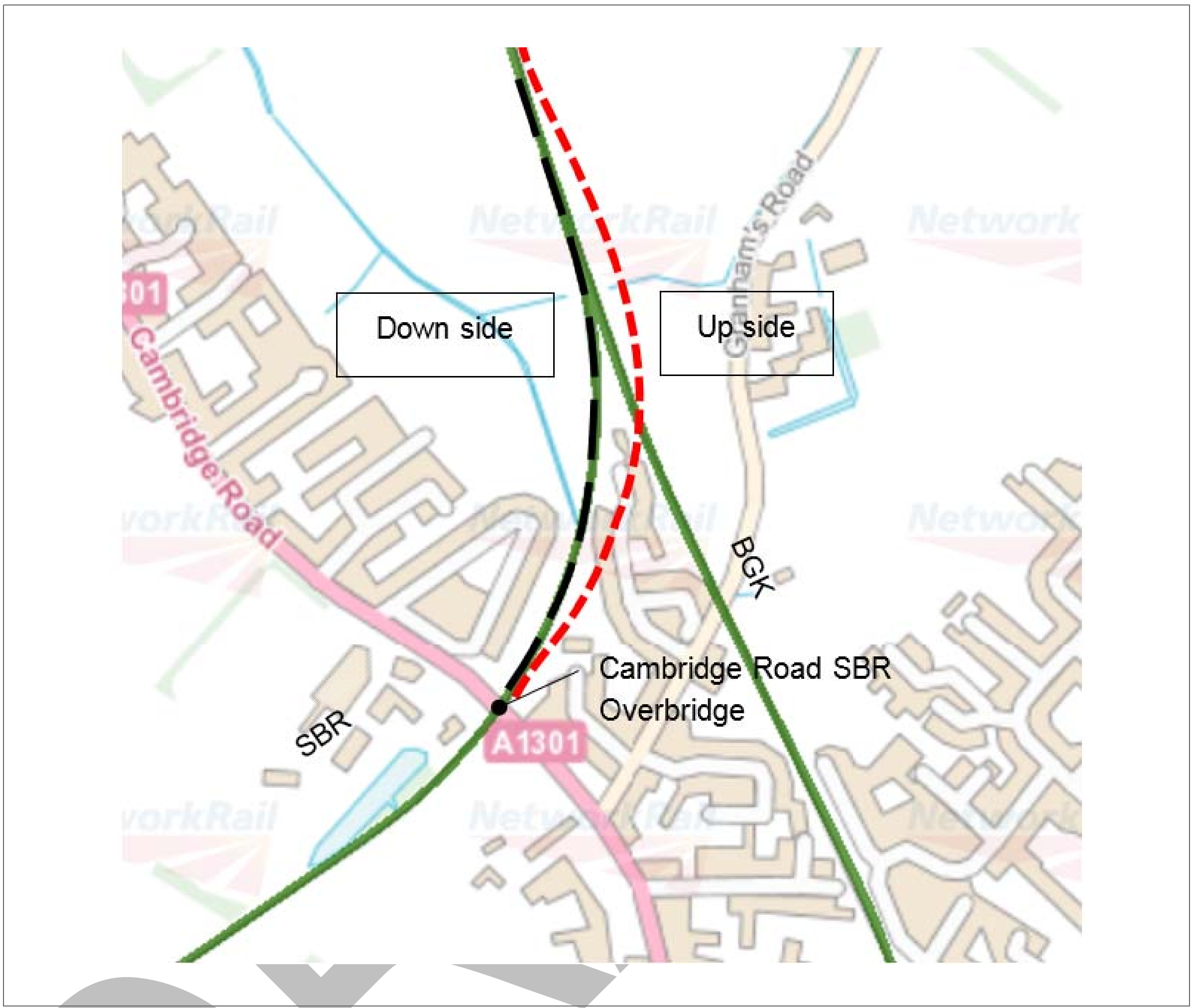
Figure B19: Shepreth Branch Junction Options 1 and 2 – Cambridge Road and BGK dive under



Option 3 Direct BGK fly-over

Several direct, over-ground, options have been explored, where the EWRCS/SBR Up line could increase in elevation following Cambridge Road overbridge to ‘fly-over’ the BGK lines. The Down line would remain with the EWRCS continuing to use the existing SBR alignment at grade. See Figure B20 for horizontal alignment.

Figure B20: Shepreth Branch Junction Option 3 – Direct BGK Flyover

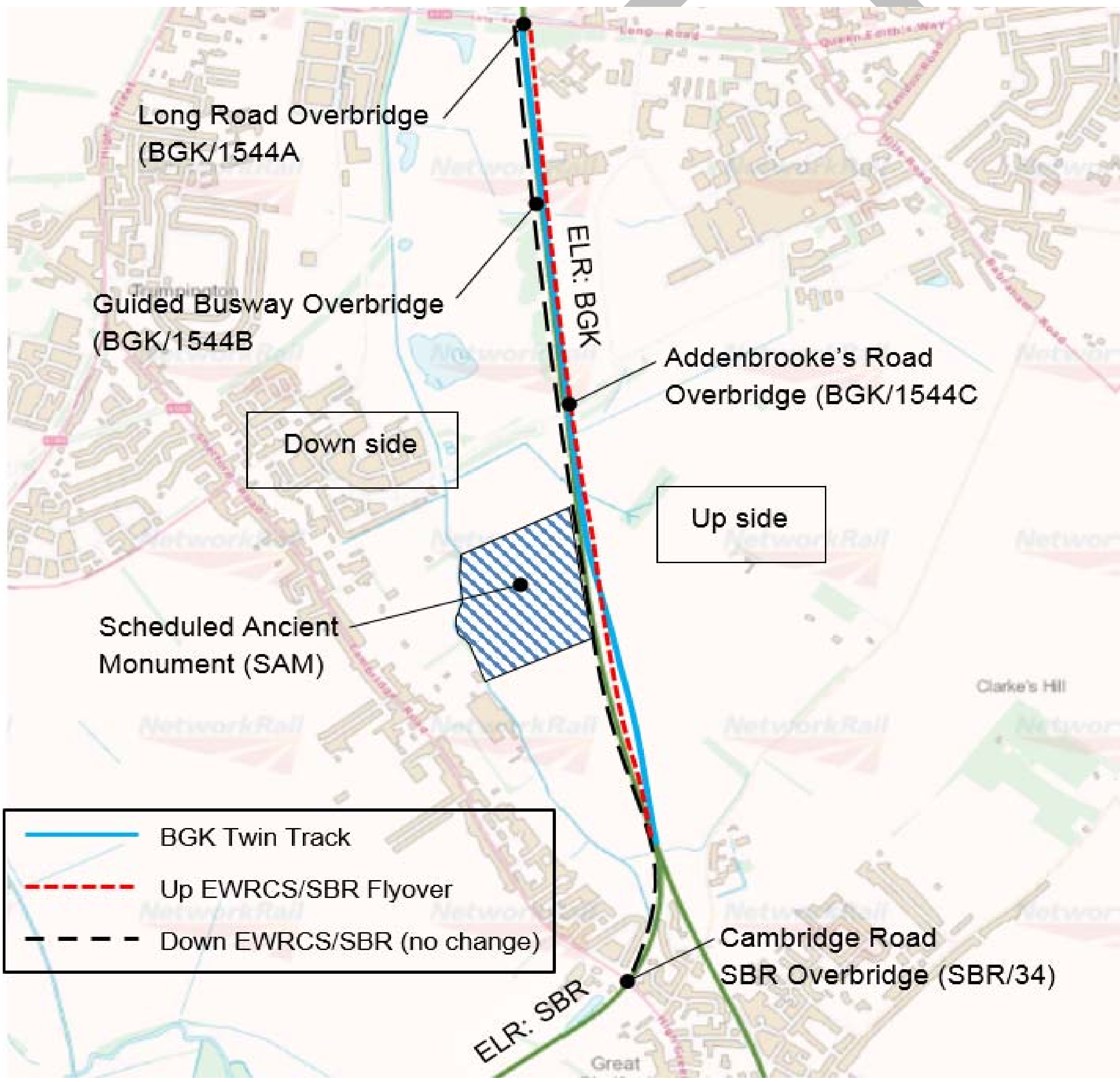


Following Cambridge Road, the Up line fly-over construction would remain close to existing SBR lines without encroachment on either existing Up, or Down, lines. The distance between Cambridge Road and the BGK lines does not allow for sufficient elevation gain at a compliant gradient to provide the required rail clearance. Lowering the BGK lines by an arbitrary 1.0m would also not provide sufficient clearance. Due to constraints discussed earlier, this option is compromised due to its limited functionality arising from gradient issues.

Option 4 Phase 2d proposed layout

This option was explored in Phase 2d as a solution to meet the requirements of the Platinum layout. It provided suitable track gradients near 1:125 but required the proposed new Cambridge South Station to be located further north between the Guided Busway overbridge over the BGK lines and A1134 Long Road overbridge. However, the schematics from the report produced by the Network Rail Anglia team for Cambridge South, (Appendix B12) indicate that the station is located south of the Guided Busway. See Figure B21 below.

Figure B21: Shepreth Branch Junction Option 4 – Phase 2d proposed layout



Route construction would begin after the residential area (and Cambridge Road overbridge), thus mitigating impact on those but would also require substantial elements of construction of the new route in open fields. The modifications could also be undertaken predominantly in a non-railway, non-operational environment with little impact on the existing SBR and BGK lines.

Key Findings

Due to the significant issues associated with developing an optimised solution for this section of EWRCS, further development of the interface is recommended to determine if a new Cambridge South Station could be located south of the Guided Busway enabling track gradients of 1:125 for the proposed grade separated junction.

Constructability of all the options should also be reviewed from a CDM Principles of Prevention perspective to see how it could be undertaken whilst the railway remains operational, maintaining OLE and electrical clearances and preserving neutral sections and signal sighting.

It should be noted that the Scheduled Ancient Monument (and Historic England At Risk Register) area has not been taken account of in detail at this stage of development and, in recent planning application determinations, indications are that any permissions to use this area will be challenged by relevant parties.

Digital signalling is assumed for this study, however, the CP6 Cambridge Signal Box renewal is understood to be for conventional control systems, implemented as Digital ready, and is expected to make provision for EWRCS and other traffic within the ERTMS readiness work scope. In any signalling demarcation discussion, regard should be given to traffic control protocols and maintenance boundaries. It is suggested that the limits of the Cambridge Signal Box should be extended to include EWRCS to enable visibility of approaching traffic. The existing boundary, between LNE&EM and Anglia Routes, is north of Royston and proposals would be expected to be geographically similar to these current arrangements (i.e. Ermine Way A1198).

Note: ETCS Level 3 would be required for existing lineside equipment to be reduced from current provisions.

Other than considering passive provision, OLE is not specified for EWRCS at this stage of development. However, Shepreth Branch Junction will have to be fully electrified to accommodate the existing OLE provision. In addition, the SBR line is currently electrified and provision to maintain this will need to be made. A run off OLE interface area will also be required between SBR and the EWRCS non- electrified route.

Costings – Shepreth Branch Junction

The connection at Shepreth junction is common to all options and is, therefore, not a factor in driving route selection, if the current assumption regarding accessing Cambridge from the south continues to be justified.

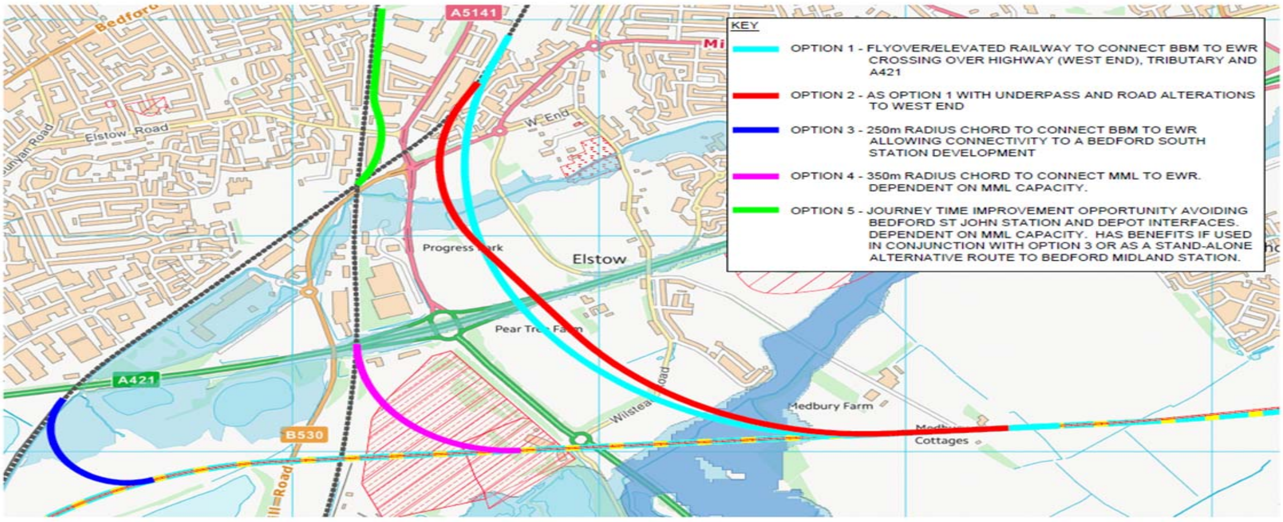
Conclusion – Shepreth Branch Junction

Having undertaken further analysis in this phase, there is a significant risk relating to the uncertainty of proposals for other interfacing infrastructure projects planned for the medium term in the same geographic area, particularly the proposal for a new station to the south of Cambridge. The location of a new station is critical to the junction layout required to accommodate EWRCS and its development should be integrated with the junction design with all associated constraints and design parameters considered. If the station is to remain between the Guided Busway bridge and Addenbrooke's Road, the impact on residents should be considered further. Positioning the station further north will result in less impact but the station may not be ideally located for the guided busway and walking/ cycling routes. Construction access and safe methods of work may also lead to issues that challenge the availability of land for the infrastructure to be implemented and it is recommended that these are considered further, with early contractor involvement to test viability and risk to the operation of the existing railway.

B.14 East of Bedford Connectivity

In response to issues raised in the NIC's report published in November 2017, Network Rail was asked by EWR Co to consider solutions for providing direct train connectivity into and out of Bedford Midland station, from a south-easterly direction from Cambridge. This would provide the equivalent ability to access Bedford Midland from the south to/from Cambridge as is provided by options that go via Bedford Midland to the north. The analysis in this section, therefore, investigated options for a twin track, eastbound connection from Bedford Midland station to Cambridge, including analysis of possible track geometry and gradient constraints, potential land take requirements, including 'rail locked' areas, and the preparation of a schedule of quantities for estimating purposes. The options considered are shown in Figure B22 below. For further details on this section please refer to Appendix B6 - Value Engineering Report for Bedford Midland Station.

Figure B22: East of Bedford Connectivity Options



BEDFORD EAST OPTIONS
NTS

For the purposes of this analysis the following was assumed:

1. Connection on to the MML shall be on to the Slow lines.
2. Bedford South Station could be constructed at either location currently proposed.
3. Service specification:
    a. 4x23m & 8x23m rolling stock
    b. Class 170 (or similar)[3] with 100mph capability
    c. An hourly service pattern for:
        i. all existing services plus
        ii. x2 additional Cambridge – Oxford fast services with no call at Bedford Midland but do call at a new Bedford South Station
        iii. x1 additional Cambridge – Bedford Midland – Bletchley – Milton Keynes Central service. (NB: includes a reverse move at Milton Keynes Central with no call at a new Bedford South Station)

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[3] Class 170 (or similar) was used for this analysis to be consistent with the indicative service specification that is being used in a separate study into capacity and linespeed improvements on the MVL being undertaken by Network Rail on behalf of EWR Co.

Key Findings

Analysis was via a desk top exercise, using data that was already available from previous option assessment phases, and previous reports on work carried out in that area. The route connecting Bletchley to Bedford Midland station (BDM) is on the MVL and is twin track from 1m 44ch until 14m 1466yds where the line becomes bi directional, and runs through Bedford St Johns station and Jowett Sidings, until reaching platform 1A of Bedford Midland station.

Four possible options were initially identified, all assuming a link to the A1 route option. There are other south Bedford route options still being considered e.g. A3 and E3, and all East of Bedford options could be adapted to suit these alternative alignments, but this has not been considered in this analysis.

These four options for a chord were developed and considered based on their geographic location.

In summary:

- Option 1 is a 1200m viaduct starting from the double junction at 14m 1466yds on the MVL with an at grade connection and connects to the A1 route option
- Option 2 is similar but goes below the highway known as West End in a box, or new, highways structure and continues over the A421 as per option 1
- Option 3 is a short chord from the MVL with an elevated, at grade junction to tie in to the A427 MML structure/embankment and connects to the A1 route option, avoiding interfaces with the former land fill site at Elstow
- Option 4 is a chord between the MML and EWRCS but joins the A1 route at the former land fill site at Elstow.

An additional option, Option 5, was identified that is a supplementary route which, if capacity permits, and S&C layouts can be amended, might avoid the remodelling of Jowett Sidings, as part of Bedford Maintenance depot, and Bedford Midland station southern throat, however, it bypasses Bedford St John's station and a nominal service would need to be retained to avoid closure. This could also be incorporated into all routes accessing Bedford Midland station and continuing north.

The works required to Bedford Maintenance depot, which has already had modifications to Jowett Sidings for Thameslink operations, and to the East Midland Trains' light service sidings area (also within Bedford Maintenance depot), to enable a 30mph twin track connection, are covered in the summary of Appendix B6 - Value Engineering Report for Bedford Midland Station. Should it be identified that the rules for the safe working and operation of the depot cannot safely be modified for the passage of trains, then it would be necessary for the EWRCS connection to be via the MVL which would require its closure in part, or in full, to accommodate this. A separate study being progressed by Network Rail for EWR Co, on options to enhance the journey time and capacity on the MVL, will be investigating this further and so a more informed view may be taken following this work which is due for completion in March 2019.

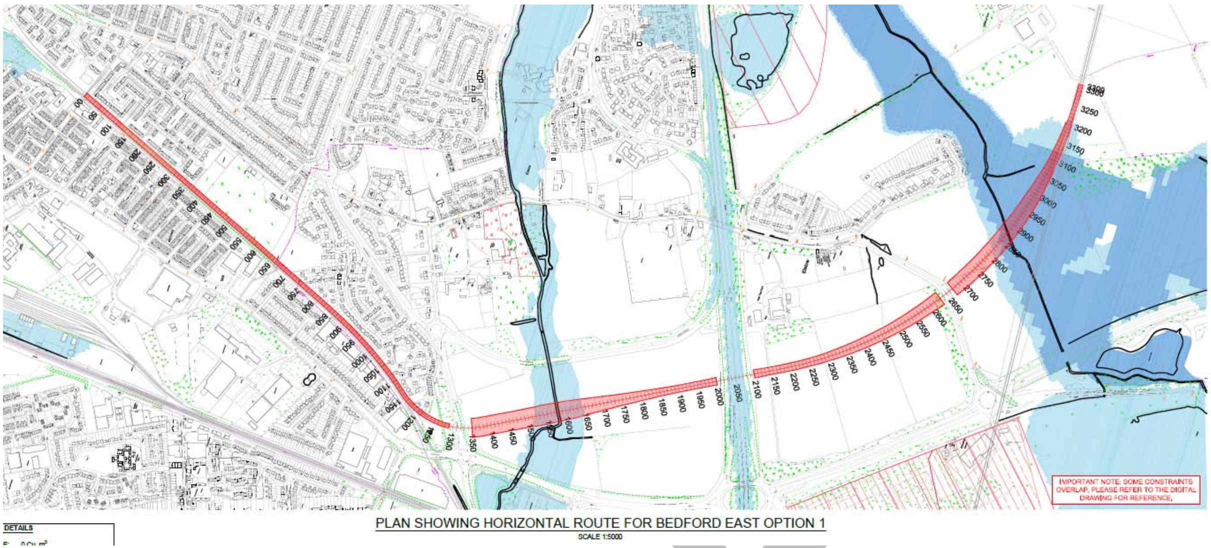
An option to provide train connectivity that would join the MVL to the Fast lines on the MML was not progressed as part of this analysis as the introduction of a new junction may reduce the line speed on the MML and it may also not be possible to install S&C, to transfer from one pair of lines to another in the approach throat to Bedford Midland station, due to the cant and level differences between tracks / platforms.

Options 1 and 3 were estimated to provide a maximum to minimum range in costs so that they can be set against journey times to give a cost per minute. All options will need further consideration and assessment for viability in future stages of development for EWRCS, depending on whether they are taken forward or not. Option 5, as discussed, may have wider benefits to the network and provides access to Cauldwell depot, located further south, and Jowett Sidings/ Bedford Maintenance depot. From a complexity of construction works perspective, it is considered that the proposal for Option 3 is most beneficial, as it is a short chord, and although it is a stand-alone option in its own right, the benefits could be optimised if it was considered in conjunction with Option 5.

Option 1 – MVL to EWRCS Viaduct

This route option, as shown in Figure B23 below, starts with a double junction which is at grade on the MVL and follows a maximum 1:80 vertical alignment to the EWRCS route. It is envisaged to be initially elevated by a viaduct structure to the north for 1200m and then embankment and bridges thereafter. The route crosses the West End highway, A412, and ties in at track level on the EWRCS alignment which is assumed to still be on embankment at this point, having crossed the A6. Track curvature is assumed to be over 250m radii, which limits linespeed to 40mph, providing the potential for services to join the EWRCS route at line speed.

Figure B23: MVL to EWRCS Viaduct



The viaduct structure will tie in on the MVL at 15m 1320yds. It is envisaged that it will have one walkway on the eastern side for track access, and will be a two-track configuration with passive structural provision for OLE. The length is anticipated to be in the order of 1200m and at a gradient of approximately 1:80, however, these parameters are open to further review in the future. Construction methods will need to consider the needs of the local residents and will be challenging if noise and dust, working hours and possession times, are inflexible. The footbridge at Sandhurst Road (footbridge reference MVL B12) should not be impacted, however, the footbridge at Elstow Road (structure reference 5MLD) will need a solution to be developed to either integrate it into the scheme, or proposals taken forward to close it.

The crossing of the West End highway requires considerable elevation to achieve highway clearances and the structure required will be a clear span of approximately 15m, with a skew angle less than 70 deg. At that height, it is anticipated that it will cause a visual impact to neighbours and potentially an increase to noise levels. This will need consideration and consulted on as part of the consents process for EWRCS. Maintenance will be constrained by the difficulty of accessing the viaduct structure and noise restriction requirements in residential areas. Construction methods will need to consider minimisation of the impact caused by traffic disruption to local roads and residents.

The crossing of the A421 will require a structure similar to the existing MML bridge (SPC1 179A), with a span of approximately 60m, across slip roads and dual carriageway. The existing bridge has a central pier which may be an acceptable solution to consider during development but is generally non-preferred due to collision protection measures being costly and disruptive to construct. This is a strategic east-west road link and construction will require road closures and lane closures in addition to the other local disruption.

Wilstead Road will require a conventional rail over road structure and there is a network of footpaths across the fields which will require amalgamation, or closure. Care has been taken to minimise the impact on property and sensitive environmental areas.

Earthworks will be merged between Option 1 and route option A1 and consequently costs and quantities are considered within the main remediation of the former land fill site at Elstow.

This option also would not connect with a new Bedford South Station as it connects east of the MML/EWRCS intersection point identified as a possibility for the site for the new station.

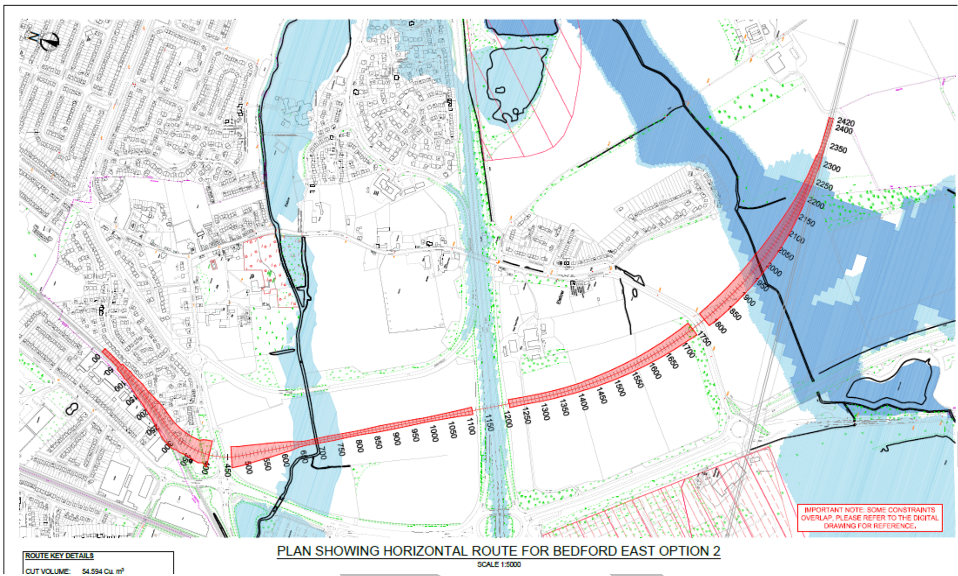
Linespeeds will be low due to the horizontal track configuration.

In summary, therefore, this option provides the connectivity required and has the shortest interface with the MVL. It also offers an opportunity for a loop at the connection point to EWRCS routes, if required, for performance purposes. This option offers the fastest journey time, being 3 minutes faster than option 3. However, there may be local objections to the loss of property and environmental issues are more significant than for options 3 and 4, as they are more extensive. In addition, extensive new infrastructure is required with high construction/maintenance costs and risks and it also is dependent on an effective solution for Jowett Sidings to be established. The gradients are at 1:80 and would not permit heavy haul freight in an easterly direction but would be suitable for intermodal and passenger traffic.

Option 2 – Road over Rail structure (Short Tunnel Option) at West End highway

Option 2, as show in Figure B24 below, is a variant of Option 1 but has a reduced boundary interface with neighbours and, therefore, reduces some of the environmental impact on residents that live adjacent to the MVL. In addition, the viaduct structure in Option 1 would be above ground and highly visible whereas this option is initially below ground which is achieved by lowering the alignment to pass under the West End highway road junction, thereby minimising the amount of structure that would be visible.

Figure B24: Option 2: Road over Rail structure (Short Tunnel Option) at West End Highway



The starting point for this option, on the MVL, is at approximately 15m 220yds. From here, the level will fall and a cutting, or retaining structures, will be required. This will then pass under the West End highway road junction approach, which could also be achieved by use of a box jack system, that would be constructed and jacked into position from the south side of the West End highway towards the north. This method would be challenging due to the ground condition risks but would minimise disruption to traffic. Alternatively, the West End highway could be lifted, with a road over rail bridge, or short tunnel, being constructed. Further investigation into the optimum solution will be required in future stages if this option is progressed further.

The route would then rise at the maximum gradient of 1:80 to achieve clearances for road to rail of approximately 10m passing over the dual carriageway of the A421, and which would be constructed as proposed in Option 1. The remainder of the route is then envisaged to be as described in Option 1.

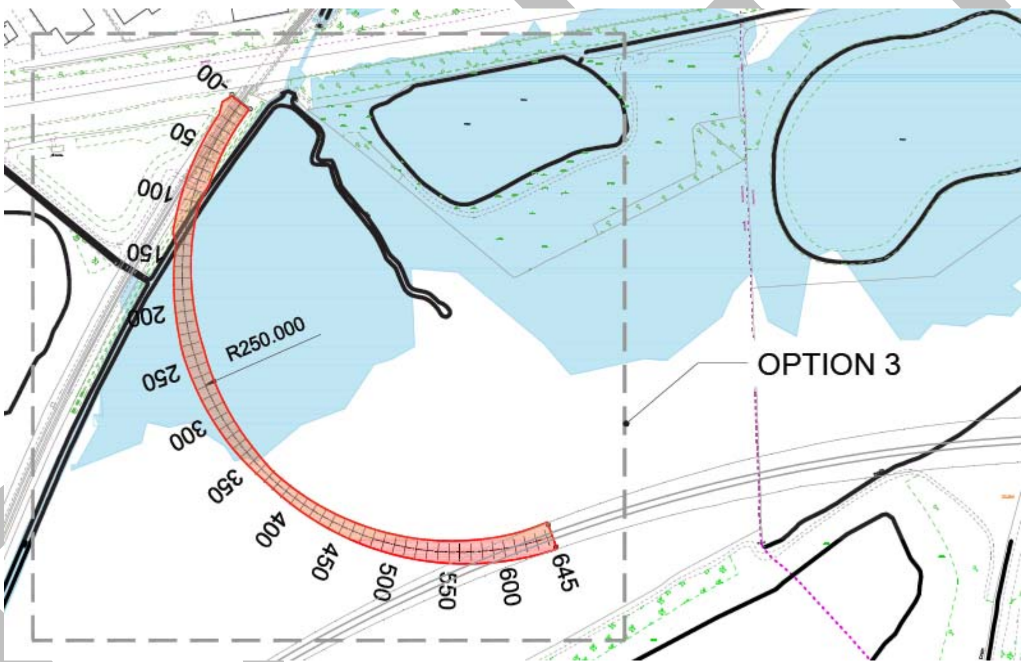
In summary, therefore, this option is a less disruptive solution to the residents than Option 1. It also requires earthworks, or retaining structures, to form cuttings.

However, the gradient may not be conducive for heavy haul freight at approx. 1:80 between the West End highway and A421, and the option will be prone to flooding as it is in the flood plain. As with other options, an effective solution to, access Jowett Sidings and Bedford Maintenance depot in general, will be required.

Option 3 – MVL Chord accessing EWRCS and Bedford South Station

Option 3, as shown in Figure B25 below, is a 250m radii chord which leaves the MVL at the south side of the A421 bridge (BBM B9N 13m 1374yds), crosses the adjacent fields and Ampthill Road, and then connects to the EWRCS route at the intersection with the MML. It is complementary to A1 route option separation from the MVL. This connection is west of the current proposed locations for either a new Bedford South Station and train connectivity could be achieved via Bedford Midland station, if required.

Figure B25: Option 3: MVL Chord accessing EWRCS and Bedford South Station



The chord shown is approximately 250m in radius and a linespeed of 40mph is envisaged, which is sympathetic to the MVL linespeed of 60mph at the tie-in. Allowance has been made for 775m standage and a 200m stopping distance off the A1 route option, if required, to enable freight services to be pathed onto EWRCS lines and avoid section occupation. Repeater signals may be required to aid the driver to make optimum use of the linespeeds.

The land is low lying and susceptible to flooding and is designated as a Flood Zone 2 category. This will require EA consents, attenuation management and other requirements as identified through further consultation as part of the consents process for EWRCS.

The soils are predominantly granular in nature – silts sands mixed with clays – and on a bedrock of mudstone. Embankment construction will need remedial measures to be undertaken prior to construction. Ground water levels will be near the surface.

This location has poor soils and sits in a flood plain. The S&C will also be under the existing road bridge to the A421 bridge (BBM B9N) and requires an effective solution for Bedford Maintenance depot to be found.

Option 4 –MML Chord at former land fill site at Elstow

Option 4, as shown in Figure B26 below, considers a chord from the MML Slow lines to the south of bridge SPC1 B179A at 47m 78ch, making the connection via an at grade junction and then turning east via a 350m radii chord. The land is drained by dykes that will require culverts and/or diversion measures. In addition, the existing railway is on a structure over the A421, so the tie in will have to be completed at this south of the bridge. S&C on structures is also non-preferred from a maintenance and accessibility perspective.

Figure B26: Option 4: MML Chord at former land fill site at Elstow

Underlying ground conditions are similar to those of Option 3, and will consist of sands-silts, mixed with clay on mudstone bedrock.

The existing, and proposed, embankments will need to be tied and benched together, both here, and at the EWRCS connection at the A6, where widening of A1 railway embankment may be required to achieve a loop with adequate standage for 775m freight, and with a 200m stopping distance to aid signal sighting and avoid section occupation as with Option 3.

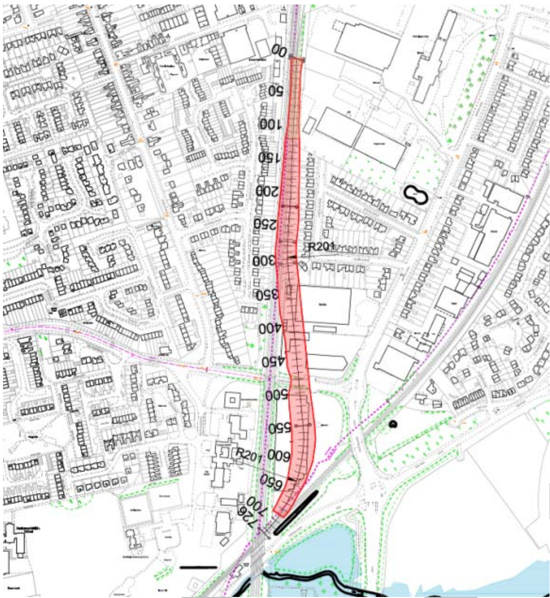
The routes will connect via an approx. 350m radius curve to achieve a linespeed of approximately 55mph connecting on to the EWRCS route option.

This option provides the shortest distance of new infrastructure and facilitates an earthworks structure. However, it has the potential to impact on capacity and performance on the MML Slow lines and this would need to be considered further in the next phase of development if this option was taken forward. It also does not provide the ability for connectivity to a new station to the south of Bedford and would require extensive work to the former land fill site at Elstow.

Option 5 – Supplementary MVL connection to MML Slow Lines

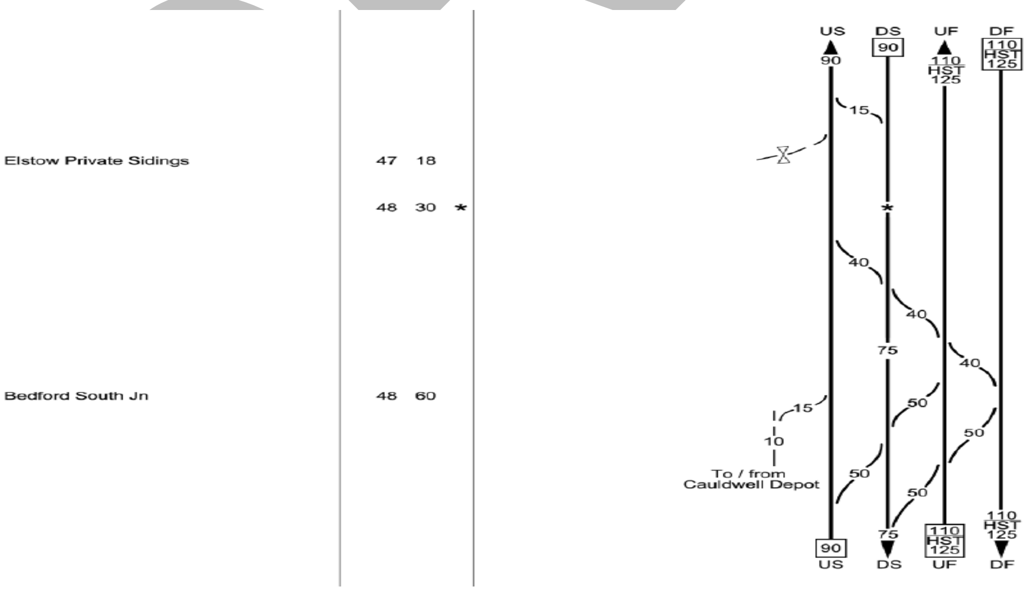
Option 5, as shown in Figure B27 below, is not a stand-alone option, but offers an opportunity to reduce the scope of works when combined with other options. It could be used in conjunction with any one of the previous 4 options, but it offers a shortened route in and out of Bedford Midland station and possibly mitigates the conflict of moves within the Bedford Maintenance depot area as it offers a shortened connection to the MVL onto the MML, via a turnout and ramped access. The current alignment for the proposed route is shown passing through an urban area which is occupied by commercial and residential properties and would require compulsory purchase powers as part of the EWRCS consents process.

Figure B27: Option 5: Supplementary MVL connection to MML Slow Lines



The MML Slow lines, at the proposed point of connection, are in a ladder approaching Cauldwell depot and are also associated with the private sidings movements at Elstow, shown in the National Sectional Appendix below (Figure B28), in addition to the pathing required to access Jowett Sidings.

Figure B28: extract from National Sectional Appendix showing location of Elstow private siding



The envisaged linespeed is up to 40mph with the option of connecting at linespeed onto the MML, however, this needs to be designed in detail to determine speeds. Gradients should be suitable for passenger and intermodal freight but may not be suitable for heavy haul freight as they are approx. 1:75. However, manipulation of the layout may be able to reduce this if further development work is carried out. An option has been identified that would extend the track through to Bedford Midland if desired, creating a 5th track.

There might be an opportunity to provide a better access arrangement at Cauldwell depot when approaching from the south on the Down Slow ladder (see Figure B28), e.g. through reconfiguring the Bedford South Junction ladder, which might, in turn, alleviate MML capacity constraints at Bedford Midland station.

As stated previously, issues relating to Jowett Sidings and Bedford Maintenance depot are being considered as part of a separate study looking at options to improve capacity and journey time on the MVL.

Costings – East of Bedford Connectivity

Two options were estimated (options 1 and 3) as being representative of the range of solutions likely to be found in answer to the NIC requirement.

- Option 1 was estimated at £121m
- Option 3 was estimated at £491m

Journey Time for Option 1 was calculated to be 14 minutes over a direct Bedford South Station connection. (4 minutes in, 6 minutes for the driver to change ends, 4 minutes out)

Option 3 was calculated to be less than 60 seconds faster than option 1, and at this point would not appear to offer value for money if an East of Bedford connection was to be required.

It should be noted that both the above estimates only allow for infrastructure directly associated with the infrastructure connection. To provide a viable system solution it is likely that both would require infrastructure works (possibly significant) at Bedford Midland, as covered in section B10. The extent of this additional work would be determined by the train service requirements.

Conclusion – East of Bedford Connectivity

Option 5 offers a viable connection off the MVL to the MML; however, the connection is not as beneficial as options 1 and 2. If considered in conjunction with either options 3 or 4, then Option 5 could avoid the remodelling of the Bedford Maintenance Depot but would still have multiple interfaces with empty stock moves.

The 4 car sets have been shown in other studies to require platform 1A at Bedford Midland to be extended, however, there are risks to signalling compliance that need to be managed. The longer sets trigger a more extensive remodelling of the station and the Slow lines in the southern station throat.

Issues have also been identified in the study around the interfaces of the service patterns of the existing and aspirational time tables and three local depots which, when combined with increased traffic to either MML or the BBM will become operationally challenging from a pathing and safety perspective.

The East of Bedford link is to provide a route in and out of Bedford Midland station from the EWRCS approach from the MVL. This can be achieved, but the scope of the work is significant, leading to areas of the network needing to be remodelled. It is assumed that works would need to be carried out in a way that would minimise disruption to existing services. If this option is progressed further, the solutions considered appear to be viable but have a high degree of engineering difficulty. It is anticipated that network change consents would be necessary to support this option, thereby requiring early consultation with relevant stakeholders.

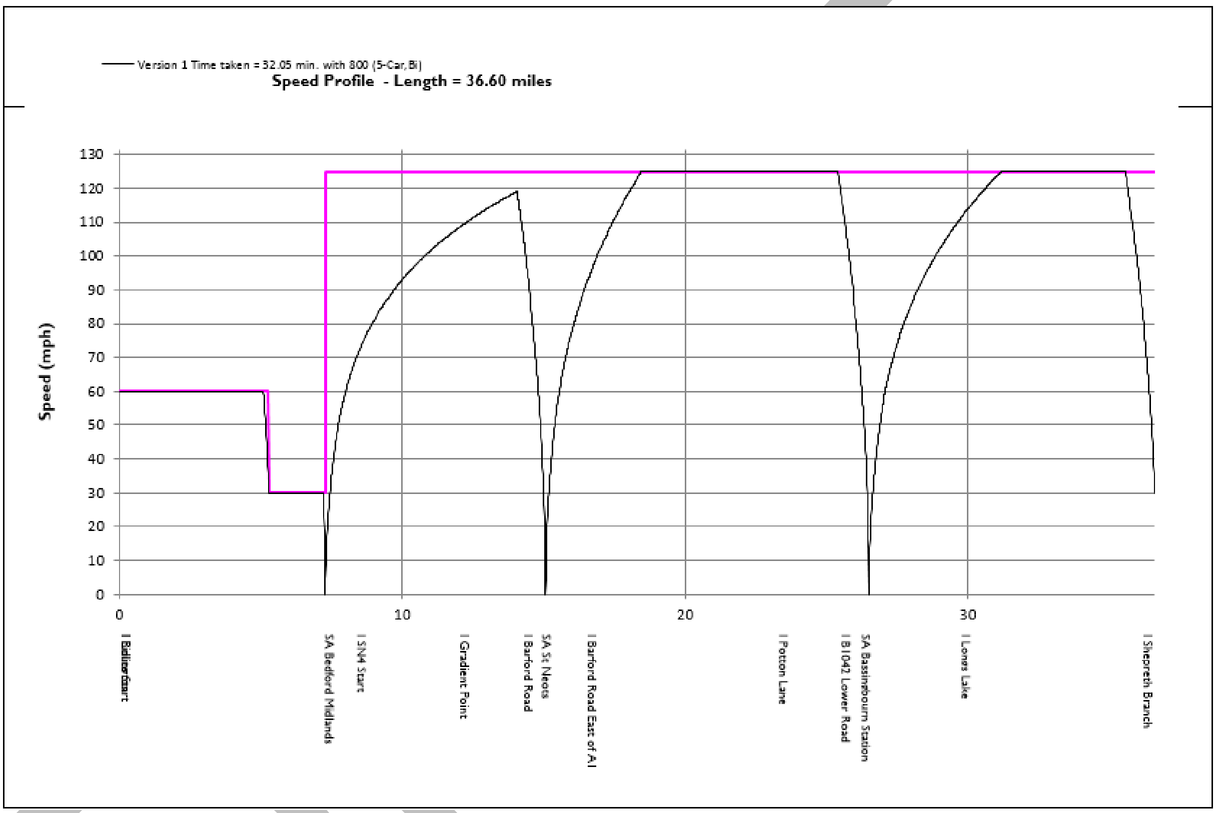
Of the options reviewed, when considered against the journey time that they offer, there is little difference between them, but Option 3 would be recommended on the basis that it serves a proposed Bedford South Station. However, the location of a new station at Wixams may lead to alternative interpretations, resulting in one of the other options being preferred.

A separate study to improve capacity and linespeed on the MVL is currently being progressed by Network Rail with the outcome due by March 2019. This would address the integration between proposals outlined in this report with any recommendations arising from that analysis.

B.15 Journey Time

Route Runner models were built to calculate journey times for 8 routes covered by this phase; A1, A3, E1, E3, C1, C3, SN4 and SN5. An example is provided in Figure B29 below.

Figure B29: Example Train Performance Graph SN5 Lidlington to Shepreth Branch Junction



Calculations assumed an 5-car Class 800 IEP, operating in diesel mode, with a maximum line speed of 125mph on new infrastructure.

The Route Runner models covered Lidlington to Cambridge, and these base outputs were then adjusted to calculate end to end times for Oxford to Cambridge journeys.

These journey times were then assessed for the following:

- Impact of reducing maximum line speed from 125mph to 100mph
- Impact of introducing additional intermediate station stops at Cambourne and Bassingbourn
- Impact of providing East of Bedford connectivity
- Testing routes via Bedford South Station against routes via Wixams

All model outputs and supporting information can be found in Appendix B15

Findings

Journey times were found to be largely consistent with the times calculated in Phase 2d, with the best Oxford to Cambridge time being circa 74 minutes. These times included stops at relevant stations (new or existing) at the nodes of Bedford, Sandy and Cambridge. SN4 and SN5 routes additionally allow for a stop at a new station at Bassingbourn. Table B22 below shows journey times with a linespeed of 125mph.

Table B22: Journey Times with a linespeed of 125mph

Est	est	Route	Bletchley	Bedford South	Bedford Midland	St Neots	Sandy	Bassingbourn	Cambourne	Shepreth Jnc.	Cambridge	Oxford to Cambridge
1		A1	0	19.2			25.3			37.5	41.3	**73.8**
2		A3	0	19.2			26.3			38.1	41.9	**74.4**
4		E3	0	19.2			25.3			37.7	41.5	**74.0**
3		E1			24.1		30.0			42.4	46.3	**78.8**
5		C1	0		24.1		31.9			44.2	48.1	**80.6**
6		C3	0		24.1	30.1				39.8	43.7	**76.2**
7		SN4	0		24.1	30.1	35.8	43.7		49.4	53.2	**85.7**
8		SN5	0		24.1	30.1		39.3		45.7	49.6	**82.1**

"A" routes continue to provide the shortest journey times, with routes via Bedford Midland typically 4-5 minutes longer. The "SN" routes via Tempsford/St Neots are generally 8-12 minutes slower than "A" routes, although these include an additional station stop at Bassingbourn, over and above the base case for other routes.

It is acknowledged that there is an aspiration for services to call at the proposed new station at Cambridge South, however, this has not currently been included in calculations as the impact would be applicable to all routes, adding an additional 2 minutes to journey time.

Impact of reducing linespeed from 125mph to 100mph

Reducing the maximum line speed from 125mph to 100mph typically adds three minutes to journeys with, as would be expected, longer routes being adversely affected more. Table B23 below provides the outcome from this analysis.

Table B23: Journey time comparison of linespeed at 125mph v 100mph

Est	est	Route	Bletchley	Bedford South	Bedford Midland	St Neots	Sandy	Bassingbourn	Shepreth Inc.	Cambridge	Bletchley - Cambridge	Oxford to Cambridge
1		A1 125	0.0	19.2			25.3		37.5	41.3	41.3	**73.8**
	12	A1 Linespeed 100	0.0	19.2			26.1		40.5	44.4	44.4	**76.9**
2		A3 125	0.0	19.2			26.3		38.1	41.9	41.9	**74.4**
		A3 100	0.0	19.2			27.0		41.2	45.0	45.0	**77.5**
4		E3 125	0.0	19.2			25.3		40.4	41.9	41.9	**74.4**
	13	E3 Linespeed 100	0.0	19.2			27.8		43.0	44.4	44.4	**76.9**
6		C3 125	0.0		24.1	30.1			41.9	43.7	43.7	**76.2**
		C3 100	0.0		24.1	31.8			42.2	46.0	46.0	**78.5**
7		SN4 125	0.0		24.1	30.1	35.8	43.7	49.4	53.2	53.2	**85.7**
		SN4 100	0.0		24.1	31.8	39.0	46.1	54.5	58.3	58.3	**90.8**
8		SN5 125	0.0		24.1	30.1		39.3	45.7	49.6	49.6	**82.1**
		SN5 100	0.0		24.1	31.8		42.8	51.0	54.9	54.9	**87.4**

Intermediate Stations

With a linespeed of 125mph, an additional station stop between Sandy and Cambridge is shown to typically add around 3.5-4 minutes to journey times.

With a linespeed of 100mph, an additional station stop between Sandy and Cambridge is shown to add around 2.5-3 minutes journey times. See Table B24 below

Table B24: Intermediate stations journey times with linespeed of 125mph v 100mph

Est	est	Route	Bletchley	Bedford South	Bedford Midland	St Neots	Sandy	Bassingbourn	Cambourne	Shepreth Jnc.	Cambridge	Bletchley - Cambridge	Oxford to Cambridge
1		A1 125	0.0	19.2			25.3			37.5	41.3	41.3	73.8
		A1 Bassingbourn 125	0.0	19.2			25.3	31.8		41.3	45.1	45.1	77.6
	12	A1 100	0	19.17			26.14			40.53	44.38	44.38	76.9
	19	A1 Bassingbourn 100	0.0	19.2			26.1	33.2		43.6	47.4	47.4	79.9
													0.0
2		A3 125	0.0	19.2			26.3			38.1	41.9	41.9	74.4
		A(D)3 125	0.0	19.2			26.3		32.0	41.7	45.5	45.5	78.0
		A3 100	0	19.17			27.03			41.2	45.1	45.1	77.6
	17	A3 100	0.0	19.2			27.0		33.9	44.0	47.9	47.9	80.4
													0.0
3		E1 125			24.1		30.0			43.6	47.4	47.4	78.8
		E1 125			24.1		30.0	36.6		47.1	51.0	51.0	82.3
		E1 100	0		24.1		32.92			45.8	49.7	49.7	82.2
	20	E1 100	0.0		24.1		32.9	42.0		49.1	52.9	52.9	85.4
													0.0
4		E3 125	0.0	19.2			25.3			40.4	44.3	44.3	74.0
		E3 125	0.0		24.1		25.3	33.8		43.9	47.8	47.8	77.5
	13	E3 100	0	19.2			27.8			43.0	46.9	46.9	79.4
	21	E3	0.0	19.2			27.8	38.9		46.0	49.8	49.8	82.3
													0.0
6		C3 125	0.0		24.1	30.1				39.8	43.7	43.7	76.2
		C3 125	0.0		24.1	30.1			36.7	44.4	48.3	48.3	80.8
		C3 100	0.0		24.1	31.8				42.2	46.0	46.0	78.5
	18	C3 100	0.0		24.1	31.8			40.3	48.0	51.9	51.9	84.4

East of Bedford

The introduction of a Bedford Midland call, and the subsequent reverse move that would be required, adds circa 15 minutes to end to end journey times over direct "A" or "E" route options. This is made up of additional time on the MVL (4 minutes x 2) and an allowance of 6 minutes for the driver to change ends and undertake the reverse move. Table B25 below provides this detail.

Table B25: Journey times for East of Bedford Connectivity

Est	est	Route	Bletchley	Bedford South	Bedford Midland	Sandy	Shepreth Jnc.	Cambridge		Bletchley - Cambridge	Oxford to Cambridge	Delta
1		A1 125	0.0	19.2		25.3	37.5	41.3		41.3	73.8	
		A1 EOB 100	0.0		24.1	41.3	55.7	59.5		59.5	92.0	18.2
		A1 EOB 125	0.0		24.1	40.4	52.6	56.5		56.5	89.0	15.2
4		E3 125	0.0	19.2		25.3	40.4	44.3		44.3	74.0	
		E3 EOB 100	0.0		24.1	43.5	58.6	62.5		62.5	92.2	18.2
		E3 EOB 125	0.0		24.1	40.9	56.1	59.9		59.9	89.7	15.7

Wixams

On current assumed alignments, variants for a South Bedford Station, at Wixams, perform up to 80 seconds better than alignments which call at an alternative location further north i.e. Elstow. This is almost entirely because of low line speeds on the MVL, and alignments at Wixams departing the MVL earlier. Any line speed enhancements on the MVL would reduce the journey time difference between the two locations. This is being considered as part of a separate study. Output of the analysis is shown in Table B26 below.

Table B26: Journey times via Wixams alignments

Route	Bletchley	Wixams	Bedford South	Sandy	Shepreth Jnc.	Cambridge	Bletchley - Cambridge	Oxford to Cambridge	Delta
E3 100	0.0		19.2	27.8	43.0	46.8	46.8	**79.3**	
E3 Wixams 100	0.0	19.2		27.8	43.0	46.8	46.8	**79.3**	0.0
A1 100	0.0		19.2	26.1	40.5	44.4	44.4	**76.9**	
A2 Wixams 100		19.2		26.1	39.2	43.0	43.0	**75.5**	-1.4

Conclusions

A 125mph line speed does generally offer journey time benefits over 100mph, however this benefit is eroded as additional station stops are added. The routes which follow the more direct southern corridor continue to offer noticeable shorter journey times than those which follow more northern routes.

There remains a significant journey time penalty to run services east of Bedford Midland when compared to more direct routes.

With further engineering development (including work to the MVL) there should be little in terms of journey time to differentiate between Elstow and Wixams as the preferred location for a Bedford South Station.

Part C: **Economic Appraisal**

C.01 **Passenger Transport Economic Analysis**

During this phase, Network Rail has revised the transport economic appraisal of the route options taking account of output from the engineering, journey time and cost evaluation elements, as well as the two new route options identified in this phase.

An updated model to be used for this purpose was utilised, as the DfT commissioned a from Leigh Fisher a recalibrated model for EWRWS (the Leigh Fisher model), during this phase of development, and it was deemed prudent to utilise the same model for consistency on the EWRCS. In using the Leigh Fisher model, however, an error was identified in the previous model, designed and used by Atkins (the Atkins Model), used to assess corridor options in phases 2a and 2b and transferred to, and used by, Network Rail in its analysis of route options in phases 2c and 2d. The Atkins Model, used by Atkins for Phases 2a and 2b, was incorrectly referencing destination population catchments within the forecast when destination employment would be consistent with the calibration of the gravity model parameters. This, therefore, has materially mis-stated the demand forecast for all flows and the error has remained in the model when it was delivered from Atkins to Network Rail for use in phases 2c and 2d.

The issue has an impact on all flows but leads to larger errors for smaller flows (where the gap between population catchment and employment catchment is greater). The error has only been discovered due to comparing results of the recently recalibrated Leigh Fisher model with the existing Atkins model.

The impact of the error has been reviewed with Atkins, EWR Co and DfT and a decision was made to progress with the economic analysis in this phase using the re-calibrated Leigh Fisher model so that the output from this phase provides the best possible, and most accurate, output on route options.

By way of illustration, the correction of the error in the Leigh Fisher model reduces the Benefit Cost Ratio (BCR) for the A1 route from 1.8 to 0.7, so although the ranking of options has been preserved, the value for money category reduces from medium value to poor value.

In addition to the error in the Atkins model, changes between the Atkins model and the Leigh Fisher model have also had a material impact on the BCRs. The Leigh Fisher demand model takes the same approach as the Atkins model (regression analysis of established flows looking at population, employment, journey time, fare, GDP per capita and car ownership) but the Leigh Fisher model has been calibrated to a much bigger selection of rail flows and does have additional segmentation by a) Generalised Journey Time b) SE/non-SE with each segment having different parameters.

The Leigh Fisher model also has a number of other changes in approach which has reduced estimated benefits from those assessed using the Atkins model. These are:

- The model is used to run a do-nothing forecast and this forecast is removed from the do-minimum and do-something forecasts

- The Atkins model had relatively high do-minimum forecasts even where no direct connection was formed

- The ‘rule of x’ used to approximate numerical integration – this reduces benefits to new users by a greater amount than the Atkins approximation of 75% of total benefits

There are advantages and disadvantages to both models.

There has also been some updates to input data used in the do-minimum modelling between phases 2d and 2e, primarily around HS2 Phase 1 and released capacity on WCML, and representation of Crossrail 1 which was not included in Phase 2d.

The analysis also suggests that benefits to flows outside of the gravity model appear to be negligible. Inclusion of long distance flows (based on MOIRA1 outputs) only improves the BCR for route option A1 by 0.01. Therefore, there doesn’t appear to be any material flows outside the study area which benefit substantially.

In terms of journey times, there is not a significant difference in journey times between Phases 2d and 2e. The route options with the fastest journey time between Bletchley and Cambridge, assuming 125mph rolling stock, are A1 and A3 which offer a journey time of 44 mins (compared to 44 mins and 45 mins respectively in Phase 2d).

In terms of the capital costs, there have been some changes between phase 2d and 2e with route option A1 now offering the lowest capital costs (2015 prices) compared to option E3 in phase 2d. A spot cost of £344m is assumed in all route options at this stage for potential improvement works on the Marston Vale Line. Full details are included in the report in the Appendix C4 – Phase 2e Economic Analysis.

The outcome of the analysis from the Leigh Fisher model, and noting the correction of the error in previous analysis using the Atkins model, is shown in Table C2 below:

Table C1: Appraisal Results

Results of socio-economic appraisal	A1	A3	E1	E3	C1	C3	SN4	SN5
	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV
Net benefits to consumers and private sector (plus tax impacts)								
Rail user journey time benefits	452	452	513	433	498	555	495	543
User Charge Benefits	118	118	122	114	119	129	119	127
Non user benefits - road decongestion	308	308	334	296	323	362	321	363
Non user benefits - noise, air quality, greenhouse gases & accident benefits	-19	-21	-27	-29	-26	-16	-32	-21
Rail user and non user disruption disbenefits during possessions	-77	-106	-93	-81	-108	-134	-102	-121
Indirect taxation impact on government	-135	-134	-144	-126	-140	-161	-137	-166
sub-total (a)	647	616	704	608	666	737	663	726
Costs to government (broad transport budget)								
Initial capital costs (c')	1,675	2,314	2,033	1,763	2,366	2,926	2,238	2,649
Renewal costs (c'')	304	379	362	332	393	448	396	426
Non user benefits - road infrastructure cost changes	-2	-2	-3	-2	-2	-3	-2	-3
Revenue transfer*	-677	-677	-736	-649	-714	-797	-709	-777
NR operating costs and TOC operating costs transfer**	557	564	641	621	631	620	686	634
sub-total (b)	1,856	2,578	2,299	2,064	2,674	3,194	2,607	2,929
Net Present Value (NPV) (a-b)	-1,209	-1,962	-1,595	-1,457	-2,007	-2,458	-1,944	-2,203
Benefit Cost Ratio to Government (BCR) (a/b)	0.35	0.24	0.31	0.29	0.25	0.23	0.25	0.25

The best performing option is route A1 at a BCR of 0.35. This indicates that from a purely transport benefits perspective, EWRCS does not represent value for money nor indicate the potential to develop into a viable scheme. EWRCS appears to deliver similar revenue, and more benefits, than EWRWS but at a significantly higher capital and operating cost. A 100mph scenario, rather than 125mph scenario, reduces the operating costs significantly to be more comparable with EWRWS.

In summary, therefore, the causes of the reduction in BCR are:

- The do-nothing forecasts mean fewer users are treated as 'existing users' than in the Atkins model
- Alternative rules for when to assess user charge benefits have been introduced
- The 'rule of x' has had an impact on benefits and user charges
- The do-minimum option has been updated to include latest data for HS2 and Crossrail

- Reduced background growth (previously 2.5% for all long-distance benefits and short distance from 2031 to demand cap) – now 2.1% reducing to 1.7%.

C.02 Freight Transport Economic Analysis

During Phase 2e, work was carried out to assess the potential freight benefits that could be attributed to EWRCS between Bedford and Cambridge, as this hadn't been considered in previous phases. This work was carried out by the Network Rail Economic Analysis Team and the full report is provided in Appendix C1 to this report. This analysis was not affected by the error in the Atkins analysis.

In summary, there were two stages to the work: stage 1 assessed the potential freight benefits of EWRCS as currently planned; and stage 2 assessed the potential freight benefits of an east to north connection at Bletchley.

No freight capacity analysis was undertaken as part of this study and, therefore, there is a limit to the conclusions that can be drawn at this stage. The methodology employed was to assess the benefits of accommodating future freight demand on the assumption that this demand could otherwise not be accommodated on the existing rail network and would be transported by road (with consequent congestion and environmental disbenefits).

The first activity was to analyse routes which could potentially benefit from EWRCS, assuming that EWRCS could represent a viable route where mileage would increase by no more than 10%. This indicated that flows such as Felixstowe to Oxfordshire and Felixstowe to the South West could potentially benefit from EWRCS.

At this stage of development and analysis, the potential freight benefits of EWRCS are estimated to lie in the range £0m to £283m Present Value (PV). Due to the significant downside uncertainty (including in particular the risk that additional demand cannot be accommodated elsewhere on the existing rail network), the current best estimate of the benefits is £71m PV. This assumes that 25% of the benefits of the relevant freight flows identified in the report can be justifiably attributed to EWRCS. This level of benefit would have a small positive impact on the overall BCR for EWRCS, increasing the EWRCS BCR for the A1, diesel rolling stock option from 1.70 to 1.73 based on the previous Atkins model with the error.

However, there are a number of risks and uncertainties that should be recognised at this stage:

- The freight demand forecasts were produced in 2013 and growth has materialised at a slower rate than forecast to date (particularly for the important intermodal traffic sector). Forecast demand growth has been reduced by 25% to provide some account for this in the analysis.

- Freight growth has been capped in 2037, in line with guidance on capping demand growth for passenger appraisals.

- Capacity elsewhere on the existing rail network has not been investigated - if other constraints on the existing rail network would prevent identified flows from operating then the benefits will fall below £283m or there will be additional costs to facilitate the flows

- The costs of making EWRCS capable for handling freight services, or capable of handling a particular frequency or weight of freight service.

Stage 2 of the study looked at the additional benefit that might arise from an east to north connection at Bletchley. This would enable additional freight flows to potentially benefit from EWRCS such as Felixstowe to Staffordshire and Felixstowe to Northamptonshire. The additional benefits associated with the connection are estimated to lie in the range £0m to £541m PV. Given the significant downside uncertainty, the current best estimate of the benefits is £100m PV. This assumes that 25% of the benefits of flows that would otherwise route via London can be justifiably attributed to the connection and that 12.5% of the benefits of flows that would otherwise route via the F2N network can be justifiably attributed to the connection.

For both stages 1 and 2, a more precise estimate of the benefits, that determines precisely where they lie in the range, will very much rest upon a more detailed capacity analysis that identifies the key constraints to accommodating freight demand forecasts for each of the routes in question. A number of other risks and issues are noted in the report.

The analysis should help inform a decision on whether further development work should be undertaken, and, if so, on what freight benefits could be provided by EWRCS and by an east to north connection at Bletchley.

C.03 Update on Corridor Analysis

As a result of the error in the Atkins model, Atkins were asked to verify that the choice of corridor option from Phase 2b remained valid when considered against the Leigh Fisher model. This has been confirmed although at a reduced BCR.

Whilst the error with the Atkins model has also had an adverse effect on the BCRs for the corridor analysis undertaken in Phases 2a and 2b, a review of the impact of the error on corridor choice has confirmed that the prioritisation of corridors is unaffected and Corridor C (Bedford – Sandy - Cambridge) remains the best performing corridor option. The worst performing route option in Corridor C is still better value than the highest performing route option in Corridor M (Bedford – Hitchin – Cambridge).

C.04 Other Economic Appraisal Activity

It is recognised that the development of a WebTAG compliant business case for EWRCS, which assesses the transport benefits for EWRCS, does not allow for benefits that could be attributed to land value or significant levels of new housing development, as outlined in the NIC report published in November 2017, to be captured. EWR Co have sought to establish a methodology that enables EWRCS to be evaluated both for transport benefits and economic growth benefits, however, this has proved challenging. The recommendations from the NIC report strengthen the case for this, given the increasing emphasis on a new strategic railway being an enabler of economic, housing and employment growth in the Oxford – Cambridge corridor. However, the scale of development/growth that the NIC recommends is in excess of current Local Development Plans and, therefore, there are only emerging views as to where additional housing developments may be. This also comes with a significant risk that such locations may not be feasible, or acceptable when progressed through the normal planning processes.

EWR Co procured Land Usage Transport Interaction modelling from KPMG. At the time of writing this report, the output from this had not been shared with Network Rail therefore it is not covered in this report.

In responding to the error in the transport modelling, Network Rail were asked by EWR Co to undertake a sensitivity test which took account of an informed view as to where potential areas of significant new housing, new settlements effectively, may be sited within the EWRCS corridor. Whilst this is not consistent with WebTAG guidance, it was considered to be an appropriate 'sense check' to understand how this could influence the business case.

A number of high growth assumptions were provided to Network Rail by EWR Co and the output from that analysis is shown in Table C3 below. These were intended to align with the transformational growth scenarios outlined by the NIC in its November 2017 report. The scenario assumes that household growth within the corridor will increase from c13,000 dwellings per annum to c30,000 per annum.

Table C2: High Growth Appraisal Results

Results of socio-economic appraisal	A1_High	A3_High	E1_High	E3_High	C1_High	C3_High	SN4_High	SN5_High
	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV	£m PV
Net benefits to consumers and private sector (plus tax impacts)								
Rail user journey time benefits	1.198	1.198	1.326	1.153	1.282	1.419	1.262	1.389
User Charge Benefits	228	230	231	217	229	248	236	242
Non user benefits - road decongestion	761	763	808	727	780	870	774	847
Non user benefits - noise, air quality, greenhouse gases & accident benefits	40	46	41	31	38	59	31	51
Rail user and non user disruption disbenefits during possessions	-79	-109	-96	-83	-111	-137	-106	-124
Indirect taxation impact on government	-369	-371	-392	-350	-379	-427	-375	-414
sub-total (a)	**1,780**	**1,756**	**1,918**	**1,695**	**1,839**	**2,033**	**1,824**	**1,992**
Costs to government (broad transport budget)								
Initial capital costs (c')	1.736	2.375	2.094	1.824	2.427	2.987	2.299	2.710
Renewal costs (c'')	336	417	397	365	431	492	433	467
Non user benefits - road infrastructure cost changes	-6	-6	-6	-6	-6	-7	-6	-6
Revenue transfer*	-1.710	-1.716	-1.823	-1.634	-1.766	-1.964	-1.759	-1.914
NR operating costs and TOC operating costs transfer**	872	855	964	831	951	937	1.032	956
sub-total (b)	**1,227**	**1,925**	**1,627**	**1,380**	**2,038**	**2,446**	**1,999**	**2,212**
Net Present Value (NPV) (a-b)	**553**	**-169**	**292**	**314**	**-199**	**-413**	**-175**	**-220**
Benefit Cost Ratio to Government (BCR) (a/b)	**1.45**	**0.91**	**1.18**	**1.23**	**0.90**	**0.83**	**0.91**	**0.90**

The best performing option under this scenario is also route option A1 with a BCR of 1.45. Whilst this analysis falls out with the WebTag guidance for transport appraisals, it does support the strategic case for EWRCS in relation to aligning transport infrastructure proposals with housing development across the corridor and was applied to both the Do Something and Do Minimum options.

C.05 Conclusion

Based on the output from using the Leigh Fisher model, and for the reasons outlined above, the transport benefits for EWRCS suggest that it does not represent value for money, nor indicate the potential to develop into a viable scheme. The best performing route option A1 has a BCR of 0.35 based on normal growth and excluding WEBs.

However, the output from the high growth sensitivity test on potential new settlements within the Oxford – Cambridge corridor, has resulted in an improvement to the BCR for the best performing route of A1 to 1.45.

Whilst this falls outside the guidance for WebTAG appraisals, it does provide justification for the strategic case for EWRCS and the need to align transport infrastructure proposals with housing development across the corridor, as recommended by the NIC November 2017 report.

Part D: **Stakeholder Management**

D.01 **Stakeholder Management**

During Phase 2e, the Network Rail development team has continued to consult with the East West Rail Consortium and other rail industry partners on the development work carried out during this phase. The Rail Industry Combined Working Group [4]forms a valuable source of local 'expert' knowledge, expertise, guidance and challenge and has the opportunity to review and comment on the draft output in each phase before it is finalised, and recommendations are put forward to the Rail Industry Steering Group (RISG).

At this stage, consultation has focused primarily on stakeholders with a regional, strategic perspective and stakeholders with an ability to influence route options within the preferred corridor. Further and wider consultation, including consultation with potentially impacted land and property owners, and the general public, will be undertaken in future stages, and non-statutory consultation is currently planned by EWR Co to commence in late 2018/early 2019.

Network Rail has produced an initial Stakeholder Management Plan to support this activity. A copy of this is included in the Appendix D1. This will need to be updated as EWRCS develops and new stakeholders are identified, or there is a change to existing stakeholders. In addition, this plan has been produced on the basis of the previous assumption that Network Rail would be promoting the consents required to authorise EWRCS, and so reflects Network Rail's internal policies and approach to consultation. As it is now known that EWR Co will promote the consents required to authorise EWRCS, this plan will need to be updated to reflect EWR Co's position on the approach to consultation.

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[4] A group of rail industry representatives from local authorities within the EWR Consortium, train operators from existing franchises in the EWRCS area, freight operators, DfT and Network Rail who are consulted on the output from the development work undertaken by Network Rail prior to it being finalised and recommendations being put forward to the RISG.

The strategy for the development of EWRCS has always focused on identifying the solutions which offer best value for money, thus allowing resources and funding to be optimised throughout the development activity to date. The consultation carried out with industry stakeholders has supported decisions being made on options to be paused, or progressed, for further development at key milestones in the EWRCS lifecycle. The process also seeks to make sure that EWRCS remains aligned to the wider strategic needs of the region and optimises wider benefits.

Options have continued to be evaluated against the strategic and economic elements of the Five Case Model which is used for assessing the value of public sector business cases, to support the development of the Strategic Outline Business Case (SOBC) For EWRCS, the strategic elements are represented by the strategic objectives outlined earlier in this report and the economic elements are represented by the output from the economic appraisal activity undertaken by Network Rail and EWR Co. These have been used to establish evaluation criteria against which to assess the route options, which were discussed with industry stakeholders in a Methodology and Evaluation Criteria workshop held in July 2016 (referenced in the Phase 2c & 2d report).

This was produced at a time when the strategic objectives and conditional outputs for EWRCS were focused on improving journey times between Oxford and Cambridge, as reflected in the strategic objectives and conditional outputs endorsed by RISG in March 2016 and referenced earlier in this report.

However, since then, the NIC report published in November 2017 identified a critical role for EWRCS in enabling housing and economic development with the corridor. As outlined in Section A.03 above, EWR Co have proposed amendments to the strategic objectives for both the EWRCS and EWRWS, and to the conditional outputs for EWRCS, which are currently awaiting approval from the DfT.

The evaluation criteria defined by the workshop in July 2016 is shown in Table D1.

Table D1: EWRCS Route Option Evaluation Criteria

Number	Evaluation Criteria
Business Case	
1	Capital Cost (Capex)
2	Operational Cost (Opex)
3	Value of benefits
Network Capability	
4	Long distance passenger services (Journey times Cambridge – Oxford).
5	Rail passenger connectivity to existing mainlines
6	Short distance passenger services (Journey times Bedford – Oxford, Bedford – Cambridge)
7	Passenger connectivity to population and employment centres
8	Rail freight capability/ aspiration
Railway Operational issues and Constraints	

9	Performance
10	Alignment with wider railway strategy/ infrastructure
Delivery Risk/ Constraints	
11	Environmental benefits and dis-benefits
12	Alignment with local development plan
13	Likelihood of securing the necessary consents
Safety	
14	Safety – Construction
15	Safety – Operation
Other criteria (enabler or opportunity)	
16	None particularly identified

No weighting was applied to the evaluation criteria. Whilst this was discussed at the workshop in July 2016 with rail industry stakeholders, no proposals or preference for the weighting of evaluation criteria were identified.

Since then, based on the proposed amendments to the strategic objectives and conditional outputs, EWR Co are proposing to amend the evaluation criteria for EWRCS to the following in Table D2:

Table D2: Revised EWRCS Route Option Evaluation Criteria

Number	Evaluation Criteria
Business Case	
1	Contribution to enabling housing and economic development within the corridor including best serving areas benefiting from developable land
2	Capex
3	Operational Cost (Opex)
4	Value of benefits
Network Capability	
4	Short distance connectivity to support commuting travel into key employment hubs (current and future)
5	Short distance passenger services (journey times Bedford and Sandy to Cambridge)
6	Rail passenger connectivity to existing mainlines
7	Short distance passenger services (Journey times Bedford – Oxford, Bedford – Cambridge)
8	Long distance passenger services

9	Satisfying existing and anticipated freight demand where affordable
Railway Operational issues and Constraints	
9	Performance
10	Alignment with wider railway strategy/ infrastructure
Delivery Risk/ Constraints	
11	Environmental benefits and dis-benefits
12	Consistency with published planning documents for location of settlements
13	Likelihood of securing the necessary consents, including from existing landowners
Safety	
14	Safety – Construction
15	Safety – Operation

EWR Co have considered whether the evaluation criteria should be weighted at all. The EWR Co advice at this stage of development is to avoid explicit prioritisation or weighting of the evaluation criteria. The preference is to carry out a narrative, reasons-based analysis and to record decision making as such.

In previous phases, route options were assessed against the original evaluation criteria. The route options in this phase need to be evaluated against the revised evaluation criteria, with a supporting narrative to inform the SOBC. This activity will be carried out by EWR Co and has not formed part of the analysis carried out by Network Rail.

D.02 Rail Industry Stakeholders

During this phase, the Rail Industry Combined Working Group (the Working Group) met on 12th March 2018 to review progress with activity being carried out in this phase, with a further meeting to share the final output from Phase 2e arranged for 9th October 2018. The Working Group consists of representatives from relevant existing train operators, both passenger and freight, and also Local Authority representatives from transport/planning within the EWR Consortium. A record of these workshops is included in the Appendices D2 to D5. These workshops have served to provide an update on the development work and provide the opportunity for rail industry stakeholders to test and challenge assumptions and conclusions resulting from the ongoing analysis prior to finalisation of development work in this phase, and prior to recommendations being made to the Rail Industry Steering Group.

During this phase, there have been no meetings of the RISG The RISG consists of a smaller number of representatives from the Working Group, with specifically representatives from:

- DfT
- EWR Co
- Network Rail
- EWR Consortium
- Train Operators

This was discussed with EWR Co as there is a recognition that a revised governance structure is required for EWRCS to reflect the need to respond to the NIC November 2017 report, and that such a governance structure needs to align rail industry representatives with local housing/planning representatives. EWR Co/DfT are taking the lead on establishing a revised governance structure for EWRCS with relevant external stakeholders.

With regards Network Rail's role, invitations have been issued recently by DfT for an EWRCS Programme Board and EWRCS Project Oversight Board with senior executives within Network Rail to be represented on both.

D.03 Statutory Consultees

The initial consultation with statutory consultees has started in this, and previous phases, to support the potential future Development Consent Order (DCO) process for EWRCS, and, in particular, a workshop was held in February 2018 to provide an update on progress with EWRCS. The output from this workshop is provided in Appendices D6 and D7.

Follow up meetings have been held with the following stakeholders who could be impacted by the route options. These are:

National Trust (NT) - A number of informal consultation meetings have been held with the NT as route options have been refined. This is to ascertain NR's position with regards to the Wimpole Estate. NT have confirmed that the estate is classified as "inalienable land" and that the hall is Grade 1 listed with further Grade 11 & 11* structures. Additionally, the estate has Registered Park status and is surrounded by Ancient Woodland. Network Rail shared the route options being considered with NT to understand their views/preferences and whether the impact of route options could be suitably mitigated. The feedback from NT was that, in all instances, they expect the estate to be avoided completely, highlighting concerns about the southern routes (A1/C1) having a detrimental impact on views, landscape and soundscape settings. A clear preference was for a route option (A3/C3) to the north of the estate and Eversden Wood SSSI/SAC/Ancient Woodland. NT provided a copy of their "Landscape Views Assessment" to Network Rail for consideration and have been asked to provide their views on cuttings, and cut & cover tunnels, as possible mitigation measures. Initial feedback has been that while these may offer some scope for mitigation, a number of concerns remain such as; impact on habitats, species, noise and archaeological assets. NT have stated that they would welcome further dialogue on EWRCS and in particular with regards to biodiversity offsetting.

Ministry of Defence (MOD) - Discussions have also been held with the Defence Infrastructure Organisation (part of the MOD) regarding options which could impact on the RAF Bassingbourn base. A number of the routes are in the vicinity of, or run through, the base, plus the base was also suggested by the NIC as a possible location for a new housing development and new intermediate station in its report published in November 2017. The MOD explained that a review of bases was underway with a number of those being closed being consolidated on to the Bassingbourn base.

An investment programme was being initiated to upgrade the base to accommodate the consolidation and part of the site was identified as a location for sensitive training that would not be conducive with having a railway pass through it. It was recognised that coordination of plans was required between all interested parties (DfT, EWR Co, Homes England & MOD).

D.04 EWR Consortium

During this phase, Network Rail has also presented to the EWR Consortium Annual General Meeting on 11th April 2018 at the request of the EWR Consortium. The output is included in Appendix D8 of this report.

D.05 England's Economic Heartland

EWRCS forms a key element of England's Economic Heartland (EEH)'s Transport Strategy. Network Rail engages with EEH via:

- South East Midlands Local Enterprise Partnership (SEMLEP)
- EEH's Strategic Transport Forum
- EEH's Transport Officers Support Group

As Network Rail has a wider strategic interface with these groups than just EWRCS, representation usually comes from other Network Rail teams, however, the EWRCS project team provides an input to relevant agenda items in advance of these meetings, as and when required.

EEH have been involved in the discussions regarding how to respond to the impact that the error in the economic analysis has had on the BCR and supporting the onward communication of that to other key stakeholders.

D.06 Oxford to Cambridge Expressway

During this phase, various meetings have been attended with the Oxford to Cambridge Expressway project team within Highways England. This has helped gain a greater understanding of the interface between the two projects, as they fall into the same geographic corridor, are both supported by the NIC report published in November 2017 and have the same stakeholders in some areas.

There is a need to continue close engagement with the Oxford to Cambridge Expressway Team as they move towards identifying a preferred corridor of their own and develop a programme to secure the consents they require and undertake the associated consultation with stakeholders.

As many of the stakeholders for EWRCS are also stakeholders for the Oxford to Cambridge Expressway project, both projects need to work together to align consultation and consents related activities where appropriate.

There is also a risk to the economic appraisal for the two projects in relation to double-counting of economic benefits.

D.07 **Network Rail Internal Stakeholders**

Network Rail has continued to consult with internal stakeholders during this phase of development work, primarily within LNE&EM Route and Anglia Route. This has included presentations to:

- Rail Industry Review Groups for both LNE& EM Route and Anglia Route
- Presentation to Head of Maintenance South for LNE & EM Route
- Route Strategy Planning Group for LNE & EM and Anglia
- Head of Strategic Planning for Anglia Route
- Director of Route Asset Management for LNE&EM Route and team
- Director of Route Asset Management for Anglia Route and team
- Digital Railway Team

Regular updates/reports have also been provided to the following stakeholders within Network Rail:

- Head of Strategic Planning, LNE&EM Route
- Head of Strategic Planning, LNW Route

- LNE&EM System Operator Senior Strategic Planners for Route G (East Coast & North East) and Route I (East Midlands)
- Anglia System Operator Senior Strategic Planner for Route D (East Anglia)
- Principal Programme Sponsor, EWRWS
- Director, Strategy & Planning (North)
- Managing Director, System Operator
- Regional Director, IP Scotland and North East

These updates are important in recognising the role of Network Rail as a future interfacing Infrastructure Manager for the existing rail infrastructure. The consultation has also supported the development of an initial Route Requirements Document with input from existing Asset Managers for all disciplines. Consultation with Network Rail stakeholders for EWRCS will need to continue as EWRCS develops further, and irrespective of the fact that EWR Co intend to procure a new Technical Advisor to progress the design and development activities.

Activities are progressing to determine the scope and scale of Network Rail's future role to support EWRCS both as the System Operator and as Infrastructure Manager for the existing rail network.

Copies of relevant presentations are included in Appendices D9 to D18.

D.08 Built Environment Accessibility Panel

During this phase, the Network Rail EWRCS team also attended the Built Environment Accessibility Panel (BEAP) which is an independent panel of experts who work with Network Rail, and other rail industry partners, to help projects and programmes plan inclusive and accessible spaces and places.

The purpose of the panel, chaired by Margaret Hickish (Network Rail - Access & Inclusion Manager), is to make sure that major building works, station designs and other amenities across Britain are as accessible and inclusive as possible. The panel consists of a wide range of people with different disabilities and access experts, all of whom have confidentiality agreements in place to participate on the panel.

Project and programme teams from across Network Rail and other rail industry partners, such as HS2, Crossrail, etc. are welcomed to present their plans to the panel at various stages of development to seek advice on accessibility and inclusiveness.

In April 2018, the Network Rail EWRCS team made their first presentation at BEAP to introduce EWRCS, covering:

- The scope and purpose of EWRCS
- EWR Co and their role
- The history of EWRCS to date
- The current development stage
- Proposed next steps

The confidential nature of EWRCS, from a consents perspective, was made clear to the panel members.

Feedback was provided throughout the presentation and the full details are in a briefing note produced for EWR Co and included in Appendix D19. In summary, the key issues raised were:

- EWR Co are welcome to continue to use BEAP without a new Technical partner as EWRCS develops
- Steps at stations, and different levels from trains to platforms, result in those requiring wheelchair access needing assistance – this is something BEAP encourages all projects to avoid
- Accessible rolling stock is something that should be considered in future phases
- Good access is integral to designs and solutions and should cater for predicted future demand growth
- With regards to stations:
    - Experimental technology should be considered with care i.e. blue lights used to help prevent suicide can hinder visually impaired people

- Ramps can be problematic as the preferred option for stairs. Lifts are preferred where at all possible

- Lifts need to be highly visible/well signposted for people to find easily and ideally two-sided access to remove reverse manoeuvres

- Customer Information Screens they tend to be placed where passengers come off stairs/escalators: passengers who take different routes need the same info as stair/escalator users

- New signs in an existing station should follow the same format as the older signs – differences in signage can cause confusion

It was, therefore, suggested that EWR Co should return to BEAP and provide an update on EWRCS post selection of a preferred route, after the non-statutory public consultation phase, planned for late 2018/early 2019. This update should also consider progress with a rolling stock strategy that addresses the needs of all passengers, and the preparation of a Diversity Impact Assessment (DIA) for the project when a preferred route is confirmed.

D.09 **Conclusion**

Rail industry stakeholders have continued to be supportive of EWRCS throughout this phase of development, particularly the EWR Consortium and England's Economic Heartland, and have been kept appraised of progress throughout this phase of development, providing them with the opportunity to review, comment on and challenge the work undertaken. However, towards the end of this Phase, EWR Co briefed key stakeholders in EEH and EWR Consortium of the impact of the error in the Atkins Model, and the impact of utilising the Leigh Fisher model, in the BCR. The Network Rail EWRCS team have supported EWR Co with these briefings. This resulted in the Working Group meeting planned for 21st August 2018 being cancelled at the request of the EWR Consortium. This has now been rearranged for 9th October 2018 where the output from this phase of development will be shared with all Working Group members.

The briefings carried out by the Network Rail EWRCs team to Network Rail internal stakeholders recognise the significant interface that EWRCS has with the existing infrastructure and the need to provide assurance of the strategic fit to the Network Rail System Operator teams, as well as the interface with Network Rail as the Infrastructure Manager for the existing infrastructure.

Going forward, consultation will continue with all relevant rail industry and statutory consultees, internal Network Rail stakeholders and non-statutory public consultation will commence late 2018/early 2019 led by EWR Co, with support from Network Rail as may be required.

As EWRCS moves towards identifying and confirming the preferred route option, challenges may arise from stakeholders who have a preference for particular route options which are more aligned to their local and political needs.

Consideration needs to be given, therefore, to reviewing the governance and decision-making arrangements for EWRCS and putting appropriate arrangements in place, recognising that the current arrangements are solely rail industry focused and are likely to be inadequate for the direction in which EWRCS is developing, with a joint focus on transport and housing/economic development.

Part E: **Land and Consents**

E.01 **Land & Consents Strategy**

A Land & Consents strategy for EWRCS has been produced by Network Rail, and updated in this phase, which outlines Network Rail's proposed strategy for securing the land and consents needed to deliver EWRCS. This strategy assumes (and is written on that basis) that the project will require authorisation by a Development Consent Order (DCO) under the Planning Act 2008 and that Network Rail will be the rail only promoter of an EWRCS DCO submission using current legislation. It also sets out the consent process proposed by Network Rail from route option selection up to submission of a draft DCO in December 2021 and proposes a four-stage consultation process as follows:

- Stage 1: 2018 - re-assessment of route options (to include strategic and economic factors for SOBC), development of and non-statutory consultation on route options, and selection of preferred route
- Stage 2: 2019 - development and assessment of and non-statutory consultation on alignment options, and selection of preferred alignment
- Stage 3: 2020 - development of preferred alignment (with local variations/options), construction impact considerations and statutory consultation
- Stage 4: 2021 - final alignment selection, statutory consultation and preparation of DCO submission

Of the four rounds of consultation, the first two are non- statutory to reach a preferred route and alignment and the third and fourth rounds are statutory to meet the reasonable requirements of meaningful consultation to reach a final alignment and for consultees to provide feedback on proposals for construction, operation, and future maintenance of the works.

The full strategy documents are included in Appendix E1.

As EWRCS will not now be a Network Rail promoted scheme, EWR Co must review and update this strategy to reflect the changing roles/responsibilities of the relevant parties. As the attached strategy was prepared on the basis of EWRCS being a Network Rail promoted scheme, certain assumptions have been made as to the possible consents strategy based on the applicability of Network Rail's existing statutory powers. In particular, where EWRCS may require changes to the existing rail network due to interfaces assumptions have been made in the strategy as to the ability to use Network Rail's existing statutory permitted development rights to authorise such works to the existing rail network. These permitted development rights would not be available to the EWR Co and so an alternative strategy for consenting works required to the existing rail network so to facilitate EWRCS will need to be prepared by EWR Co in consultation with Network Rail.

Non-statutory public consultation, currently planned to commence in early 2019, will be led by EWR Co with support from Network Rail. Network Rail will, of course, remain a consultee of an EWR Co promoted DCO in future phases for this scheme.

E.02 **Statement of Community Consultation**

A draft Statement of Community Consultation (SoCC) has been prepared in this phase and is included in the appendix to the Land and Consents Strategy (See Appendix E1 and E2). A SoCC is not required for non-statutory consultation; however, Network Rail applies the same principles and methods throughout all consultation for a scheme.

At present, non-statutory public consultation is due to start in the next phase of development activity, led by EWR Co as the promoter of the scheme, with support, as may be required, from Network Rail.

In accordance with section 47 of the Planning Act 2008 (the Act), a draft SoCC, has been prepared which summarises the proposal, Network Rail's approach to pre-application consultation and an indicative timeline. The SoCC will be a key document that forms part of the DCO public consultation process and will need to be formally agreed by the relevant local planning authorities prior to commencing statutory consultation.

EWR Co should review the SOCC as it has been written assuming that Network Rail is the promoter of the rail elements of a future DCO.

E.03 Stakeholder Consultation

Consultation has continued in this phase, both in relation to the development of EWRCS, and the Land & Consents strategy. An update on consultation with key stakeholders is provided in Part D Stakeholder Management of this report, including with statutory consultees. It is recommended that, in advance of further informal consultation commencing, a comprehensive geographic based stakeholder database and management system is implemented that can be used throughout the development of EWRCS and DCO process to ensure efficient and effective stakeholder consultation and this has been identified as an activity for the next phase of development.

Part F: **Risk & Opportunities**

F.01 **Programme Level Risks**

During this phase of work, a number of key risks have been identified, both by the Network Rail EWRCS team during risk workshops and by external stakeholders through Working Group meetings. These risks are currently at a programme level of detail. A live copy of the Quantitative Project Risk Actions and Exposure database is maintained by Network Rail. An internal Network Rail risk review workshop on 26th April 2018 identified the highest risks as, at this stage of development, as:

- Additional, or new scope, may be introduced into EWRCS due to EWRCS requirements / outputs changes
- Additional infrastructure may be required between Lidlington and Bletchley / Milton Keynes Central
- Decisions regarding Digital Railway may not be achievable if the tools / outputs to inform development and design are not available when required, with an impact on programme
- There is a risk that raw material cost fluctuations (above normal assumptions) may impact upon the capital cost and route choice (not design)
- Additional pedestrian and services capacity may have to be reviewed at existing stations

For further information on this section please refer to Appendix F1.

F.02 **Development Phase Risks**

In additional to these, a number of short term risks, related specifically to the current phases of development, have been identified. These include;

1. Integration with EWRWS and EWRES. Regular contact is maintained with the EWRWS project team, however, with different remits and requirements driving EWRWS and EWRCS, it is recognised that there is a disconnect between a number of aspects of these projects, including ITSS, rolling stock, infrastructure requirements on the MVL, business

case and revenue assumptions. The only activity on the EWRES, at present, is a Conditional Output Report, commissioned by the EWR Consortium, and which is being considered as part of the Cambridge Corridor Study

2. Integration with Oxford to Cambridge Expressway. This is a parallel highway proposal and meetings have been held with representatives of Highways England to discuss their proposals and identify opportunities to integrate the two projects and avoid potential conflicts in terms of user abstraction. Further work is required as the patronage model is developed for EWR to ensure these projects make consistent assumptions

3. Cost of infrastructure, particularly the high cost of crossing flood plains. This has been investigated as an opportunity in this phase and the capital cost estimates for EWRCS have reduced through replacing viaducts with embankments. Further consultation, and location specific discussions, with the EA are required to identify the most appropriate and acceptable solutions

4. Patronage at Bedford Midland versus Bedford South Station. Bedford Borough Council have advised Network Rail of their preference to retain the public transport interchange hub in the centre of Bedford. Current population is also currently more concentrated around the existing Bedford Midland Station, than a new Bedford South Station. However, with existing congestion problems around Bedford Midland, significant development proposals south of Bedford, varying demographics around Bedford and potential improvements to the A421, a Bedford South Station option may provide opportunity for greater patronage than at Bedford Midland. Understanding this issue, and how journeys on the Midland Main Line may be affected by an additional stop at Bedford South Station, will be critical to determining the optimum route through Bedford.

5. Construction staging, and the extent of temporary works, particularly at Bedford Midland. The current cost estimates for the works at Bedford Midland are taken from the outturn costs of other typical, inner city station works. There is a significant risk that the works at Bedford Midland will require a number of temporary stages before the final layout is realised. This could increase the cost significantly. It is recommended that this is developed at a concept level before this option is recommended or paused. There is also a significant risk that the ITSS would require significant works to depot facilities in the Bedford Midland area, to maintain safe working arrangements and maintain current operational requirements

6. Environmental impacts, particularly the acceptability of impacts on the Wimpole Estate. The best performing route, from a purely transport benefits perspective, is A1 which suggests that a route across the tree lined Wimpole Avenue, south of Wimpole Hall, could

be developed to the satisfaction of National Trust and at minimum cost. Whilst Cambridge Road (A603) already crosses this Avenue, this follows the route of a roman road which predated the Avenue. Specific consultation with the National Trust is required before options, such as southern diversions, or tunnels, can be eliminated. This consultation has already commenced, and indications are that mitigations, beyond those assumed, would be required to gain support from the National Trust.

7. Capacity requirements on existing rail corridors, particularly between Shepreth Junction and Cambridge. A separate study, being led by Network Rail's System Operator Anglia Team, is currently underway to determine an appropriate long-term solution, for the rail industry and local stakeholders, for the section of the West Anglia Main Line between Shepreth Junction and Cambridge (and on to Ely). The outcome of this study could have a significant (positive or negative) impact on the proposals for EWRCS.

8. Highways impacts. This risk is twofold; 1) the physical interfaces between the new railway and existing highways, and 2) the impact of traffic generated around stations as the result of any permanent diversions, or rationalisation of the highway network, proposed as part of the new railway development. Both have the potential to change the capital costs for the project

9. Utilities. Network Rail is aware, through visiting site and local knowledge, that there are a number of strategic utility corridors through the study area, including oil pipelines and overhead power lines. The cost and time required to negotiate these could have a significant impact on EWRCS which will need investigating in future phases of this study.

F.03 **Phase 2e Update**

A review of risks was carried out in this phase. A copy of the output from this is provided in Appendix F1.

As a result of this workshop, further activities will be undertaken in Phase 2f by Network Rail that will seek to define programme level and location specific risks that can be handed over to EWR Co and their new development partner for further consideration in future phases.

F.04 Opportunities

During this phase of work, a number of key opportunities have been identified, both by the Network Rail project team, through internal workshops, and also through discussions and consultation with external stakeholders. These opportunities have been detailed within a combined Risks & Opportunity Register (Appendix F1) maintained by Network Rail. The key opportunities, identified at this stage of development, include:

- Developing options to design the "A" route options to avoid the former land fill site at Elstow. Alternatively, the methodology of working within the vicinity of the landfill could be optimised to reduce the cost

- Reviewing the level of services within the ITSS, particularly the number of services to terminate at Cambridge, as this may negate the need to provide grade separation at Shepreth Branch Junction

- Funding for a new station at Wixams being provided by 3rd Parties

- Identification of options that would allow access to Bedford Midland station without the need to relocate the existing Thameslink Depot

- The ability to design steeper cut/fill slope gradients than assumed for in current order of magnitude cost estimates

- The cost for signalling at linespeeds lower than 125mph may be less than reported - the working headway has imported infrastructure costs that the operational solution does not need.

- If a route designed to run in parallel to the ECML, via the existing Sandy station, is progressed, further capacity modelling may demonstrate that 6 tracking is not required

F.05 Conclusion

Network Rail has continued to assess the risks at this stage of development for EWRCS in line with its GRIP process. However, to date, this has largely been an internal exercise for the Network Rail EWRCS team to inform areas where further development work could be undertaken.

As EWR Co take the lead role in the development of EWRCS, an integrated risk register should be developed that recognises risks and opportunities to all parties and allocates appropriate owners.

Part G: **Safety, Interoperability & Compliance, Environment & Performance**

G.01 **Safety**

In this, and previous phases of development activity, consideration has been given to compliance with the Construction (Design and Management) Regulations 2015 (CDM) and the Common Safety Method on Risk evaluation and assessment (CSM RA).

To date, Network Rail has assumed the role, under the CDM Regulations 2015, of both Client and Principle Designer. However, in assuming these roles, it needs to be acknowledged that this acceptance is limited to the development of rail infrastructure to achieve specified indicative/outline requirements using assumed parameters (rolling stock etc).

When viewed as a broader programme, EWRCS forms a small part of a much larger picture. The System Definition Document (Appendix G1), prepared within this phase, highlights the spectrum of influence that EWRCS will have on both the overall operation of the UK rail network, and the infrastructure and functionality of local, and national, non-rail systems.

For example, the broader impact of EWRCS on the "functioning" of the railway network/system, would include:

- The shape, size and competencies need to be established (so that the railway can be managed) by the Infrastructure Manager for the new strategic rail link
- Any changes to DfT and ORR oversight, approvals and inspection that may need to be established and agreed in relation to the Infrastructure Manager, and train operating company for EWR services
- Train servicing and stabling requirements need to be considered so that the trains can be serviced, cleaned and suitably located when not in use

- The impact on rail franchise agreements, driver training, rostering, locations etc needs to be considered
- Ticketing systems and relationship with travelcards, and local authority travel schemes, also needs to be identified

Examples of non-rail systems that may need specification criteria and design to support EWRCS include:

- Natural habitat areas, corridors and migratory patterns
- Agricultural and farming practices
- Journeys by other modes of transport
- Impact on other/adjacent infrastructure and/or their associated systems (i.e. local drainage components, surface run-off, flooding and flood attenuation)

As noted above, the scope of EWRCS, as remitted to Network Rail by EWR Co/DfT, is presently only to develop route options for railway infrastructure and provide an initial view of those other assets or systems that may be impacted by EWRCS.

For this phase, activities that were both required and relevant, in relation to CDM and CSM requirements, are summarised below:

1. Project Safety Strategy (Appendix G2). This strategy explains how adherence to the Construction (Design and Management) Regulations 2015 (CDM) and the Common Safety Method on Risk evaluation and assessment (CSM RA) shall be managed and monitored.
2. CDM Plan (Appendix G3). The CDM Plan records the arrangements (as identified by Network Rail) that shall be put in place to manage the safe development of EWRCS.
3. CSM Hazard Log (Appendix G4). This record has been undated during this present development phase to record hazards as identified by the Network Rail EWRCS team. It also contains a record of identified control measures that are to be used. It is to be noted that a number of hazards form this log may be 'owned' by others, or may transfer in ownership during the life of the design, construction or operation of this railway.
4. System Definition Document (Appendix G1). This document records and supports the remit by defining the scope of EWRCS and identifying those aspects that need to be considered as part of the larger (infrastructure and functional subsystem) design.
5. Requirements Management Plan (Appendix G5). This document sets the out the framework for the remit scope to be broken down into identifiable and manageable

/measurable articles. Network Rail understands that the design, verification and validation activities are likely to be undertaken by other parties, and so the content of this document focuses on the presently remitted work items and provides a frame of reference for the Route Requirements Document (RRD) (Appendix G6).

6. Initial iteration of a Route Requirements Document. This document records, at a relatively high level at this stage of development, the requirements of Network Rail, both as the assumed Infrastructure Manager for new railway, and the Infrastructure Manager for existing/adjacent railway, that are to apply, and provides appropriate information that guides the project as it progresses through the development phase. It is to be noted that this is not about listing standards, or legislation, that are to apply, but is more relevant and particular to the existing assets and the characterisation or performance of new/modified infrastructure.

For further details on the documents stated above please refer to Appendices G1

G.02 Interoperability & Compliance

The development of EWRCS needs to be considered in the context of the legislative framework in which the rail industry operates, covering railway-specific regulations and some non-railway specific regulations, which govern the management of change on the GB mainline railway system.

The key legislation is as follows:

The Railways and Other Guided Transport Systems (Safety) Regulations (as amended) 2006, commonly referred to as ROGS. These transpose the European Railway Safety Directive into UK law and place a duty on railway undertakings (RU) and Infrastructure Managers (IM) to:

- Develop safety management systems that must meet certain requirements.
- Have a safety certificate (for RUs) or a safety authorisation (for IMs).
- Show that they have procedures in place to introduce new or altered vehicles or infrastructure safely.
- Carry out risk assessments and put in place the measures they have identified as necessary to make sure that the transport system is run safely.

- Work together to make sure the transport system is run safely (ROGS regulation 22)

Railways (Interoperability) Regulations 2011 - these transpose the Railway Interoperability Directive 2008/57/EC ('the Directive') into UK law. RIR 2011 came into force on 16 January 2012, superseding the earlier Railways (Interoperability) Regulations 2006. RIR 2011 require new, upgraded, or renewed structural subsystems or vehicles to be authorised to be placed in service, before they can be put into use on mainline railway network in the UK (that is, before they are 'used on or as part of the rail system in the United Kingdom for the transportation of passengers or freight or for the purpose for which it was designed').

New, upgraded, or renewed structural subsystems or vehicles must comply with the relevant Technical Specifications for Interoperability (TSIs) in order to demonstrate they meet the 'essential requirements'. The essential requirements can be summarised as safety, reliability and availability, health, environmental protection, technical compatibility and accessibility.

Common Safety Methods - the Railway Safety Directive 2004/49/EC required 'Common Safety Methods' (CSMs) to be drafted by the European Rail Agency, working to a mandate from the European Commission. The CSMs are defined as 'the methods to be developed to describe how safety levels and achievement of safety targets and compliance with other safety requirements are assessed'. Currently, there are six CSMs:

1. CSM for assessment of achievement of safety targets
2. CSM for assessing conformity with the requirements for obtaining a railway safety authorisation
3. CSM for assessing conformity with the requirements for obtaining railway safety certificates
4. CSM for supervision by national safety authorities
5. CSM for monitoring to be applied by railway undertakings, infrastructure managers and entities in charge of maintenance
6. CSM for risk evaluation and assessment (CSM REA)

All CSMs take the form of Commission Regulations. As such, they are directly applicable in all Member States without the need for transposition into domestic legislation. They therefore have the same force as a UK statutory instrument.

Common Safety Targets – these are European-wide safety targets. They are set by the European Railway Agency (ERA) and are designed for member states to achieve at their level, rather than at the level of the individual transport operator.

Construction (Design and Management) Regulations 2015 – these describe law that applies to a *construction site* during the period when *construction work* is being carried out. For example, part of a station platform, usually subject to the requirements of a transport operator's safety management system, would become subject to CDM Regulations while any *construction work* is being carried out.

The development of EWRCS falls under these pieces of legislation and future phases will need to recognise the compliance requirements associated with them. In this, as in previous phases, the cost planning (estimating) work has been derived from what we would recognise as a current typical cross-section of UK railway. For example, passage for double decker train would not be possible, but many aspect of power, signalling and accessibility at stations would be compliant. These assumptions have been generated in conjunction with stakeholders and while they allow the generation of cost plans for (like for like) comparison purposes, they do not dictate nor confirm, the form of railway that would be acceptable. On selection of a preferred route, it is recommended that work to understand and remit/cascade requirements is commenced.

In addition, the requirements of the Railway industry including Network Rail (as the System Operator) will need to be confirmed for many functional requirements including:

- Capability for passenger and freight traffic (including electrification)
- Connectivity with East Coast, West Anglia and Midland Main Lines
- Interface with other functional rail subsystems.

G.03 Environment

Concept

This Phase 2e report follows on from previous reports and adopts the same Environmental Policies as directed by Network Rail standards. These are to be applied in the event the infrastructure is to be a network rail asset but in other circumstances may be considered best practice to deliver a sustainable railway for the benefit of the community its economic benefit and protection of its environment.

Method

Generally, route alignment re-assessment and sensitivity route design have been undertaken predominantly from an engineering standpoint with consideration for residential and business areas as well as other constraints. Principally these constraints are townships/villages, topography and flood plains.

An environmental impact assessment for each option has not been undertaken but the headlines noted. Unless specifically stated, designated environmental and heritage sites, such as SSSI's, SAC's, SPA's, Nature Reserves, Listed Buildings and Scheduled Ancient Monuments etc. have not been used to drive route alignment at this stage of design however they have been noted and are reflected in the risk register. An impact assessment will follow once options have been consolidated to a preferred single option.

Specified Environmental Impact Areas - Design (post option selection)

- Air Quality
- Archaeology and Cultural Heritage
- Contaminated Land
- Ecology
- Energy
- Landscape
- Lighting
- Materials
- Noise and Vibration
- Waste
- Water

All these areas are applicable to the programme and will need consideration and mitigation.

Report Findings

Route alignment re-assessment and sensitivity route design is to be undertaken predominantly from an engineering standpoint with consideration for residential and business areas as well as other constraints. Principally these constraints are townships/villages, topography and flood plains. Unless specifically stated, designated environmental and heritage sites, such as SSSI's, SAC's, SPA's, Nature Reserves, Listed Buildings and Scheduled Monuments etc. have not been used to drive route alignment at this stage of design.

Headline examples of sites identified are given below (not exhaustive)

- Sandy Warren SSSI
- Former land fill site at Elstow
- Wimpole Estate
- Bedford Maintenance Depot and Bedford Midland station
- Interfaces with highways byways
- Residential areas notably at Cambridge, Sandy, Bedford, Wixams and numerous villages and farms dependant on alignment
- Interface with rivers and ground water including extraction protection
- No hydrology study has been conducted however consultation with the EA has been undertaken to understand and consider flood risks and mitigation proposals put forward
- The earthworks design philosophy has been assumed the balance is achieved between exacted material and deposited material
- The materials used will be specified and sourced at a later stage, but it is assumed they will consider whole life costs where data can be generated to make an informative judgement, and be compliant and responsibly sourced.

Next Steps

In future phases EWRCS will be subject to exhaustive consents processes and these are identified in the draft land and consents strategy. To inform the consents requirements, the design will follow best practice considerations and identify, logging issues. Various administrative, stewardship, designated and statutory areas, as shown in the web site Magic.defra.gov.uk, are encountered where conditions will need to be complied with as determined by the consents determination.

Below is a list of Network Rail standards that may apply

NR/L2/ENV/015 Environmental and Social minimum requirements – design and construction

NR/L2/ENV/015 – Appendix B - Environmental Management Plan

NR/L1/ENV/100 Network Rail Environment and Social Performance Policy

NR/L1/INI/GRIP/100 Governance for Railway Investment Projects – Policy Manual

NR/L2/INI/CP0070 Principal Contractor Licensing Scheme

NR/L2/MTC/006 Maintenance and Contents of the National Hazard Directory.

NR/L2/TRK/5201 Management of Lineside Vegetation

NR/L3/MTC/MG0194 Communicating with the Public

NR/L2/INV/002 Accident and Incident Reporting and Investigation

NR/L3/OPS/045/4.04 Incidents

NR/L3/INV/3001/RIM101 Reporting of Accidents, Incidents and Occupational Ill Health

NR/L3/INV/3001/RIM102 Reporting of Accidents, Incidents and Occupational Ill Health to SMIS

NR/L3/INV/3001/RIM113 Statutory Reporting of Accidents, Incidents and Occupational Ill Health

NR/L1/ELP/27000 Policy Requirements for Electrical Power Assets

NR/L2/INF/02202 Records management of health and safety files

NR/L3/OPS/045/5.10 Management of Environmental Arrangements

NR/L3/OPS/045/5.04 Management of Station Works

G.04 **Performance**

In relation to the existing network, Network Rail have agreed CP6 performance targets that are detailed within the Strategic Business Plan 2019-2024 for each route and targets such as PPM, etc. are agreed with individual TOC's. Establishing and assessing schemes that are in this stage of development with regards to these type of performance KPI's is not feasible due to the lack of detailed information with regards to the infrastructure and/or working timetable. It is recommended that as more detail on the infrastructure and proposed timetable is understood that a more detailed view of performance can be provided. Measurement such as "Capacity utilisation" where the EWRCS is interfacing with existing Network Rail assets such as at Bedford Midland, Cambridge, etc., can provide indications as to performance potential recognising that any changes to the network will also have to undergo either the Network Change or Station Change consultation process.

Part H: **Conclusion**

Progress has been made in Phase 2e both in testing the scope, cost and value of a number of elements of route options identified in the previous phases, as well as considering a number of potential new route options in response to the NIC November 2017 report and recommendations.

Against the standard WebTAG compliant transport appraisal criteria used by Network Rail in this phase and using the recently recalibrated model produced by Leigh Fisher, the analysis indicates that the best value, non-electrified, with diesel rolling stock, route option is route option A1. This option offers a BCR of 0.35 at this stage of development, which represents poor value for money, suggesting EWRCS no longer has the potential to be developed into a viable scheme based on transport benefits alone.

It is recognised that this varies the output from Phases 2d as a result of the error identified in the Atkins model which is addressed in Part C Economic Appraisal of this report.

Recognising the objectives and recommendations from the NIC November 2017 report into the Oxford-Milton Keynes-Cambridge corridor published in November 2017, EWR Co requested Network Rail to use a high growth assumption, out with the WebTAG guidance, which resulted in an increase to the BCR for route option A1 to 1.45. This high growth assumption is intended to align with the transformational growth scenarios outlined by the NIC. Additionally, EWR Co have procured some Land Usage Transport Interaction modelling from KPMG to take better account of benefits that could be attributed to economic growth, housing/job development and land value capture. Network Rail has not yet had sight of the outcome of this analysis and therefore it is not referenced in this report.

If the high growth assumptions can be justified, this would suggest that EWRCS continues to represent value for money and could develop into a viable scheme. This information will support the strategic case for the scheme as part of the SOBC to be developed by EWR Co.

In relation to the engineering activities undertaken in this phase, the conclusions from this phase of development are:

- There is an opportunity to reduce the capital cost of EWRCS in relation to linespeed and gradient, through reduced footprint and cut and fill volumes, but this needs to be considered against any future proofing and strategic requirement needs

- An intermediate station between Bedford and Cambridge can be accommodated but results in additional journey time for both northerly and southerly options. However, diverting route option C3 further north to accommodate a station at Cambourne reduces the capital cost due to passing over less challenging topography

- There is an opportunity to reduce cost for a new Sandy South Station through using embankments over viaducts however this invokes additional design risks such as attenuation compensation.

- There is a risk associated with the number of services that need to access Bedford Midland Station due to a level crossing that serves Bedford Maintenance depot and Thameslink rolling stock moves. There would need to be significant remodelling of the depot to maintain an acceptable level of risk for both use of the level crossing, and depot operations. Solutions to address this are being considered as part of a separate study being progressed by Network Rail, due for completion in March 2019.

- Options for EWRCS to align with a new station at Wixams on the MML include a split-level station, with EWRCS passing over the MML, or an at grade station. The split-level options bring additional construction and maintenance costs. The key variable is the interface with the former land fill site at Elstow that needs to be investigated further. A new station at Wixams, constructed in advance of EWRCS, would likely determine the location of a new Bedford South Station

- Opportunities to reduce the length of viaduct structures and replace with earthworks embankment, thus reducing costs through cheaper construction methods, have been identified. The benefits of this on route options passing through low lying flood plains are noticeable, however, this alters the risk profile as flood attenuation and compensation areas need to be evaluated, provided and maintained to a level that would be acceptable to the Environment Agency

- A new grade separated junction at Shepreth Branch Junction will not easily fit within the current Network Rail boundary and, therefore, land acquisition would be required. The location for a new station proposed to the south of Cambridge, to serve the biomedical campus, is critical to the junction layout for EWRCS and development for the junction and the station needs to be integrated so that the optimum design can be identified

- Options to provide direct train connectivity into and out of Bedford Midland station from a south-easterly direction from Cambridge are possible but require issues with the Bedford Maintenance depot to be resolved as referenced earlier.

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Part I: **Next Steps**

Network Rail has been asked by EWR Co/DfT to continue with development activities through to the end of March 2019, after which, EWR Co anticipate that they will have a new supplier to lead the development and design activities through to DCO submission.

However, Network Rail will continue to support EWR Co and DfT with the development activities through to March 2019, activities which will include handover to a new supplier as well as supporting the public consultation activities planned in early 2019.

Other development activities have been identified and agreed with EWR Co/DfT which will continue to inform the choice of preferred route and Network Rail will support on-going consultation with stakeholders during this period.

It is anticipated that an announcement on a preferred route will be made in Spring 2019 by EWR Co.

Part J: **Appendices**

J.01 **List of Appendices**

Appendix	Title/ Description
A1	NIC Report
A2	Review of SO/Cos
A3	Consultation with EWR Consortium
A4	Consultation with Working Group
A5	Phase 2c & 2d report
A6	Client's Requirement Document (CRD)
A7	Grant Funding Agreement (GFA)
A8	Variation to GFA
A9	Variation to GFA
A10	Project Change Log
A11	NR ITSS Workshop
A12	EWRWS Output Specification
A13	Marston Vale Line Study GFL
A14	Atkins EWRES CO Study
A15	CRD for Cambridge Corridor Study
B1	Key Assumptions register
B2	Network Rail Cost Plan report
B3	Sensitivity Assessment Report for Line Speed and No Freight
B4	Sensitivity Assessment Report for Intermediate Stations
B5	Value Engineering Report for Sandy South Station
B6	Value Engineering Report for Bedford Midland Station
B7	Wixams Route Option Sensitivity Report
B8	Value Engineering report for Flood Plain Strategy
B9	Value Engineering Report for Shepreth Branch Junction
B10	St Neots to Bassingbourn Route Option Development Report

B11	Tempsford analysis
B12	Anglia Report
B13	Journey Time Modelling
C1	Freight benefits report
C2	Freight forecast consultation
C3	Freight forecast consultation
C4	Phase 2E Economic Analysis - Socio-Economic Appraisal Report
D1	Stakeholder Management Plan
D2	August Working Group Slides
D3	August Working Group attendees
D4	March Working Group Slides
D5	March Working Group attendees
D6	Statutory Consultee Workshop
D7	Statutory Consultee Workshop Attendees
D8	EWR Consortium AGM
D9	RIRG LNE&EM
D10	RIRG Anglia
D11	RSPG LNE & EM
D12	RSPG Anglia
D13	DRAM LNE&EM
D14	DRSAM LNE&EM
D15	Head of Strategic Planning Anglia
D16	Head of Maintenance South LNE&EM
D17	Asset Management Support
D18	Digital Railway presentation
D19	BEAP Briefing note
E1	Land & Consents Strategy
E2	Statement of Community Consultation
F1	Qualitative Risk Review Report
G1	System Definition Document
G2	Project Safety Strategy

G3	CDM Plan
G4	CSM Hazard Log
G5	Requirements Management Plan
G6	Route Requirements Document

Part K: **Abbreviations & Glossary**

Abbreviation	Existing Terminology	Translation and notes
AiP	Approval in Principle	The Approval In Principle (AIP) document outlines the concept for the design of the structure.
ALCRAM	All Level Crossing Risk Assessment Model	The All Level Crossing Risk Model (ALCRAM) was rolled out across Network Rail during 2007, and has subsequently been populated with data. The current version of the model represents the culmination of nearly eighteen years' work of modelling, calibration, upgrades, and related activities.
BBM	Marston Vale Line	
BCDG	Buildings and Civils Design Group	
BCR	Business Case Ratio	Measures company's ability to meet financial obligations.
BDM	Bedford Midland Station	Bedford railway station is the larger of two railway stations in the town of Bedford in Bedfordshire, England. It is on the Midland main line from London St Pancras to the East Midlands and the terminus of the Marston Vale line from Bletchley through Bedford St Johns.
BGK	Bethnal Green to Kings Lynn	
BoQ	Bill of Quantities	
BSP	Bedford South Parkway	
CDM	Construction Design and Management	The main set of regulations for managing health, safety and welfare of construction projects.
CEN60		CEN60 (60 kg/m) rail section was introduced in the UK during the 1990s.
Ch	Chainage	ch25km

CO	Conditional Output	Something beneficial that could be delivered by the railway, but which isn't guaranteed to be affordable, deliverable or necessarily the best thing to do. Conditional outputs are a useful way of capturing high level aspirations ("4 trains per hour between A and B, with a journey time no greater than X"). But they are easily misunderstood by stakeholders and investors – especially their conditionality.
CRD	Client Requirement Document	Defines the high level outcomes that the business aims to achieve. It represents the clients high level aspirations and needs such as extra capacity, shorter journey times etc.
CSM	Common Safety Method	It is a framework that describes a common mandatory European risk management process for the rail industry.
CWR	Continuous Welded Rail	
DCO	Development Consent Order	
DfT	Department for Transport	
DMRB	Design Manual for Roads and Bridges.	
DNO	Distribution Network Operator	
DOWN line		In the context of EWRCS the DOWN line is travelling East to West from Cambridge to Oxford
EA	Environmental Agency	Department for Environment, Food and Rural Affairs, with responsibilities relating to the protection and enhancement of the environment in England.
ECI	Early Contractor Involvement	
ECML	East Cost Mainline	The major railway link between London and Edinburgh.
EEH	England Economic Heartland	
EM	East Midlands	
EMGTPA	Equivalent Million Gross Tonnes per Annum	

EMU	Engineering Maintenance Unit	
ERTMS	European Rail Traffic Management System	A traffic management system which is specified by Europe to provide a unified signalling and control system throughout the European area. A key component of ERTMS is the on-board signalling equipment (referred to as the European Train Control System or ETCS).
ERTMS Lv0 & STM	ERTMS - Levels and Modes	Level 0, which is meant for trains equipped with ETCS running along non-equipped lines; and Level STM, which is meant for trains equipped with ETCS running on lines where the class B system needs to be operated. Regarding the STM level, the ETCS acts as an interface between the driver and the national ATP.
ERTMS Lv1	ERTMS - Levels and Modes	Level 1 involves continuous supervision of train movement while a non-continuous communication between train and trackside (normally by means of Euro-balises). Lineside signals are necessary and train detection is performed by the trackside equipment out of the scope of ERTMS.
ERTMS Lv2	ERTMS - Levels and Modes	Level 2 involves continuous supervision of train movement with continuous communication, which is provided by GSM-R, between both the train and trackside. Lineside signals are optional in this case, and train detection is performed by the trackside equipment out of the scope of ERTMS.
ERTMS Lv3	ERTMS - Levels and Modes	Level 3 is also a signalling system that provides continuous train supervision with continuous communication between the train and trackside. The main difference with level 2 is that the train location and integrity is managed within the scope of the ERTMS system, i.e. there is no need for lineside signals or train detection systems on the trackside other than Euro-balises. Train integrity is supervised by the train, i.e. the train supervises being complete and not having been accidentally split.

ETCS	European Train Control System	The European Train Control System (ETCS) is the signalling and control component of the European Rail Traffic Management System (ERTMS).
EWR Co	East West Rail Company	
EWRCS	East West Rail Central Section	The corridor linking Bedford to Cambridge via Sandy
EWRES	East West Rail Eastern Section	
EWRWS	East West Rail Western Section	
FWI	Fatality Weighted Index	
GDP	Gross Domestic Product	Gross domestic (GDP) is a monetary measure of the market value of all the final goods and services produced in a period (quarterly or yearly) of time.
GFL	Grant Funding Letter	
GI	Ground Investigations	
GJT	Generalised Journey Time	
GRIP	Governance For Railway Investments Projects	A management and control process developed by Network Rail for delivering projects on the operational Railway
GTR	Govia Thameslink Railway	
HazID	Hazard Identification	
HS2	High Speed Two (projects or company)	High Speed Two (HS2) Ltd.
IDBs	Internal Drainage Boards	
IDC	Inter Disciplinary Check	
IDG	Integrated Design Group	
IDR	Inter Disciplinary Check	
ITSS	Indicative Train Service Specification	
KPI	Key Performance Indicator	A performance measurement to enable organisations to track and monitor the success of their operations

KPMG	KPMG	KPMG is a professional service company and one of the Big Four auditors, along with Deloitte, Ernst & Young, and PricewaterhouseCoopers. Seated in Amstelveen, the Netherlands, KPMG employs 189,000 people and has three lines of services: financial audit, tax, and advisory
kV	Kilovolt	
LiDAR	Light Detecting and Ranging	
LNE	London North East	
LNW	London North West	
LOWs	Lookout Operated Warning System	A person appointed, when required to ensure staff are in a position of safety for a minimum of 10 seconds. He/She will be appointed if the line/s cannot be blocked and work has to take place.
LTPP	Long Term Planning Process	
MML	Midland Mainline	
MoD	Ministry of Defence	The Ministry of Defence (MoD or MOD) is the British government department responsible for implementing the defence policy set by Her Majesty's Government and is the headquarters of the British Armed Forces.
MRAO	Mullard Radio Astronomy Observatory	The Mullard Radio Astronomy Observatory near Cambridge is home to a number of large aperture synthesis radio telescopes
MVL	Marston Vale Line	
NESA	National Electronic Sectional Appendix	
NIC	National Infrastructure Commission	
NR	Network Rail	
NR60		In Great Britain there are designs for both vertical S&C (CEN56) and inclined S&C (NR60), the latter inclined at 1/20
NT	National Trust	The National Trust, is a conservation organisation in England, Wales and Northern Ireland. The charity works to preserve and protect historic places and spaces.

OLE	Overhead Line Equipment	Overhead line equipment (OLE) refers to the overhead wires and supporting infrastructure that carry electricity at 25,000 volts to power electric trains.
OMCEs	Order of Magnitude Cost Estimates	
OPEX	Operating Expenditure	
ORR	Office of The Railway Regulator	The Office of Rail and Road is a non-ministerial government department responsible for the economic and safety regulation of Britain's railways, and the economic monitoring of Highways England.
PPM	Public Performance Measure	Takes into account cancellations and all causes of delays and combines figures for punctuality and reliability into a single performance measure. As an example, to achieve PPM, a train must a) complete its full scheduled journey, b) make all of its scheduled station stops and c) arrive at its final destination on time or less than 5 minutes late (for Chiltern, West Midlands Trains and Merseyrail services) or less than 10 minutes late (for Virgin Trains and TransPennine Express services).
PTI	Platform Train Interface	
PV	Present Value	
PVD	Prefabricated Vertical Drains	
RA	Risk Assessment	A term used to describe the overall process or method where you identify hazards and risk factors that have the potential to cause harm
RAM	Route Asset Manager	
RDD	Route Requirements Document	The purpose of the Route Requirements Document is to transform higher level requirements defined at the start of the development phase into a set of route requirements to fulfil the business needs. i.e. What is the best option to achieve the client's business need.
RISG	Rail Industry Steering Group	

S&C	Switches and Crossings	Switches and Crossings: the specially machined rails designed to permit trains to transfer between tracks.
SAC	Special Areas of Conservation	
SAMs	Scheduled Ancient Monuments	
SBR	Shepreth	
SEMLEP	South East Midlands Local Enterprise Partnership	
SEU	Signalling Equivalent Units	Signalling Equivalent Units
SOBC	Strategic Outline Business Case	
SoCC	Statement of Community Consultation	
SPA	Special Protected Areas	
SSSI	Site of Special Scientific Interest	
TOC	Train Operating company	Train Operating Companies (TOCs) run rail passenger services, leasing and managing stations from Network Rail.
TOWs	Train Operated Warning System	An audible warning to those working on the track of the approach of the Train
TPH	Trains Per Hour	
TSI	Technical Standards for Interoperability	
TSS	Train Stopping System	Train stop sensor is located immediately on the approach side of a signal and will activate if a train passes it when the signal is at danger
UP line		In the context of EWRCS the UP line is
UXO	Unexploded Ordnance	Unexploded ordnance (UXO) is any sort of military ammunition or explosive ordnance which has failed to function as intended.
VFM	Value For Money	Used in reference to something that is well worth the money spent on it.
WAML	West Anglia Mainline	The West Anglia Mainline is one of the two main lines from London Liverpool Street.

WCML	West Coast Mainline	The West Coast Mainline is one of the most important railway corridors in the United Kingdom, connecting the major cities of London, Birmingham, Liverpool, Manchester and Glasgow. It is one of the busiest mixed-traffic railway routes in Europe.
WebTAG		WebTAG provides information on the role of transport modelling and appraisal