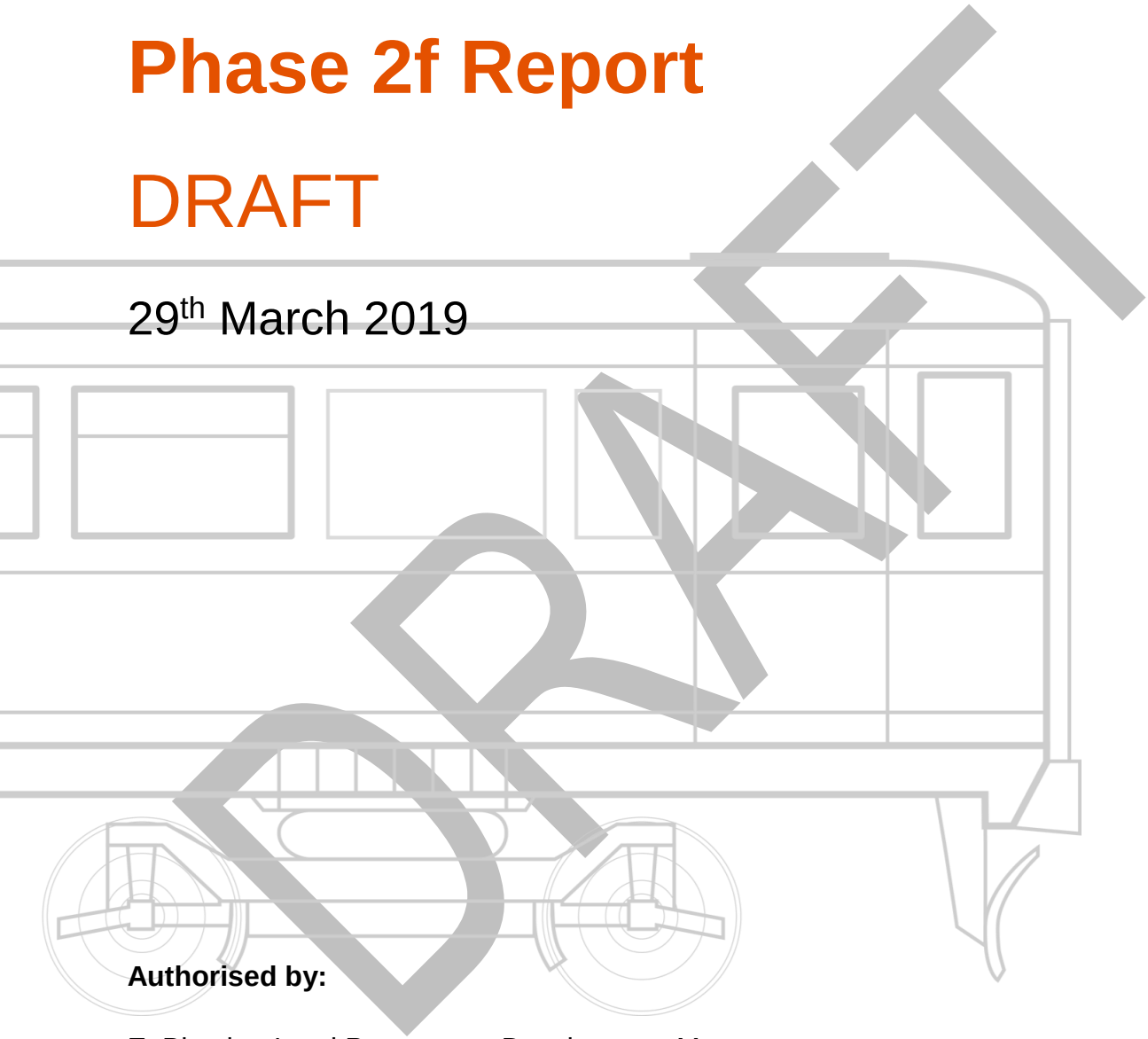
East West Rail Central Section

Phase 2f Report

DRAFT

29th March 2019



Authorised by:

E. Blamire, Lead Programme Development Manager

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 the Grant Funding Agreement dated 28th August 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 (EWRCS) in the period between 1st August 2018 and 31st March 2019 (known as Phase 2f). This document and its appendices only represent a report on the output of NR's evaluation in this phase 2f 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 EWRCS undertaken by EWR Co following the production of this document and its appendices.

Version	Date	Comments	Author	Checker
Draft	29/03/2019	Issued to EWR Co for comment	Various	Various

Contents

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 August 2018 and 31st March 2019, referred to as Phase 2f. It continues analysis undertaken in Phase 2e 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 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 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 he was setting 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.

Figure X1: Illustration of EWR Sections

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 on changes to both the strategic objectives and conditional outputs (see section A.03) for EWRCS, improving alignment with East West Rail Western Section (EWRWS), and focusing more on connectivity than journey time. These were instructed to NR in this phase 2f.

The objectives of the development activity to be undertaken, or supported, by NR in this phase were:

- commencement of public consultation on route options
- improved understanding of scope and cost estimates of different route options to support economic appraisal
- confirmation of a single preferred route
- development of a Strategic Outline Business Case for the preferred route to support a Decision to Develop by the Department
- handover of development work undertaken to date to East West Railway Company and their future development/design supplier

Following on from the work on route options in the previous Phase 2e, EWR Co identified a short list of options for this phase and to include in the consultation documentation, this then informed the development activities identified for phase 2f. These are shown in Figure X2.

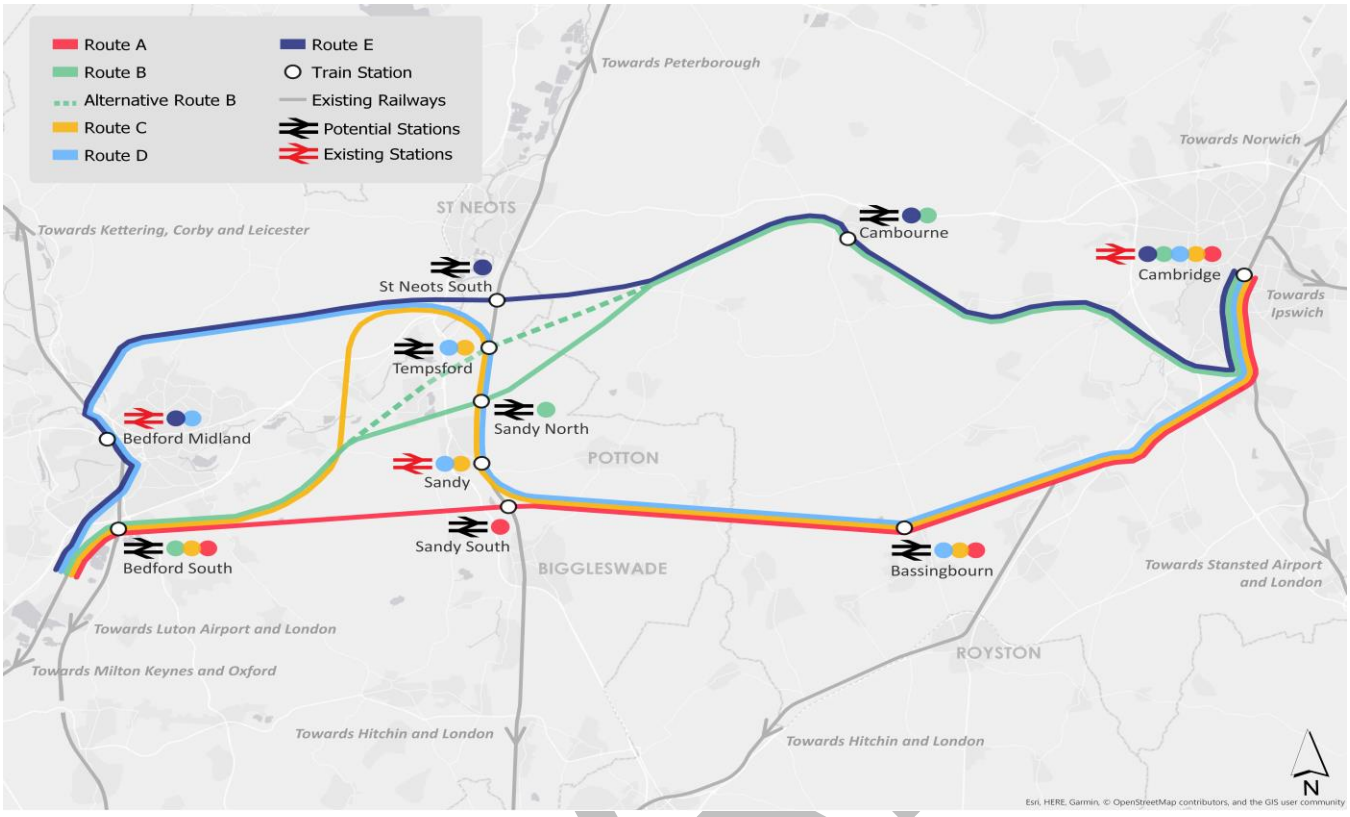


Figure X2: Routes shortlisted by EWR Co

These route options use a different referencing system to that used by Network Rail in its development work, therefore, the table below cross references EWR Co's route options with Network Rail's route options.

Table X1: Cross referencing between EWR Co route options and Network Rail development work

EWR Co Reference	NR Reference
A	A1
B	A3 CAM
B Alternative	E5
C	E4
D	SN4
E	CAM2

The ITSS in this phase has developed to take account of the revised conditional outputs of up to 6tph between Bedford and Cambridge, and up to 4tph between Bedford and Bletchley (plus 1 tph existing passenger service and 1 tph freight). 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, as has been highlighted by the review of options to access Cambridge, which is significantly impacted by the assumption that some, if not all, EWR services will continue on to Ipswich and Norwich.

The key findings from the work carried out in this phase were:

Impact Assessment

Following the changes to the strategic objectives and conditional outputs for EWRCS, Network Rail was asked to undertake an impact assessment of these changes on the previous development work undertaken and the decisions made regarding which options to pause from further development.

Overall the assessment has shown that the revised strategic objectives and conditional outputs for EWRCS have no identified material impact on decisions made during previous option development phases. However, the greater focus on supporting housing development means that previous choices, potentially going back to corridor level discussions, will need to be kept under review and re-visited at appropriate intervals as further information becomes available, including the availability of more detailed housing development plans as produced by the Government and/or local authorities.

In addition, due to changes to the strategic objectives and conditional outputs for EWRCS, and challenges from a local lobby group, the CamBed RailRoad group, a review of options to access Cambridge from the north was undertaken with key industry stakeholders in October 18. Whilst a preferred option to access Cambridge from the north was identified, overall, it did not perform better than the current preferred to access Cambridge from the south, due to greater distance and onward connectivity to Norwich and Ipswich. Therefore, the group supported the position that no further development work on any northern option(s) to access Cambridge was to be carried out at this stage of development.

Geotechnical Sensitivity Assessment

This analysis was undertaken to test the assumptions made in previous phases with regards to cutting and embankment slope angles. The general findings were that the 1:4

slope for cuttings and 1:2 slope for embankments was reasonable for the area's geology. The study found that some of the excavated material from the cuttings could be re-used in the embankments. An allowance has been made for the removal of the top metre within the site strip volumes as this is unlikely to be reusable in the embankments. Therefore, allowances have been made to the estimates to reflect these findings. Route options that pass-through low-lying ground benefit less from this approach than route options passing through higher ground. A more detailed analysis will be required, however, with ground investigations undertaken and results obtained in future phases of development.

Alternative Solutions

A number of alternative solutions, to those previously considered, were considered in this phase to establish whether the current preferred options represent the most viable solutions.

- **Bedford Area**

Three alternative solutions have been identified for further consideration in future stages because they provide opportunities to mitigate potential infrastructure costs and operational constraints on the BBM in the Bedford St Johns/depots area (Train Care depot and Jowett Sidings). However, these solutions would involve significant works to the MML.

- **Sandy Area**

The alternative options considered do not represent a better alternative to the current preferred solution as capacity on the ECML Slow Line cannot be identified for EWR services. It is not proposed that these solutions are progressed further unless use of the ECML Slow Lines changes in the future.

- **Cambridge South**

A southern connection onto the WAML could be a viable alternative solution because it could provide a different approach in to Cambridge avoiding the grade separation of Shepreth Branch junction that has been included to date. However, this option requires further detailed assessment to fully ascertain the impact on the WAML particularly in Great Shelford due to the location of the station and level crossings.

- **South of Bassingbourn**

It is possible to accommodate a diversion of the southerly route options to mitigate impact on Wimpole Estate and MOD site. Further discussion of these alternative options should be discussed with relevant stakeholders.

- **London Connections**

Options to accommodate EWR services going to London from Cambourne could be developed. Currently the costs for this are not included within the costs for EWRCS, and consequently have not been taken into account in the business case.

- **Milton to Cambridge**

There are significant challenges associated with 4 tracking the WAML north of Cambridge, and there would be a significant impact on existing services, and other modes of transport in/out of Cambridge, during the construction period.

- **Wimpole Estate**

A number of options to mitigate the impact of a southerly route option on the Wimpole Hall Avenue have been considered, with varying costs. Should an alignment be chosen that would impact on the Wimpole Hall Avenue, then these options should be discussed further with National Trust.

Route Development

An update on the development activity has been undertaken in this phase to assess all route options for EWRCS to the same level of engineering understanding and cost estimation.

Highways Traffic Modelling

In this phase, some initial highways modelling has been undertaken, using framework contracts used by Bedford Brough Council and Central Bedfordshire Council for their own highways modelling. This work was intended to inform whether the changes in journeys to existing and new stations within these areas would have an impact on the existing highways network. Cambridge was omitted at this stage as all route options access Cambridge from the south and therefore was not a differentiating factor at this stage.

Whilst more detailed analysis will be required in future phases, particularly when a preferred route option is confirmed, the initial indications are that the existing highways network could accommodate the changes to existing road journeys, as well as new journeys by road, as a result of the introduction of EWR services onto a new strategic rail link between Bedford and Cambridge.

Throughout this phase, consultation has continued with various stakeholders, external rail industry stakeholders and statutory consultees in particular with some specific meetings attended with the National Trust and RSPB. Network Rail also supported EWR Co with a series of non-statutory public consultation events on the shortlisted route options.

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, Network Rail has continued to undertake the Client's Representative role under the Construction (Design and Management) Regulations 2015 (CDM) but this role must now transfer to EWR Co for future development phases and the EWR Co will need to prepare their own strategy.

In summary, therefore, development work has continued in this phase on route options, providing updated information to EWR Co on key issues, risks and opportunities that have been identified in relation to the remaining route options. EWR co will use this output to inform the development of the SOBC and the identification of a single preferred route, which it is anticipated, that the EWR Co will announce in 2019.

The interfaces with Network Rail, when EWR Co bring on board their new technical partner, will be in relation to their role as the System Operator and the Infrastructure Manager for the existing rail network and appropriate arrangements, including commercial, will be required to continue the required level of engagement with Network Rail.

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 2018 to 31st March 2019, referred to as Phase 2f. It continues analysis undertaken in Phases 2c, 2d and 2e 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 East West rail Consortium (EWR Consortium) and sought to establish that there was a case to progress further development of the East West rail (EWR) project.

The 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 the setting up of the separate EWR co to lead the development, delivery and operation of EWR. The EWR Co, is now legally established with some delegated authority from DfT, however, at the time the Grant Funding Agreement (GFA)[1] needed to be signed for this phase 2f those delegated authorities were not in place before the GFA was agreed.

EWR encompasses a corridor 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:

[1] GFA means the Grant funding Agreement dated 28 August 2018 between DfT and Network Rail

- 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 (Phase 1), to be followed later with connections to Bedford (phase 2).
- The Central Section (EWRCS) between Bedford 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.

EWR Co are remitted to develop and deliver the Western and Central sections as shown in Figure A1 below. 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 and Central Sections

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

A.02 National Infrastructure Commission

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 has resulted in a review of the strategic objectives and conditional outputs for EWRCS, and a number of changes were consulted with stakeholders by EWR Co, and formally instructed to Network Rail at the start of this phase 2f. The current strategic objectives and conditional outputs for EWRCS are shown in section A.03 below. These place a greater emphasis on providing an inter-urban, commuter railway compared to previous focus on a long-distance, high-speed output between Oxford and Cambridge.

A.03 Strategic Objectives and Conditional Outputs

In accordance with the instructions from EWR Co in this phase 2f, the current strategic objectives for EWRCS are:

- Improve east-west public transport connectivity by providing rail links between key urban areas (current and anticipated) in the Oxford-Cambridge Arc
- Stimulate economic growth, housing and employment through the provision of new, reliable and attractive interurban passenger train services in the Oxford-Cambridge Arc
- Meet initial forecast passenger demand
- Consider and plan for future passenger demand, making provision where it is affordable
- Contribute to improved journey times and inter-regional passenger connectivity by connecting with north-south routes and routes beyond Oxford and Cambridge
- Maintain current capacity for rail freight and make appropriate provision for anticipated future growth
- Provide a sustainable and value for money transport solution to support economic growth in the area.

These are consistent with the strategic objectives for EWRWS.

The current conditional outputs for EWRCS, based on the "<50 miles, best possible future" characteristics are:

- Shorter distance connectivity to support commuting travel into key employment hubs
  - Capability for up to 6 trains per hour (tph) between Cambridge and Bedford[2]
  - Target of 30 mins or less between Cambridge and Bedford
- Longer distance connectivity for business to business connectivity
  - At least 2 tph between Cambridge and Oxford
  - Target of around 80 mins between Cambridge and Oxford[3]
- Passenger interchange facilities at all node points (Bedford, Sandy and Cambridge) to facilitate longer distance journeys.
- Average end to end journey speed of 60mph Oxford to Cambridge
- Freight capability to support anticipated growth, where affordable

During this phase, Network Rail undertook an impact assessment of the changes to the strategic objectives and conditional outputs on previous development work undertaken in earlier phases (see section A.05 for more details). This assessment is covered in Section B of this report.

A.04 Project Phase/History

All of the development work undertaken 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 (SOBC). 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.

[2] *The current planning assumption is that at route opening these will be 2 tph Cambridge-Bedford-Oxford and 2 Cambridge-Bedford-Bletchley and subsequently there could be the introduction of 2 tph Cambridge - Bedford.*

[3] *Whether around 80 minutes is achieved as a target depends inter alia on what improvements are made to the Marston Vale Line and the number of stops between Bedford and Cambridge*.

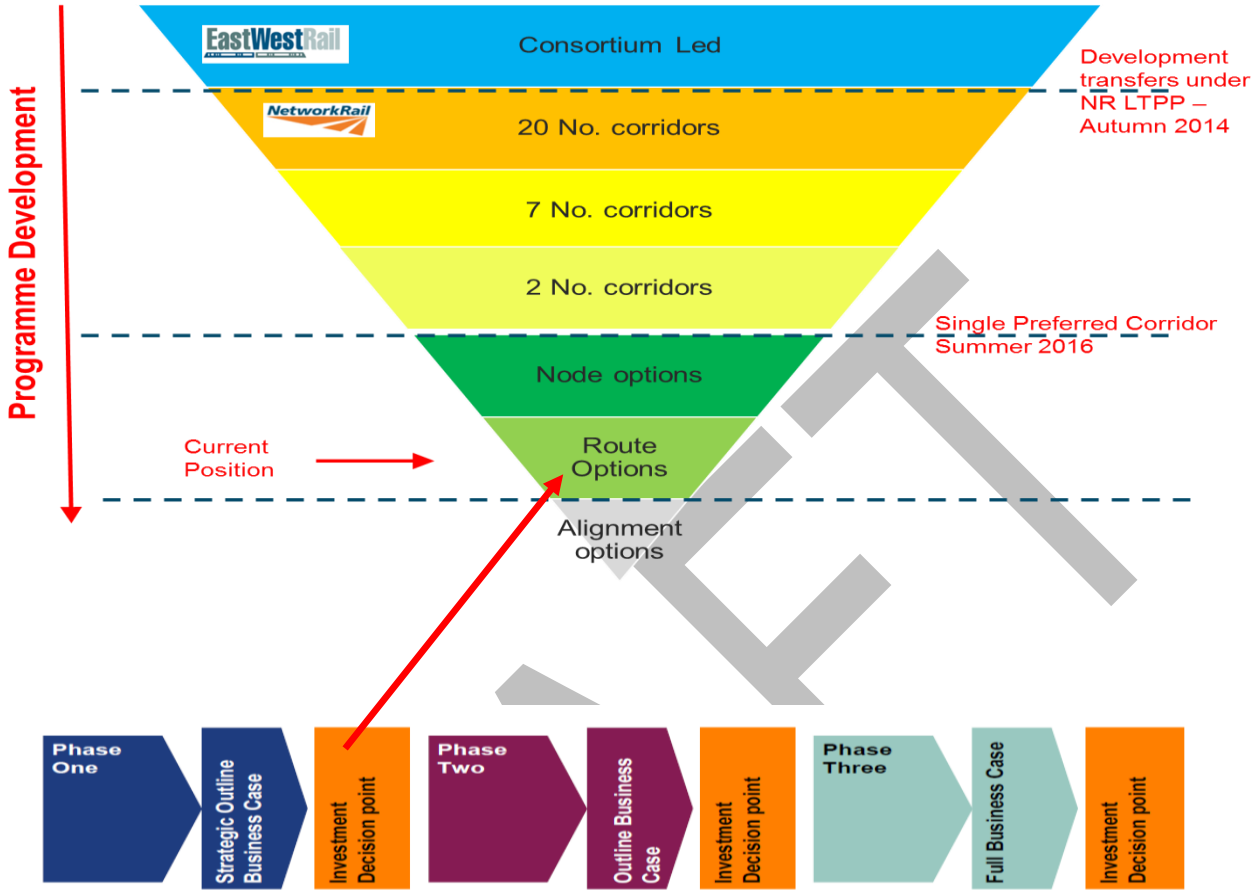


Figure A2: Development Strategy for EWRCS

EWR Co are leading the development 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, 2d and 2e and this report should be read in conjunction with the analysis and output from those phases.

EWR Co anticipate being in a position to confirm a preferred single route in 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. Network Rail's Client Requirement Document (CRD), version 1.5, dated March 2019. This is included in Appendix A1. This is a Network Rail GRIP product, produced by the LNE&EM Strategic Planning team within the System Operator function. This has been updated in this phase to reflect the revised strategic objectives and conditional outputs.

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

This document will form part of the handover documentation to EWR Co and can be used at their discretion to gain an understanding of the issues that will be of importance to Network Rail as the System Operator and Infrastructure Manager for the existing network, particularly recognising the ongoing interface that will be required with Network Rail when EWR Co procure their new development partner.

2. Phase 2f Grant Funding Agreement (GFA). This is included in Appendix A2, 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):

Table A1: Grant Funding Agreement details

A geotechnical sensitivity study to refine the scope and cost of earthworks for an agreed sample of route options to inform business case
Provide support to East West Railway Company at public consultation events on route options, including the provision and/or preparation of documentation for communication and presentational material and attendance at planned consultation events
Provide support to East West Railway Company for the development and completion of the Strategic Outline Business Case for a preferred route to support a Decision to Develop
Carry out an impact assessment on previous development work undertaken in relation to revised strategic objectives and conditional outputs for the Project as instructed by East West Railway Company, with regards to previously discounted options, business case models, rolling stock assumptions and service specification
Undertake further activities to improve scope, cost estimates and business case analysis to include: ○ infrastructure capacity and capability analysis on existing Bedford Midland (Wixams to Bedford North) and Cambridge station areas (including Foxton to Shepreth Branch Junction, and Shepreth Branch Junction to Cambridge station), and ECML (Tempsford to south of Sandy station) to accommodate indicative service specification(s) ○ initial highways modelling for existing stations and proposed new stations ○ options to mitigate consents risk on the National Trust property at Wimpole ○ options to mitigate risk to level crossings on the existing infrastructure, particularly the Cambridge Branch (SBR)
Preparation and provision of a set of handover documentation from all phases of development activity to date to East West Railway Company and their supplier. Also provide support in terms of giving briefings on work undertaken to date, as required, subject to a new supplier being procured by East West Railway Company within this Funding Period. Plus the establishment of a stakeholder database that will be accessible to all parties and populated with existing stakeholder information held by Network Rail.
Items to be agreed with the Department & East West Railway Company before commencing: ○ Preparation of a cost estimate range at assumed mid-point of construction ○ Identify and develop options for Bedford Midland Station that tie in with the Local Authority's Bedford Masterplan ○ Identify and develop alternative solutions for Bedford Midland to reduce capital cost

○ Identify and develop alternative solutions to access Cambridge Station from the south ○ Review of industry consents and interoperability requirements
Support for any other meetings/stakeholder engagement that may be required

Some of the scope above was agreed with EWR Co, during the phase, to not proceed. This included:

- Preparation of a cost estimate range at assumed mid-point of construction
- Identify and develop options for Bedford Midland Station that tie in with the Local Authority's Bedford Masterplan
- Review of industry consents and interoperability requirements

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.

A.07 Change Control

There were no material change controls during this phase to the work agreed in the GFA. A number of minor requests were received from EWR Co, e.g. environmental mapping but these were accommodated within the contingency and did not require formal variation to the GFA.

A.08 Indicative Train Service Specification (ITSS)

During Phase 2f, the development work has addressed a revised ITSS that takes account of the conditional outputs for up to 6tph between Bedford and Cambridge and up to 4 tph between Bedford and Bletchley (see section B.03 for more details).

At present, up to 4tph between Bletchley and Bedford is being considered as part of a separate study being progressed by Network Rail for EWR Co on the Marston Vale Line[4], however, it is already known that the infrastructure could not accommodate this level of service beyond Bletchley without additional/enhanced infrastructure.

The requirement for up to 6tph into Cambridge has also been included in the Cambridge Corridor Study being progressed by Network Rail's System Operator Anglia Strategic Planning Team on behalf of the DfT. The output from this is expected shortly.

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. This also applies to EWR services continuing beyond Cambridge.

A.09 Interfaces

The key infrastructure enhancement interfaces for EWRCS at this phase 2f stage of development have currently been identified as follows:

- 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 (WCML) 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 East Coast Main Line (ECML) Route Study – the interface being passenger connectivity with north- south services on the East Coast Main Line (ECML)

[4] The Marston Vale Line study is a separate report produced by Network Rail looking at options to support an increased level of train service and improved journey time between Bletchley and Bedford.

- 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 A3)
- 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 Branch Junction, that caters for the outputs of that project, the Cambridge Corridor Study and EWRCS
- Marston Vale Line 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[5]
- 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

[5] The Marston Vale Line study is a separate report produced by Network Rail looking at options to support an increased level of train service and improved journey time between Bletchley and Bedford.

Regular discussions will need to continue with relevant Network Rail teams regarding the interfaces with the existing infrastructure in the Bedford area and at Cambridge, as well as potentially in the Sandy area if the preferred route option utilises the ECML.

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

A.10 Route Options

Following on from the work in the previous phase 2e development stage, EWR Co identified a short list of options for this phase and to include in the consultation documentation for EWRCS. These are shown in Figure A3.

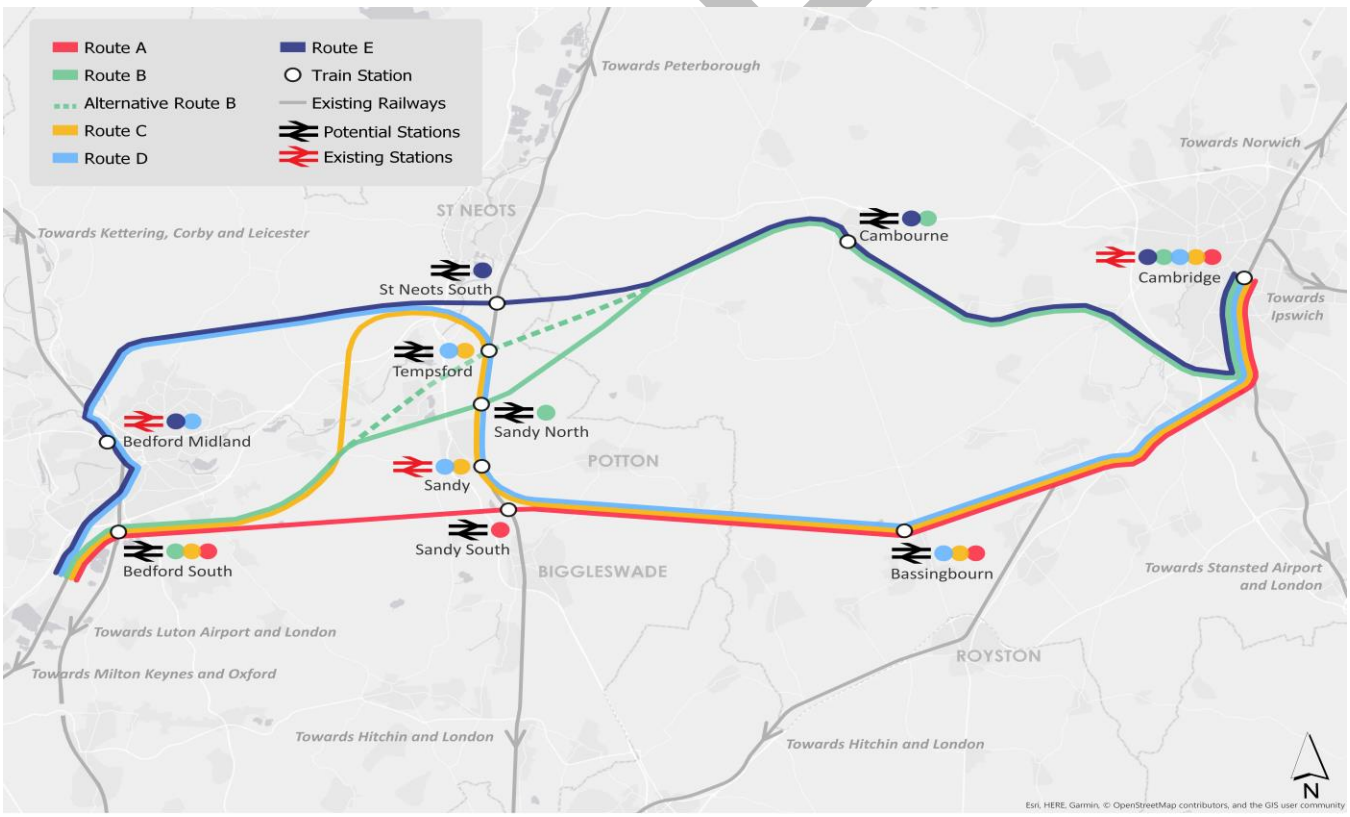


Figure A3: Route options shortlisted by EWR Co

These route options use a different referencing system to that used by Network Rail in its development work, therefore, the table below cross references EWR Co's route options with Network Rail's route options.

Table A2: Route option nodes and indicative alignments

EWR Co Reference	NR Reference	Bedford Node	Sandy Node	Intermediate Station	Cambridge Node
A	A1	Bedford South	Sandy South	Bassingbourn	Shepreth Branch Junction (south of Wimpole Estate)
B	A3 CAM	Bedford South	Sandy North	Cambourne	Shepreth Branch Junction (north of Wimpole Estate)
B Alternative	E5	Bedford South	Tempsford/St Neots South	Cambourne	Shepreth Branch Junction (north of Wimpole Estate)
C	E4	Bedford South	Tempsford/Sandy	Bassingbourn	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
D	SN4	Bedford Midland	Tempsford/Sandy	Bassingbourn	Shepreth Branch Junction (via ECML, south of Wimpole Estate)
E	CAM2	Bedford Midland	St Neots South	Cambourne	Shepreth Branch Junction (north of Wimpole Estate)

Figure A3 and Table A2 show the route options developed further in this phase and should be used as a reference for this report.

Part B: **Impact Assessment**

B.01 **Scope**

As a result of changes to the strategic objectives and conditional outputs for EWRCS, as instructed by EWR Co, Network Rail was asked to undertake an impact assessment of these changes on previous development work undertaken up to the end of Phase 2e, and with regards also to options that have been previously paused from further development during the previous phases.

B.02 **Impact assessment for strategic objective changes**

The key findings of the changes relating to the strategic objectives for EWRCS are:

- Amendments were generally a 'natural development' of previous strategic objectives and did not represent a material change
- There is an increased focus on 'urban development', both current and anticipated, and their link to the strategic rail link
- There is a new objective for the rail link to stimulate housing development as well as economic growth
- There is an increased focus on commuter journeys

B.03 **Impact assessment for conditional output changes**

Recognising the changes to the Strategic Objectives in section B.02 above, particularly the increase focus on commuter journeys, the key findings of the changes relating to the conditional outputs for EWRCS are:

- Journey time target between Oxford and Cambridge increased from 60 mins to 80 mins, representing the focus on commuter journeys and creating links to housing development, as outlined in the strategic objectives
- An increase from 1-2 tph to at least 2 tph between Oxford and Cambridge
- An increase from 1-2 tph to up to 6 tph between Bedford and Cambridge
- Journey time target between Bedford and Cambridge increased from 24 mins to 30 mins
- Average end to end journey speed reduced from 80mph to 60mph between Oxford and Cambridge

B.04 Summary of Findings and Recommendations

Overall the assessment has shown that the revised strategic objectives and conditional outputs for EWRCS have no identified material impact on decisions made during previous option development phases. However, the greater focus on supporting housing development means that previous choices, potentially going back to corridor level discussions, will need to be kept under review and re-visited at appropriate intervals as further information becomes available, including the availability of more detailed development plans as may be produced by Government and/or local authorities.

The following should be considered during future development phases:

1. The greater focus on 'housing' development within the route evaluation criteria should continue to be reviewed for its impact on previous route and corridor decisions.

2. Potential future decisions on EWR services continuing east of Cambridge will need to continue to inform decisions made on the appropriate way for EWRCS to approach Cambridge (see Phase d report and Cambridge Workshop Report– Appendix B1).

Table B1: strategic objectives review

In March 2016, the strategic objectives for EWRCS were endorsed by the Rail Industry Steering Group as being:	Mar 2019 Proposed amendments to Strategic Objectives for EWRCS and EWRWS	Key Change Summary	Assessment of Impact on route choices
• improve east west public transport connectivity	• *Improve east west public transport connectivity by providing rail links between key urban areas (current and anticipated) in the Oxford – Milton Keynes – Cambridge corridor*	**Adds** Rail Link Key Urban Areas (current and anticipated) Oxford- Milton Keynes - Cambridge corridor	As a natural development of the previous SO it is considered that this change has no effect on route choices (driven by strategic alignment and WebTAG evaluations) made up to this point. If "anticipated urban areas" becomes a significant factor in route selection, previous decisions (potentially to corridor level) should continue to be reviewed as more detailed development plans emerge
• increase economic growth, prosperity and employment within the South-East of England through improvements to east west rail links	• *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;*	**Adds** Stimulate economic growth housing inter-urban **Omit** increase economic growth, prosperity	As a natural development of the previous SO it is considered that this change has no effect on route choices (driven by strategic alignment and WebTAG evaluations) made up to this point. If "housing" becomes a significant factor in route selection, previous decisions (potentially to corridor level) should continue to be reviewed as more detailed development plans emerge
	• *Provide a sustainable and value for money transport solution to support economic growth in the area.*	**Adds** Sustainable transport Value for money	It is considered that this change would have no effect on route choices (driven by strategic alignment and WebTAG evaluations) made up to this point.
• provide faster, more reliable and additional rail links from the west to Cambridge, Norwich and Ipswich		**Omit** Objective removed, however the key elements of this objective are covered in other Objectives.	The removal of the objective to serve Norwich and Ipswich may potentially have affected the node choices to serve Cambridge; however this objective is incorporated within other objectives and the previous decision-making is therefore judged to remain sound Potential future decisions on EWR services continuing east of Cambridge will need to continue to inform decisions made on the appropriate way to approach Cambridge (see Phase D report and Cambridge Workshop Report
• improve journey times and reliability of inter-regional and commuter journeys	• *Contribute to improved inter-regional passenger connectivity and journey times by connecting with north-south routes and routes beyond Oxford and Cambridge;*	**Adds** contribute to connecting to north-south routes and routes beyond Oxford and Cambridge **Omits** reliability commuter journeys	As a natural development of the previous SO it is considered that this change has no effect on route choices (driven by strategic alignment and WebTAG evaluations) made up to this point.
• increase capacity for inter-regional and commuter journeys	• *Meet initial forecast passenger demand;* • *Consider and plan for future passenger demand, making provision as affordable;*	**Adds** Meet initial forecast passenger demand **Omits** increase capacity for inter-regional and commuter journeys and commuter journeys	As a natural development of the previous SO it is considered that this change has no effect on route choices (driven by strategic alignment and WebTAG evaluations) made up to this point. Future decisions on train service specifications will need to take account of up-to-date forecasts for passenger demand, including reflecting plans for additional growth
• maintain and enhance capacity for rail freight; and contribute to tackling climate change	• *Maintain current capacity for rail freight and make appropriate provision for anticipated future growth;*	**Adds** Make appropriate provision for future growth **Omits** Enhance capacity for freight contribute to tackle climate change	As a natural development of the previous SO it is considered that this change has no effect on route choices (driven by strategic alignment and WebTAG evaluations) made up to this point.

Table B2: Conditional Outputs Review

Existing conditional Outputs (C2014)	13th Nov 2018 Proposed amendments to conditional Outputs for EWRCS	Key Change	Assessment of Impact on route choices
Longer distance connectivity for business to business connectivity	• *Longer distance connectivity for business to business connectivity*		
-Target of 60 mins or less between Cambridge and Oxford.	o Target of around 80 mins between Cambridge and Oxford	Target has increased from 60min to 80min	JT has always been a factor in route evaluation (via WebTAG evaluation). No route or corridor choice has been paused or discounted on the basis on not achieving the 80min target. It is considered that this change has no effect on route/corridor choices made up to this point.
-1-2 tph between Cambridge and Oxford.	o At least 2 tph between Cambridge and Oxford	"1-2tph" has become "at least 2"	The change in service level is assessed as only effecting the Opex element of the BCR calculation. It would likely effect all routes equally and is assessed as being unlikely to have effected route or corridor choice. Particularly as much of the economic modelling already assumed a service level above 2tph, as this improved the BCR assessment values.
-Passenger connectivity for longer distance services onto the MML, ECML, WCML and West / South West of Oxford.	• *Passenger interchange facilities at all node points (Bedford, Sandy and Cambridge) to facilitate longer distance journeys.*	MML, ECML, WCML has become "all node points (Bedford, Sandy and Cambridge)"	This is a refinement of the objective that reflects the decisions made, and is not considered to have driven those decisions.
Shorter distance connectivity to support travel into Cambridge and Oxford	• *Shorter distance connectivity to support commuting travel into key employment hubs*		
-1-2 tph between Cambridge and Bedford, Oxford and Bedford.	o Capability for up to 6 tph between Cambridge and Bedford	"1-2tph" has become "up to 6tph".	The current assessments show that this increase does not drive additional infrastructure for any routes and therefore Capex calculations for the routes remain unchanged. The change also correctly recognisees the Central Section boundary as being Bedford to Cambridge.
-Target of 24 mins or less between Cambridge and Bedford.	o *Target of 30 mins or less between Cambridge and Bedford*	"target of 24mins or less" has become "target of 30mins or less"	JT has always been a factor in route evaluation (via WebTAG evaluation). No route or corridor choice has been paused or discounted on the basis on not achieving the 24min target. It is considered that this change has no effect on route/corridors choices made up to this point.
-Average end to end journey speed of 80mph Oxford to Cambridge.	Average end to end journey speed of 60mph Oxford to Cambridge	Average end to end speed of 80mph has become average end to end speed of 60mph.	A significant element of the Av Journey speed lies outside of the Central Section and with the Western Section. Where Av Speed translates into JT, it has been factored into decision making through its impact on the BCR, but no route or corridor choice has been paused or discounted on the basis on not achieving the 80mph average
Freight Capacity			
-Provision for one freight tph.	Freight capability to support anticipated growth, where affordable	"Provision for 1 freight tph" has become "support anticipated growth, where affordable"	Freight capability has always been a factor in route evaluation. No route or corridor choice has been paused or discounted on the basis on not providing freight capability. It is considered that this change has no effect on route/corridors choices made up to this point.
-Passive provision for potential intermodal terminals on the EWRCS route.		The conditional output for passive provision for potential intermodal terminals has been removed.	Passive provision for Intermodal terminals has not been a factor in corridor or route choices up to this point, and the removal of the objective is therefore not considered to have an impact n decision made.

B.05 Access into Cambridge

Previous analysis of how to access into Cambridge was undertaken in 2016 and considered all possible options to access into Cambridge against a number of evaluation criteria that represented the strategic objectives and conditional outputs that EWRCS was seeking to address at that time, primarily a journey time of 60 mins between Oxford and Cambridge. Achievement of this journey time was a high priority for EWRCS at the time, resulting in the pausing of a number of options from further development work, where they did not support this output.

This analysis, and further development work, resulted in the identification of a single preferred option for accessing Cambridge from the south, via Shepreth Branch Junction (option 1) and this has been progressed as part of the route identification and analysis activity that is currently being progressed.

Since then, the NIC report has been published recommending that EWRCS should focus more on providing an inter-urban, commuter railway, that seeks to align with housing and job growth in the corridor, rather than the long-distance, high speed railway previously proposed.

As a result of this, the strategic objectives and conditional outputs for EWRCS have been revised, and, consequently, it was deemed appropriate to revisit the options for accessing Cambridge, particularly from the north, to take cognisance of emerging views on potential housing developments within the corridor and to recognise the reduced focus on achieving a fast journey time between Oxford and Cambridge. Options to access Cambridge have also been challenged by a local lobby group, the CamBed RailRoad group, who are actively promoting solutions to access Cambridge from the north.

As a result, EWR Co requested that a review of previous work with regards to a northern approach into Cambridge be undertaken to provide assurance that decisions to pause the development of these options was still justified, particularly in light of the change to strategic objectives and conditional outputs. A site visit and workshop was held at Shire Hall, Cambridge in October 2018. Representatives included EWR Co, Cambridgeshire County Council and Network Rail with the findings included within Appendix B1.

Furthermore, two additional briefing papers were produced (Appendix D8 & D9) that assessed potential route options from Cambourne north towards Cambridge and the WAML route from Milton into Cambridge station and these are covered in Section D16 of this report.

The methodology used is outlined in the report in Appendix B1 and included evaluating options against the revised route evaluation criteria, updated by EWR Co, to align with the recommendations arising from the NIC report.

The evaluation of options was based on the following assumptions:

- All northerly route options considered would call at Cambourne – this justifies the need to revisit northerly options to access Cambridge as, if the assumption was that route options would go via Bassingbourn, then a southerly route option to access Cambridge would be the preferred solution.
- Some (or all) EWR services will continue on to Norwich/Ipswich – if this was not the case, then this would possible result in a different outcome of options assessed against the evalation criteria but is a reasonable assumption given the analysis being carried out as part of the Cambridge Corridor Study for future growth assumptions through to 2033 and 2034.

As a result of the review carried out, Option 4 Milton was deemed to be the preferred option to access Cambridge from the north. However, overall, it does not perform better than the current preferred Option 1 Shepreth Branch Junction to access Cambridge from the south, and, therefore, the group supported the position that no further development work on any northern option(s) to access Cambridge was to be carried out at this stage of development.

Part C: **Geotechnical Sensitivity Assessment**

This section captures the geotechnical earthwork assessment activity covered during this phase.

C.01 **Scope**

Three route options from Phase 2e have been considered for the purposes of undertaking an early stage geotechnical sensitivity assessment.

The 3 different route options used for this analysis, which were identified as being representative of all route options still being considered, are:

- A1
- C3
- C3 Cambourne

These were selected prior to the shortlist of route options identified by EWR Co for this phase and for the avoidance of doubt, C3 and C3 Cambourne are not included within EWR Co's shortlist. They are shown in Figure C1 overleaf.

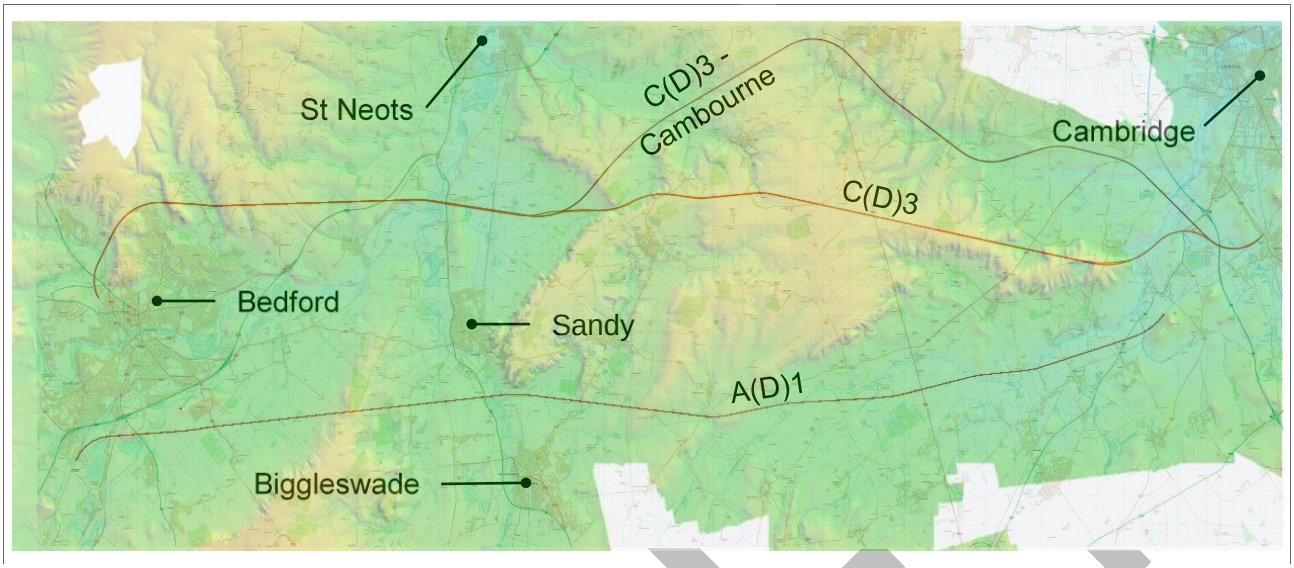


Figure C1: Study Area and Route Options

The objective is to test the assumptions and design parameters for earthworks in previous phases as a desk top study and identify opportunities for refinement and the reduction of volumes generated, leading to a reduction in quantities for disposal offsite. These include:

- Previous work assumed a cutting slope of 1:4 and fill of 1:2. These slope angles of repose are to be reviewed, based on geology type as identified in ground investigation reports available in the public domain and other associated applicable data
- The previous studies assumed that there should be a cut fill balance to avoid importation. This net minimum approach was used to derive a vertical alignment for track from the earthworks profile. This desk top study revisits the vertical alignments looking at opportunities to reduce overall quantities for fill/disposal whilst refining the gradient profile applying the 1:125 limits
- An inclusion for site strip has been made to show potential impact on overall volumes not previously identified
- Estimators have factored in potential re-use of cut material where it is expected to be considered suitable for inclusion in the permanent works, as opposed to being disposed of offsite so reducing the volumes of fill material being imported

The output from this analysis is summarised in this section.

C.02 Source Data

The development work for this study was based on a collation of topographical, environmental and other geographical information collected during Phase 2e, for example British Geological Survey 1:50,000 Geological Mapping. Please refer to Appendix C1, the Geotechnical Sensitivity Assessment Technical Memo, for further details.

C.03 Assumptions

A number of assumptions have been made in relation to undertaking this geotechnical sensitivity assessment. These are shown in Table C1 below.

Table C1: Assumptions for Geotechnical Sensitivity Assessment

No.	Assumptions
1	Earthwork volume and footprint estimation – it is assumed that the transition areas from cut to fill are unlikely to be significant in terms of the overall volume of material and therefore they have been simply assessed and not fully modelled.
2	It is assumed that the height of embankments, many of which are over 10m above the prevailing ground level, are an appropriate solution. There is opportunity to value engineer the embankment viaduct benefit point dependant on whole life cost analysis in future stages.
3	It has been assumed that the site will need to be stripped of topsoil sub soil and unsuitable materials prior to commencing the earthworks operations. This site strip is based on a depth of 1.0m throughout new route lengths. This is an assumed average depth and ground investigation (GI) along the chosen preferred route options will be required to further inform the assessment as depth will vary throughout.
4	It is assumed that the 1.0m site strip makes some allowance for the unsuitable material which can be expected to be found in the cutting and other areas.
5	For the purposes of previous studies the cutting slopes angle of repose has been assumed at the outset to be 1:4. This has now been considered in conjunction with TRRL research for road earthworks, which publishes data on cutting and embankment failures in various types of superficial and solid geology. The TRRL data is assumed to be representative for Rail construction as well as roads and an appropriate source.
6	It has been assumed that no noise barriers are to be provided at this stage of development. Where consultation requires these to be provided appropriate reconsideration of the earthworks profiles should be undertaken to support such structures as required by latter design

C.04 Exclusions

The study has not considered the measures that may be required for the management of settlement, heave or other ground effects and these will require full investigation and assessment at a latter design stage

C.05 Key Dependencies

The analysis is only for the routes shown and is intended to be informative only. The ground in this area can be described as disturbed so it is to be considered variable in quality. Ground models could be developed within BIM or other systems of data management if deemed of value in future design stages

C.06 Key Findings

The range of reduction observed in overall route earthwork volumes, due to geology-based slope angles, is ~2.5 – 3.6% stemming from cut reduction. However, as cut volume has reduced, this volume must be sourced from elsewhere.

This suggests the simplified 1:4 cutting earthwork slope angles previously applied, was a reasonable initial estimate for the region. The slope angle has a direct influence on the footprint and therefore land acquisition costs. Future works should look at areas of land acquisition cost against the slope stability risks and alternative engineered earthworks solutions, but these would attract additional costs to the project. A value management study at a later design stage would help inform the debate and decision making.

For all the routes considered a greater route earthwork volume reduction was achieved through the amendment of the vertical alignments (referred to in the reports as the net minimum approach) compared to manipulating the alignment to producing an earthwork balance. In summary of the positive impact of the new alignments has been to reduce the cut required. This has increased the volume of fill to be quarried and imported from outside the site boundaries. It should be noted that the low-lying areas are restricted to level variation due to the existing road and rail network that has to be crossed. Below in table C2 is the total volume of cut and fill.

Table C2: Comparison of the advantages of the vertical alignment adjustment

	2d Balanced	2e Net minimum
Route	**m^3**	**m^3**
A1	3,405,716	2,965,702
C3	13,844,548	13,207,106
C3 Cambourne	12,918,084	9,719,972

The report also considers the site strip volumes, and these generate volumes of material suitable for landscaping or top soiling sites. Introducing this has increased the volumes of material overall from the 2D assessments but is a more reflective measure of the sites earthworks item coverage. Below in table C3 is the total volume of cut and fill with the site strip added

Table C3: Net Minimum site strip impacts

Net Minimum approach to alignments	Net minimum volumes excl. site strip	Site strip 1.0m deep	Net minimum method Total
Route	**Earthwork volume m^3**		
A1	2,965,702	2,525,380	5,491,082
C3	13,207,106	4,158,484	17,365,590
C3 Cambourne	9,719,972	3,981,152	13,701,124

A high-level assessment of civil infrastructure requirements and route impact has been undertaken based on a revised 'net minimum' vertical profile. At this level of assessment, the impact on estimated bridge infrastructure is minimal, as crossings are still to be provided and accommodation of floodplains and road crossings remain necessary regardless of profile. Length of track infrastructure and signalling provision is unchanged due to horizontal route alignment remaining unchanged, and changes in the vertical profile having negligible impact on overall route lengths.

Should these sensitivities need to be explored, at later stages of EWRCS lifecycle, then it is recommended that the following areas are investigated:

- cost benefit comparison of material re-use (double handling, storage etc) against imported material

- further iteration of the vertical alignment could be undertaken to further reduce total earthwork requirements
- the economy of importing locally sourced material identified in this report would need to be explored against a further option of 'mining' cuttings where suitable material exists to supply embankment construction
- cost-benefit of importing granular fill material and resulting steeper embankment slope
- material classification and slope stability angles of repose / factors of safety and resulting reduction in cost of footprint and volume.
- assessment of earthwork construction, such as simultaneous cutting and adjacent embankment construction to minimise earthwork storage / haulage requirements.

C.07 Summary and conclusion

This analysis was undertaken to test the assumptions made in previous phases with regards to cutting and embankment slope angles. The general findings were that the 1:4 slope for cuttings and 1:2 slope for embankments was reasonable for the area's geology. The study found that some of the excavated material from the cuttings could be re-used in the embankments. An allowance has been made for the removal of the top metre within the site strip volumes as this is unlikely to be reusable in the embankments. Therefore, allowances have been made to the estimates to reflect these findings. Route options that pass through low lying ground benefit less from this approach than route options passing through higher ground. A more detailed analysis will be required, however, with ground investigations undertaken and results obtained in future phases of development.

It is clear that in the selection of a route the earthworks can be a significant influence on the overall project outturn cost and the minimisation of exposure of EWRCS to these variables can only be determined with intrusive investigation. It is clear that the three routes chosen offer different challenges but the overall volumes of measured material required are starkly different. A1 volumes are half that of C3 Cambourne and a third of C3 (see section C.01).

Vertical track alignments can to some extent generate savings. The slope stability assumptions of previous studies can be considered robust (i.e.1:4 cut 1:2 fill). The omission of site strip has been corrected and the value of the excavated material realised in the route estimates

For each of the route options, consideration should be given to the potential sources of embankment construction fill material from quarries identified in the region, as discussed in the report. Consideration may also be given to possibility of opening new quarries for the sole purpose of generating fill material or quarrying cuttings where material is suitable and can be transported along the corridor for deposition. Construction programme logic will also be significant in determining the overall efficiency of the operation. Some temporary roads and crossings (Rail / Road / River) will also need to be factored in and identified in any future consent applications for EWRCS as a construction traffic management plan will be required to support such consent applications.

Revised Costs as a result of this analysis are set out in section E16.

Part D: **Alternative Solutions**

D.01 **Introduction**

This section considers alternative solutions which have been assessed in this phase, to ascertain whether the solutions considered in previous phases of work at various locations are appropriate, or whether suitable alternatives are available. It should be noted that the Capability & Capacity Analysis (C&CA) assessments have been undertaken by geographic location, and the resulting recommendations should be re-considered upon the creation of a holistic concept timetable which may alter the infrastructure requirements necessary to fulfil the service specification. As an example, where dedicated infrastructure is not provided for EWR services, there is a high risk of timetable paths, that have been identified for EWR services, not being able to be mapped across to other locations either on EWRCS, EWRWS and existing infrastructure. This section should be read in conjunction with Appendices D11, D12 and D13.

D.02 **Source Data**

The development work in this phase was based on options produced during Phase 2e which included a collation of topographical, environmental and other geographical information collected during Phases 2c and 2d 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.

D.03 Key Dependencies

A number of key dependencies exist to realise the proposals set out in this study which include:

- The interface with EWRWS is a key dependency in terms of consistency of service specification and capability.
- The EWRCS scope may require the closure of a number of existing level crossings, dependent on the route option selected, with such closures being subject to obtaining the required consents.
- There have been no allowances made for depots, as it is assumed that these are to be provided by other parties.
- It is assumed that consents and land acquisition can be obtained, where required, to support all route options and that the utility diversions, railway possessions and passenger movements, road closures and road user issues, can all be resolved to mitigate disruption to the local area.

D.04 Systems and Engineering commentary

Track alignment designs within this phase 2f have, as in previous phases, allowed for a 125mph linespeed, other than at the end connections discussed in this report. A limitation on gradients of 1:125 has also been used. Radii for speeds of 125mph are between 2000m and 2500m with normal limits on the Cant values. The track category is assumed to be Category (CAT)1 for the speed and level of service proposed, however, this may rise to CAT1A were the route to be electrified in the future. It can be assumed that stations are on 1:500 gradients for 300m and S&C will be co-planar. High speed S&C may be required at some points and this should be reviewed at the next design stage.

The routes are not to be electrified other than a short section between Bedford Midland Station and Jowett Sidings, and where the currently electrified Shepreth Branch Line (SBR) / Bethnal Green to Kings Lynn (BGK) lines interface with the EWRCS. Should the route be fully electrified in the future, the electrical clearance regulations will require many of the existing overbridges to be reconstructed, however, this is outside the scope of the study and is for advisory purposes only. Infrastructure solutions have been developed to provide passive provision for electrification in the future.

It is assumed that EWRCS will be digitally signalled in the future, however, at this stage of development, due to there being limited information to support design and costing of this,

for the purposes of this study the signalling has been considered as conventional with digital ready capability. This is considered compatible with a Level 1 system being superimposed onto the conventional system. To achieve this, GSM-R (Global System for Mobile Communications – Railway) will need to be introduced and this has not yet been considered but would impact all route options.

Power supplies for signalling, points heating and S&C are assumed to be available and consideration has been given to various requirements within the reports.

Control of certain aspects of the system will require further stakeholder discussions in future phases, including with Network Rail as the Infrastructure Manager for the existing network, to secure their agreement to proposals for EWRCS. Areas such as cyber security, signal control and management of the traction supply to the OLE at interfaces will need integration with the NR's existing interoperable system.

Ground condition considerations have been included following the outputs from the Geotechnical Sensitivity study covered in Part C of this study and the routes evaluated accordingly. Likewise, the Flood Plain strategy developed in Phase 2e has been considered and the viaducts reduced in span with earthworks approaches. These will all need full site investigation and surveys in future phases and it is advised that further analysis is undertaken prior to a single route option selection being made.

For the purposes of this report, NR engineering terminology is used but it is acknowledged that EWRCS may not be delivered by NR and alternative models may be progressed. This may be altered in the future however, a Common Safety Method approach has been used with Hazard Identification (HazID). HazID have been mitigated in the main through the use of systems that have been specified by the NR, RSSB, and the ORR as the national safety authority, to aid a successful outcome when applying for a letter of authorisation on entry into service.

D.05 **Bedford Area**

Network Rail's Capability & Capacity Analysis (C&CA) team assessed the capability of a number of alternative options for how the EWRCS route could integrate with the Midland Main Line (MML) (ELR: SPC1 or SPC2), and accommodate the ITSS for EWRCS, compared to other infrastructure interventions proposed in previous development work. This

analysis examined the effect of 4 trains per hour (tph) between Bletchley and Cambridge, plus an additional 2tph shuttle services between Bedford and Cambridge in accordance with the agreed conditional outputs (see section B.03 for more details).

Route options CAM2 and SN4 rely on an optimal integration with the MML around the Bedford area. Previous analysis has assessed different options as to how the two routes can be connected. Work to date has assumed the following interventions and assumptions:

1. Double tracking of the Marston Vale Line (MVL) (also referred to in this report as BBM being the Engineers Line Reference (ELR) for MVL).
2. Works to Jowett Sidings to facilitate ECS movements to and from the depot and Bedford Midland.
3. Two new platforms on the east side of Bedford Midland station.
4. That EWR services can be accommodated on the MML Slow Lines north of Bedford Midland station.
5. An at grade junction on to the EWRCS route, to the south of Bromham viaduct at 51 miles on the MML.

C&CA Remit

In previous phases, the capacity of the existing infrastructure, particularly on the MML in the Bedford area, was identified as a risk that warranted further investigation. As a result, this phase has sought to undertake further analysis to inform the scope of potential infrastructure enhancement works required to establish whether the most appropriate infrastructure interventions are being proposed in the Bedford area, in order to accommodate the proposed level of EWRCS services. The main objectives for the analysis were:

1. Can the proposed 4tph EWR services be accommodated on the MML Slow Lines south of Bedford between Wixams and Bedford, alongside current and proposed MML service patterns?
2. If (1.) is not possible, what infrastructure interventions could resolve capacity constraints?
3. Can the proposed 6tph EWR services be accommodated on the MML Slow Lines north of Bedford, alongside current & proposed MML service patterns?
4. If (3.) is not possible, what infrastructure interventions could resolve capacity constraints?
5. How can the 2tph services between Bedford and Cambridge be accommodated at Bedford, either via a northern or southern EWRCS route option?

6. Can the junction for the EWRCS route north of Bedford, off the MML Slow Lines, be at grade or is grade separation required?

Assumptions

The analysis was based on the following assumptions:

- The EWRCS conditional outputs:
  - Capability for up to 6 trains per hour (tph) between Cambridge & Bedford
  - Capability for up to 4 trains per hour (tph) between Bletchley & Bedford
  - Freight capability to support anticipated growth (1tph), where affordable
- May 18 timetable, Monday – Friday (SX) services.
- Morning peak hours assessed (07:00 – 10:00)
- Timetable Planning Rules 2019 v4.1 applied
- Thameslink timetable is fixed (as of May 18)
- EMT services (within current or future franchise) were not considered as they currently occupy the Fast lines in this area

Findings

The analysis (Appendix D1) concluded that:

1. The aspiration to run 6 tph passenger services and 1 tph freight train on the Slow Lines to the north of Bedford Midland station for the CAM2 & SN4 routes could be accommodated. Additionally, grade separation would not be required from the MML to the EWR route options for CAM2 & SN4, north of Bedford.
2. As previously identified, Bedford Midland station would require two additional through platforms to accommodate the quantum of services proposed, as per proposals in previous phases.
3. The MML to the south, between a new station at Wixams/Bedford South and Bedford Midland, can mathematically accommodate the proposed train service of 4tph passenger services and 1tph freight. However, these cannot be accommodated within a clockface scenario, which would result in the requirement to 6-track this section of the MML, including an appropriate headshunt facility for Cauldwell Depot ECS moves.
4. With regards to the MVL route, twin tracking of the Bedford St. Johns section would be required and addressing the access arrangements for Jowett sidings, which currently use the MVL as a headshunt facility for ECS moves.

5. The southern routes (A1, A3CAM & E4) that call at a Wixams/Bedford South station would not require any additional infrastructure on the MML, unless a north facing chord is provided to facilitate the 2tph Bedford-Cambridge services, which would result in the need for additional infrastructure to allow services to access Bedford Midland station depending on the number of services to be accommodated.

In conclusion, to fulfil EWR service aspirations into Bedford Midland, additional infrastructure will be required. It has also been established that the MVL will require upgrading, and that whilst connecting on to the MML to the south of Bedford Midland, to avoid the Bedford St Johns area (and resulting works) would be achievable, the opportunities to accommodate a clockface service path scenario cannot be achieved. Consequently, utilising the MML south of Bedford would require some element of 6 tracking to facilitate the service specification. With regards to the MML north of Bedford Midland station, the analysis concludes that there is available capacity on the Slow lines for the proposed service specification.

D.06 **Bedford - Alternative Solutions**

Recognising the output from the C&CA analysis outlined above, alternative infrastructure solutions were assessed within this phase, to ascertain whether the solutions considered to date at Bedford (i.e. twin tracking through Bedford St Johns, alterations to Bedford Train care depots and utilisation of the existing four track MML north of Bedford Midland) are appropriate, or whether suitable alternatives are available.

Options to enhance the BBM line have been considered as part of a separate study undertaken by Network Rail on behalf of EWR Co[6]. The results and implications of this study should be considered in due course in relation to solutions in the Bedford area to ensure that they are mutually compatible.

It should be noted that the MML track layout (Fast-Fast-Slow-Slow) is different to both the ECML track layouts (Slow-Fast-Fast-Slow), consequently different solutions need to be assessed to suit the different layouts.

The following options have been assessed in this phase:

[6] The Marston Vale Line study is a separate report produced by Network Rail looking at options to support an increased level of train service and improved journey time between Bletchley and Bedford.

Option 1 – Segregation north of Bedford

As per Figure D1, route alignments were developed in Phase 2d, stopping at Bedford Midland Station then continuing north-west on MML (ELR:SPC2) and diverging at grade onto the EWRCS route options towards Cambridge. These routes are referenced as CAM2 and SN4 and were based on pre-determined node points for development purposes.

Access to the northern route options is currently assumed to be via the four track MML layout currently provided. If the SPC2 is capacity constrained the route may not be viable, therefore, this option explores two new tracks (six in total), from Bedford Midland Station and continuing north to where EWRCS would diverge east from the MML. This option would enable EWR services to operate on a segregated railway, however, it would impact on a number of residential properties and key highway infrastructure in Bedford.

A previous report (Appendix D2) details modification to Bedford Midland Station to accommodate two additional platforms (Platforms 1a and 0). This option builds on the modifications required to Bedford Midland station to support twin-tracking for EWR services through to the point where it would divergence from the MML route north of Bedford.

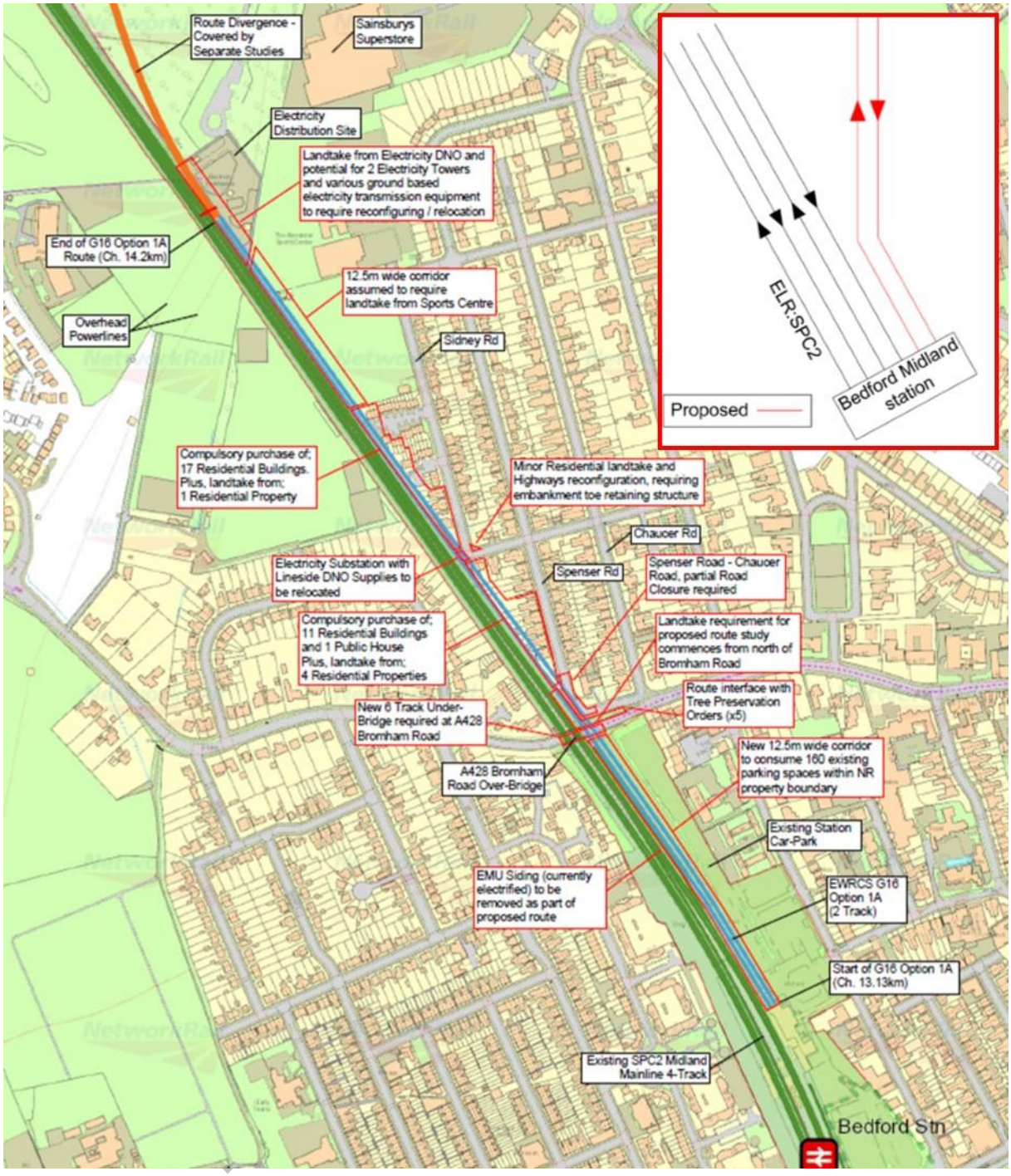


Figure D1: Drawing of Option 1

Assumptions

1. Geographic Limits - Southern limit is the end of platforms, north end of Bedford Midland Station. Northern limit is the EWRCS alignment divergence from MML corridor.
2. EMU turnback assumed to be removed with a replacement not considered at this time, assumption is that the additional platforms will provide appropriate capability.
3. EWRCS junction (north of Bedford) is 'at grade' / same elevation as SPC2.
4. Bromham Road overbridge would need to be replaced/modified to facilitate additional twin track construction, i.e. a new 6 track overline bridge. **Note**: Works to Bromham Road overbridge to accommodate electrical clearance and W12 for MML electrification project are currently being progressed. In addition, Bedford Borough Council are understood to be designing a separate bridge for cyclists in this location.

Capacity

The C&CA report referenced earlier indicates that there is likely to be sufficient capacity in this area on the MML to accommodate the new EWR service paths, therefore this option would only be needed if this was no longer the case.

Order of magnitude Cost Estimate: £154m - £171m

These costs would be incremental to Base Route Cost as

Conclusion

This option would provide additional capacity and EWR with a segregated route, however, the C&CA analysis has concluded that sufficient capacity is available on the existing infrastructure in this area to negate the need for this option. The previously assumed option included to date is deemed more appropriate than this alternative.

Option 2 – St Johns Station & Depot Scope Alternatives

The following options have been assessed in order to establish whether alternative infrastructure options exist south of Bedford to avoid the disruption and associated costs that would be incurred by utilising the MVL into Bedford Midland Station.

Option 2a – BBM/MML Connection south of Bedford

As per the drawing in Figure D2, this option assesses the provision of an EWRCS grade separated junction from the BBM (MVL) line, converging with the MML (ELR:SPC1) at grade. EWRCS services would continue to Bedford Midland station (for routes CAM2 and SN4, utilising the existing SPC1 Up and Down Slow lines. This option currently has limited

impacts on local residential property and existing civil infrastructure, however, due consideration of the developments taking place in this area should be considered. This alignment requires a gradient in order to climb from the MVL over the MML and local highway infrastructure hence the grade separation of the MVL. In reality if this option was chosen it would result in the decommissioning of the MVL between this junction and Bedford St Johns.

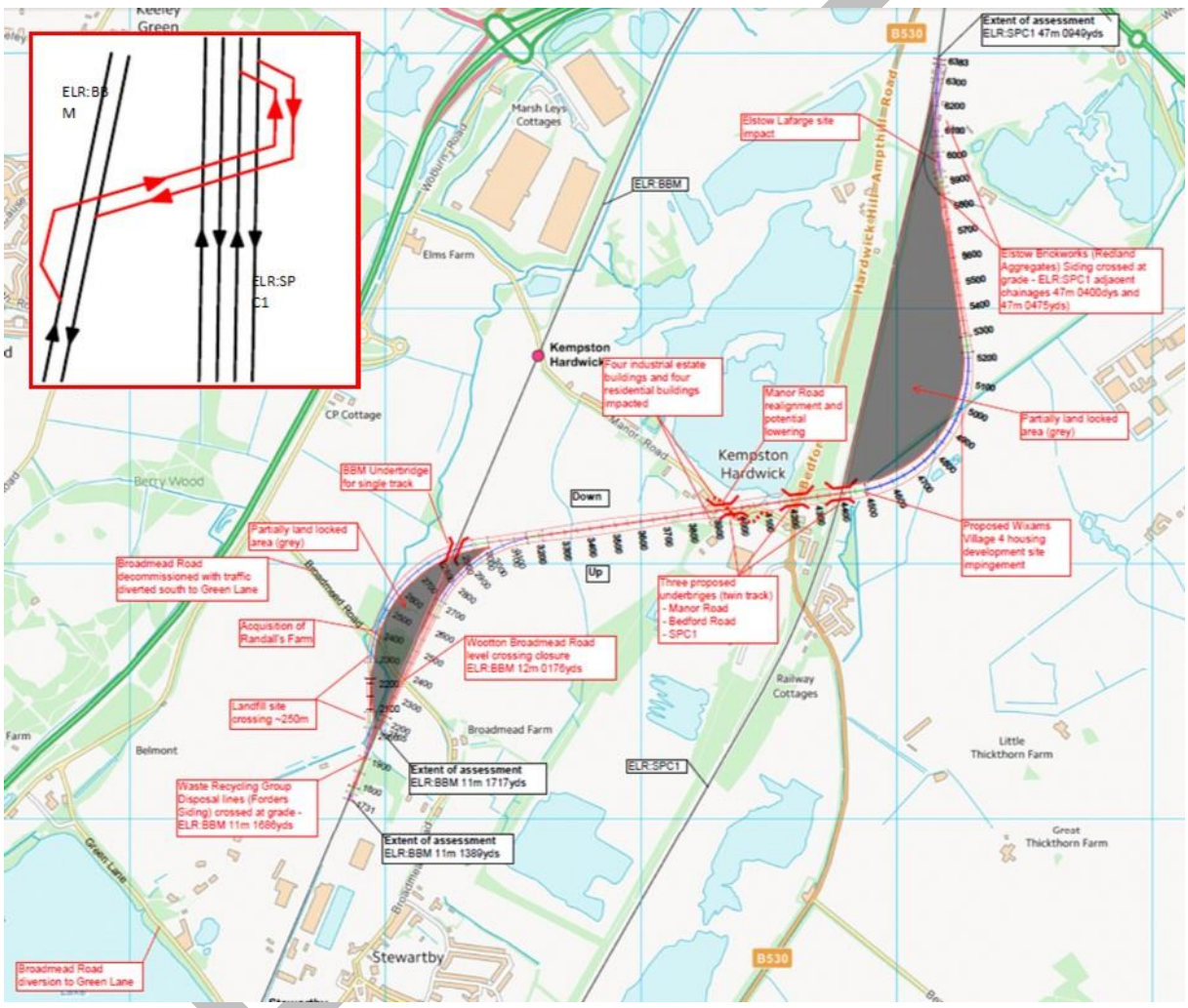


Figure D2: Drawing of Option 2a

Assumptions

1. Assumes no upgrade of SPC1 Up and Down Slow lines from EWRCS convergence to Bedford Midland station would be required.
2. New junctions designed for 50mph and assumed appropriate due to location.

3. Assumes there is sufficient capacity on SPC1 Up and Down Slow lines for proposed EWRCS services.
4. The geographical limit of the assessment provided is local to the proposed junction only.
5. Assumed that a solution for Forder's sidings and Elstow Brickworks siding can be identified to make way for the proposed turnouts without the need to relocate existing infrastructure.
6. To avoid blocking existing junctions, maximum train length is assumed to be 350m.
7. BBM line to be retained.

Capacity

The C&CA report indicates that there is unlikely to be sufficient capacity in this area due to existing services, on the MML, to accommodate the proposed level of EWR services (4tph) and, therefore, currently this option is unlikely to fulfil the output requirements.

Order of magnitude Cost Estimate: £177m - £195m

These costs would be incremental to Base Route Cost for EWRCS but would avoid circa £80m depot redevelopment costs identified within the Marston Vale Line study.

Conclusion

Whilst this option avoids the Bedford St Johns area and the depots, it utilises an already capacity constrained MML Slow lines via an at grade junction and so is not considered acceptable.

Option 2b – Southern route MML connection in Wixams area

As shown in Figure D3, this option provides the opportunity to serve Bedford Midland station and adopt one of the southern routes (A1, A3CAM & SN4), with the provision of an EWRCS grade separated junction from the BBM (MVL) line, converging with the MML (ELR:SPC1) at grade. EWRCS services could continue to Bedford Midland station utilising the existing SPC1 Up and Down Slow lines. This option provides provision for train connectivity for route alignments commencing south of Bedford and from Bedford Midland station continuing toward Cambridge via the southern routes. An opportunity exists for EWR services to continue to Cambridge to the south of Bedford without serving Bedford Midland offering an opportunity for a reduced journey time between Oxford and Cambridge. This alignment requires a gradient in order to climb from the MVL over the MML and local highway infrastructure hence the grade separation of the MVL. In reality if this option was

chosen it would result in the decommissioning of the MVL between this junction and Bedford St Johns.

As per other alternatives reviewed here, this option provides a means of reducing the infrastructure impact on the MVL through the Bedford St Johns area. This option impacts on circa 19 local residential properties and existing civil infrastructure.

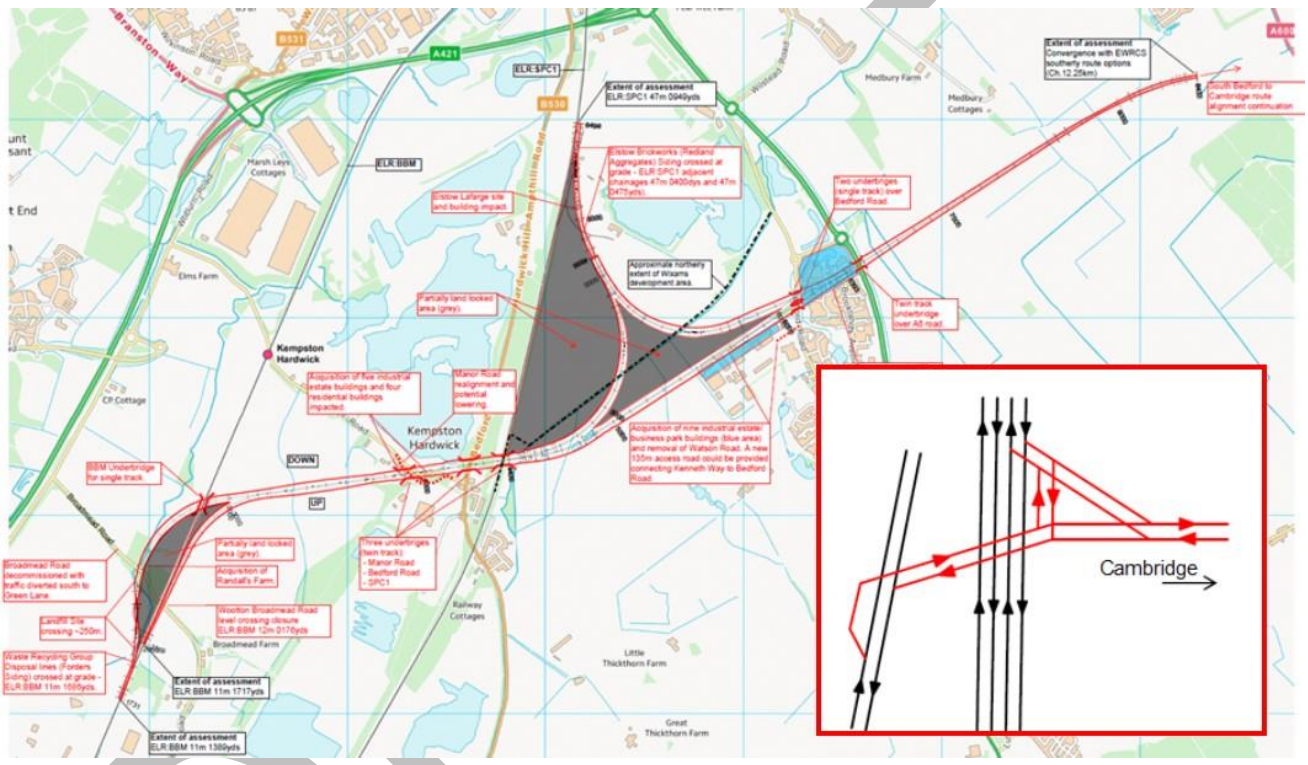


Figure D3: Drawing of Option 2b

Assumptions

1. Arrangement excludes consideration of a Bedford South station or Wixams station because the option serves Bedford Midland direct with a turnback required. Direct services could be facilitated without a call at Bedford.
2. For signalling purposes, maximum train length is approximately 350m.
3. For signalling purposes, all existing signals now required to protect new junctions are to be upgraded to include a junction indicator, counted as one signalling equivalent unit (SEU).
4. A solution for Forder's sidings and Elstow Brickworks siding can be identified to accommodate the turnouts without relocation of existing infrastructure.

5. No upgrades are remitted to existing SPC1 lines with existing linespeed remaining.
6. New junctions designed for 50mph and assumed appropriate.
7. The geographical limit of this assessment is local to the proposed junction only and assumed to be sufficient.
8. To avoid blocking existing junctions, maximum train length is assumed to be 350m.
9. BBM (MVL) line to be retained.

Capacity

The C&CA report indicates that there is likely to be insufficient capacity in this area on the MML to adopt new paths and, therefore, currently this option is unlikely to fulfil the output requirements.

Order of magnitude Cost Estimate: £274m - £303m

These costs would be incremental to Base Route Cost for EWRCS but would avoid the costs associated with upgrading the BBM from Kempston Hardwick through Bedford St Johns and the associated depot modification costs (circa £120m).

Conclusion

This option is not recommended, as per the previous option it utilises the already capacity constrained MML slows via an at grade junction and so is not considered to be better than the option included to date (and described earlier in this section D.06).

Option 2c – Six tracking south of Bedford

As shown in Figure D4, this option is to assess the provision of an EWRCS grade separated junction from the BBM (MVL) line, MML (ELR:SPC1) flyover and continuation into Bedford Midland station running parallel to the SPC1 lines on a separate alignment. Adopting this option removes the requirement to twin track the Bedford St Johns area, relocate the station and reduce the scope at Jowett Sidings and Bedford Traincare depot. This is an alternative that would be applicable for routes CAM2 and SN4.

The following assessment is based on a route up to Ford End Road bridge, south of Bedford Midland station, and is circa 8km in length. This option impacts on circa 52 local residential properties and existing civil infrastructure.

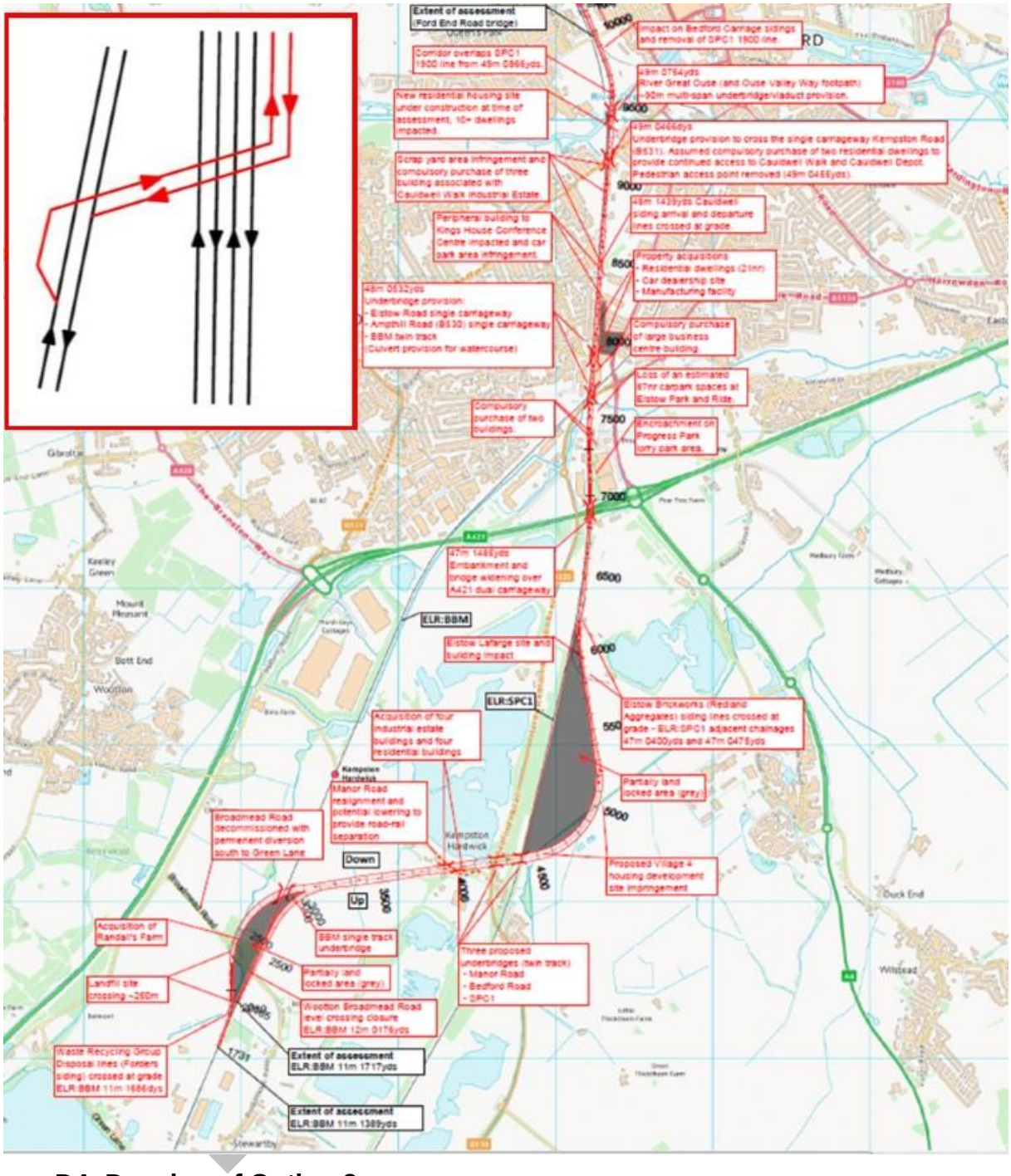


Figure D4: Drawing of Option 2c

Assumptions

1. That access to Cauldwell Depot and Bedford Traincare depot can be accommodated within the design for this option.

2. New junctions designed for 50mph and assumed appropriate.
3. Assumed that a solution for Forder's sidings and Elstow Brickworks siding can be identified to accommodate the proposed turnouts without the need to relocate the existing infrastructure.
4. To avoid blocking existing junctions, maximum train length is assumed to be 350m.
5. BBM line to be retained.

Capacity

The C&CA analysis indicates that as there is likely to be insufficient capacity in this area on the MML to incorporate new EWR service paths, this option is likely to fulfil the output requirements as it is discrete from NRCI.

Order of magnitude Cost Estimate: £436m - £482m

These costs would be incremental to the Base Route Cost for EWRCS but would also avoid the costs associated with upgrading the BBM from Kempston Hardwick through Bedford St Johns and the associated depot modification costs (circa £120m).

Conclusion

This option provides the additional capacity on the MML by upgrading it from 4 tracks to 6 tracks, effectively providing EWR services with a segregated infrastructure into Bedford Midland. This option could be an acceptable solution, however the option included in the route development work to date (and described earlier in this section D.06) is deemed to be appropriate at this time.

Option 2d – MML 6 tracking south of Bedford for southern routes

As shown in Figure D5, this option assesses the provision of an EWRCS grade separated junction from the BBM (MVL) line, with a twin track MML (ELR:SPC1) flyover and continuation into Bedford running parallel to the SPC1 lines on a separate alignment, effectively 6 tracking this section. This option also provides for connectivity of route alignments commencing south of Bedford and from Bedford Midland station, continuing towards Cambridge, via the southern route options.

This option impacts on circa 211 local residential properties on the Wixams housing development and existing civil infrastructure i.e. highways.

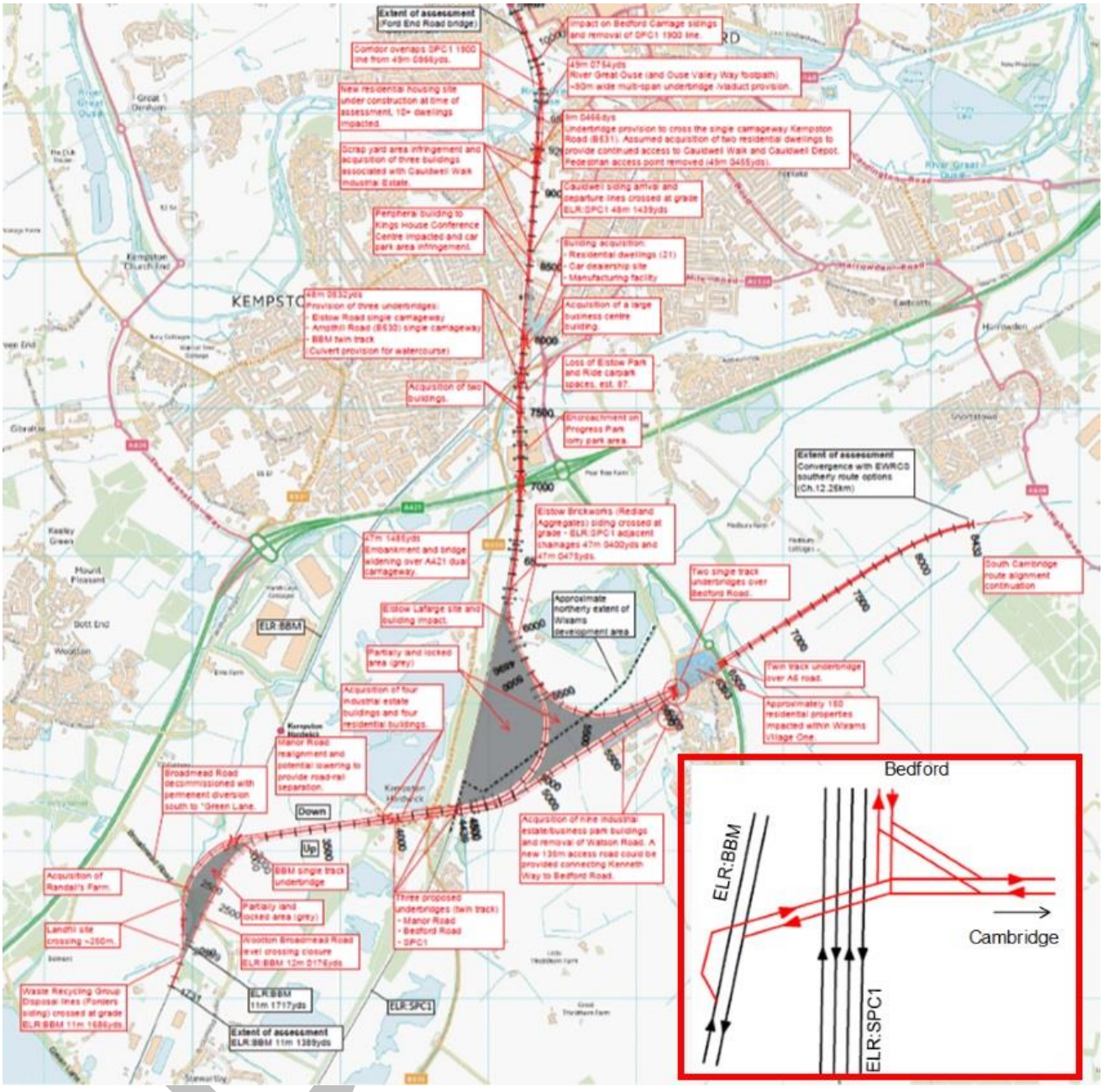


Figure D5: Drawing of Option 2d

Assumptions

1. That access to Cauldwell Depot and Bedford Traincare depot can be accommodated within the design for this option.
2. Arrangement excludes consideration of a Bedford South Parkway station/Wixams station as option provides direct connectivity into Bedford Midland station.
3. New junctions designed for 50mph and assumed appropriate.

4. The geographical limit of assessment is from BBM divergence to Ford End Road overbridge (south of Bedford Midland station) in the north and the EWRCS route A1 connection to the east.
5. A solution for Forder's sidings and Elstow Brickworks siding can be identified to accommodate the proposed turnouts without the need to relocate existing infrastructure.
6. BBM line to be retained.

Capacity

The C&CA analysis indicates that as there is unlikely to be sufficient capacity in this area on the MML to facilitate new paths for EWR services and, therefore, this option is likely to fulfil the output requirements as it is segregated from NRCI.

Order of magnitude Cost Estimate: £474m - £524m

These costs would be incremental to the Base Route Cost for EWRCS but would also avoid the costs associated with upgrading the BBM from Kempston Hardwick through Bedford St Johns and the associated depot modification costs (circa £120m).

Conclusion

This option provides the additional capacity on the MML by upgrading it from 4 tracks to 6 tracks, effectively providing EWR services with a segregated infrastructure into Bedford Midland. This option could be an acceptable solution, however the option included in the route development work to date (and described earlier in this section D.06) is deemed to be appropriate at this time.

Option 3 – MML 6 tracking south of Bedford

As shown in Figure D6, this option assesses the provision of an EWRCS double junction from the BBM (MVL) line after it passes under the MML (SPC1), continuing into Bedford Midland and running parallel to the SPC1 lines on a separate alignment. This shorter route (circa 3km) provides an alternative for the northern routes (CAM2 & SN4) that serve Bedford Midland station, removing the enhancements of the Marston Vale Line through Bedford St. Johns and the associated depots. However, this option would impact the headshunt of Cauldwell depot which utilises the MML slow lines to facilitate the moves.

The following assessment considered up to Ford End Road Bridge south of Bedford Midland station as part of the scope. This option impacts on circa 130 local residential properties and existing civil infrastructure i.e. highways.

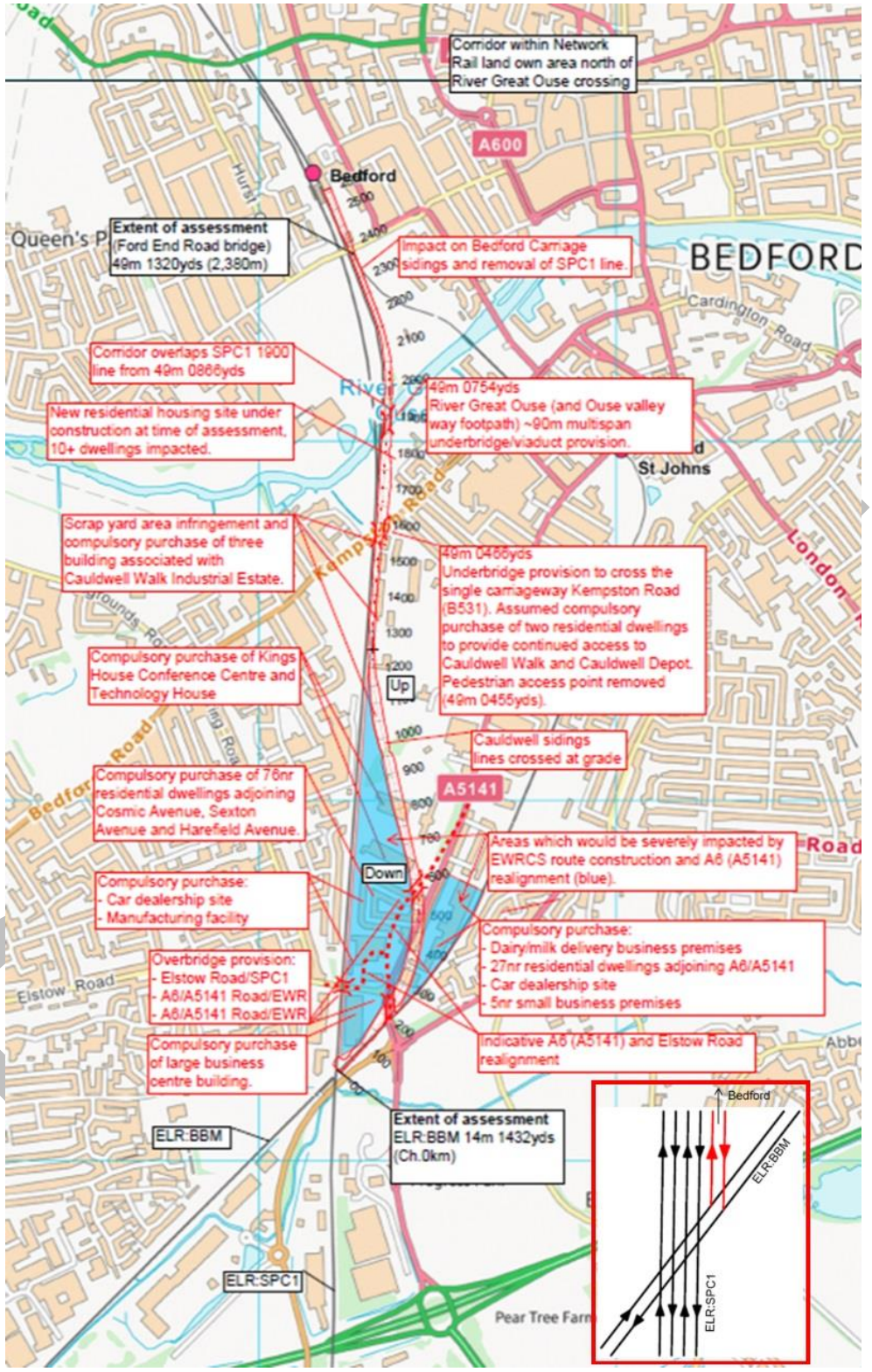


Figure D6: Drawing of Option 3

Assumptions

1. That access to Cauldwell Depot and Bedford Traincare depot can be accommodated within the design for this option.
2. Where proposed EWRCS tracks run immediately adjacent to MML, elevation is consistent with the existing SPC1 lines.
3. BBM line to be retained.
4. Assumed existing BBM line, and SPC1 flyover bridge at EWRCS divergence, is suitable for new EWRCS services without upgrade or infrastructure replacement.

Capacity

The C&CA report indicates that as there is likely to be insufficient capacity for this area on the MML to adopt new paths and, therefore, this option is likely to fulfil the output requirements as it is discrete from the NRCI.

Order of magnitude Cost Estimate: £444m - £491m

These costs would be incremental to the Base Route Cost for EWRCS northerly routes from Bedford Midland but would also avoid the costs associated with upgrading the BBM through the Bedford St Johns and the associated depot modification costs (circa £120m).

Conclusion

This option provides the additional capacity on the MML by upgrading it from 4 tracks to 6 tracks, effectively providing EWR services with a segregated infrastructure into Bedford Midland over a shorter distance. This option could be an acceptable solution, however, the option included in the route development work to date (and described earlier in this section D.06) is deemed to be appropriate at this time.

Summary of Bedford Area Alternatives

In conclusion, three options assessed are worth further consideration should a route be selected that serves Bedford Midland and a northerly route. Table D1 below summarises the engineering assessment with the conclusions from the C&CA analysis which indicates whether each option provides the required level of capacity in this area.

Table D1: Summary of Alternative Solutions for Bedford

	Engineering Option	C&CA conclusion
1	Segregation north of Bedford (6 tracking of MML)	×
2a	BBM/MML Connection south of Bedford	×
2b	Southern route MML connection in Wixams area	×
2c	MML 6 tracking south of Bedford	✓
2d	MML 6 tracking south of Bedford for southern routes	✓
3	MML 6 tracking south of Bedford	✓

Table D1 indicates that three options are unviable. However, three options are worth further detailed consideration in future stages of development. The infrastructure included within the route development to date, in the Bedford area is deemed appropriate for this stage of assessment.

D.07 Sandy Area

Previous phases have undertaken development work on the basis of a segregated EWR alignment, running parallel to the ECML to the east side, for routes E4 & SN4. This segregated alignment would provide a double track structure over the ECML to the north, effectively 6-tracking this section of the ECML, 2 new platforms at Sandy station and an at grade chord to the south, running between Sandy Warren (RSPB site/SSSI) and Biggleswade Common (CRoW land). In this phase, this proposal has been tested by Network Rail's C&CA team to establish whether paths are available on the ECML and appropriate alternative solutions have been tested. (Appendix D3)

It should be noted that the ECML track layout (Slow-Fast-Fast-Slow) is different to both the MML and WCML track layouts (Fast-Fast-Slow-Slow), consequently different solutions need to be assessed to suit the different layouts.

C&CA Remit

This study was to ascertain whether the ECML Slow Lines have the available capacity for the proposed level of EWR services. Consequently, the following infrastructure interventions were considered for their appropriateness:

1. A grade separated junction, connecting the EWR route to the ECML Up Slow Line, to the north of Sandy (46 miles).
2. An at grade chord, connecting the ECML Down Slow Line to the EWR route, to the north of Sandy (46 miles).

3. An at grade chord connecting the ECML Up Slow Line to the EWR route to the south of Sandy (43 miles).
4. A grade separated junction connecting the EWR route to the ECML Down Slow Line to the south of Sandy (43 miles).

In addition, the analysis looked at whether there is sufficient capacity available on the ECML Slow Lines in the Sandy area, permitting a station call, and aligned with future service provision planned on the route.

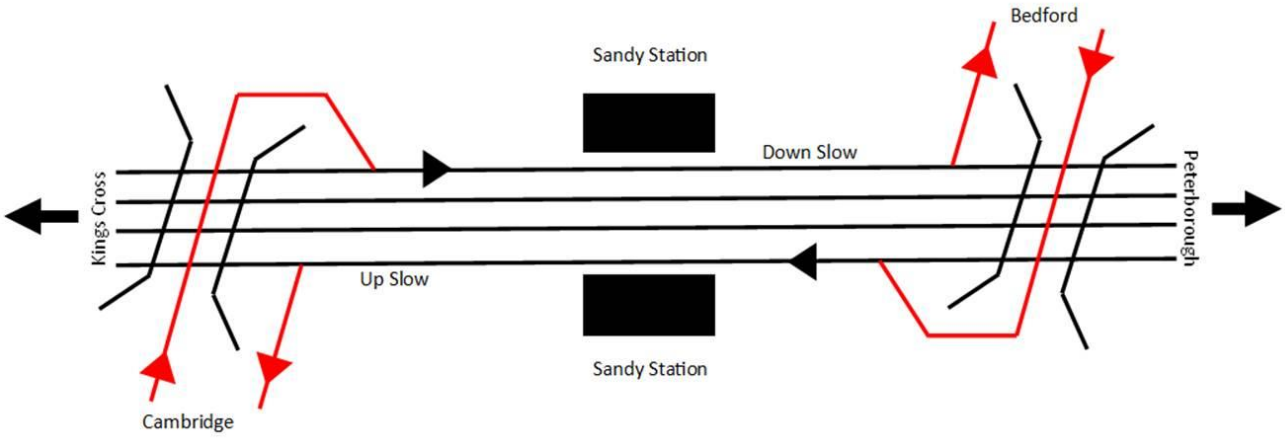


Figure D7: Drawing of Alternative Sandy Layout

Assumptions

The analysis was based on the following assumptions:

- The EWRCS conditional outputs:
  - Capability for up to 6 trains per hour (tph) between Cambridge & Bedford
  - Freight capability to support anticipated growth (1tph), where affordable
- The May 2018 timetable and ECML 2021 concept timetable v3 (taken from East Coast IPG) was used as a baseline, containing ECML services that utilise the ECML Slow Lines
- Issues in the wider rail network area are resolved or suitably mitigated, such as capacity constraints at Bedford, Milton Keynes etc
- Potential service paths are available to arrive at Sandy from Oxford and Cambridge for the potential paths identified

- Due to the ECML 2021 concept timetable proposals, flat crossings to/from the ECML Slow Lines are not desirable and have not been considered appropriate.

Findings

The analysis concluded that:

1. The aspiration to run 6 passenger services and 1 freight train per hour through the Slow Lines in the Sandy area cannot be consistently fulfilled with the current infrastructure, however, it is possible to achieve a consistent, even interval, 4 EWR services per hour and 1 freight per hour. However, it is currently unknown whether these would integrate into a wider timetable.
2. Freight was accommodated, in-between the proposed EWR passenger paths but outside the tolerance for the EWR potential path variation[7], hence omitting the freight path would not benefit the identification of potential EWR passenger service paths.
3. Diverting the fast Thameslink services from the Slow Lines to the Fast Lines, and back again, in this area was assessed and not considered feasible, due to the lack of capacity on the Fast Lines, plus the additional pathing time required in order to make the crossing moves.
4. Due to the number of significant interactions with multiple, constrained main lines between Oxford and Cambridge and beyond, it is essential to study the impact that any delays to these potential, identified EWR paths, could have on the overall system and validate their robustness as a timetable, through performance modelling.

In conclusion, to fulfil the aspirations for EWR to consistently run 6 passenger services and 1 freight service per hour, additional infrastructure, as identified in previous phases, will be required to accommodate this i.e. EWR services being segregated from other services on ECML with 2 new tracks on the east side of the ECML and with 2 new platforms at Sandy station, as long as the risks to the end to end timetable can be suitably mitigated.

[7] As discussed within the report, deviation with a maximum of +/-4 minutes has been adopted for the analysis

D.08 Sandy – Alternative Solutions

The working assumption in the Sandy ECML corridor for routes E4 & SN4, has been to develop a six-track railway, with the interface at Sandy Station being for passenger connectivity via additional platforms, and not for rolling stock connectivity. Within this phase, alternatives to this assumption have been assessed to ascertain whether the assumption to date has been appropriate.

Figure D8 below shows a section of the SN4 route, in the Sandy area. The current proposal is for a twin track Viaduct Bridge crossing the River Ivel and its flood plain, intersecting with the ECML where a new station at Tempsford could be sited. The route continues south and runs parallel to the existing tracks to the east of the ECML requiring land acquisition and planning consents. The route is then proposed to serve the existing Sandy Station with two new platforms, then diverging east at the point where the former Varsity Line was located, avoiding Biggleswade Common and the RSPB SSSI/Scheduled Monument sites.

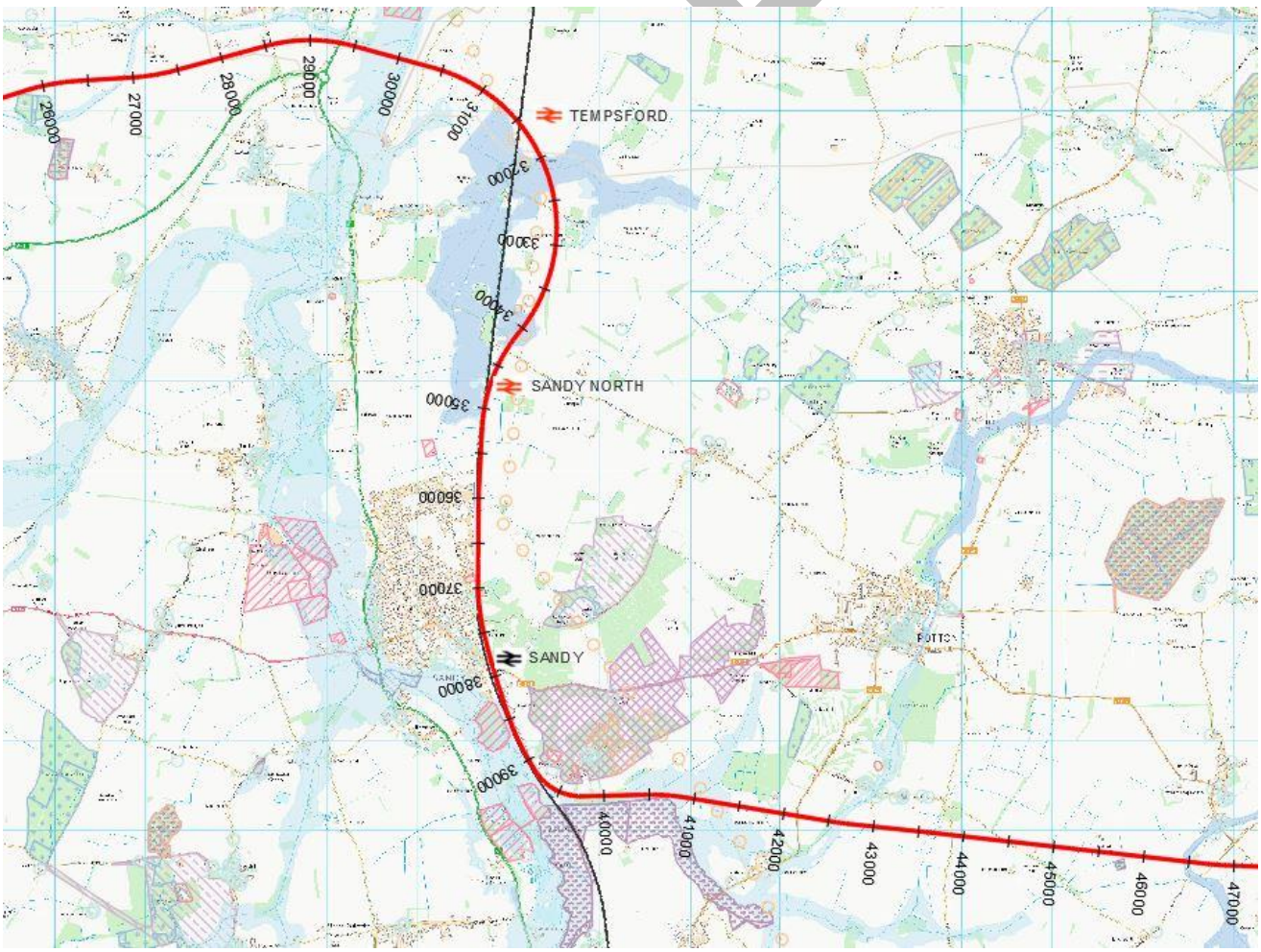


Figure D8: Drawing of extract of E4 in the Sandy area

There are areas of floodplain adjacent to the River Ivel and River Great Ouse to the west of the ECML that will need to be negotiated as outlined in the Flood Plain Strategy (Appendix D4) . The requirement to serve the existing Sandy Station and a new station at Tempsford is considered. EWRCS would have to mitigate/close Tempsford and Everton Level Crossings due to the increase in train paths and impact on barrier down time.

Two alternatives have been assessed, to consider whether six tracking the ECML, with a segregated EWR route, as per the previous assumptions is appropriate. The alternatives have assumed utilisation of the ECML Slow lines and the existing platforms at Sandy station with either at grade, or grade separated, junctions.

Note: The configuration (from west to east) of the ECML at this location is Down Slow – Down Fast – Up Fast – Up Slow. Effectively the Slow lines are on the outside and this affects both the type of junction that can be designed and the impact on route performance.

Option 1 – At Grade onto ECML Slows

As shown in Figure D9, this option provides junctions on to the ECML Slow Lines through the installation of at grade S&C ladders both to the north and south of Sandy, in order to facilitate the crossing moves on and off the Slow lines.

The benefit of this option would be to remove the bridge structure required to achieve grade separation and the additional costs associated with installation of the 6 tracks i.e. land acquisition, highway alterations and additional platforms. However, this type of solution is unlikely to be acceptable to the railway industry due to the performance impact this type of junction will incur to the existing services. It should be noted that the Fast lines are 125mph and the Slow lines are 75mph in this area. This type of junction would also import a number of whole life cost considerations with regards to future maintenance and renewal. Additionally, significant possessions of the ECML would be required to install this type of junction.

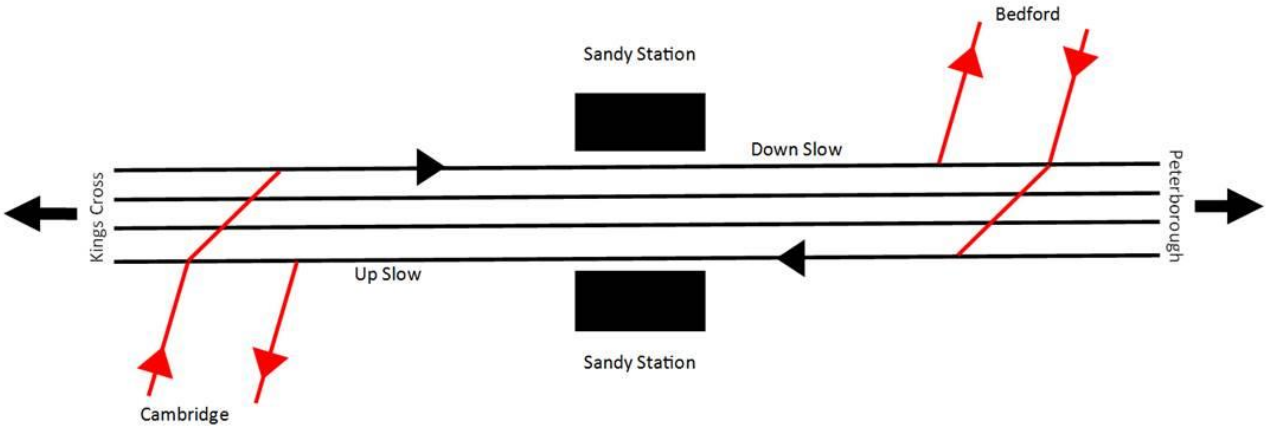


Figure D9: Drawing of Alternative At Grade Sandy Layout

Capacity

The C&CA assessment (see previous section), concluded that due to the ECML 2021 concept timetable proposals, flat crossings to/from the ECML Slow Lines are not desirable and have not been considered appropriate. It should be noted that Network Rail have, over the last few control periods, removed a number of similar junctions on the ECML to eradicate this type of constraint (Hitchin, Shaftholme and Werrington).

Order of magnitude Cost Estimate:

This option was not progressed due to the output from the C&CA analysis which deemed it to be unacceptable.

Conclusion

This option is unlikely to be acceptable to the industry due to the introduction of at grade junctions on the ECML.

Option 2 – Grade Separation on to ECML Slows

As shown in Figure D10, for a grade separated junction option, the layout would be similar to that constructed at Hitchin with two structures required, one to the north of Sandy connecting on to the Up Slow and a second to the south connecting on to the Down Slow. The flyovers would be single track structures passing over the ECML in a single span. The mid span would be circa 70m long and at a high skew to minimise the land take requirement.

The approaches will need to be elevated by approximately 9m, rail to rail, at the point of intersection and are assumed to be a viaduct structure to minimise the footprint in the corridor of the ECML. The maximum gradients have assumed 1:125 giving an approach of 1125m plus vertical curves and compensated gradients factored in. It should be noted that should a similar alignment as Hitchin be considered this would introduce linespeeds of 50/55mph. These junctions would require possessions of the ECML in order to deliver two structures to the south and north of Sandy, noting the constraints discussed earlier in this section particularly with regards to the flood plain, SSSI and Biggleswade Common.

The routes that do not cross the ECML (i.e. from the Up Slow to EWRCS & from the Down slow to EWRCS) will be able to access the Slow Lines at grade, via a turnout.

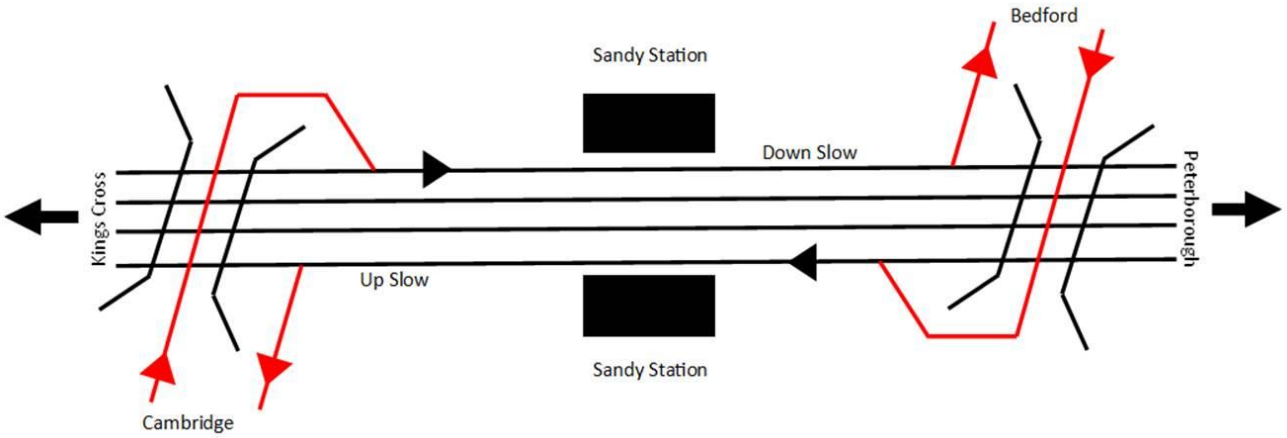


Figure D10: Drawing of Alternative Grade Separated Sandy Layout

Capacity

The C&CA assessment (see previous section) concluded that whilst this option would be more preferable than option 1, the Slow Lines are unable to accommodate the level of service aspirations for EWRCS of up to 6 passenger services and 1 freight service per hour. Additionally, these options further increase the number of interactions that EWR services would already have with constrained main lines and the associated risks that operationally this interaction will bring.

Order of Magnitude Cost Estimate: £95m - £105m

These costs would be incremental to the Base Route Cost for EWRCS, the 6 tracking of the ECML with a discrete EWR alignment and additional platforms would be avoided.

Conclusion

Whilst this option utilises the existing ECML slow lines, grade separated junctions would be required to the north and south of Sandy. C&CA analysis concludes that the proposed service specification could not be met by this option. Consequently, the option assumed to date (and described earlier in this section D.08) is preferable.

Summary of Sandy Alternatives

In conclusion, the options assessed, whilst technically feasible, are not considered to be worth further consideration due to the lack of available paths on the existing infrastructure to support the level of service aspiration for EWRCS in this area. Table D2 below summarises the engineering assessment with the conclusions from the C&CA analysis.

Table D2 Summary of Alternative Solutions for Sandy

	Engineering Option	C&CA conclusion
1	At Grade onto ECML Slows	×
2	Grade Separation on to ECML Slows	×

Table D2 indicates that the above options do not represent a better alternative to the Phase 2e solution, however should there be a change to the level of EWR services proposed, or the utilisation of the Slow Lines change in any way, further consideration of these options in future stages of development should be reviewed.

D.09 Cambridge South – Alternative Solutions

Work undertaken in previous phases has assumed the following interventions and assumptions derived from the "intermediate" solution proposed by the Cambridge South project as shown in Figure D11:

1. Grade separation (under or over) of Shepreth Branch Junction BGK to SBR Up lines
2. Four tracking of the BGK from Shepreth Branch Junction to Cambridge
3. Provision for a call at the proposed Cambridge South station
4. Grade separation of the new EWR junction onto the SBR is **not** required
5. Four tracking of the SBR from the new EWR junction to Shepreth Branch Junction is not required

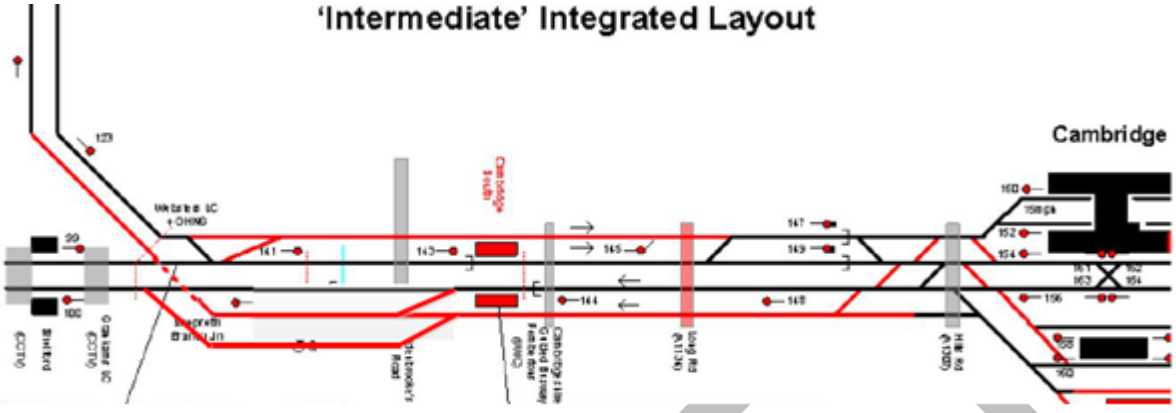


Figure D11: Alternative Cambridge Layout

C&CA Remit

A number of alternative infrastructure interventions were identified for assessment in order to establish whether more viable alternatives, to the Intermediate Layout in Figure D11, were available. The following were considered for appropriateness:

1. Whether grade separation of the junction connecting the EWR route to the SBR east of Foxton (52 miles) is required.
2. Consider the impact of the EWR route connecting directly on to the BGK south of Shelford (circa 51 miles).
3. Whether connecting the SBR prior to Meldreth (circa 47 miles) is more appropriate.
4. Diverting the SBR to connect on to the EWR alignment prior to Meldreth and the consequences of doing so.
5. The capacity available on the SBR from the EWR junction to Shepreth Branch Junction aligned with future service provision planned on the route.
6. Test the requirement for grade separation of Shepreth Branch Junction and four tracking of the BGK into Cambridge.

Assumptions

The analysis worked with the following assumptions:

- The EWRCS Conditional Outputs:
  - *Capability for up to 6 trains per hour (tph) between Cambridge & Bedford*
  - *Freight capability to support anticipated growth (1tph), where affordable*
- May 18 timetable, Monday – Friday (SX) services.

- Morning peak hours assessed (07:00 – 10:00)
- Timetable Planning Rules 2019 v4.1 applied

Conclusion

Based upon the assumptions outlined above, the analysis (Appendix D5) concluded that:

1. Grade separation of the new EWR route onto the SBR, east of Foxton, was not required.
2. The current 2 track section on the SBR, between Foxton and Shepreth Branch Junction, would be sufficient.
3. The WAML, south of the Shepreth Branch Junction through Great Shelford, would have capacity
4. The WAML, between Shepreth Branch Junction and Cambridge, would need 4 tracking to accommodate the proposed EWR services

It's recommended that a more detailed assessment Is undertaken within a future phase to confirm and establish the capacity on the WAML, both to the north and south of Cambridge, in order to understand the impact on Cambridge station itself with regards to platform capacity and utilisation. This should be integrated in to a wider network study for EWR services.

D.10 SBR to south Cambridge – Alternative Solutions

The alternative solutions considered within this section assess whether the most appropriate options have been considered on the Hitchin to Cambridge Branch (SBR), the geographical extent of which is from Shepreth Station to Shepreth Branch Junction, where it connects to the WAML, south of Cambridge. Previous phases have all assumed an at grade connection on to SBR, east of Foxton, existing SBR track layout, and grade separation of Shepreth Branch Junction.

Option 1 – SBR connection west of Shepreth

Route alignments were developed in Phase 2d, and an additional tie-in option has been examined which diverges from the A1, E4 and SN4 route options and connects into the existing SBR line, southwest of Shepreth station at SBR 49m 1385yds.

As shown in Figure D12, whilst this option reduces the length of the new EWRCS infrastructure, the impact of connecting on to the SBR, to the west of Shepreth, is the introduction of further capacity challenges onto the operation of an already busy, twin track

railway. The option of utilising the existing SBR infrastructure as a route option to connect into Cambridge was considered as part of Phase 2a, but the C&CA analysis concluded that there was insufficient capacity in the area where the stations (Meldreth, Shepreth & Foxton) are located, due to the number of stopping services that call at these stations. EWR Co requested a briefing paper (Appendix D6) in December 18 to understand the implications of this in more detail.

Should this option be considered further, due cognisance should also be made to the additional infrastructure work that would be required between Shepreth and Foxton. From analysis undertaken in Phase 2a, this scope is likely to require the closure of 3 level crossings, four tracking of this section to create capacity (or passing loops at the stations), and station platform rebuilds. This is currently excluded from the cost estimate for this option, but further information is provided in the briefing paper (Appendix D6).

This option will impact on a number of local residential properties and highways, both for the new route, where it connects on to the SBR west of Shepreth, and the upgrading of the SBR between Shepreth and Foxton.

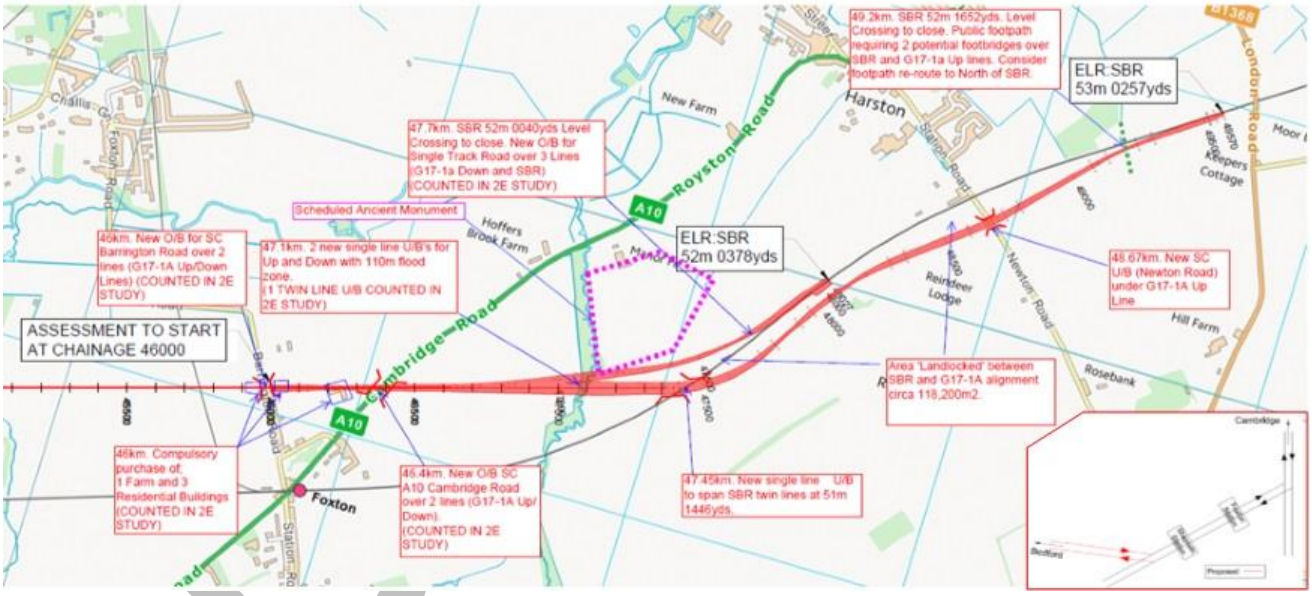


Figure D12: Drawing of Option 1

Assumptions

1. Western limit of option consideration is the tie in to the A1 route option, and eastern limit is the tie in junction to the existing SBR line.
2. Alignment of C1 to remain unchanged from previous development and reports.

3. Detailed horizontal and vertical alignment of option has not been considered as part of this study.
4. Additional infrastructure changes between Shepreth and Foxton will be required to enable this option.
5. New junctions have been designed for 50mph and assumed appropriate.

Capacity

The C&CA report indicates that there is likely to be insufficient capacity in this area on the SBR for new EWR service paths, until northeast of Foxton. Therefore, this option will not fulfil the output requirements, unless the options include significant upgrades of the stations, level crossings and potential passing facilities/four tracking.

Order of Magnitude Cost Estimate: -£33m - -£37m

These costs would be **deducted** from the Base Route Cost for EWRCS. The deduction is due to the shortened route length brought about by connecting onto the SBR prior to Shepreth. **NOTE**: These costs do not include for the scope required to address the capacity constraints on the SBR between Shepreth and Foxton.

Conclusion

This option is not appropriate due to connecting on to the SBR at the point where it's capacity constrained due to the number of existing stopping services. This option would require further enhancement of the existing SBR than has previously been considered within phase 2a.

Option 2 – SBR Diversion on to new EWRCS alignment

As shown in Figure D13, an alternative option has been identified for the southern route options (A1, E4 & SN4), where the existing SBR route runs in parallel for circa 4km before both lines would connect with each other. This option considers diverting the existing rail alignment on to the EWR alignment prior to Shepreth station. Were the stations at Shepreth and Foxton to be relocated, an opportunity exists to address the 3No. level crossings and decommission that section of the existing SBR route. Both lines could then continue in a four-track arrangement (providing EWR segregation) to Shepreth Branch Junction, where the SBR line joins the WAML (BGK), and the EWRCS alignment could continue in parallel to the west side of the BGK, again in a four track configuration, which is considered in section D.09. The scope of this study concludes at A1134 Long Road overbridge at BGK 54m 1054yds.

A number of residential properties could be affected by this option, both alongside the railway corridor and as a result of the subsequent changes to the highways. Additionally, relocating Shepreth and Foxton stations, slightly further way from their conurbations, will need careful consideration and consultation with relevant stakeholders, including the opportunity to combine them into one station. These changes would require consultation within the rail industry, local authorities and with the public residing in the area to support any future station closure/ network change.

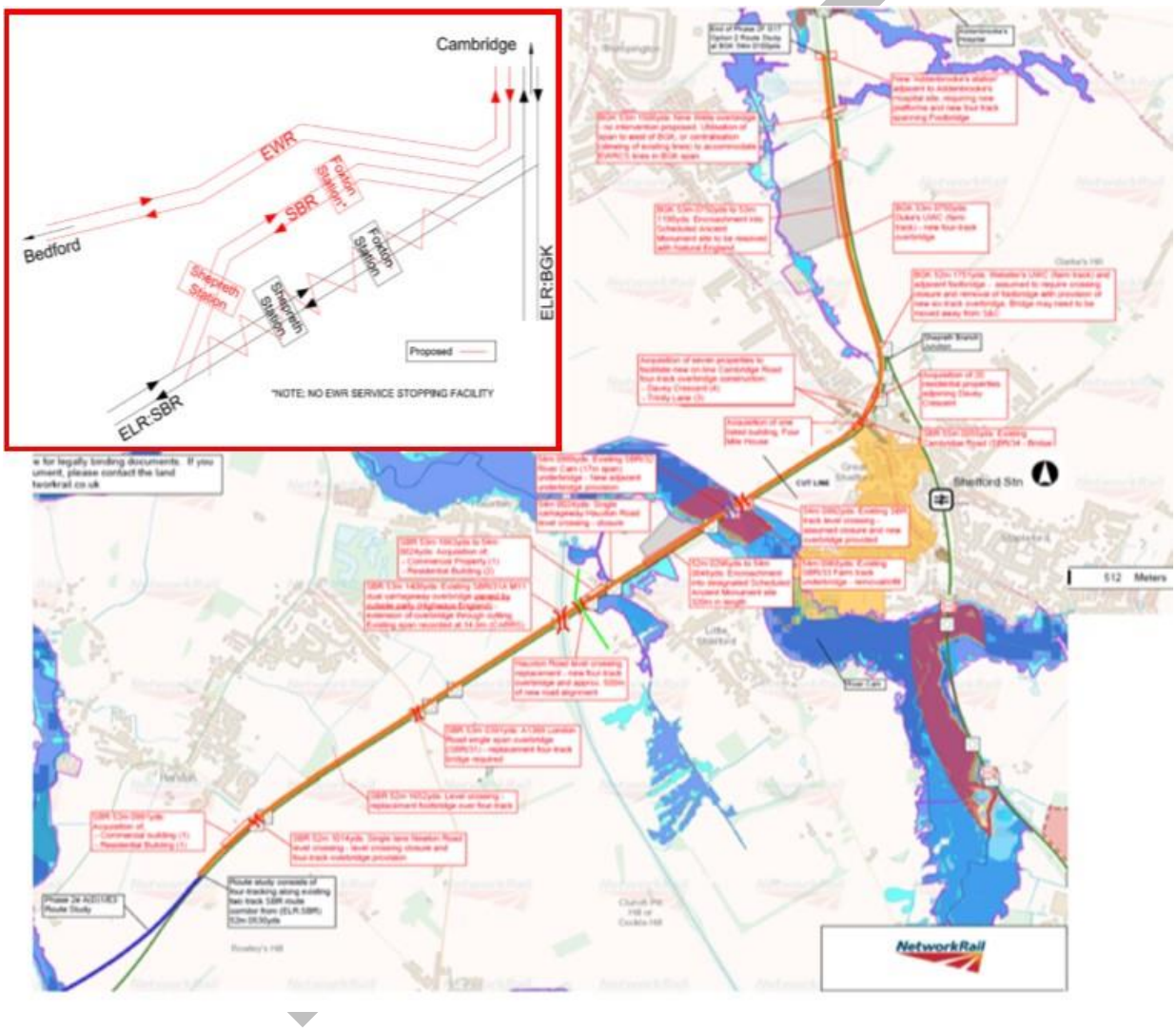


Figure D13: Drawing of Option 2

Assumptions

1. Western limit of option consideration is the tie in to the SBR line, with eastern limit to be A1134 Long Road overbridge.
2. Alignment of A1, E4 & SN4 to remain unchanged from earlier reports.
3. Line speed to be 125mph with minimum curve radius of 2500m along all newly installed corridor (i.e. Phase 2e report), but to follow existing route alignment, where proposed, to run parallel with the SBR and BGK lines.
4. Line speed of 50mph (i.e. minimum curve radius of 500m) assumed at SBR junction with BGK. New SBR twin track assumed to be 90mph (as existing).
5. All new track, where running parallel with the existing SBR and BGK lines, is assumed to be at grade with existing tracks.
6. SBR 2800 siding to Cement Works, west of Foxton, would be closed as part of route development.
7. The three overbridge structures owned by Cambridgeshire County Council; Addenbrooke's Road, Guided Busway Route ADR&U with National Cycle Route 11, and A1134 Long Road, have the capacity to accommodate a four track railway along the existing BGK corridor.

Capacity

The C&CA report indicates that there is likely to be insufficient capacity in this area, on the SBR, to accommodate new EWR paths, until northeast of Foxton and, therefore, this option, which has the routes connecting east of Foxton, would not be affected by the constraints caused by the stations on this section of the SBR. The analysis has also concluded that four tracking, between Foxton and Shepreth Branch Junction, would not be required, with trains operating at a higher linespeed, and no further stations impacting on capacity in to Cambridge.

This option offers an opportunity to effectively condense the infrastructure, for EWRCS and the existing SBR, into one corridor and remove the existing level crossings and the associated risks. A single rail corridor in this area provides opportunities for synergies with regards to highway structure solutions, however, relocating two stations, or relocating and combining the stations, (and the cost impact of doing so), further away from their existing conurbations, will not be easy to achieve, or secure support for, and may be subject to objections from local stakeholders.

Order of Magnitude Cost Estimate: £364m - £403m

These costs would be incremental to the Base Route Cost for EWRCS. This option could provide a means to avoid the grade separation of Shepreth Branch Junction.

Conclusion

This option could be considered as a viable alternative, however it would require station and network change in order to close and relocate the existing stations at Shepreth and Foxton. This should be considered further upon the preferred route selection and in conjunction with the Network Rail Cambridge South project.

Option 1a – EWR to SBR Grade Separated Junction

Previous route option development has considered an ‘at grade’ double junction type connection onto the Hitchin - Cambridge (ELR:SBR) line. As shown in Figure D14, the following option assesses the provision of an alternative grade separated junction from the Up line on the SBR.

This option provides a grade separated junction that is compatible with the southern route options (A1, E4 & SN4). Divergence of the Up line and Down line alignments occurs at 46.53km with the Down line curving to the north on the northern side of the SBR and the Up line curving north on to the southern side of the SBR line. The grade separation of the Up line would require an embankment either side, with a bridge over the existing SBR prior to Foxton Station and Level Crossing. A small number of residential properties and roads are likely to be affected by this option.

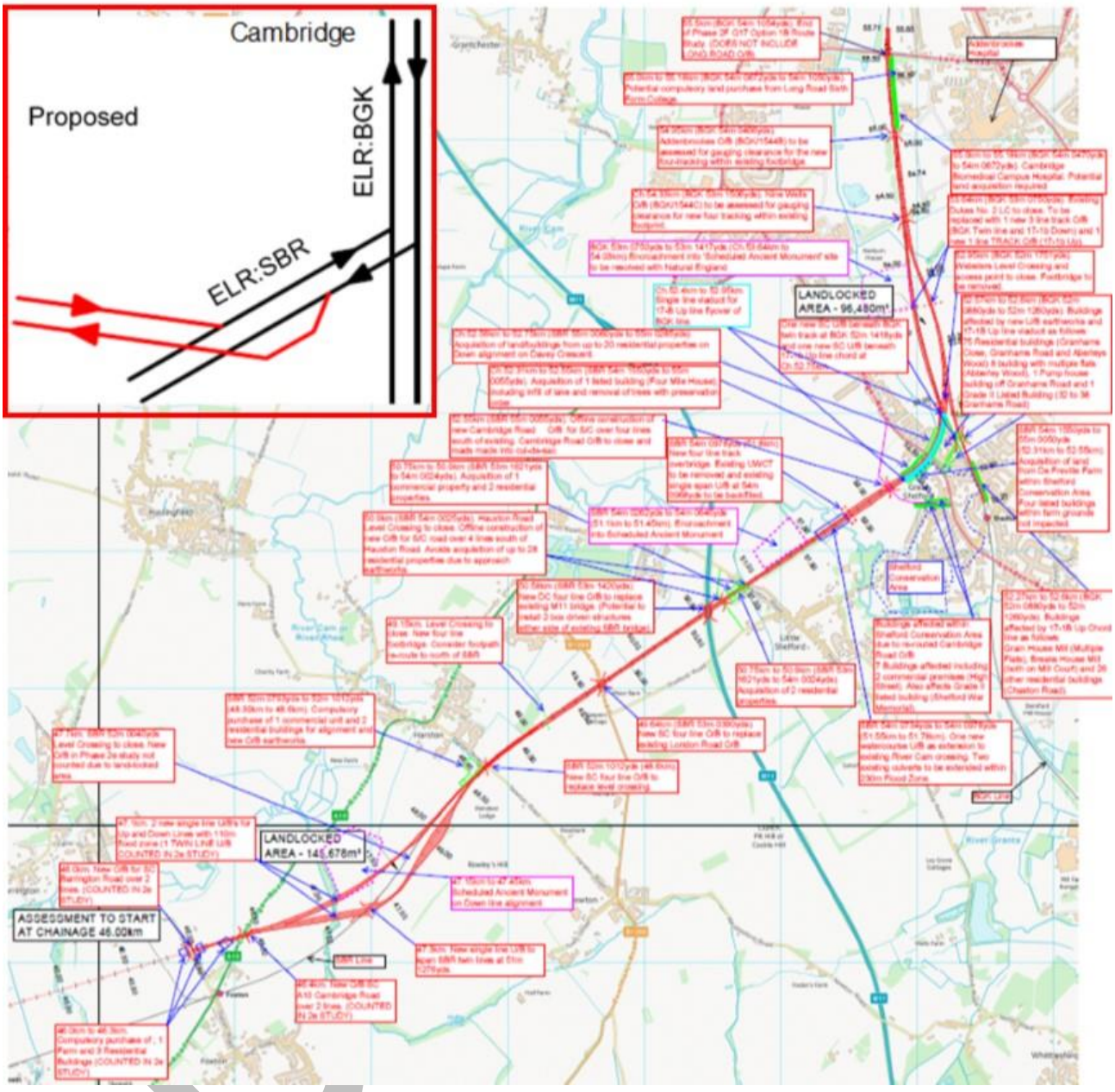


Figure D14: Drawing of Option 1a

Capacity

The C&CA report indicates that there is likely to be insufficient capacity on the SBR to accommodate new EWR service paths prior to Foxton. However, the assessments indicate that, once east of Foxton, capacity would exist due to there being no further stations constraining capacity in this area. Consequently, based upon current knowledge, it is felt

that grade separation and four tracking between Foxton and Shepreth Branch Junction would not be required.

Order of Magnitude Cost Estimate: £42m - £46m

These costs would be incremental to the Base Route Cost for EWRCS.

Conclusion

The C&CA assessment has concluded that the grade separation of this junction would not be required.

Option 1b – SBR Four tracking (Foxton to Shepreth Branch Junction)

As part of East West Rail Central Section (EWRCS) Phases 2d and 2e studies, the proposed EWRCS route options converged at grade using a double junction to join the Shepreth Branch line (ELR: SBR) prior to the Bethnal Green - Kings Lynn line (ELR: BGK).

Following the route alignments developed during Phase 2e, as shown in Figure D15, this option has been developed as an alternative for the Cambridge connection up to long Road. However, no provision for a new station at Cambridge South has been included as assumed to be outside the scope of this project. This option includes an A1, SN4 and E4 Up line link via a grade separated Junction of both SBR and BGK lines and four tracking to Cambridge beyond Shepreth Branch Junction.

The 4 tracking of the SBR will require an increase in existing railway footprint as well as the widening of a number of highways bridges on the A10, a new underbridge to accommodate the M11, and the impact on existing level crossings will need to be assessed.

The Up line vertical alignment rises on approach to the BGK flyover. The alignment is to be accommodated on a single line viaduct. Beyond the flyover, a new embankment, up to 8.3m, high will be required to bring the alignment back down to grade. Beyond this the alignment remains largely at grade and parallel to the BGK line to the end of this option assessment at Long Road. The chord alignment connecting the EWR routes with the BGK line runs on embankment at a height of 4.8m where it diverges from the southerly route options Up line alignments.

An additional chord has also been considered linking the EWR routes with the Up line parallel to the BGK line as part of the Cambridge South project being led by Network Rail Anglia team.

This option impacts on residential properties (circa156) and existing highways infrastructure in Great Shelford.

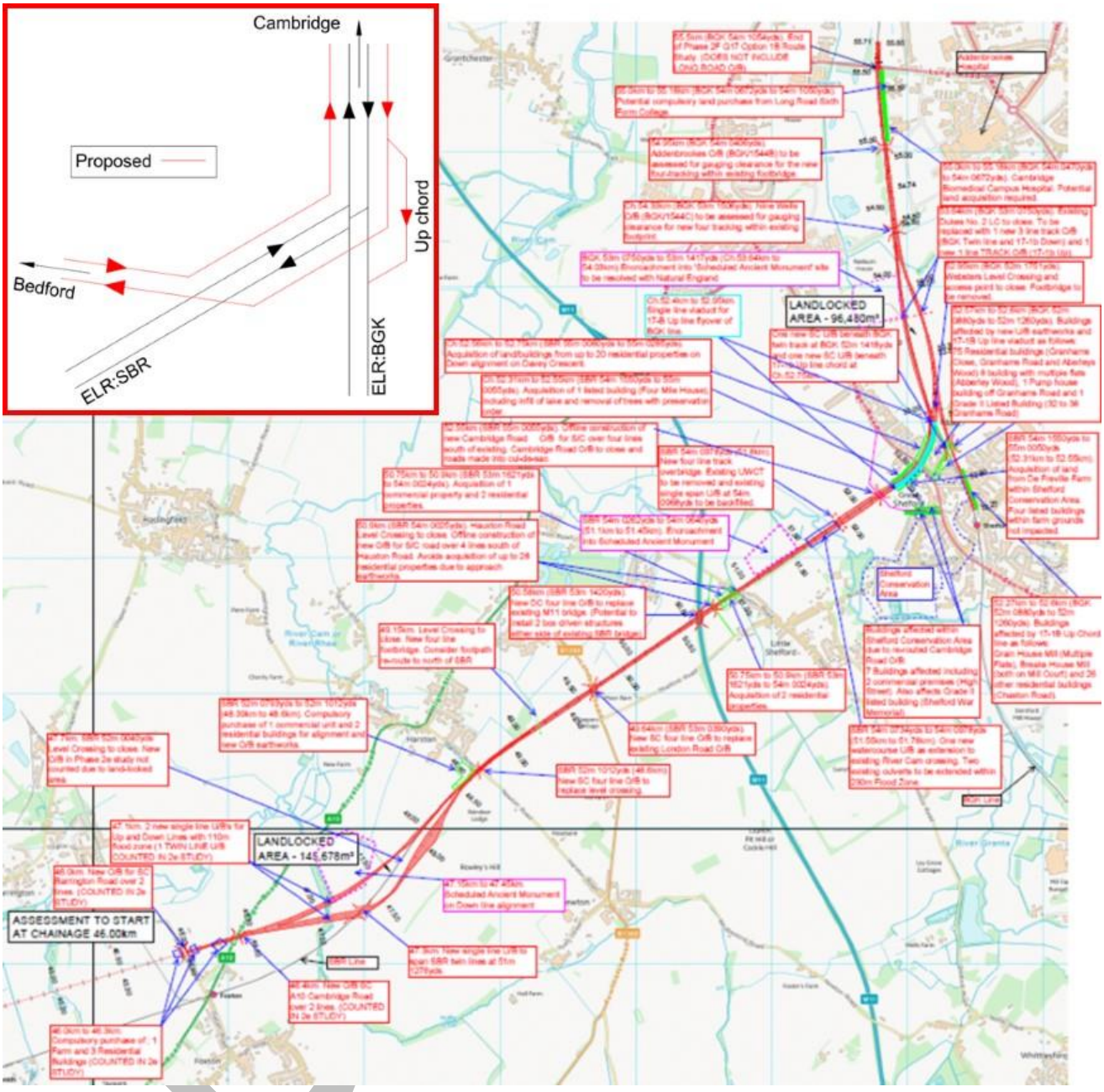


Figure D15: Drawing of option 1b

Assumptions

1. The previously developed Shepreth Branch Junction horizontal (at grade junction) alignment connecting to SBR, is to form the general basis of the new options commencement. This has been termed the Intermediate layout

2. New tracks, where running parallel and immediately adjacent to existing lines, are to run at the same level.

3. To avoid blocking junctions, maximum train length is assumed to be 350m.

Capacity

The C&CA report indicates that there is likely to be insufficient capacity in this area on the BGK for the new EWR service paths. This option would provide the capacity to accommodate the additional EWR services whilst maintaining a level of performance that would likely be deemed acceptable to the rail industry.

Order of Magnitude Cost Estimate: £876m - £969m

These costs would be incremental to the Base Route Cost for EWRCS, this option would remove circa £423m from within the Base Route Cost for this area.

Conclusion

This option would provide the necessary capacity, though the C&CA analysis concludes that there is sufficient capacity on the SBR in this section between Foxton and Shepreth Branch Junction. Therefore the solution included within the development of the routes to date is deemed appropriate.

Option 2a – Segregated route to Cambridge South

As shown in Figure D16, a new alternative alignment running separately and parallel to the existing SBR and BGK corridors is considered by this option. This provides an option for a discrete segregated railway for EWR services, or for it to be integrated at the proposed Cambridge South station and onward into Cambridge station.

This option removes the grade separated junction and structure at Shepreth Branch Junction and reduces the impact both visually and physically, however, this option will impact on circa 33 local residential properties with one being listed and existing civil infrastructure. Additionally, there is potentially an encroachment into a Scheduled Ancient Monument site that would need to be resolved with Historic England.

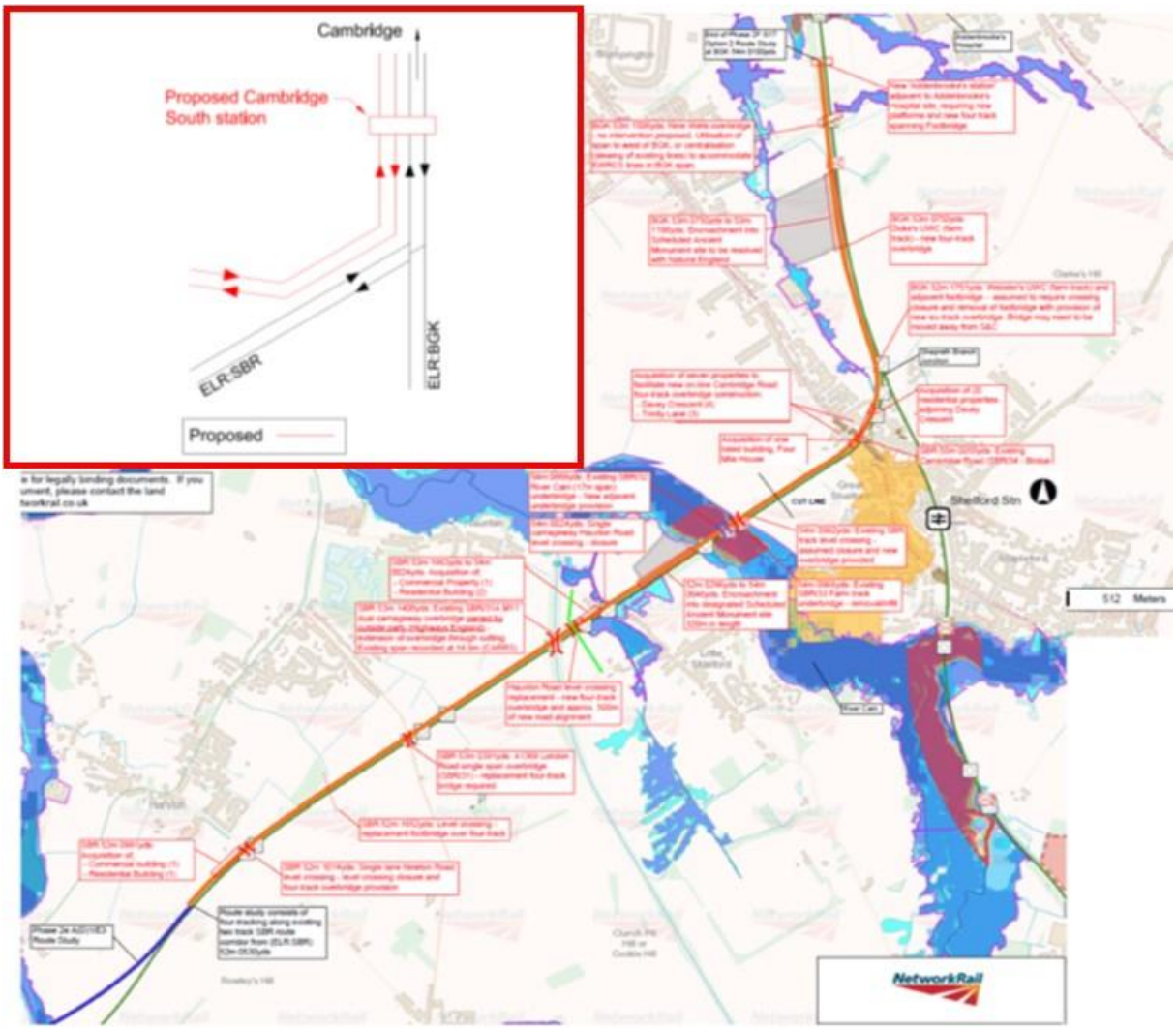


Figure D16: Drawing of Option 2a

Assumptions

1. Western limit of option consideration is the tie in to the Phase 2d A(D)1 route study, with eastern limit defined as the new Cambridge South Station at BGK 54m 0100yds.
2. Alignment of the A1, E4 & SN4 routes to remain unchanged from earlier reports.
3. Line speed of 50mph (i.e. minimum curve radius of 500m) assumed at SBR junction with BGK. New EWRCS twin track assumed to be 90mph (as existing).
4. All new track, where running parallel with the existing SBR and BGK lines, are assumed to be at grade with existing tracks.

5. Connection from Foxton 2800 Down Sidings to CEMEX plant assumed to be removed with replacement not currently considered.
6. The overbridge structure owned by Cambridgeshire County Council; Nine Wells Overbridge (i.e. Addenbrooke's Road), assumed to have adequate capacity to accommodate a four-track railway along the existing BGK corridor.
7. Road level crossings could be closed and replaced with bridges. No new level crossings would be introduced. Existing footpath or user worked level crossings would be assumed to require closure or diversion.
8. Design and cost of Cambridge South station is outside the scope of this project.

Capacity

The C&CA analysis indicates that there is likely to be insufficient capacity in this area on the BGK to accommodate additional EWR paths. This option is likely to alleviate future congestion given the paths remain separate from the NR infrastructure. Integration could be accommodated by the Cambridge South Station project, through management of the throat layouts to north and south of this new station, allowing onward access to Cambridge station.

Order of Magnitude Cost Estimate: £191m - £211m

These costs would be incremental to the Base Route Cost for EWRCS. This option potentially removes circa £423m of works included within the Base Route Cost, providing a potential saving of circa £200m.

Conclusion

This alternative solution provides additional capacity on the SBR between Foxton and Shepreth Branch Junction however this isn't required based on the output from the C&CA assessment. Further development should be considered in conjunction with Network Rail's Cambridge South project to understand whether the construction of a grade separated route is appropriate at the junction. The options included in the route development to date (as described above) are suitable due to taking grade separation into account.

Option 3 – At grade SBR connection with four tracking

Shepreth Branch Junction options**,** investigated under separate study**,** have highlighted potential for high impact on the residential area in Great Shelford, or other constraining factors (Cambridge Road proximity to BGK lines) producing unfavourable track design gradients.

As shown in Figure D17, this option considers EWRCS routes, which previously converged near Shepreth, forming a four track railway, with an at grade Up line switches and crossings (S&C) ladder arrangement to traverse both SBR and BGK lines.

As per the previous option, this option removes the grade separated junction and structure at Shepreth Branch Junction and reduces the impact both visually and physically, however this option will impact on circa 47 local residential properties with one being listed and existing civil infrastructure. Additionally, there is potentially an encroachment into a Scheduled Ancient Monument site that would need to be resolved with Historic England.

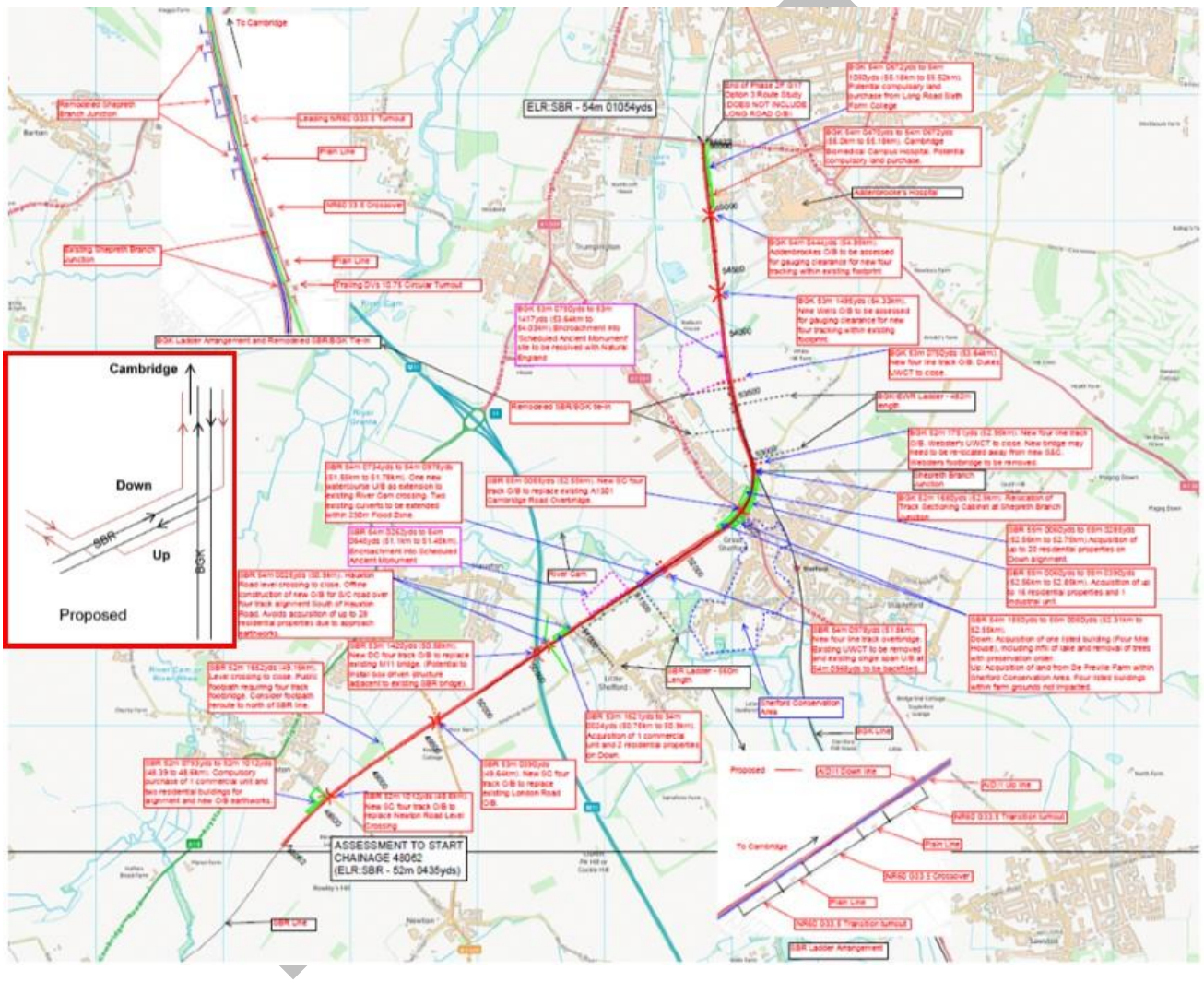


Figure D17: Drawing of Option 3

Assumptions

1. Detailed horizontal and vertical alignment of option not required as part of this study.

2. All new track, where running immediately adjacent and parallel with the existing SBR and BGK lines, is assumed to be at the same elevation as existing tracks.

Capacity

As per the previous options, the C&CA analysis concludes that there would be capacity available between Foxton and Shepreth Branch Junction, however, there would not be sufficient capacity available on the BGK to accommodate EWR services. Whilst the four tracking of the BGK will improve capacity into Cambridge, the at grade crossing would constrain the existing infrastructure further.

Order of Magnitude Cost Estimate: £374m - £413m

These costs would be incremental to the Base Route Cost for EWRCS. This option potentially removes circa £423m of works included within the Base Route Cost.

Conclusion

This solutions at grade junction from the BGK to the SBR would introduce a constraint and consequently is unlikely to be an acceptable solution to the industry, this option is not considered to be better than others included and assessed to date.

Summary of Cambridge Alternatives

Table D3 below summarises the engineering assessment with the conclusions from the C&CA analysis which indicates whether each option provides the required level of capacity in this area.

Table D3: Summary of Alternative Solutions for Cambridge South

	Engineering Option	C&CA conclusion
1	SBR connection west of Shepreth	×
2	SBR Diversion on to new EWRCS alignment	✓
1a	EWR to SBR Grade Separated Junction	×
1b	SBR Four tracking (Foxton to Shepreth Branch Junction)	×
2a	Segregated route to Cambridge South with four tracking	×
3	At grade SBR connection with four tracking	×

In conclusion Table D3 indicates that most of the options are unviable, however, one option may be worth further detailed consideration in future stages of development. Additionally, the infrastructure considered to date for this area is deemed appropriate to facilitate further development and assessment.

D.11 WAML Connection South of Shepreth Branch Junction – Alternative Solutions

This section considers whether various options for a connection on to the WAML, south of Great Shelford, provide a viable alternative to connecting on to the SBR, and the associated upgrades required on it, and at Shepreth Branch Junction.

Option 4a - WAML Connection South of Shepreth Branch Junction

As shown in Figure D18, this option considers a new alternative alignment from the Bassingbourn area, entering Great Shelford from the south. Connection onto the existing BGK lines which a twin tracked as this location and is to be achieved using a grade-separated junction. The benefit from this option is the potential to remove the need for a grade separated junction at Shepreth Branch Junction by bringing the additional EWR services up the BGK and removing the conflicting crossing moves. This option could provide better management of paths if serving Ipswich and Norwich, however, a negative impact would be on felt on the level crossings around Great Shelford that would see increased downtime for circa 4,000 cars and 900 pedestrian users per day.

This option will impact a number of residential properties (circa 8) and a number of highways, including the M11, and those mentioned previously in Great Shelford that have level crossings that will incur increased barrier downtime. The current number of trains per day operating on the WAML is likely to be doubled, assuming the EWR service specification of 6tph passenger and 1tph freight in each direction.

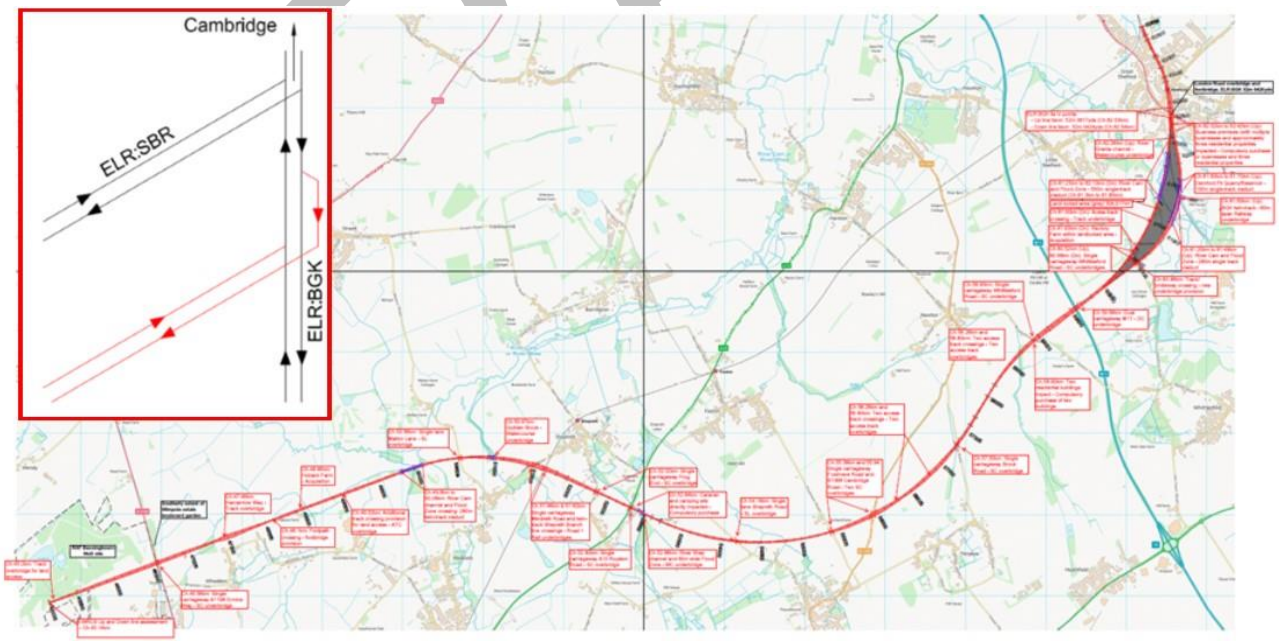


Figure D18: Drawing of Option 4a

Assumptions

1. This geographical assessment is from route option E3, as defined in previous phases, Bassingbourn route option divergence providing access to Long Road overbridge at BGK 54m 1054yds.
2. The new BGK-EWRCS junction location could be located on the (Stour Valley) dismantled railway location.
3. 125mph alignments have been assumed to ascertain the potential route, but this could be reduced in order to achieve a slightly shorter and tighter route should this option be considered further.

Capacity

The C&CA report indicates that there is unlikely to be sufficient capacity for this area on the BGK to accept new paths between Shepreth Branch Junction and Cambridge. However, with the Cambridge South station being proposed to the north of Shepreth Branch Junction this may be manageable with the required headways subject to analysis. This option is unlikely to alleviate future congestion given the paths integrate with NRCI restricting existing capacity in this layout with regards to the station and level crossings in Great Shelford which may constrain this option.

Order of Magnitude Cost Estimate: £345m - £382m

These costs would be incremental to the Base Route Cost for EWRCS. This option potentially removes circa £423m of works included within the Base Route Cost to address Shepreth Branch Junction to Long Road bridge.

Conclusion

This option increases the length of new EWR infrastructure and it presents services on to the BGK south of the Shepreth Branch Junction. C&CA analysis indicates that this option is worth further consideration from a capacity perspective and would assist in validating the current options being considered within this area. This option would also present challenges with the station and level crossings in Great Shelford but provides a viable alternative to grade separation of Shepreth Branch Junction.

Option 4b – WAML Connection South of Shepreth Branch Junction & 4 Tracking

As shown in Figure D19, this option adopts the previous option 4a but considers a new BGK flyover with continued four-tracking of the BGK/EWRCS corridor northward. The proposed flyover is to be located south of Shepreth Branch Junction

The new EWRCS alignment assumes a 125mph linespeed and curvature, this alternative affects circa 66No. residential properties and a number of highways including crossing the M11 and A10.

Whilst an at grade solution where the new Down line crosses at Shepreth Branch Junction, is technically feasible, it is unlikely to be acceptable to the rail industry particularly for reasons of maintenance and capacity.

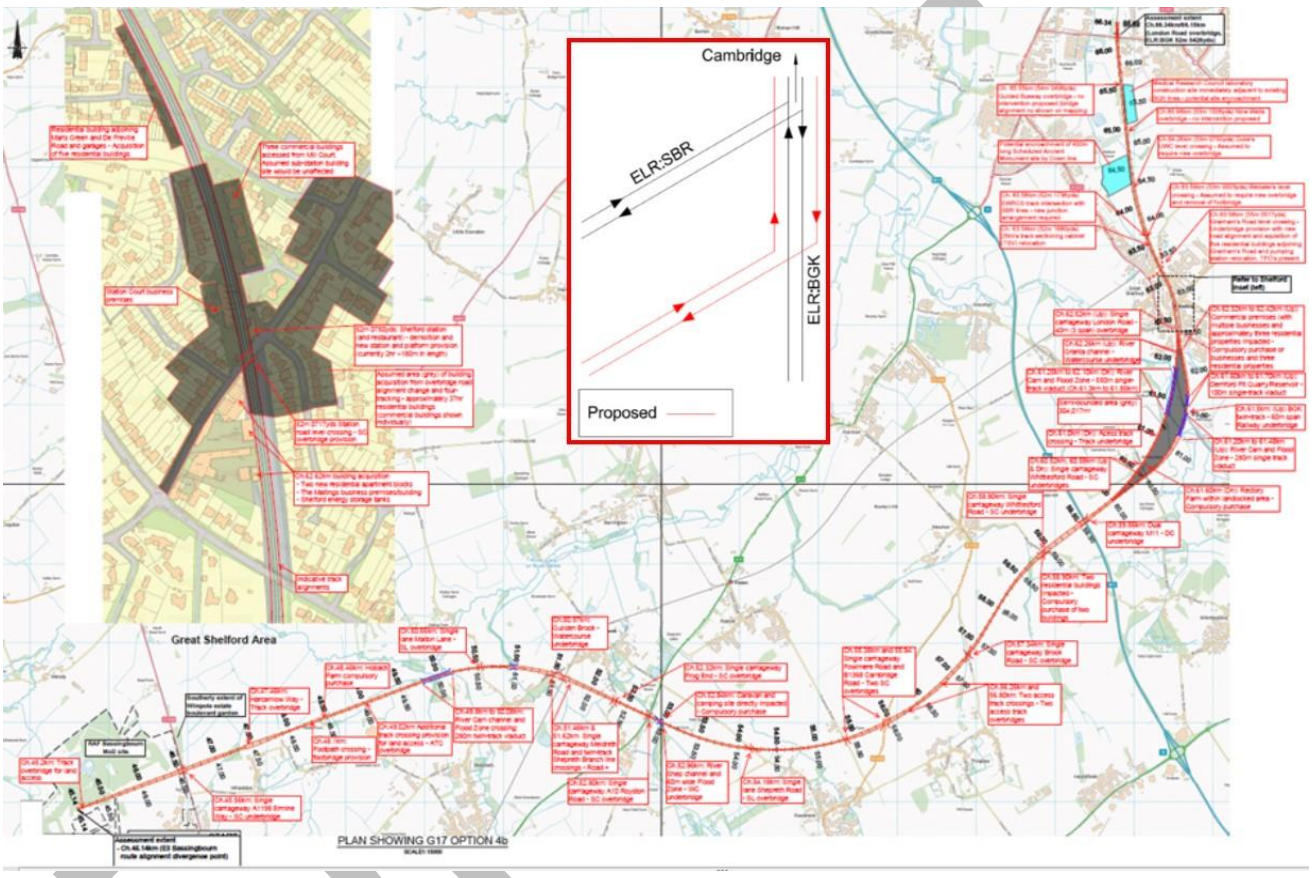


Figure D19: Drawing of Option 4b

Assumptions

1. The new Down Line intersection crosses the Hitchin to Cambridge Branch line (ELR:SBR) at grade and a redesign of the Shepreth Branch Junction is not required.
2. New EWRCS tracks to run at the same level as existing BGK tracks where four-tracked.
3. This option is based on the E3 Bassingbourn route alignment, which passes south of Wimpole Estate.

4. This geographical assessment is from Bassingbourn route option (E3) divergence (Ch.45.14km) to Long Road overbridge, at BGK 54m 1054yds, and excludes the proposal for a new station at Cambridge South.
5. The new BGK-EWRCS junction location is to be located south of Great Shelford, on the junction of the dismantled railway.

Capacity

The C&CA report indicates that there is unlikely to be sufficient capacity in this area, on the BGK, between the Shepreth Branch Junction and Cambridge, to accommodate new EWR paths without further infrastructure. However, four tracking through Great Shelford, with its station and level crossings, will be a significant enhancement on the WAML into Cambridge.

Order of Magnitude Cost Estimate: £538m - £595m

These costs would be incremental to the Base Route Cost for EWRCS. This option potentially removes circa £423m of works included within the Base Route Cost.

Conclusion

As per the previous option 4a however, the C&CA analysis indicates that 6 tracking of the BGK would not be required. This option would also present challenges with the station and level crossings in Great Shelford.

Summary of WAML Alternatives

Table D4 below summarises the engineering assessment with the conclusions from the C&CA analysis which indicates whether each option provides the required level of capacity in this area.

Table D4: Summary of Alternative Options for WAML connections

	Engineering Option	C&CA conclusion
4a	WAML Connection south of Shepreth Branch Junction	✓
4b	WAML Connection south of Shepreth Branch Junction & 4 Tracking	×

In conclusion Table D4 indicates that a southern WAML connection could be a viable alternative solution, however, four tracking of the WAML is not required as suggested by the C&CA assessment. Option 4a may, therefore, be worth further detailed consideration in future stages of development compared to the current preferred solution of grade separating Shepreth branch Junction.

D.12 South of Bassingbourn

During this phase, EWR Co requested a high-level desktop assessment (Appendix D7) on the impact of diverting route options A1/E3/SN4 further south, in order to avoid both the National Trust Wimpole Estate and the MoD site at RAF Bassingbourn. Both of these stakeholders have raised concerns about the existing proposals in this location. This study considered where an indicative diversion of the route could be made, with indicative journey time and cost impacts, based on a per mile basis of the A1 route option. The options are shown in Figure D20.

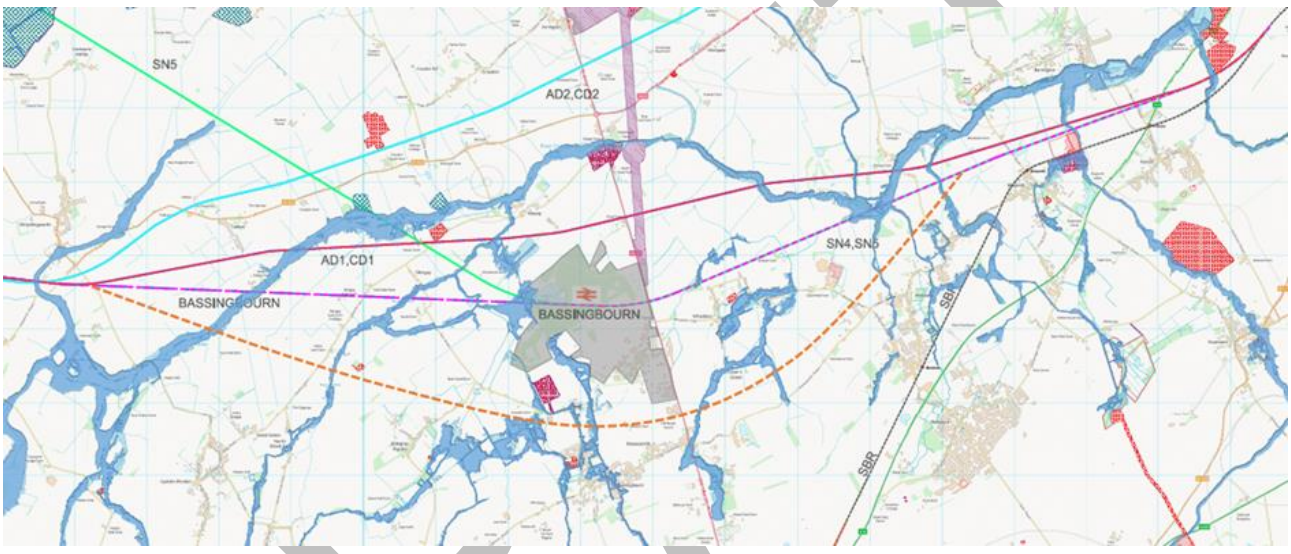


Figure D20: Indicative route diversions south of Bassingbourn

The dashed amber route in Figure D20 above equates to a circa 1.5km diversion from the E3/SN4 Bassingbourn station route options that were assessed in Phase 2e. In terms of journey time, and assuming no stop at a new station at Bassingbourn, this section would be undertaken at linespeed of 125mph. This would equate to circa 27 seconds additional journey time versus 33 seconds for 100mph on the E3/SN4 route.

To provide an indication of cost impact for this deviation at this stage of development, an average, 'all in' rate, per kilometre, has been established. The impact would be in the range of £60m to £100m in addition to the cost estimate for the E3/SN4 route options, but subject to several caveats and more detailed assessment.

Considerations

1. Diverting the route further south would move the alignment closer to the conurbations of Bassingbourn and Kneesworth, with a number of residential properties potentially affected by this.
2. There are a similar number of highways and flood zones as per the original route options outlined in Phase 2e.
3. There may still be issues to consider with regards to any impact on the views from Wimpole Hall, and additionally the diverted route would run close to 2No. scheduled ancient monuments.
4. The diverted route would run close to the twin-tracked Hitchin-Cambridge (SBR) line, which has restricted capacity due to the number of stations within a short distance (circa 4 miles). The close proximity of both lines may offer options to consolidate the routes, alternative options to address this are considered within this report (section E).

To conclude, diverting the southerly route options further south, to avoid both the Wimpole Hall estate and MoD Bassingbourn, could be achieved. Further consultation with local stakeholders would be recommended, should this option be pursued, with a more detailed engineering assessment undertaken in a future development phase.

D.13 London Connections

During this phase, EWR Co requested a high-level assessment (Appendix D8) of the impact of providing direct links to London, from a new station at Cambourne, in relation to route options for EWRCS. The scenarios assessed were as follows:

1. Northern approach down WAML into Cambridge.
2. South facing WAML connection at Shepreth Branch Junction.
3. ECML connection at Tempsford.

The paper considered where an indicative diversion of the route could be made, with supporting indicative journey time and cost impacts based on a per mile basis.

Northern Approach into Cambridge

As shown in Figure D21, this scenario considers a diversion to the CAM2 route to the west of Cambourne. The options identified are circa 22km in length and connect on to the WAML, somewhere between Cambridge and Waterbeach. The solid red line in Figure D20 connects to the WAML south of Waterbeach, whilst the red/blue dashed line utilises the

route of the Guided Busway, and connects onto the WAML north of Cambridge North station.

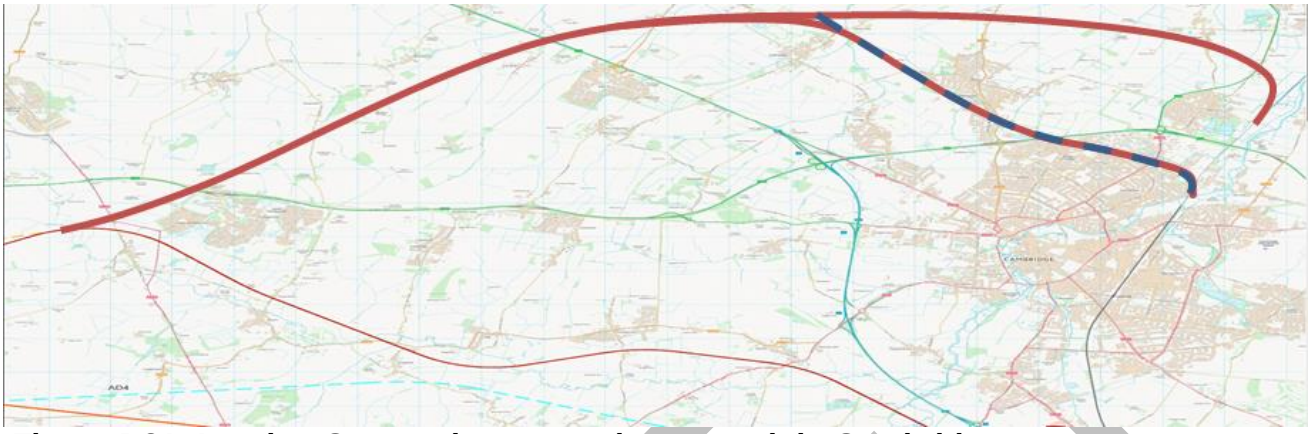


Figure D21: London Connections – north approach in Cambridge

The first 10km of the route is on higher terrain, with an additional circa 6km utilising the existing WAML railway corridor into Cambridge. Further analysis would need to be undertaken to establish the availability of train paths to London on the WAML.

The paper concluded the following:

- The effects on the Guided Busway (circa 9km) would be significant and would likely require it to be relocated, in part, with work required to enable the route for railway operations
- The capability of the WAML to the north of Cambridge, to accommodate the level of service proposed, requires further examination, including the impact on Cambridge North station platform requirements, the need for grade separation & whether 4-tracking is required
- Current WAML linespeed is 70/75mph between Cambridge and Milton, compared with 80/90 to the south of Cambridge, further assessment should be undertaken to assess whether an increased linespeed is required and achievable
- EWR services, that would continue to Norwich/Ipswich, would need a time-consuming change of ends for drivers, potentially affecting platform utilisation in Cambridge, with potential additional infrastructure required for capacity and/or operational flexibility
- There is potential for Park and Ride stations to be built on a number of key highways (A428 & A14), plus the option for EWR services to serve Cambridge North, but recognising the journey time impact of these additional calls

South Facing WAML Connection at Shepreth

As shown in Figure D22, this scenario considers a south facing connection on to the WAML (ELR: BGK), which could be made off the proposed Cambourne route (red line on Figure D22 below), and the indicative route is illustrated by the dashed amber line in Figure D22 below. The WAML is twin tracked at this location, and it is likely that grade separation would be required on to the Up Line on the eastern side of the WAML to accommodate the level of service proposed. Further analysis would need to be undertaken to establish the availability of train paths to London.

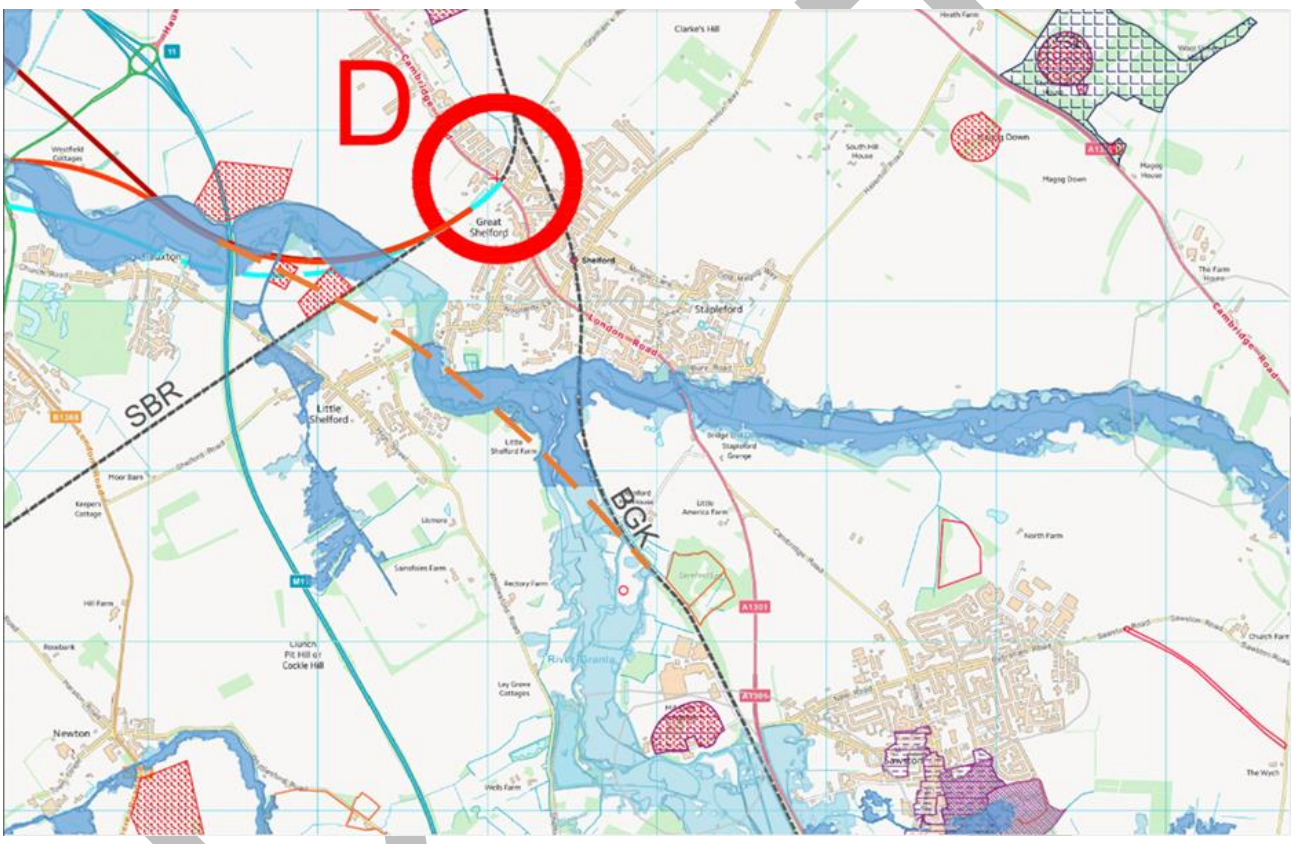


Figure D22: London Connections - South Facing WAML Connection

The following would need to be considered for this scenario:

- The capacity on the WAML to accommodate additional services to London, number of trains per hour unconfirmed by EWR Co
- Loss of passenger connectivity at Cambridge
- Whether there is sufficient demand for a Cambourne - London service
- The impact on the flood plain and heritage sites in the Shelford & Little Shelford area

- The points at which the route would cross the M11 & Hitchin - Cambridge line (ELR: SBR) are in close proximity to each other, potentially requiring a large structure that crosses both

ECML Connection at Tempsford

As shown in Figure D23, providing a south facing connection on to the ECML could be made in two potential locations to connect on to either the proposed Cambourne (red line), or Cambourne2 (yellow dashed line) routes in Figure D23 below. A small number of heritage sites exist in this area.

The two options for chords are highlighted by amber dashed lines, and each would be circa 3km in length. It is envisaged that grade separation would be required of the ECML Down Slow Line on to the EWRCS route, but this requirement would need to be analysed by Network Rail's C&CA team, or other party (and assured by Network Rail's C&CA Team).

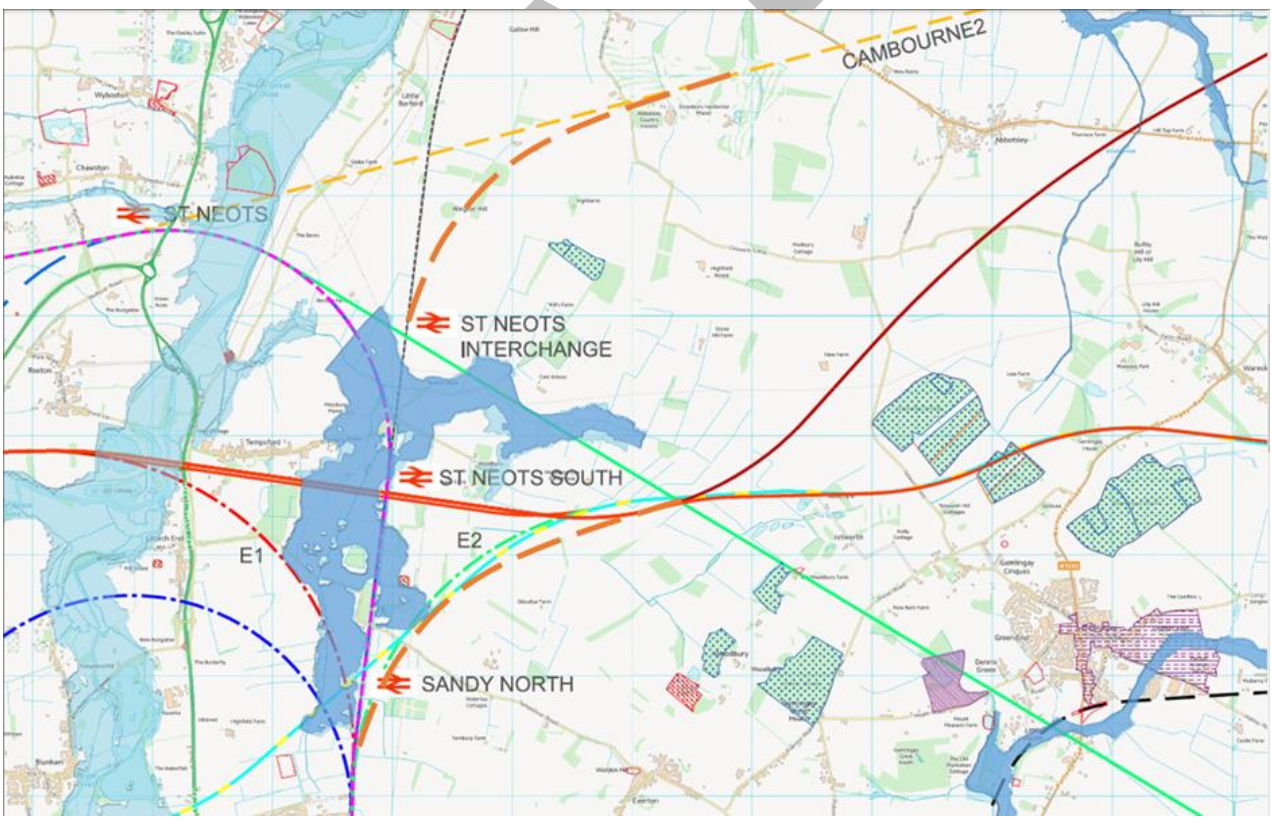


Figure D23: London Connections - South Facing ECML Connection

The following would need to be considered for this scenario:

- the assumption is a connection on to the ECML Slow Lines, but available capacity on the ECML to accommodate this needs testing
- establishing the optimum location for an interchange station between the ECML and EWRCS
- the impact on the level crossings at Everton & Tempsford, due to the introduction of additional services, needs assessing and confirming, with potential for additional mitigation being required
- journey time assessments/connectivity comparison with alternative scenarios e.g. Cambridge/WAML

Conclusion

To provide infrastructure that would accommodate a London Connection for EWR services, the northern route scenarios would require between 1km and 3km of additional new railway infrastructure, however, the upgrading of circa 6km of the twin-track WAML would also need to be considered. Providing grade separated junctions on to the ECML at Tempsford, and the WAML south of Shepreth Branch Junction, would have an OMCE of circa £200-£250m. Further analysis would be required to ascertain whether capacity is available on both WAML and ECML into the relevant London termini station. However, confirmation would be required as to whether connectivity to London forms part of the strategic objectives for EWRCS to progress this option further as it is currently not included.

D.14 Milton to Cambridge WAML Briefing Paper

During this phase, EWR Co requested a briefing paper (Appendix D9) that provided an overview of the existing Network Rail infrastructure on the WAML (ELR: BGK), between Waterbeach and Cambridge, in order to understand the potential requirement for 4-tracking, should a northern approach into Cambridge be supported. This paper was to provide additional data to support the Technical Report being produced by EWR Co for EWRCS public consultation events. Whilst a capability and capacity assessment has not been undertaken to date, it is a reasonable assumption that 4-tracking, with the potential addition of a grade separated junction at Milton, will be required, and the paper was based on this assumption.

The route options considered for the preferred corridor all enter Cambridge from the south in order to provide the opportunity to serve a proposed new station at Cambridge South and to accommodate onward services to Ipswich & Norwich. These routes all connect onto the Hitchin to Cambridge Branch (SBR) between Foxton and Shepreth Branch Junction, with additional infrastructure being required to accommodate EWR services. It should be noted

that any changes to the existing Network Rail infrastructure will have to undergo network and/or station change as required.

Considerations

Figure D24 below provides an overview of the geographic scope of this study. A northern approach would be made onto the WAML between the A14 at Milton and Waterbeach station. The impact of the River Cam, and its proximity to the WAML, should be noted. The distance from a connection north of Milton to Cambridge station is circa 5-6km in length.

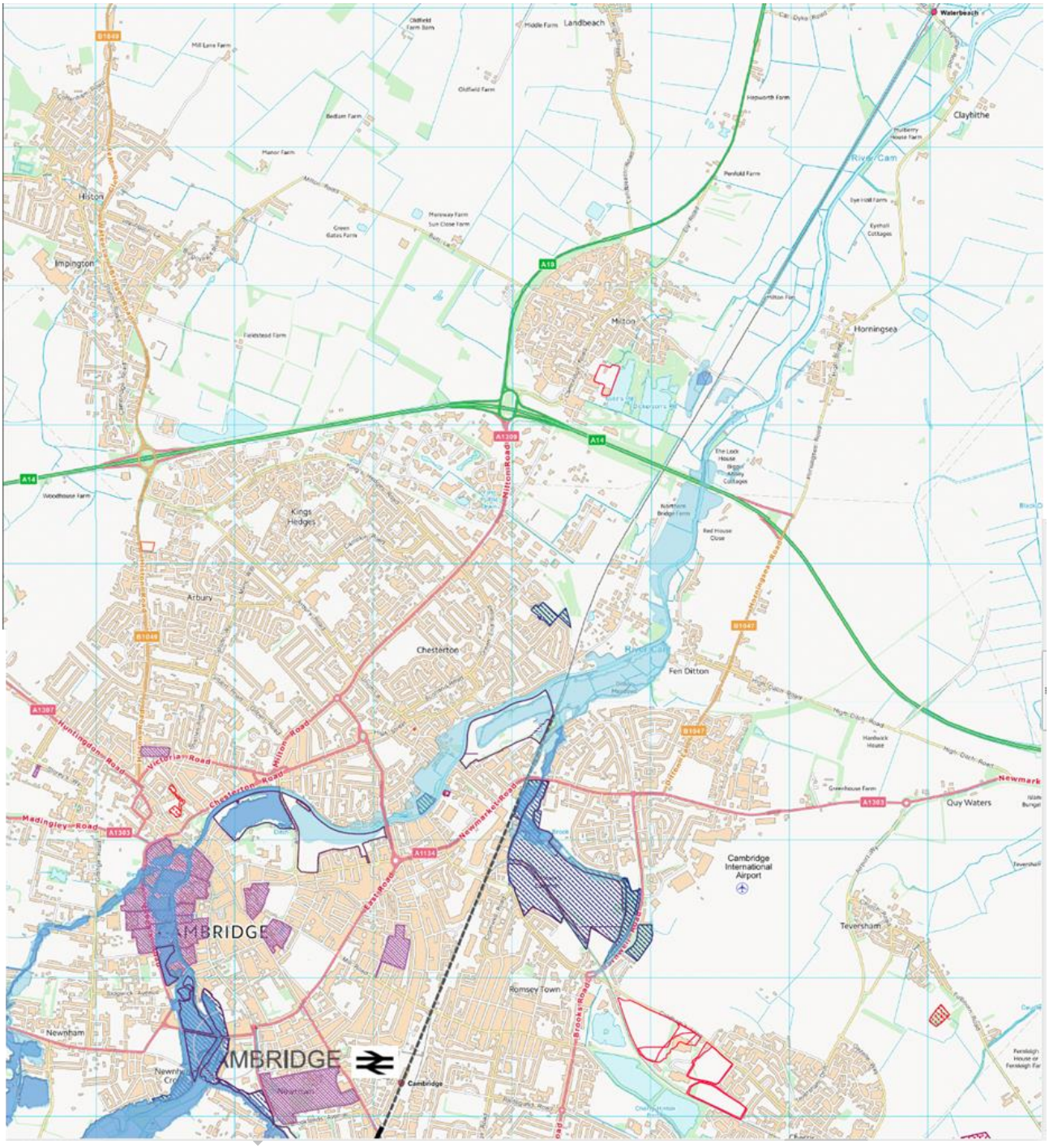


Figure D24: Milton to Cambridge Option

In the absence of a capability and capacity assessment being undertaken, and due to the quantum of EWR services proposed, it has been assumed that a grade separated junction will be required on to a new 4-track railway i.e. upgrading the existing 2-track WAML.

Further analysis of this would be required if this option is progressed. However, this infrastructure could be minimised should EWR services be segregated on a new twin-track railway, running parallel to the WAML, into Cambridge potentially removing the need for OLE. Any grade separation in this area will be constrained, from a linespeed perspective, due to the proximity of the River Cam near Milton the area available for the track curvature being constrained by the river.

Additionally, the WAML corridor already has a number of constraints along this stretch into Cambridge, with the following areas of particular significance, that will need to be assessed:

- Flood plains (Stourbridge Common & Ditton Meadows)
- A number of level crossings
- A number of highway bridge structures (A14, A1134 & Coldhams Lane)
- An Electricity Sub-station
- Cambridge North Station
- The requirement for the railway to cross over the River Cam
- The Leper Chapel of Saint Mary Magdalene
- Residential and industrial/commercial properties located next to the railway corridor

Conclusion

The challenges that will be encountered in 4-tracking this section of existing railway should not be underestimated and further analysis, to confirm that 4-tracking is required, will need to be carried out if this solution is progressed further. This option will result in disruption to the existing train services, using this section of line during the construction period, as well as wider disruption to Cambridge, and other modes of transport, with the required widening of highway bridges which are key arteries into/out/within the city.

Should a northern route option and approach into Cambridge be progressed, the existing infrastructure in this area will need further consideration in conjunction with proposals via Cambourne.

Any change to the existing railway corridor will be required to undergo Network/Station Change and, dependent upon whether the additional lines are segregated for EWR services, the new infrastructure should be electrified to provide full operational flexibility of the network, noting that the existing infrastructure is already electrified.

Note: The impact on Cambridge station itself, with regards to platform occupation and future capacity/operational requirements, has not been assessed to date by EWRCS.

D.15 Wimpole Hall Mitigation Options

A number of meetings have been held with the National Trust with regards to route options that either cross, or are in close proximity, to the Wimpole Estate. During this phase of development, EWR Co commissioned LUC Ltd to undertake some visualisation assessments, from different viewpoints on the Wimpole Estate, with data being provided by Network Rail on the infrastructure scenarios proposed, to support this assessment. Additionally, EWR Co sought to understand a number of mitigation scenarios, should a route (e.g. A1, E4 or SN4) be preferred that crosses the Wimpole Estate avenue to the south. With this in mind, the following infrastructure solution scenarios were considered for the interface with the Wimpole Estate avenue:

5. At grade – base case used in the development work for routes options.

2a. 6m cutting with a garden bridge.

2b. 3m cutting with a garden bridge.

3. Open cutting with cut & cover box.
4. Continuous wall, with cut & cover box.
5. A tunnel.

These scenarios were all assessed from the same mileage points, to provide consistency with the base case (scenario 1 - at grade). The work undertaken included initial engineering drawings, a Bill of Quantities, and provision of OMCEs for each scenario. A brief summary of each option is detailed below with the additional data being contained within Appendix D10.

Scenario 1 – At Grade

The base case is developed from a low embankment that would bisect the Wimpole Estate avenue, and a number of local highways, culverts and the River Cam. This scenario would require a number of bridges to mitigate severance, including one for the Estate's avenue.

Scenario 2a – 6m Cutting with Garden Bridge

This cutting should be sufficient to screen the non-electrified route, and rolling stock, from the viewpoints identified on the Wimpole Estate. Based upon desktop geological information, engineering assumptions have been made with regards to the appropriate cutting slopes, with a pumped holding pond required for drainage purposes. As per scenario 1, this scenario would require a number of bridges to mitigate severance of highways, including one for the Estate's avenue and addressing the culverts and River Cam.

Scenario 2b – 3m Cutting with Garden Bridge

This scenario is similar to option 2a but with a shallower cutting to reduce the earthworks impact. Whilst the cutting alone would not screen the railway from the Wimpole Hall viewpoints, this scenario has provision for a 1.5m Ha-Ha type, landscaping arrangement to reduce the visual impact from the north. As per the previous scenarios, bridges would be required to address severance of the Estate's avenue, highways, culverts and River Cam.

Scenario 3 – Open Cutting with Cut & Cover Box

In order to provide continuity of the Wimpole Estate avenue, this scenario provides a box for the railway that enables the avenue to be reinstated over it. As per previous scenarios, earthwork cuttings will be required, and a number of bridges to address severance. Additionally, a storage tank will be required for ground water which will be pumped to a storage pond for onward discharge.

Scenario 4 – Continuous Wall with Cut & Cover Box

A variant of scenario 3, the provision of a structural wall reduces the railway footprint and earthwork slope requirements. Construction of the structural walls could be formed from contiguous piles, subject to ground investigation, to confirm ground water ingress potential. As per the previous scenarios, ground water management will need to be considered and bridges will be required to address severance.

Scenario 5 – Tunnel

The final scenario is for a twin bored tunnel, subject to ground conditions being appropriate. The provision of twin bores reduces the depth of coverage required, due to the small bore of the tunnels as opposed to the larger single bore tunnel requiring more coverage,

however, the length of the tunnels will also be dictated by the interface with the River Cam and other culverts within the area. Whilst this scenario addresses the visual concerns from the Wimpole Estate, the relatively short length of the tunnel and the associated costs of construction, deems this option as representing poor value for money in comparison to other scenarios.

Conclusion

These scenarios have all been considered from a desktop perspective, without the benefit of site surveys and ground investigations. However, the reports contained within the Appendix D10 provide an adequate level of data for further discussions with National Trust, with regards to mitigating the physical and visual impact on the Wimpole Estate, should a southern route be selected as preferred.

The briefing paper provides an assessment of the costs above the base case (option 1), which is included as part of the Base Route Case for the southerly options. The OMCE for each of the options detailed above from +£39m for option 2a to +£668m for option 5.

Part E: **Route Development**

E.01 **Introduction**

This section provides an update on the development activity undertaken during this phase to assess all route options to the same level of engineering understanding and cost estimation. This section should be read in conjunction with Appendix E1.

E.02 **Source Data**

- See section D.02

E.03 **Key Dependencies**

- See section D.03

E.04 **Systems and Engineering commentary**

- See section D.04

E.05 **Route A1**

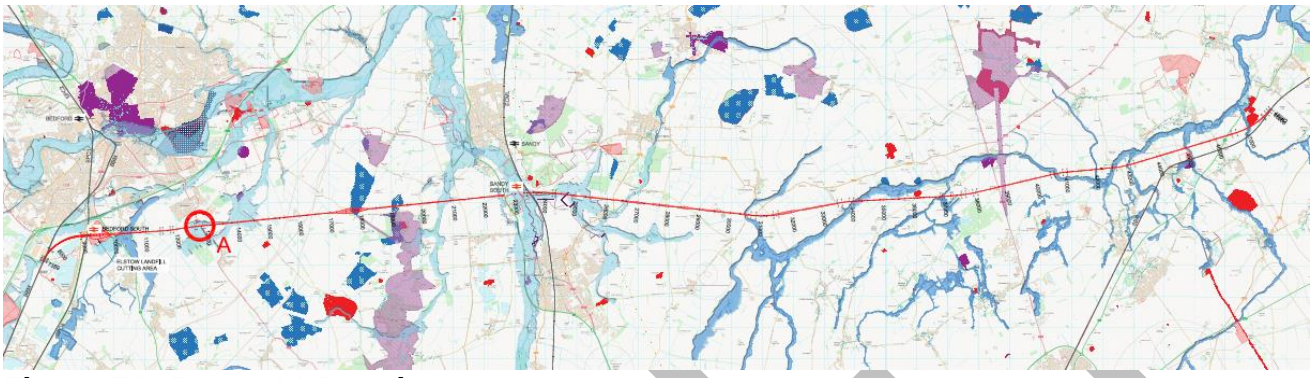


Figure E1: Route A1 Drawing

The drawing above is for the route designated as A1. The chainage originates at Lidlington, continues North to Kempston Hardwick and diverts form the BBM Marston Vale Line south of Bedford and south of Sandy, connecting to the SBR east of Foxton with the lines running via the BGK (WAML) into Cambridge.

The route has some notable challenges. The alignment is on low lying and flood susceptible land which is liable to have a high-water table. The substrata are variable and both cohesive and granular with chalk to the east and may therefore be susceptible to varying degrees of settlement dependant on the location. Embankment construction will increase pour water pressures, and these will need time to dissipate as the early consolidation processes take place. This can be accelerated with wick or band drains and other geotechnical soil improvement methods, but it may prolongate the programme if not addressed in the design at an early stage.

From the turnout at Kempston Hardwick the route heads east and at the intersection with the MML, it is proposed to site a Bedford South station, an interchange hub facility. Continuing East the route crosses a land fill site at Elstow which it is assumed will require remediation. The route then continues past two ancient woodlands. Clearance to these will need to be determined and the horizontal alignment may need adjustment to mitigate the impact.

A new station at Sandy South is located at the intersection with the ECML, south of the existing Sandy Station. From the ECML the route passes between a SSSI and the RSPB headquarters, and the Biggleswade Common to then head east through the Cam valley. The Wimpole Estate crossing is then a constraint to the route and the subject of a separate briefing note discussed in Section D.15. An alternative is to divert the route further south close to Bassingbourn where a further station could be developed.

The route then heads further east connecting on to the NR infrastructure on the SBR east of Foxton and then on to the WAML (BGK) and to Cambridge South / Cambridge station. Alternative connections on to Network Rail infrastructure in this area are considered within Part D of this report.

Order of Magnitude Cost range for this route is: £1.8bn-£2.0bn

(see Section E.15 and associated appendices)

E.06 **Route CAM2**

Figure E2: Route CAM2 Drawing

From Lidlington station, the CAM2 route goes via Bedford Midland station before continuing north on the MML (SPC2) to the EWRCS divergence northwest of Bedford. The route follows a new northerly alignment south of St Neots towards Cambourne.

From the divergence, the route is constrained by National Grid overhead lines, Great Ouse Way, the River Great Ouse, A6 Paula Radcliffe Way, residential areas of Bedford and the topography to gain elevation onto high ground around Clapham Green. Please refer to other sections of this report and appendices for the options and issues to be considered.

The route skirts the periphery of Bedford's northern residential areas before diverging on to the new CAM2 alignment heading towards a proposed St Neots South station, to the south of the existing St Neots station, at the ECML intersection and then continuing east towards Cambourne where another station facility could be established. The route continues from Cambourne, avoiding the Cambridge Mullard Radio Astronomy Observatory (MRAO) site, and travelling telescope, continuing through open fields, crossing various Flood Zones and the M11, to join the existing Shepreth Branch Line (SBR), east of Foxton, at point D, south of Cambridge.

From this point the route continues on via a connection to the SBR line leading on to BGK and Cambridge South / Cambridge station.

Order of Magnitude Cost range for this route is: £2.2bn-£2.4bn

(see Section E.15 and associated appendices)

E.07 **Route SN4**

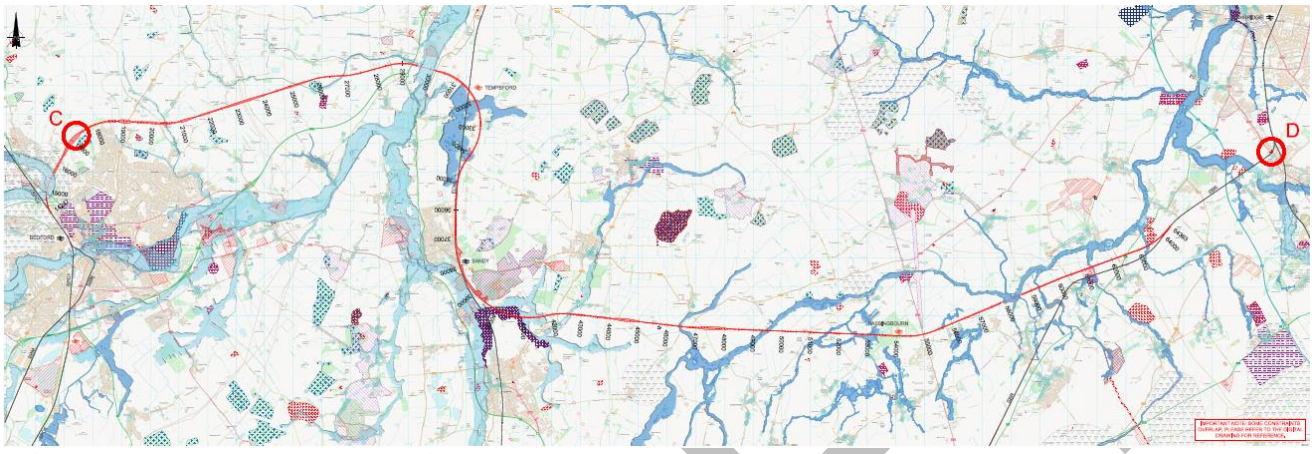


Figure E3: Route SN4 Drawing

As with CAM2 above the route originates at Lidlington Station on the Marston Vale Line (BBM) and would utilise go via Bedford Midland station before continuing on the MML (SPC2) to the EWRCS divergence towards the northwest of Bedford. It should be noted that the ground condition risks are shared with the A1 alignment but to a lesser extent.

From the MML (SPC2) divergence, north of Bedford at Point C, the route follows a new northerly alignment via Tempsford to the existing Sandy Station. It is constrained by the Great Ouse Way, the Great Ouse river, A6 Paula Radcliffe Way, residential areas of Bedford and Clapham Green and the prevailing topography complicating the need to gain elevation onto high ground around Clapham Green.

Beyond Clapham Green the route skirts the periphery of Bedford's northern residential areas before adopting the CAM2 alignment heading towards the proposed Tempsford Station continuing over the ECML turning to the southeast of Tempsford Station, and heading south towards Sandy station. The route continues south, cutting into Cox Hill around Sandy Station with 2No. new platforms and from the ECML the route passes between a SSSI and the RSPB headquarters, and then skirts around Biggleswade Common, being a CRoW[8] designated area; All Access Land.

[8] CRoW means The Countryside and Rights of Way Act 2000

The SN4 alignment then continues through open land on to Bassingbourn, where a station could be proposed, avoiding the Wimpole Estate, before joining the existing Shepreth Branch Line (SBR), south of Harston east of Foxton, at point D, south of Cambridge as Route A1. From this point the route continues on via a connection to the SBR line leading on to BGK and Cambridge South / Cambridge station.

Order of Magnitude Cost range for this route is: £2.3bn-£2.6bn

(see Section E.15 and associated appendices)

E.08 **Route E4**

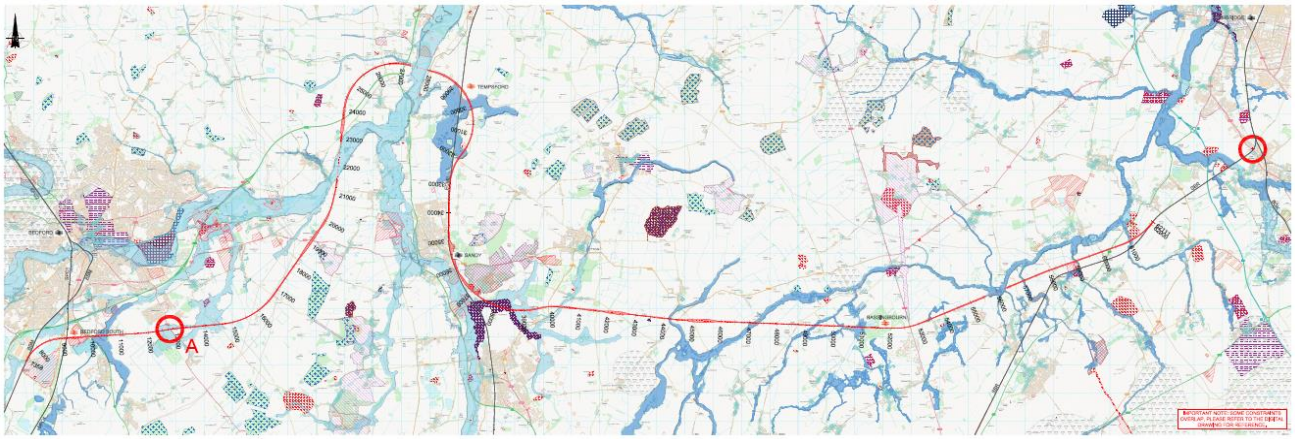


Figure E4 – Route E4 Drawing

The drawing above is for the route designated as E4. The chainage originates at Lidlington, continues north to Kempston Hardwick via the BBM Marston Vale line south of Bedford at Point A. The route follows a new Bedford south alignment looping up to Tempsford and turning south to the existing Sandy Station connecting with the ECML and then on to Bassingbourn and the SBR lines running via the BGK into Cambridge. It should be noted that the ground condition risks are shared with the A1 alignment but to a lesser extent.

The route from the MVL is constrained by the MML, residential areas of south Bedfordshire and topography to gain adequate elevation over Elstow Landfill site which has been identified for relocation. The route skirts the periphery of Bedford's south eastern residential areas before diverging on to the new E4 alignment heading north towards the southeast of St Neots, then turning south, over the ECML towards Sandy. The route continues heading over the ECML towards a proposed Tempsford Station to the southeast of St Neots, continuing towards Sandy, cutting in to Cox Hill around the existing Sandy Station and from the ECML the route passes between a SSSI and the RSPB headquarters, and then skirts

around Biggleswade Common, being a CRoW[9] designated area; All Access Land.. The route continues through open land via Bassingbourn, where a station is proposed, avoiding the Wimpole Estate, before joining the existing Shepreth Branch Line (SBR), south of Harston east of Foxton, at point D, south of Cambridge.

From this point the route continues on via a connection to the SBR line leading on to BGK and Cambridge South / Cambridge station.

Order of Magnitude Cost range for this route is: £2.4bn-£2.7bn
(see Section E.15 and associated appendices)

[9] CRoW means The Countryside and Rights of Way Act 2000

E.09 **Route E5**

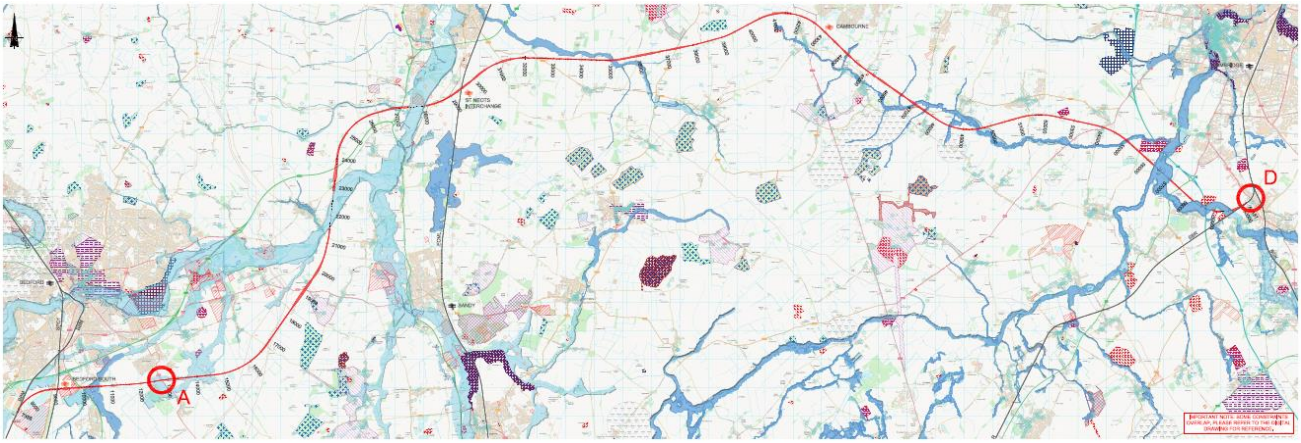


Figure E5 – Route E5 Drawing

The drawing above is for the route designated as E5. The chainage originates at Lidlington, continues north to Kempston Hardwick via the BBM Marston Vale line south of Bedford at Point A. The route follows a new Bedford south alignment looping up towards St Neots and turning east connecting with the ECML at Tempsford Interchange and then on to Cambourne and the SBR lines running via the WAML (BGK) into Cambridge.

The route is constrained by the MML, residential areas of Bedford and topography to gain elevation over Elstow Landfill. The route skirts the periphery of Bedford's south eastern residential areas before heading north and over the ECML towards the southeast to Tempsford station, continuing east, towards Cambourne. The route joins the previously proposed CAM2 route (at approximately 25.7 km), and continues, avoiding the Cambridge Mullard Radio Astronomy Observatory (MRAO) site and travelling telescope. The route continues through open fields, crossing various Flood Zones and the M11, to join the existing Shepreth Branch Line (SBR), east of Foxton and the M11, at point D, south of Cambridge

The E5 alignment then adopts the same route into Cambridge as all of the routes, connecting on to the SBR line and then on to BGK and Cambridge South / Cambridge station.

Order of Magnitude Cost range for this route is: £2.3bn-£2.5bn
(see Section E.15 and associated appendices)

E.10 **Route A3CAM**

Figure E6 – Route A3CAM Drawing

The Schematic above is for route A3CAM. The chainage originates at Lidlington, continues North to Kempston Hardwick on the BBM Marston Vale line diverting (at point A) south of Bedford and north of Sandy Station to Cambourne then heads South East to point D connecting to the NR infrastructure running via the SBR and BGK into Cambridge.

The route has some notable challenges. Two thirds of the alignment at its east and west extremities is on low lying and flood susceptible land which is liable to have a high-water table. The substrata are variable with cohesive and granular material being predominantly evident along most of the route, but also chalk to the west, and may therefore be susceptible to varying degrees of settlement dependant on the location. Embankment construction will increase pour water pressures, and these will need time to dissipate as the early consolidation processes take place. This will take place mainly during construction but can be accelerated with wick or band drains and other geotechnical soil improvement methods, but it may prolongate the programme if not addressed in the design at an early stage.

From the turnout at Kempston Hardwick the route heads east and at the intersection with the Midland Main line it is proposed to site a Bedford South station, an interchange hub facility. Continuing East the route crosses Elstow land fill site which it is assumed will require remediation. The route then continues past two ancient woodlands. Clearance to these will need to be determined and the horizontal alignment may need adjustment depending on planning directives. In addition, there is a designated land fill site on the western side of the River Ival.

To provide ECML connectivity a new station would be proposed at Tempsford north of the existing Sandy station. From the ECML the route heads east over Abbottsley Brook and on to Cambourne. On the middle section the village of Cambourne is the highest point at 65mtrs AÔD some 35mtrs above Bedford and 50mtrs above Cambridge. This area will generate suitable material from its cuttings to be used in embankments to east and west but requires a constructability assessment.

From Cambourne the alignment follows the Bourne Brook which joins the River Cam and then joins point D. Alternative connections into Cambridge from point D are covered previously within this report (see Part D).

Order of Magnitude Cost range for this route is: £2.2bn-£2.4bn
(see Section E.15 and associated appendices)

E.11 Constructability

A constructability assessment has not been undertaken during the development work to date and it is recommended that some key areas are considered:

Civils and Structures

The engineering reports (see Appendix E1) contain table of quantities that have been quantified for the cost models and route comparisons. The notable differences within these tables are around Flood Plain crossings and earthworks volumes. Within these, there are however some issues of constructability to be considered. The routes that are low lying and predominantly in the south will have the most exposure to poor ground conditions, settlement and drainage issues; whereas the northerly routes will have greater volumes of excavated material to manage. The material may not be readily available to meet programme needs or constrained by the ECML or the A1, soil classification and availability will be key to gaining the greatest efficiencies. In addition, procurement strategies need to consider the optimum mapping of the earthworks balance so that the material is available to meet programme.

A maintenance route alongside each route has been allowed for and this will aid access along the site during construction however a full construction traffic management plan is required so that access, transport routes, laydown and compound areas are identified and authorised through the consenting process for EWRCS.

E.12 Operations Risks and Opportunities

- The identification of rolling stock to be deployed and their full performance modelling is influential on the whole system performance and design
- Infrastructure may not be as represented in the NR records, upon route selection site surveys should be instigated to confirm
- Ground conditions have been considered as a desktop study only. It is recommended that a Ground Investigation survey is undertaken, and it will be required for detailed design.
- If OLE is re-introduced into the scope – this will not have a significant impact on the new structures and earthworks scope as these have been mitigated in the main by passive provision, however, existing NR infrastructure will need to be assessed.

During phase 2d, a number of key risks were identified both by the Network Rail project team during risk workshops and by external stakeholders. 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. Following the internal Network Rail high level risk review these are identified as;

- There is a risk that raw material cost fluctuations may impact upon the cost, causing the need for redesign.
- Future legislation changes or new legislation may impact on the project e.g. noise pollution.
- Stakeholders may impact on the project resulting in significant redesign and precedents being set for future projects.
- Decisions regarding Digital Railway may not be aligned to the programme.
- Additional or new scope may be introduced into the project due to project requirements/outputs changes including non-alignment of opinions between the EWR Co. and DfT).
- There may be issues securing suitable resources (including critical resources such as Testers) to develop and deliver the EWRCS project.
- Major highway works may be required which could attract objections from local communities and the highways authorities.
- Additional pedestrian and services capacity may have to be considered at existing stations.

In additional to these risks, a number of short term risks related specifically to the next phase of EWRCS development have been identified in this phase. These include;

- Integration with EWRWS and a future EWR Eastern Section. A number of meetings with the EWRWS team have taken place over the course of this phase however, with different remits and requirements driving these two projects it is recognised that there is a disconnect between a number of aspects of these projects, including ITSS, rolling stock type and infrastructure requirements on the MVL.
- The Cambridge South study development is at a very early stage. The impacts of EWRCS in relation to it are not fully understood.
- Integration with the Oxford to Cambridge Expressway. We are aware of the parallel highway proposal and have met with representatives of Highways England to discuss this proposal, opportunities to integrate the two projects and potential conflicts in terms of user abstraction.
- Cost of infrastructure, particularly the high cost of crossing flood plains. Further consultation and location specific discussions with the Environment Agency are required to identify the most appropriate solutions.
- Patronage at Bedford Midland versus Bedford South. Stakeholders in Bedford have made us aware of the desire to retain the public transport interchange hub in the centre of Bedford. Understanding this issue and how journeys on the MML may be affected by an additional stop at Bedford South will be critical to determining the optimum route through Bedford.
- Construction staging and the extent of temporary works should be identified as part of the CDM requirements. It is recommended that this is developed at a concept level before these options are rationalised, recommended or paused.
- Environmental Impacts, there are a number of potential environmental constraints in all of the route options including SSSI's, SAM and Ancient Woodland and these are identified within the engineering reports. Of particular note, is the acceptability of impacts on the Wimpole Estate. The southerly routes include a potential alignment across the tree lined Wimpole Avenue (south of Wimpole Hall) Specific consultation with the National Trust has been facilitated and options developed for evaluation see section D.15.
- Capacity requirements on existing rail corridors, particularly between Shepreth Branch Junction and Cambridge. A separate study is currently underway to determine an appropriate long term solution for the rail industry and local stakeholder for the section of WAML between Shepreth Branch Junction and Cambridge (and

Ely). The outcome of this study could have a significant (positive or negative) impact on the proposals for EWRCS.

- Highways impacts. This risk is twofold; the physical clashes between the new railway and existing highways and the impact of traffic generated around stations and 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 outturn cost of EWRCS. Consideration of the impact of construction traffic must also be taken into account
- Utilities. We are aware through visiting site and local knowledge that there are a number of strategic utility corridors throughout the study area including oil pipelines and overhead power lines. The cost and time required to negotiate these could have a significant impact on this project which will need investigating in the next phases of this study upon the selection of a prefered route.
- This study is for the assessment of 6 routes only, for the Lidlington to Cambridge section whereas services will continue beyond these limits, understanding the interaction with the wider rail network needs to be understood further..

E.13 Hazard Identification

In accordance with the requirements of the Regulations on the Common Safety Method on Risk Evaluation and Assessment (CSM-RA), railway enhancement projects such as EWRCS are required to undertake a risk assessment and management process to identify hazards and mitigate so far as reasonably practicable (SFAIRP), system wide safety risks associated with the proposed railway system change.

Hazards can be broad or very specific in nature and relate to interfaces new or existing, subsystems and stakeholders which may be affected by the change.

The hazard identification process undertaken for EWRCS in this early stage of development was designed to identify and manage foreseeable hazards relating to Option Selection, Construction Workforce, Maintenance and Operations Workforce, Passenger and wider Public, and considered both Engineering and Environmental Hazards which may arise out of the changes being implemented across all stages of EWRCS development.

Initial hazard identification was undertaken with representation from relevant stakeholders from the Regional Working Group on 24th July 2017 – representatives of Network Rail, Department for Transport, Local Authorities and Train Operating Companies.

The output from this hazard identification exercise can be found in Appendix J2 and forms part of a wider initial Project Hazard Record (PHR). The PHR is a live document that

should be revised and expanded at regular stages throughout the project lifecycle, and will contain the details of hazards affecting design, construction, maintenance, operation and decommissioning and will establish that the requirements imposed by UK and European legislation are met by EWRCS.

E.14 Cost Plan Analysis Core Routes

This Order of Magnitude Cost Planning guidance is based upon limited scope information and has not been assured by the NR Cost Planning Governance Process; however, the Independent Assurance Review has identified the need for a Peer Review to test rates at National Level and this requirement has been met. The report is intended to provide an indicative range of costs to filter route options only. None of the costs stated in this report or its appendices are to be regarded as Anticipated Final Costs.

The reader should also note that Inflation has been calculated to a single base date for all options (i.e. backdated to 2015).

No programme construction/completion dates and/or programme durations were provided for any option, hence, there is no consideration of the effect of future escalation or cost sensitivity attributable to differing programme lengths and start/completion dates.

The end to end cost of a route from the Bedford area to Cambridge have been built up from a number of sectional components. This section will outline the component and set out how they make an “end to end” overall cost allowance. There are areas where alternatives have been produced, either to mitigate against the risk that an underlying assumption may be incorrect or to investigate if alternatives have the potential to offer better value and should be investigated further. These alternatives are set out in Appendix E2

Table E1: Route Comparison Table

EWRC Route	NR Eng Ref	Low (p50) £,000M	Midpoint (p80) £,000m	High (P90) £,000m	Midpoint Delta against A1
A	A1 (exc bass)	1822	1918	2014	0
E	Cam 2	2075	2184	2293	266
D	SN4	2240	2358	2476	440
C	E4	2439	2567	2695	649
BAlt	E5	2252	2370	2489	452
B	A3CAM	2374	2499	2624	581

Key Cost Plan Clarifications, Assumptions and Exclusions

Key items are listed here, a full list is contained within the Cost plan report in Appendix E2

Clarifications

- Estimates have been compiled using 3Q17 rates and de-escalated to 4Q15 consistent with preceding Estimates.
- All rates are taken from preceding EWRCS estimate phases unless the scope is such that it was deemed necessary to adjust the rate.
- SEUs counts have been used in place of the Signalling linear km rate (used in previous estimate phases) where appropriate.
- To avoid duplication no inclusion has been made for Cost of Work Done.
- Stations and or Interventions which were priced in preceding Estimate Phases (e.g 2.E) have either been included as items in the BoQ (where the Station was included as separate BoQ items in the preceding Estimate eg Platform, Building, Footbridge etc) as a single Capital item or, if the Station was the subject of a separate Estimate BoQ entirely dedicated to that Station or Intervention, then the Summary of Costs has been included in the current Estimate Summary Front Page.

Assumptions

- Where SEU counts have been used to calculate Signalling costs the cost is deemed to include such work as is required in readiness to receive Digital Signalling modifications.
- Allowances have been made for OLE run offs and for instances in which significantly more OLE works may be required than allowed for in the passive provision scope.
- A unitary cost has been allowed for individual new Station buildings in accordance with preceding estimates.
- Land acquisition cost is £30k per acre (direct cost) as per previous estimate phases and is deemed enough to meet the cost on aggregate.
- Rights of Way, Wayleaves and associated fees have been derived by uplifting Acquisition of Land fees by 20% to reflect the practice in preceding estimate phases.
- An allowance of £100k per item (direct costs) has been made for the acquisition of private gardens of residential properties and is enough to meet costs on aggregate.
- A benefit for re use of earthworks arisings has been allowed where appropriate and can be materialised during construction.
- A benefit for reduction of m2 of viaducts (in relation to previous phases estimates) has been applied in line with the flood plain strategy and can be materialised during construction.
- An uplift of 3.5% has been applied to the total of the value of the works in BoQ RMM section 1.07 (Civils) to account for civils ancillaries such as fencing, troughing and general drainage which have been itemised separately in preceding estimates.
- Where a new (or reconstructed) Road over Rail Bridge is required an allowance of £400k is included to account for Service diversions in accordance with preceding estimate phases.

Exclusions

- The SEU rate does not include for any physical items such as balises or additional GSMR towers.
- No allowance for any other works affecting existing utilities.
- No inclusions for items identified as ‘Passive Provisions’.
- No inclusion for disposal of contaminated arisings.
- Taxation or Grants.

- Site of Interest for Nature Conservation (SINC).
- Third party costs i.e. local authority.
- Way Leave Issues.
- Asbestos Removal.
- Mineworking remediations.
- Works associated with Sites of Archaeological Interest.

E.15 Route Cost Plan by Discipline

Table E2: Summary of Group Element Cost (direct discipline cost with uplifts)

Summary of Group Element Costs		A	E	D	C	B	B Alt
Total	£ -	A1-2F 'A'	BoQ CAM-2 'E'	BoQ SN-4 'D'	BoQ E-4 'C'	BoQ A3CAM 'B' Flood Zone Adjusted	BoQ E-5 'B-Alt'
RMM Volume 1 Ref	Group Element	5' Routes Study					
1	**Direct Construction Works**						
1	Railway Control Systems	21,385,774	24,898,414	25,931,543	28,256,084	29,444,182	27,274,611
1	Train Power Systems	0	0	0	0	0	0
1	Electric Power and Plant	9,176,013	10,683,184	11,126,470	12,123,863	12,389,834	11,702,741
1	Permanent Way	82,235,199	98,333,843	102,203,297	110,909,569	116,413,580	107,233,588
1	Telecommunication Systems	11,887,811	13,513,974	14,074,720	15,336,398	15,953,219	14,803,690
1	Buildings and Property	40,280,000	85,139,606	96,142,306	95,989,094	52,910,000	84,986,394
1	Civil Engineering	371,981,454	458,721,021	419,987,447	492,466,550	486,956,884	513,528,278
1	Enabling Works	19,714,540	17,250,000	29,320,000	20,730,000	122,797,170	18,100,000
	TOTAL DIRECT CONSTRUCTION COSTS (A)	**556,660,792**	**708,540,042**	**698,785,783**	**775,811,558**	**836,864,869**	**777,629,301**
2	**Preliminaries, Overheads and Profit**						
2	Preliminaries	195,638,859	238,882,137	239,206,509	264,986,095	289,985,825	261,931,119
2	Contractor Overheads and Profit	91,330,198	115,821,642	115,978,914	128,478,107	135,833,894	126,996,906
	TOTAL INDIRECT CONSTRUCTION COSTS (B)	**286,969,057**	**354,703,779**	**355,185,423**	**393,464,201**	**425,819,719**	**388,928,025**
	TOTAL CONSTRUCTION COSTS (A + B)	**843,629,849**	**1,063,243,821**	**1,053,971,206**	**1,169,275,759**	**1,262,684,588**	**1,166,557,326**
3	**Project / Design Team Fees and Other Project Development Costs**						
3	Project / Design Team Fees	139,165,198	180,971,316	181,217,053	200,747,042	210,129,919	198,432,666
3	Project Management Team Fees	76,776,570	108,582,789	108,730,232	120,448,225	118,105,534	119,059,599
3	Other Project Costs	40,892,549	69,636,615	80,447,543	87,400,720	90,845,767	75,631,162
	TOTAL EMPLOYER INDIRECT COSTS (C)	**256,834,317**	**359,190,720**	**370,394,827**	**408,595,987**	**419,081,220**	**393,123,427**
	POINT ESTIMATE (A + B + C)	**1,100,464,167**	**1,422,434,542**	**1,424,366,033**	**1,577,871,746**	**1,681,765,808**	**1,559,680,753**
4	**Risk**						
4	Risk (P80)	440,185,667	568,973,817	569,746,413	631,148,698	645,089,693	623,872,301
	TOTAL POINT ESTIMATE + RISK (D)	**1,540,649,834**	**1,991,408,358**	**1,994,112,446**	**2,209,020,445**	**2,326,855,501**	**2,183,553,055**
5	**Inflation**						
5	Inflation (RPI Indices)	-46,324,098	-59,877,458	-59,958,764	-66,420,595	-80,052,891	-65,654,845
	TOTAL INFLATION ALLOWANCE (E)	**-46,324,098**	**-59,877,458**	**-59,958,764**	**-66,420,595**	**-80,052,891**	**-65,654,845**
6	**Taxation and Grants**						
6	Tax allowances and grants						
	TOTAL CAPITAL COST ESTIMATE FOR ROUTE COMPARISON	**1,494,400,000**	**1,931,600,000**	**1,934,200,000**	**2,142,600,000**	**2,246,900,000**	**2,117,900,000**

Table E3: Hitchin Branch Alternative Connections

Summary of Group Element Costs			
Total	£ -	G14 Option 1A	G14 Option 2
RMM Volume 1 Ref	Group Element		
1	**Direct Construction Works**		
1	Railway Control Systems	5,000,000	15,400,000
1	Train Power Systems	0	0
1	Electric Power and Plant	-811,213	5,932,850
1	Permanent Way	-7,081,101	24,322,834
1	Telecommunication Systems	-1,026,165	4,514,004
1	Buildings and Property	-3,000,000	37,178,000
1	Civil Engineering	-5,693,783	48,007,440
1	Enabling Works	-400,000	6,800,000
	TOTAL DIRECT CONSTRUCTION COSTS (A)	**-13,012,262**	**142,155,127**
2	**Preliminaries, Overheads and Profit**		
2	Preliminaries	-4,294,046	50,440,392
2	Contractor Overheads and Profit	-2,076,757	22,744,820
	TOTAL INDIRECT CONSTRUCTION COSTS (B)	**-6,370,803**	**73,185,212**
	TOTAL CONSTRUCTION COSTS (A + B)	**-19,383,065**	**215,340,339**
3	**Project / Design Team Fees and Other Project Development Costs**		
3	Project / Design Team Fees	-3,253,065	35,538,782
3	Project Management Team Fees	-1,951,839	21,323,269
3	Other Project Costs	-1,331,600	12,084,355
	TOTAL EMPLOYER INDIRECT COSTS (C)	**-6,536,504**	**68,946,405**
	POINT ESTIMATE (A + B + C)	**-25,919,570**	**284,286,745**
4	**Risk**	**0**	
4	Risk (P80)	-10,367,828	113,714,698
	TOTAL POINT ESTIMATE + RISK (D)	**-36,287,398**	**398,001,443**
5	**Inflation**	**0**	
5	Inflation (RPI Indices)	1,091,086	-11,967,066
	TOTAL INFLATION ALLOWANCE (E)	**1,091,086**	**-11,967,066**
6	**Taxation and Grants**	**0**	
6	Tax allowances and grants	0	
	TOTAL CAPITAL COST ESTIMATE FOR ROUTE COMPARISON	**-35,200,000**	**386,100,000**

Table E4: Bedford Area Alternative Connections

Summary of Group Element Costs							
Total	£ -	G16 Option 1	G16 Option 2A	G16 Option 2B	G16 Option 2C 0.2	G16 Option 2D	G16 Option 3
RMM Volume 1 Ref	Group Element						
1	Direct Construction Works						
1	Railway Control Systems	-1,600,000	2,400,000	400,000	4,200,000	600,000	4,200,000
1	Train Power Systems	0	0	0	0	0	0
1	Electric Power and Plant	237,158	1,776,311	2,671,272	2,208,514	3,331,767	1,321,943
1	Permanent Way	-929,842	10,613,417	13,728,648	15,897,780	19,505,780	9,247,227
1	Telecommunication Systems	299,999	1,247,659	1,337,379	1,794,387	2,172,890	672,895
1	Buildings and Property	59,036,000	10,000,000	165,000,000	52,000,000	206,000,000	130,000,000
1	Civil Engineering	3,597,660	33,246,161	-76,961,240	93,978,668	-48,744,995	27,318,019
1	Enabling Works	600,000	8,100,000	-880,000	0	3,740,000	3,200,000
	TOTAL DIRECT CONSTRUCTION COSTS (A)	**61,240,975**	**67,383,548**	**105,296,059**	**170,079,349**	**186,605,442**	**175,960,083**
2	Preliminaries, Overheads and Profit						
2	Preliminaries	20,209,522	22,256,371	34,747,699	56,126,185	61,579,796	57,884,897
2	Contractor Overheads and Profit	9,798,556	10,790,968	16,847,369	27,212,696	29,856,871	28,065,405
	TOTAL INDIRECT CONSTRUCTION COSTS (B)	**30,008,078**	**33,047,339**	**51,595,069**	**83,338,881**	**91,436,667**	**85,950,302**
	TOTAL CONSTRUCTION COSTS (A + B)	**91,249,052**	**100,430,887**	**156,891,127**	**253,418,230**	**278,042,108**	**261,910,385**
3	Project / Design Team Fees and Other Project Development Costs						
3	Project / Design Team Fees	15,310,244	16,860,887	26,324,015	42,519,837	46,651,360	43,852,195
3	Project Management Team Fees	9,186,146	10,116,532	15,794,409	25,511,902	27,990,816	26,311,317
3	Other Project Costs	4,769,473	10,482,386	15,188,644	18,802,511	17,463,288	14,418,322
	TOTAL EMPLOYER INDIRECT COSTS (C)	**29,265,863**	**37,459,805**	**57,307,068**	**86,834,251**	**92,105,465**	**84,581,834**
	POINT ESTIMATE (A + B + C)	**120,514,915**	**137,890,692**	**214,198,195**	**340,252,481**	**370,147,573**	**346,492,219**
4	Risk						
4	Risk (P80)	48,205,966	55,180,277	85,679,278	136,100,992	148,059,029	138,596,888
	TOTAL POINT ESTIMATE + RISK (D)	**168,720,882**	**193,070,969**	**299,877,473**	**476,353,473**	**518,206,603**	**485,089,106**
5	Inflation						
5	Inflation (RPI Indices)	-5,073,082	-5,805,238	-9,016,684	-14,322,946	-15,581,382	-14,585,608
	TOTAL INFLATION ALLOWANCE (E)	**-5,073,082**	**-5,805,238**	**-9,016,684**	**-14,322,946**	**-15,581,382**	**-14,585,608**
6	Taxation and Grants						
6	Tax allowances and grants	0					
	TOTAL CAPITAL COST ESTIMATE FOR ROUTE COMPARISON	**163,700,000**	**187,300,000**	**290,900,000**	**462,100,000**	**502,700,000**	**470,600,000**

Table E5: Shepreth Jnc. WAML alternative connections

Summary of Group Element Costs							
Total	£ -	G17 Op 1A	G17 Op 1B	G17 Op 2	G17 Op 3	G17 Op 4A	G17 Op 4B
RMM Volume 1 Ref	Group Element		Incl G17 1A				
1	Direct Construction Works						
1	Railway Control Systems	0	10,800,000	8,600,000	11,000,000	8,000,000	10,400,000
1	Train Power Systems	0	10,000,000	0	10,000,000	1,000,000	1,000,000
1	Electric Power and Plant	580,704	11,669,689	3,827,243	4,150,933	18,485,661	18,485,681
1	Permanent Way	4,608,985	14,608,985	12,309,198	19,422,935	-96,344,003	-89,411,707
1	Telecommunication Systems	734,577	6,602,782	1,850,461	2,102,797	5,671,944	6,843,903
1	Buildings and Property	-1,000,000	157,000,000	11,000,000	49,000,000	8,000,000	66,000,000
1	Civil Engineering	9,195,188	124,014,420	33,403,590	45,706,159	173,919,630	184,013,733
1	Enabling Works	1,070,000	10,350,000	3,200,000	4,700,000	14,400,000	12,400,000
	TOTAL DIRECT CONSTRUCTION COSTS (A)	15,189,454	345,045,876	74,190,492	146,082,824	133,133,233	209,731,609
2	Preliminaries, Overheads and Profit						
2	Preliminaries	7,653,444	121,201,039	28,012,062	53,012,492	51,758,927	77,569,911
2	Contractor Overheads and Profit	2,430,313	55,207,340	11,870,479	23,373,252	21,301,317	33,557,057
	TOTAL INDIRECT CONSTRUCTION COSTS (B)	10,083,757	176,408,379	39,882,541	76,385,744	73,060,244	111,126,968
	TOTAL CONSTRUCTION COSTS (A + B)	25,273,211	521,454,255	114,073,034	222,468,568	206,193,477	320,858,577
3	Project / Design Team Fees and Other Project Development Costs						
3	Project / Design Team Fees	3,797,364	86,261,469	18,547,623	36,520,706	33,283,308	52,432,902
3	Project Management Team Fees	2,278,418	51,756,881	11,128,574	21,912,424	19,969,985	31,459,741
3	Other Project Costs	1,139,209	25,878,441	5,564,287	10,956,212	9,984,992	15,729,871
	TOTAL EMPLOYER INDIRECT COSTS (C)	7,214,991	163,896,791	35,240,484	69,389,341	63,238,285	99,622,514
	POINT ESTIMATE (A + B + C)	32,488,202	685,351,046	149,313,517	291,857,909	269,431,762	420,481,092
4	Risk						
4	Risk (P80)	12,995,281	274,140,418	59,725,407	116,743,164	107,772,705	168,192,437
	TOTAL POINT ESTIMATE + RISK (D)	45,483,483	959,491,465	209,038,924	408,601,073	377,204,467	588,673,528
5	Inflation						
5	Inflation (RPI Indices)	-1,367,593	-28,849,889	-6,285,360	-12,285,774	-11,341,744	-17,700,174
	TOTAL INFLATION ALLOWANCE (E)	-1,367,593	-28,849,889	-6,285,360	-12,285,774	-11,341,744	-17,700,174
6	Taxation and Grants						
6	Tax allowances and grants						
	TOTAL CAPITAL COST ESTIMATE FOR ROUTE COMPARISON	44,200,000	930,700,000	202,800,000	396,400,000	365,900,000	571,000,000

Table E6: Geotech Sensitivity Study

Summary of Group Element Costs				
Total	£ -	A(D)1	C(D)3	C(D)3+ Cam
RMM Volume 1 Ref	Group Element	(Geotech Sensitivity Study)		
1	**Direct Construction Works**			
1	Railway Control Systems	24,020,254	28,307,740	30,167,373
1	Train Power Systems	0	0	-
1	Electric Power and Plant	10,062,584	11,126,470	11,924,384
1	Permanent Way	96,602,812	108,927,541	115,892,559
1	Telecommunication Systems	13,009,303	14,355,093	15,364,435
1	Buildings and Property	55,890,000	37,790,000	46,760,000
1	Civil Engineering	395,689,441	676,109,718	654,018,704
1	Enabling Works	112,780,640	30,573,190	28,579,990
	TOTAL DIRECT CONSTRUCTION COSTS (A)	**708,055,035**	**907,189,753**	**902,707,445**
2	**Preliminaries, Overheads and Profit**			
2	Preliminaries	245,047,183	320,607,171	318,643,380
2	Contractor Overheads and Profit	114,175,989	145,604,077	145,888,152
	TOTAL INDIRECT CONSTRUCTION COSTS (B)	**359,223,172**	**466,211,248**	**464,531,532**
	TOTAL CONSTRUCTION COSTS (A + B)	**1,067,278,207**	**1,373,401,000**	**1,367,238,977**
3	**Project / Design Team Fees and Other Project Development Costs**			
3	Project / Design Team Fees	177,927,461	227,711,140	226,590,563
3	Project Management Team Fees	99,706,466	128,966,184	128,394,776
3	Other Project Costs	64,113,138	98,336,241	98,000,068
	TOTAL EMPLOYER INDIRECT COSTS (C)	**341,747,064**	**455,013,566**	**452,985,408**
	POINT ESTIMATE (A + B + C)	**1,409,025,271**	**1,828,414,566**	**1,820,224,385**
4	**Risk**			
4	Risk (P80)	562,271,390	730,027,108	726,751,036
	TOTAL POINT ESTIMATE + RISK (D)	**1,971,296,661**	**2,558,441,674**	**2,546,975,421**
5	**Inflation**		**0**	
5	Inflation (RPI Indices)	-59,272,742	-76,926,956	-76,582,190
	TOTAL INFLATION ALLOWANCE (E)	**-59,272,742**	**-76,926,956**	**-76,582,190**
6	**Taxation and Grants**		**0**	
6	Tax allowances and grants		0	
	TOTAL CAPITAL COST ESTIMATE FOR ROUTE COMPARISON	**1,912,024,000**	**2,481,515,000**	**2,470,394,000**

Part F: **Highways Traffic Modelling**

This section provides details on traffic modelling studies undertaken during this phase to assess the impact of the proposed EWRCS scheme on the local highway networks surrounding Bedford and Sandy, as a result of the introduction of potential new stations to serve these nodes. Further analysis will be required in later phases of development, which would also need to include the Cambridge node and a potential new station between Sandy and Cambridge, whether Cambourne or Bassingbourn.

F.01 **Highways Traffic Modelling**

The scope of this analysis was to undertake modelling assessment to estimate and quantify the impact of the proposed EWRCS scheme on the local highway networks in the Bedford Borough Council and Central Bedfordshire Council geographical boundaries, covering the existing/proposed stations at Bedford Midland Station, Bedford South Parkway, St Neots South Station, North Sandy Station, Sandy Station and South Sandy Station.

For potential EWR services introduced to the Bedford area, the two possible options considered were:

- EWR services coming through the existing Bedford Midland station; and
- EWR services using a purpose built, new station referred to as Bedford South

For potential EWR services introduced to the Sandy area, the two possible options considered were:

- EWR services coming through the existing Sandy station; and
- EWR services using a purpose built, new station referred to as any of St Neots South Station, North Sandy Station or South Sandy Station.

The studies modelled, and tested, two forecast scenarios reflecting different potential locations for access and egress from the relevant stations to a new EWR service in the Bedford and Sandy areas. These used a valid Reference Case, consistent with recent Local Plan assumptions, and including all committed developments and schemes.

Please refer to Appendix F1 Highway Assessment for the Bedford Area report and Appendix F2 Highway Assessment for the Sandy Area report for further details including

any changes to the highways network which are significant enough to warrant intervention through mitigation as a result of the additional traffic which would be introduced as a result of additional road journeys to travel on EWR services.

F.02 Highways Traffic Modelling Summary

In this phase, some initial highways modelling has been undertaken, using framework contracts used by Bedford Brough Council and Central Bedfordshire Council for their own highways modelling. This work was intended to inform whether the changes in journeys to existing and new stations within these areas would have an impact on the existing highways network. Cambridge was omitted at this stage as all route options access Cambridge from the south and therefore was not a differentiating factor at this stage.

Whilst more detailed analysis will be required in future phases, particularly when a preferred route option is confirmed, the initial indications are that the existing highways network could accommodate the changes to existing road journeys, as well as new journeys by road, as a result of the introduction of EWR services onto a new strategic rail link between Bedford and Cambridge.

Part G: **Conclusion**

Progress has been made in Phase 2f in understanding the scope, cost and value of a shortlist of route options. They key findings from this development work are as follows:

Impact Assessment

Following the changes to the strategic objectives and conditional outputs for EWRCS, Network Rail was asked to undertake an impact assessment of these changes on the previous development work undertaken and the decisions made regarding which options to pause from further development.

The assessment indicates that there is no identified material impact on previous choices, but that the introduction of aligning EWRCS with housing development as a key criteria for route options has the potential to challenge previous choices, potentially back to corridor choice. At present, however, besides the housing proposals contained within Local Development Plans, there are only emerging views as to where additional housing may be proposed based on work being progressed by Homes England in support of the NIC report. Therefore, as clarity on additional housing developments is made available, this should be reviewed further as it will be a key element of the consents process that could be challenged by objectors if there isn't confidence of a robust basis for choices that are made throughout the development process which are justified on the basis of supporting proposed housing developments.

Geotechnical Sensitivity Assessment

This analysis was undertaken to test the assumptions made in previous phases with regards to cutting and embankment slope angles. The general findings were that the 1:4 slope for cuttings and 1:2 slope for embankments was reasonable for the area's geology. The study found that some of the excavated material from the cuttings could be re-used in the embankments. An allowance has been made for the removal of the top metre within the site strip volumes as this is unlikely to be reusable in the embankments. Therefore, allowances have been made to the estimates to reflect these findings. Route options that pass-through low-lying ground benefit less from this approach than route options passing through higher ground. A more detailed analysis will be required, however, with ground investigations undertaken and results obtained in future phases of development.

Alternative Solutions

A number of alternative solutions, to those previously considered, were considered in this phase to establish whether the current preferred options represent the most viable solutions.

- **Bedford Area**

Three alternative solutions have been identified for further consideration in future stages because they provide opportunities to mitigate potential infrastructure costs and operational constraints on the BBM in the Bedford St Johns/depots area (Train Care depot and Jowett Sidings). However, these solutions would involve significant works to the MML.

- **Sandy Area**

The alternative options considered do not represent a better alternative to the current preferred solution as capacity on the ECML Slow Line cannot be identified for EWR services. It is not proposed that these solutions are progressed further unless use of the ECML Slow Lines changes in the future.

- **Cambridge South**

A southern connection onto the WAML could be a viable alternative solution because it could provide a different approach in to Cambridge avoiding the grade separation of Shepreth Branch junction that has been included to date. However, this option requires further detailed assessment to fully ascertain the impact on the WAML particularly in Great Shelford due to the location of the station and level crossings.

- **South of Bassingbourn**

It is possible to accommodate a diversion of the southerly route options to mitigate impact on Wimpole Estate and MOD site. Further discussion of these alternative options should be discussed with relevant stakeholders.

- **London Connections**

Options to accommodate EWR services going to London from Cambourne could be developed. Currently the costs for this are not included within the costs for EWRCS, not have been taken into account in the business case.

- **Milton to Cambridge**

There are significant challenges associated with 4 tracking the WAML north of Cambridge, and there would be a significant impact on existing services, and other modes of transport in/out of Cambridge, during the construction period.

- **Wimpole Estate**

A number of options to mitigate the impact of a southerly route option on the Wimpole Hall Avenue have been considered, with varying costs. Should an alignment be chosen that would impact on the Wimpole Hall Avenue, then these options should be discussed further with National Trust.

Development of Route Options

Further development work was undertaken in this phase on all route options for EWRCS to bring all route options to the same level of development and cost estimation.

Highways Traffic Modelling

In this phase, some initial highways modelling has been undertaken, using framework contracts used by Bedford Brough Council and Central Bedfordshire Council for their own highways modelling. This work was intended to inform whether the changes in journeys to existing and new stations within these areas would have an impact on the existing highways network. Cambridge was omitted at this stage as all route options access Cambridge from the south and therefore was not a differentiating factor at this stage.

Whilst more detailed analysis will be required in future phases, particularly when a preferred route option is confirmed, the initial indications are that the existing highways network could accommodate the changes to existing road journeys, as well as new journeys by road, as a result of the introduction of EWR services onto a new strategic rail link between Bedford and Cambridge.

In summary, therefore, development work has continued in this phase on route options, providing updated information to EWR Co on key issues, risks and opportunities that have been identified in relation to the remaining route options. EWR Co will use this output to inform the development of the SOBC and the identification of a single preferred route, which it is anticipated, they will announce later this year.

Part H: **Stakeholder Management**

H.01 **Stakeholder Management**

During Phase 2f, the Network Rail development team has supported EWR Co with stakeholder management as required. Normally, during a development phase, draft output is shared with the Rail Industry Working Group[10] giving them the opportunity to review and comment on the draft output before it is finalised. However, this has not yet happened for this phase of development work as EWR Co are currently reviewing the format/terms of reference of the Rail Industry Steering Group.

At this stage of development, 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. Non-statutory consultation was undertaken between Jan-Mar 2019 and representatives from the Network Rail EWRCS project team supported these events which were led by EWR Co and their consultants.

Network Rail has produced a Stakeholder Management Plan in accordance with its GRIP process. A copy of this is included in Appendix H1. This plan reflects Network Rail's internal policies and approach to consultation. As EWR Co will now promote the consents required to authorise EWRCS, this plan is provided as an advisory tool that EWR Co can use, if required, to support future stakeholder management, consultation and communications. The interfaces with Network Rail, when EWR Co bring on board their new technical partner, will be in relation to their role as the System Operator and the Infrastructure Manager for the existing rail network and appropriate arrangements, including commercial, will be required to continue the required level of engagement with Network Rail.

[10] 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 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 and these have been updated by EWR Co following the amendments to the strategic objectives and conditional outputs. The current route option evaluation criteria for EWRCS are shown in Table H1 below:

Table H1: 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 servives (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

Evaluation of the route options has not formed part of the analysis undertaken by Network Rail in this phase, but the criteria has been recognised.

H.02 Public Consultation

Members of the Network Rail EWRCS project team have supported EWR Co at a series of non-statutory public consultation events from January-March 2019. These included two. 'drop in' sessions for MPs, Councillors and officers at Bedford and Cambridge, plus eight. public consultation events at St Neots, Bedford, Bassingbourn, Potton, Cambridge, Orwell, Sandy and Cambourne.

Additionally, the Network Rail EWRCS project team produced a briefing paper on the cost drivers of the northern route options that serve Bedford Midland Station, requested by Bedford Borough Council (BBC) to enable them to respond within the consultation period. Network Rail supported EWR Co at a meeting with BBC's Chief Executive and their transport consultants (SLC & Kilborn Consulting).

In response to challenges from a local lobby group, the CamBed RailRoad group, who are actively promoting solutions to access Cambridge from the north, EWR Co requested that a review of previous work with regards to a northern approach into Cambridge be undertaken to provide assurance that decisions to pause the development of these options was still justified, particularly in light of the change to strategic objectives and conditional outputs. In response to this, a site visit and workshop was held in October 2018 at Shire Hall,

Cambridge. Representatives included EWR Co, Cambridgeshire County Council and Network Rail with the findings included within Appendix B1 Furthermore, 2 additional briefing papers were produced (Appendix D8 & D9) that assessed potential route options from Cambourne north towards Cambridge and the WAML route from Milton into Cambridge station. These briefing papers are discussed in Section B of this report.

H.03 EWRCS Programme Board and Programme Oversight Board

During this phase, DfT put new governance arrangements in place to review progress with EWRCS. This consists of the EWRCS Programme Board, attended by the Managing Director, System Operator, and the EWRCS Programme Oversight Board, attended by Director, Strategy & Planning North. Where appropriate, the Lead Programme Development Manager has also attended this meeting, with papers prepared and presented as requested, relevant to this phase of development. The DfT maintains a record of these meetings.

H.04 Statutory Consultees

During this phase, Network Rail supported a meeting, arranged by EWR Co, with statutory consultees to provide an update on progress with EWRCS. The output from this workshop is maintained by EWR Co.

Network Rail has also supported specific meetings with the following stakeholders who could be impacted by the route options. These are:

National Trust (NT) – Whilst theNetwork rail EWRCS project team have not been required to attend any further meetings with the National Trust in this phase, a number of briefing papers, drawings and assessments have been provided to assist EWR Co in their discussions with NT and to inform the landscape visualisation commission undertaken by Land Use Consultants (LUC) for EWR Co.

Royal Society for the Protection of Birds (RSPB) - EWR Co requested support from the Network Rail EWRCS project team during this phase to attend a meeting in Sandy with representatives from the RSPB. The meeting discussed the potential routes that are in closest proximity to the RSPB's estate at The Lodge, Sandy, and, in particular, the proposal to utilise the old railway alignment on the southern perimeter of the site and the potential concerns that the RSPB may have. A number of supporting documents (which form part of the output from Phase 2f and other phases) were provided to EWR Co to aid the consultation process with the RSPB.

H.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 Network Rail EWRCS project team provides an input to relevant agenda items in advance of these meetings, as and when required.

However, EWR Co now lead the interface with EEH for EWRCS.

H.06 Network Rail Internal Stakeholders

As development work has progressed, updates/reports have been provided to the following stakeholders within Network Rail:

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

Consultation with Network Rail stakeholders for EWRCS will need to continue as EWRCS develops further, and irrespective of the fact that EWR Co will procure a new Technical Advisor to progress the design and development activities. In preparation for this, activities need to continue 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, and to identify a suitable commercial mechanism for these services to be provided.

Part I: **Risks**

I.01 Key Risks

During this phase of work, a number of key risks have been identified by the Network Rail EWRCS team during risk workshops.

These risks are currently at a programme level of detail that capture location specific risks that are to be handed over to EWR Co and their new development partner for further consideration in future phases. A live copy of the Quantitative Project Risk Actions and Exposure database is maintained by Network Rail.

Internal Network Rail risk review workshops held between November 2018 and February 2019 which identified the highest risks for site specific risks at this stage of development as:

Table I1 – Highest Site Specific Risks

Bedford Midland area risk	
Risk Description	Undertake capacity analysis on relevant section (south of Bedford
Risk Mitigation Action	At Bedford due to the constrained nature of the railway if may be difficult achieving the additional capacity at the south end
Sandy area risk	
Risk Description	It may be difficult to design a solution that is compatible with any major power lines that run at the side of the ECML which may result in additional design. (Particular risk for options to the North of Sandy)
Risk Mitigation Action	Early liaison to be undertaken with National Grid
Cambridge area risk	
Risk Description	There may not be capacity at Cambridge Station to timetable a stop at the station
Risk Mitigation Action	Consider capacity at Cambridge Station as part of future development

Bedford Midland area risk

In addition to these generic risks, system integration and risks that may be retained by Network Rail were identified and the highest risks at this stage of development are:

Table I2 – Highest Site Specific Risks

Generic risk	
Risk Description	Objections may be received from local residents / businesses to the works
Risk Mitigation Action	On-going liaison and stakeholder consultation to take place with local neighbours / businesses. To be managed by route.
System Integration risks	
Risk Description	Any late delivery of digital railway may require conventional signalling system to be installed as an interim measure
Risk Mitigation Action	EWR Co to agree specification and requirements and interface with the NR digital railway team on technology issues

Please refer to Appendix I1 for further details on risks identified

I.02 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 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 J: **Safety, Interoperability & Compliance, Environment & Performance**

J.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 REA).

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

Following the establishment of EWR Co as a legal entity, and therefore, assuming the Client role for EWRCS, this legal responsibility needs to transfer to EWR Co. This has been highlighted in this phase, and Network Rail has advised that it will not undertake this role beyond the end of Phase 2f.

When viewed as a broader programme, EWRCS forms a small part of a much larger picture. The System Definition Document prepared during Phase 2e, (Appendix J1) 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 of the organisation 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 Ttrain 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.

In this phase, activities that were both required, and relevant, in relation to CDM and CSM, have been recorded in the updated CSM Hazard Log (Appendix J2) This hazard log has been reviewed and revised during the present development phase to record hazards identified by the Network Rail EWRCS project team. It also contains a record of identified control measures that may be adopted to suitably manage risk to inform future design. It is to be noted that a number of hazards identified in this log may be 'owned' by other stakeholders or may transfer ownership during the life of the design, construction or operation of this project.

J.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 2006 (as amended), commonly referred to as ROGS. These implement the European Safety Directive 2004/49/EC in UK law and place a duty on Railway Undertakings (RU) and Infrastructure Managers (IM) to:

- Develop safety management systems that must meet certain requirements. (ROGS regulation 5)
- Have a safety certificate (for RUs) or a safety authorisation (for IMs). (ROGS regulation 7 & 10)
- Show that they have procedures in place to introduce new or altered vehicles or infrastructure safely. (ROGS regulation 11)
- 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. (ROGS regulation 19)
- Work together to make sure the transport system is run safely (ROGS regulation 22)

The Railways (Interoperability) Regulations 2011, (RIR), implement the Railway Interoperability Directive 2008/57/EC ('the Directive') in the UK. 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' set out in the 'Directive'. 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. (This is likely to remain the case in the immediate future).

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 (CDM) – is domestic UK legislation that applies to the whole construction process on all construction projects, from concept to completion. 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 whilst any *design and 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 aspects of power, signalling and accessibility at stations require compliance. 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.

J.03 Environment

Concept

This Phase 2f report follows on from previous phase 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 scenarios where another party is Infrastructure Manager, they may be considered as best practice to deliver a sustainable railway for the benefit of the community its economic benefit and protection of its environment. Elements of EWRCS, will, of course, operate over existing Network Rail infrastructure regardless of who the Infrastructure Manager is for the new infrastructure.

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
- Biggleswade Common
- Former land fill site at Elstow
- Wimpole Estate
- Bedford Maintenance Depot and Bedford Midland station
- Interfaces with highways and 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 assumed the balance is achieved between extracted 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 informed judgement and be compliant and responsibly sourced.

Next Steps

In future phases, EWRCS will be subject to extensive consents processes. To inform the consents requirements, the design should follow best practice considerations, with issues will be identified and logged. Various administrative, stewardship, designated and statutory areas may be identified from existing databases e.g. the website www.Magic.defra.gov.uk. Where these are encountered, conditions will need to be complied with as determined by the consent's determination.

On the basis that EWR Co will be the promoter of the consents required for EWRCS and will bring on board a new development partner to support this, the list of Network Rail standards shared in previous phase reports has been removed.

J.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 train operators. Establishing and assessing schemes that are in this stage of development, with regards to these type of key performance indicators, is not yet feasible owing 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, then a more detailed view of performance will need to be considered, particularly where EWRCS interfaces with the existing network. Measurements such as "capacity utilisation", where EWRCS is interfacing with existing Network Rail assets, such as on the Midland Main Line, East Coast Main Line and West Anglia Main Line, can provide indications as to performance potential/impact, recognising that any changes to the network will also be subject to the regulatory Network/Station/Depot Change consultation process, as appropriate.

Part K: **Next Steps**

K.01 **Next Steps**

Network Rail has been asked by EWR Co/DfT to continue with development activities through to the end of October 2019, after which, EWR Co will have a new supplier to lead the development and design activities through to the submission of the consent applications required for EWRCS.

A number of development activities have been identified and agreed with EWR Co/DfT which will continue to inform the choice of preferred route. It is anticipated that an announcement on a preferred route will be made in 2019 by EWR Co.

However, the interface with Network Rail will need to continue beyond this due to Network Rail's role as System Operator and as Infrastructure Manager for the existing network and there will be a need to identify services that Network Rail is funded to provide to support EWR Co and what services EWR Co will need from Network Rail that they are not funded to provide e.g. asset protection services.

Part L: **Appendices**

L.01 **List of Appendices**

Appendix	Title/ Description
A1	Client Requirement Document (V1.5 March 2019)
A2	Grant Funding Agreement
A3	Conditional Outputs
B1	Cambridge Workshop Report
C1	Geotech Sensitivity Assessment
D1	Bedford C&CA Report
D2	Previous Bedford Report
D3	Sandy C&CA report v1.0
D4	Flood Plain Strategy
D5	Cambridge South Area C&CA Report
D6	SBR Briefing Paper
D7	Bassingbourn Briefing Paper
D8	London Connections Briefing Paper
D9	Milton to Cambridge Briefing Paper
D10	Wimpole Hall Briefing Paper
D11	Shepreth Branch Line Tie-in Options Package
D12	Bedford Junction Options Package
D13	Shepreth Junction Options Package
E1	Route Option Development Report
E2	Order of Magnitude Cost Range Report
F1	Highway Assessment for BBC Area
F2	Highway Assessment for CBC Area
H1	Stakeholder Management Plan

I1	Risk Report
J1	System Definition Document
J2	CSM HAZID Log

Part M: **Abbreviations & Glossary**

M.01 **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 deployed 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	Bletchley Bedford Midland	Engineers Line Reference for the Marston Vale Line
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	
C&CA	Capability & Capacity Assessment	
CDM	Construction Design and Management	The main set of regulations for managing health, safety and welfare of construction projects.
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.
CRoW	Countryside and Rights of Way Act 2000	

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.
CSM REA	Common Safety Method Risk Evaluation Assessment	
DCO	Development Consent Order	A statutory order which can be made by the Secretary of State under the Planning Act 2008 so as to grant the necessary statutory powers required to deliver certain railway works
DfT	Department for Transport	
DOWN line		In the context of EWRCS the DOWN line is travelling East to West from Cambridge to Oxford
DRRD	Detailed Route Requirements Document	
EA	Environmental Agency	The EA is an executive non-departmental public body sponsored by the 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 Coast Mainline	The major railway link between London and Edinburgh.
ECS	Empty Coaching Stock	
EEH	England Economic Heartland	
ELR	Engineering Line Reference	
EM	East Midlands	
EMGTPA	Equivalent Million Gross Tonnes per Annum	
EMT	East Midlands Trains	
EMU	Engineering Maintenance Unit	
ERA	European Railway Agency	
EWR	East West Rail (Project)	
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	The corridor linking Oxford to
EWRWS	East West Rail Western Section	The corridor linking Cambridge to Norwich/Ipswich
GETS	General Electric Transportation Systems	
GFA	Grant Funding Agreement	
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	
HE	Highways England	
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	
IM	Infrastructure Managers	
IPG	Industry Plan Group	
ITSS	Indicative Train Service Specification	
KPI	Key Performance Indicator	A performance measurement to enable organisations to track and monitor the success of their operations
LNE	London North East	
LNW	London North West	
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	The existing railway between Bletchley and Bedford
MVLS	Marston Vale Line Study	
MVL SCC	Marston Vale Line Signal Control Centre	
NESA	National Electronic Sectional Appendix	
NIC	National Infrastructure Commission	
NR	Network Rail Infrastructure Limited	
NRCI	Network Rail Controlled Infrastructure	
NRDD	Network Rail Design Delivery	
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	
OOM	Order of Magnitude	
OPEX	Operating Expenditure	
ORR	Office of Rail and Road	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	Route Availability	the system by which the permanent way and supporting works (bridges, embankments, etc.) of the railway network of Great Britain are graded. All routes are allocated an RA number between 1 and 10.
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.
RIR	Railways (Interoperability) Regulations 2011	
RISG	Rail Industry Steering Group	
ROGS	Railways and Other Guided Transport Systems (Safety) Regulations 2006	
RSPB	Royal Society for the Protection of Birds	
RSSB	Railway Safety and Standards Board	
RU	Railway Undertakings	
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 Branch	Engineers Line Reference (Hitchin to Cambridge
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	
SPC1/2	St Pancras to Chesterfield	Engineers Line reference for the Midland Mainline
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
TWAO	Transport and Works Act Order	A statutory order which can be made by the Secretary of State under the Transport and Works Act 1992 so as to grant the necessary statutory powers required to deliver certain railway works
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.
VHLC	Vital Harmon Logic Controller	
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