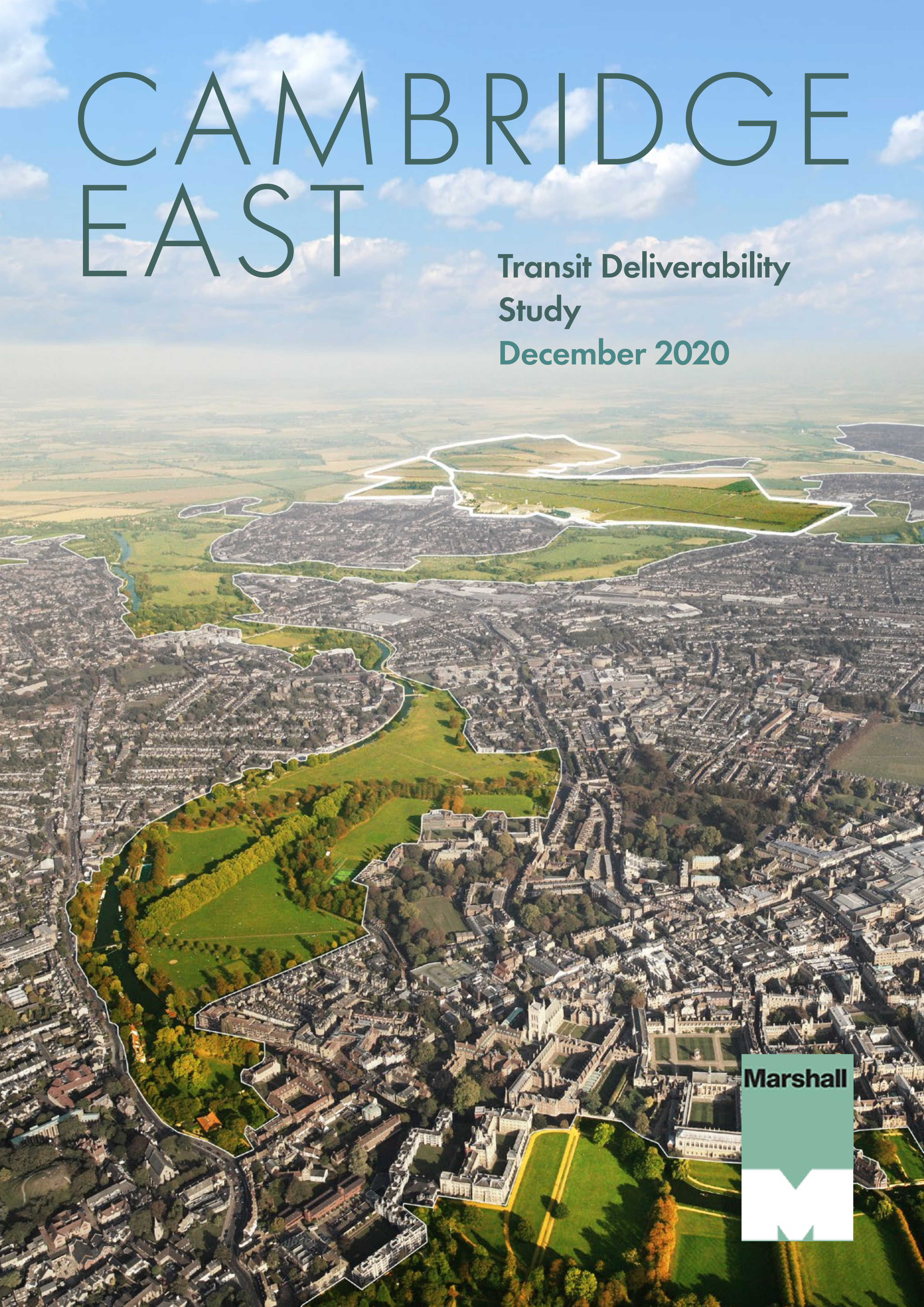
CAMBRIDGE EAST

Transit Deliverability Study

December 2020



Marshall

Report
December 2020

Cambridge East Transit Deliverability Study

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1 Introduction

Background

1.1 In developing its plan for Cambridge East, Marshall Group Properties preference and hope is that the Cambridgeshire Autonomous Metro (CAM) – which includes a line serving Cambridge East – will come forward to implementation, and they will continue to work collaboratively with all parties to this end. In this report, which forms part of the evidence to be submitted for the Local Plan, a standalone mass transit line ('transit') is identified, linking the site with Cambridge railway station. The intention is that this would only be promoted on a stand-alone basis if CAM was not proceeding, or if its delivery timescale fell behind the delivery programme for Cambridge East. In the latter case, the 'stand-alone' transit could form a first phase of CAM.

1.2 The 'stand-alone' transit line that has been formulated in such a way that it can be readily extended into a wider CAM network. It delivers a segregated route across the length of the planned development and it also provides a transition to a tunnelled section (with the portal works provided for within the development site) and, at its eastern limit, a depot that can support the wider CAM network as it develops. Marshall Group Properties is committed to working with the CAM team to see this and the wider CAM scheme delivered.

1.3 The transit proposal forms part of a wider transport strategy for Cambridge East, applicable in three of the four Cambridge East development scenarios (see below). The strategy builds on the work carried out by the Greater Cambridge Partnership (GCP) in their examination of ways to improve access from the eastern side of Cambridge to the rest of the city – especially the city centre.

1.4 This document is one of the documents being submitted as part of the Local Plan which addresses transport matters. This document should be read in conjunction with the "Cambridge East: Transport Vision and Emerging Transport Strategy" document prepared by Stantec which sets out the overarching transport vision for Cambridge East.

Definitions

1.5 In this report we draw a distinction between mass transit/CAM and high-quality public transport services. We are assuming that – at least within the Cambridge urban area – that mass transit/CAM will be a high capacity system, electrified and operating on fully segregated alignments (we abbreviate mass transit to transit). All transit schemes so identified are capable of forming part of the CAM network. Over their surface sections, it is assumed they are also capable, of permitting operation of high-quality public transport services over the same (segregated) rights-of way.

1.6 We also refer in this report to complementary public transport measures, which include a range of high-quality public transport measures, surface schemes including guided bus and bus priorities on existing streets, with attention to measures for ease of passenger access. For both high-quality public transport measures and transit, we would assume that by the time of implementation there would be a user friendly 'smart' multi-modal ticketing systems in use across the wider Cambridge area to allow easy transfer between transit, bus and train.

Consistency with GCP work and with CAM proposals

1.7 While the Greater Cambridge Partnership (GCP) Eastern Access work was not intended to address the opportunity provided by the planned Cambridge East development, Marshall Group Properties has worked closely with the GCP and its Eastern Access study team throughout and is fully supportive of the emerging conclusions. The proposals reported here are consistent with the GCP work and can be seen as an extension of the Eastern Access study emerging findings, which identify a number of valuable ways by which public transport service and 'active modes' can be supported and developed in Cambridge's eastern side. These comprise both 'quick fixes' – for instance along Newmarket Road – and more ambitious schemes that are reflected in the overall development transport strategy. The GCP plans also provide an indicative future CAM/transit alignment which is entirely consistent with the proposals discussed in this report.

1.8 This Deliverability Study has been framed within this important context of the CAM and GCP's work. Marshall Group Properties immediate priority, through this work, is to show that a transit link to Cambridge railway station can be delivered. A connection to the station is needed for a set of reasons fully explained in paragraph 1.17 below. In this report, we set out fully the options that exist to deliver this aim and set out surface as well as tunnelled options so that their relative merits can be judged.

1.9 Assumptions have had to be made in this work on transit technology. This is a subject on which Marshall Group Properties is agnostic but recognises that to provide certainty in support of the Local Plan submission, a specific transit technology has to be assumed. For the purposes of this work, the transit system has been presumed to use Light Rail Transit (LRT) technology, which while continuously evolving itself, has known and proven characteristics. This allows 'Proof of Concept' for the transit link, based on known design parameters and safety criteria and offers assurance for the local plan process on its deliverability, with a wide range of possible suppliers and contractors. Marshall Group Properties is not promoting LRT, simply using its known characteristics to help define and understand interfaces, likely costs and output performance capabilities.

1.10 The aim and intention of this transit deliverability report, in short, is to explore and, consistent with this early stage of design development, provide assurance on the deliverability of the planned transit component of the Cambridge East development, prior to Local Plan deposition.

Development Scenarios

1.11 The proposed Cambridge East development comprises a large-scale mixed-use scheme expressed as four possible development scenarios:

- **Scenario A** – a scheme covering the Safeguarded Airport land which is compliant with the adopted Cambridge East Area Action Plan. This scheme includes high quality public transport (HQPT) links as envisaged in the AAP, a relocated P&R and dedicated transit corridor through the site. It does not require a dedicated off site mass transit link connecting to Cambridge Station. It includes delivery of a Country Park to the east of Airport Way.
- **Scenario B** – a scheme covering the Safeguarded Airport land, but which achieves a greater mix of uses than is envisaged in the AAP, including a significant increase in the provision of commercial development to enable and capitalise on the delivery of a research hub. This scheme is supported by comparable on site transport infrastructure as Scenario A (including relocated P&R and dedicated on segregated transit corridor), but with a dedicated off-site mass rapid transit link connecting to Cambridge Station with further connections to Cambridge North.
- **Scenario C** – a scheme covering the Safeguarded Airport land and additional Green Belt land to the east of Airport Way, which enables the delivery of a significantly greater quantum of development than Scenarios A or B, including a greater mix of uses, notably more residential units, and a greater scale of commercial development. This scheme is supported by comparable on site transport infrastructure as Scenario A (including relocated P&R and segregated transit corridor), but with a dedicated off-site mass rapid transit link connecting to Cambridge Station with further connections to Cambridge North. It also provides a Green Infrastructure network which extends beyond the redline of the site to the east.
- **Scenario D** – a scheme which achieves the same amount of development as Scenario C but covering the Safeguarded Airport land only. This scheme is supported by comparable on site transport infrastructure as Scenario A (including relocated P&R and segregated transit corridor), but with a dedicated off-site mass rapid transit link connecting to Cambridge Station with further connections to Cambridge North. It is being tested to examine the potential to densify Option B.

1.12 The Cambridge East: Transport Vision and Emerging Transport Strategy document sets out the rationale behind the transport strategies defined for each Scenario and is informed by technical assessment of forecast future demand and origin destination data. It also contains details regarding the scale of the development scenarios which are summarised here:

Scenario	Homes	Jobs
A	9,500	4000
B	9,500	28,000
C	12,000	38,000
D	12,000	38,000

1.13 The transit scheme forms part of the development plan in all scenarios apart from Scenario A, which is a lower density residential only scheme. The other scenarios (B-D) present a larger scale, mixed use development of the airport site and in some cases, local authority land immediately east of the airport.

Why a Transit System is Needed

1.14 The requirement for a transit facility associated with the development arises from three specific needs:

- The need to provide an attractive alternative to car use, alongside active travel and other measures, to ensure that the traffic impacts of the Cambridge East development on the surrounding highway network are constrained to acceptable levels
- The need to ensure the viability of the development, consistent with the ambition to provide a worthy extension to the City of Cambridge, capable of attracting world-class businesses and achieving high values on residential properties
- The need to contribute to the wider development aim of making a net positive contribution to Cambridge, its residents and businesses.

1.15 These needs and the forecast demands associated with the higher growth scenarios were translated into a requirement for a transit component of an overall transport strategy to link the development speedily and safely with Cambridge (city centre, broadly defined); to the other key developments and centres within Cambridge and the surrounding area; and to the wider world beyond.

1.16 It is concluded that a high capacity transit connection to Cambridge station would meet this requirement; there would be complementary high quality public transport facilities too, which are reported in the “Complementary Public Transport Interventions” report appended to this report at Appendix B as well as high quality and comprehensive facilities for active travel. A full list of transport interventions supporting each development scenario is summarised in Stantec’s Cambridge East: Transport Vision and Emerging Transport Strategy document.

A Broad Search of Options

1.17 Preliminary assessments of various options that would meet this transit requirement have been carried out over a two-year period. The early assessments considered a comprehensive range of technologies and alignments. They were carried out contemporaneously with work that was underway by the Combined Authority to develop the CAM project.

1.18 Options which relied on bus or light rail transit (and other technologies) were examined using existing streets, concentrating on the major thoroughfares, and also on options such as using the Newmarket rail alignment and on cutting across Coldham’s Common. Existing streets considered included Coldham’s Lane, Mill Road and Cherry Hinton Road, each of which would require use of other streets to provide a connection into the airport development site. It was considered that the most direct of these, Mill Road could not readily support a reliable high frequency transit service without an area-wide traffic calming scheme.[1] Fashioning a suitable route onwards to Cambridge station, which lies to the south of Mill Road was examined but found to be problematic (See Chapter 5 for more details).

1.19 It was concluded that the existing streets on the eastern side of built-up Cambridge, including Mill Road, could play a very useful role in supporting conventional bus routes which could be extended to serve the development site in its early development stages – and clearly if general road traffic is restricted over this route, that is helpful for public transport service delivery.

[1] In 2020, through traffic restrictions were placed on Mill Road, while allowing bus and cycle trips to continue

1.20 Routes across Coldham's Common were ruled out as being incompatible with its recreational use and environmental value. Using the Newmarket railway line was also ruled out because of the impracticability of accommodating a high-frequency metro-style service into Cambridge station from the north. Instead, it was concluded, a new route would be needed for the transit system to serve the Cambridge East development.

1.21 More recent work has considered the idea that the Cambridge-Newmarket railway line could be re-routed to pass through the development site. For a number of reasons, this idea has not been progressed:

- It would make the development of Cambridge East dependent on a radical change to the national rail network in the area, with an indeterminate impact on implementation timescales (it could not be added later), so it could not be known when the development could commence.
- It would be unlikely to support a suitably high train service frequency (current expectations are for an increase from 1 train/hour to possibly 3 trains/hour), and service reliability would be dependent on the vagaries of operations through remote locations on the national rail network; these characteristics are inconsistent with the scale of demand and connectivity needs of the Cambridge East development.
- To avoid adverse impact on the development masterplan, the route would need to be tunnelled across the airport site to avoid severance, noise and other negative impacts, adding to its cost.
- Such a proposal would similarly adversely impact adversely on the planned Land North of Cherry Hinton development.

1.22 The transit scheme for the Cambridge East development was specified using established transit system characteristics and design standards. This ensures it is not dependent on the delivery of CAM (which is continuing to explore new and innovative technologies). But the transit system for Cambridge East has throughout been developed with the aim that it could, in due course, form part of the CAM network – and possibly its first phase. The planned transit route developed for Marshall in Cambridge East is mirrored by one of the routes identified in the wider CAM network envisaged by the Mayor/Combined Authority for the Cambridge area in 2019 as detailed on their website.

1.23 It was concluded previously that the three specific needs set out above, would best be met by a transit system that operates across the development site, from a multi-modal interchange at its eastern limit, including a park and ride facility (part of the Newmarket Road Travel Hub), across the development site on the surface with several intermediate stops before using tunnelling to pass underneath the established urban fabric between the airport and Cambridge station, where a high quality interchange would be provided.

1.24 This initial line could be extended in several ways, including in tunnel – as per current CAM plans to a city centre station and onwards to the west and north of Cambridge (to Cambourne or further west and Cambridge North and beyond)). Provision for such later extensions would not form part of the transit scheme committed to be delivered with the development, but clearly the first phase, from the Multi-modal interchange/Newmarket Road Travel Hub, across the development to Cambridge station would need to be committed and specified in a way that allowed for subsequent extensions.

Report Objectives

1.25 The work carried out in preparation of this report is designed to help provide answers to questions that might arise in respect of the deliverability of the planned transit system when it comes under consideration in the Local Plan process. Such questions include:

- its buildability;
- availability of suitable system providers and contractors;
- integrity and reliability of any adopted technologies;
- inter-dependencies with other projects and developments;
- the suitability of tunnelling in this particular area;
- acceptability of the scheme to those affected by its construction and operation;
- the ability to assure an attractive and high standard of operational performance that will discourage people from using cars to access the development;
- suitable levels of capacity to accommodate projected demand levels
- consistency with wider environmental and strategic objectives for Cambridge; and
- achievement of transport investment benchmark tests set by Government for funding support.

1.26 The technical work has been informed by demand forecasts generated as part of origin/destination work undertaken by Stantec,

1.27 This work specifically seeks to take the preferred alternative and see whether there are variations to it that can, at this early stage, provide added assurance to the deliverability of the transit proposal.

1.28 To this end, we looked in particular at a surface alternative to the tunnelled scheme. Surface routes to Cambridge station were considered and rejected in earlier studies, but, only less direct corridors to that chosen for the preferred tunnelled scheme had been considered. In the deliverability work, we look to the same corridor as the tunnelled scheme for a surface scheme, a variant not previously considered. We also looked at terminating the route at a surface station adjoining Cambridge railway station initially, with a view to constructing an underground station at this location later as/when the route is incorporated into a wider CAM network. We also examined shorter tunnelled alignments, with lengthier on-surface construction.

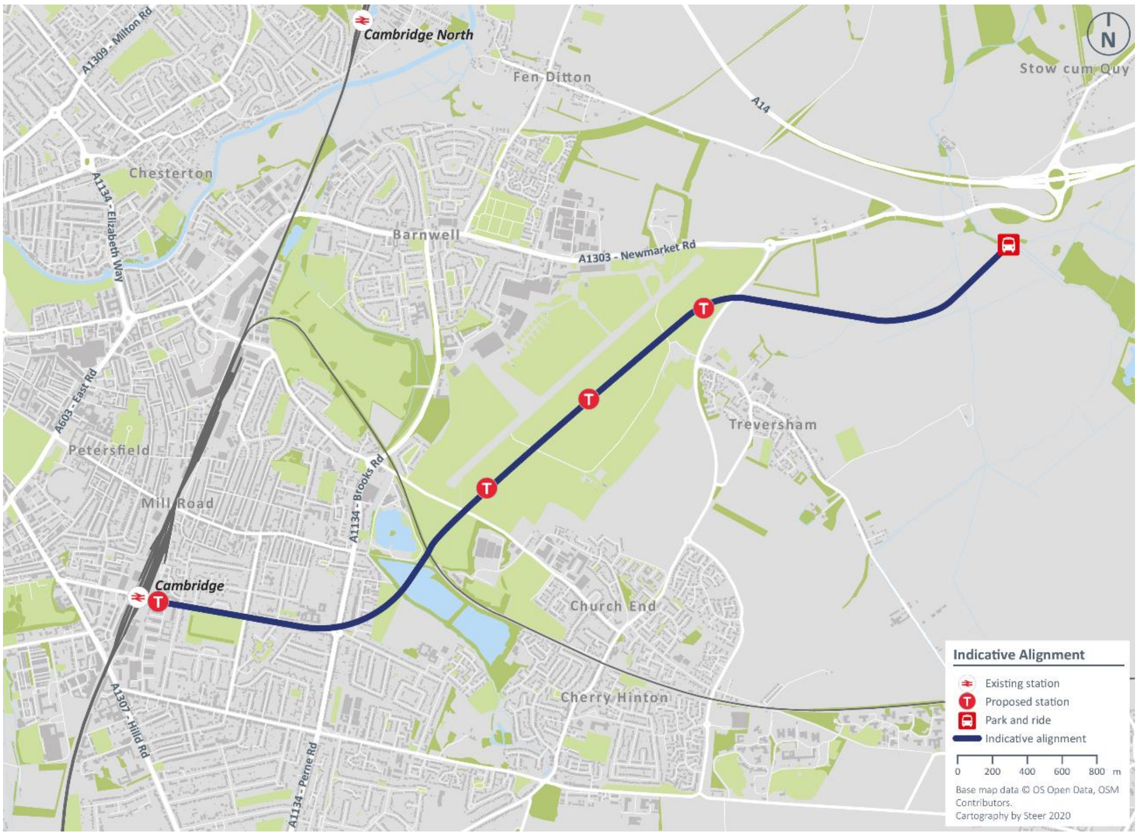
2 Approach

Transit Background

2.1 A transit system to serve the Cambridge East site was studied previously. The study developed a comprehensive range of route and technology options for a transit system linking the Cambridge East development with Cambridge railway station.

2.2 It was concluded that the best approach was a transit link serving the Cambridge East development site with three stops; extending eastwards to a Park and Ride site on the A1303 at Longfield Farm (to provide eastern access both to the development and the city as a whole), and westwards passing into tunnel as it leaves the airport development site to a station built below ground level, on an east-west orientation, at Cambridge Station. From this location, the line could be extended further west in due course as part of a city-wide network to Cambridge city centre and beyond. This route is shown indicatively in Figure 2.1.

Figure 2.1 Central Option Indicative Route



2.3 Projected demand levels for such a scheme were expected to increase from around 1,300 passengers/hour (busiest directional flow) in the peak period when it is first operated to around 3,800 passengers/hour (busiest directional flow) when the Cambridge East development is fully built out and assuming the line formed part of a city-wide (CAM) network. These patronage forecasts are updated within this report in Chapter 6 and detailed further in Appendix A and originate from Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

2.4 The location of the park and ride close to the A14 would intercept car-based journeys coming into the city from the east, reducing traffic travelling further west towards Cambridge City centre.

Cambridgeshire Autonomous Metro (CAM)

2.5 In parallel with development of the Cambridge East project and its transit connection to Cambridge station, the Mayor and Cambridgeshire & Peterborough Combined Authority (CPCA) have been developing proposals for a city-wide transit system known as Cambridgeshire Autonomous Metro (CAM). CAM would operate in tunnel under central Cambridge, with segregated surface rights of way beyond, aiming to serve all of the key demand locations in the city region. The CAM studies have focussed on autonomous metro technology, using rubber-tyred vehicles which could use the new surface and tunnelled alignments as well as existing (and new) busways.

2.6 While it is envisaged that the Cambridge East transit line could form a pilot for the proposed city-wide network, it is possible that the city-wide network might not proceed as currently envisaged and its delivery timescale could be attenuated because of the intention to embrace innovative technology and the need to secure funding. Until further work is carried out, possibly involving proving stages with new technology, there is some uncertainty about technology and the infrastructure parameters that will be adopted for the CAM system. This uncertainty led Marshall Group Properties, two years ago, to make a cautious assumption that the preferred scheme should be examined using proven light rail transit (LRT) technology. This assumption has the virtues of:

- there being multiple suppliers of LRT systems which will help ensure competitive and (if desired) whole-life pricing; and
- being a technology proven in service, while continuing to evolve (for instance to embrace hybrid power systems and automated operation).

2.7 This remains a suitably cautious assumption at this stage, because pricing such transit systems can be made with reference to current market prices and because other technologies (for instance those which use LIDAR and other guidance systems rather than steel rails) offer the prospect of capital cost savings ahead. This is a further virtue, since it removes an element of optimism bias which is always present in early scheme definitions.

2.8 While the CAM system has been the subject of further development work, it is clear that the intention to use innovative technology remains, with a call made this year for innovative new systems/technologies by the CAM project team.

2.9 The Combined Authority has recently launched a market testing exercise to shape the future of CAM by developing conceptual designs for the vehicle, its infrastructure and how the system might operate. Participants are being invited to develop conceptual designs, which are not intended to be the conclusive delivery solution for CAM, but which will help inform how the scheme develops further. They will help identify opportunities for innovative approaches, support the development of a business case, and build interest from suppliers more widely who at some stage may want to bid on future phases of CAM work.

2.10 In advance of any outcome from this phase of CAM development, the reasoning behind the presumption of LRT technology for the Cambridge East transit previously is judged to remain valid. Its design parameters are well understood, as are its costs and capabilities. While its use at this stage of Cambridge East's development is prudent and helps to ensure certainty and deliverability, it is entirely possible to adopt a new technology solution in due course, as/when CAM reaches a conclusion on its preferred approach and proves its deliverability. The Cambridge East transit alignment fits as part of the overall CAM network plan.

2.11 With a short journey time through the tunnelled section of the scheme (circa 3 minutes) and a service frequency of (say) 10/hour it was considered practicable to operate the initial transit line with a single-track tunnel, which could be duplicated if and when the system becomes part of a wider network.

2.12 The LRT system would use low-floor vehicles and low platforms at stops to ensure level boarding suitable for buggies, wheelchairs etc. The fleet requirements are reviewed in Chapter 5. A small depot site would be built at the P&R site where vehicles would be stabled and maintained. The depot could also support and become part of the CAM network.

National Rail Developments

2.13 Network Rail is forecasting significant growth in rail use in the Cambridge area, including additional passenger services between London and Cambridge, East West Rail services and additional freight trains.[2] A range of infrastructure investments necessary to support these additional services has been identified. These include four-tracking south of Cambridge Station, capacity improvements at Cambridge Station, additional stabling sidings, double tracking of the line from Cambridge towards Newmarket and a new Cambridge South Station.

2.14 The works at Cambridge Station include two new additional 12-car platforms, relocation and removal of switches and crossings, relocation of an engineering siding and amended access to/from existing stabling sidings. These works are shown diagrammatically in Figure 2.2.

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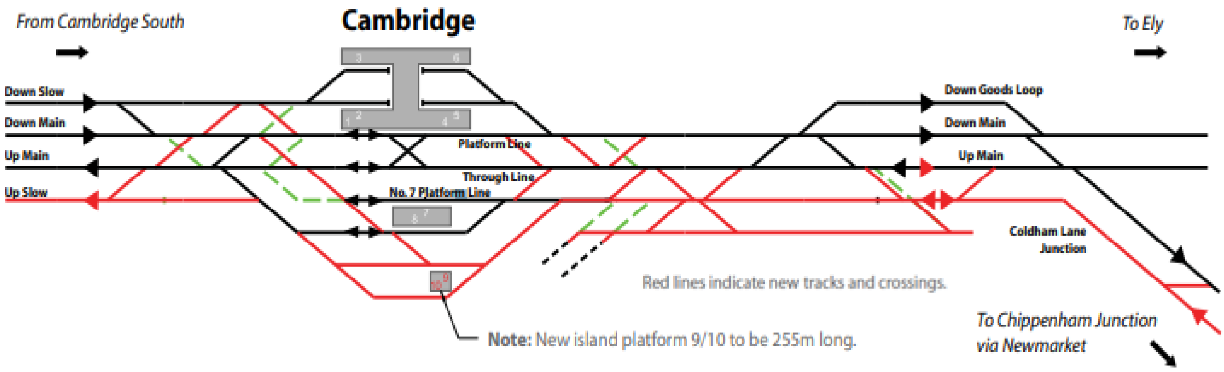
2 See https://www.networkrail.co.uk/wp-content/uploads/2016/12/Cambridgeshire-Corridor-Study-2019.pdf

Figure 2.2 Cambridge Station Layout - Growth Scenario 1 to achieve 2033 and 2043 train service requirements



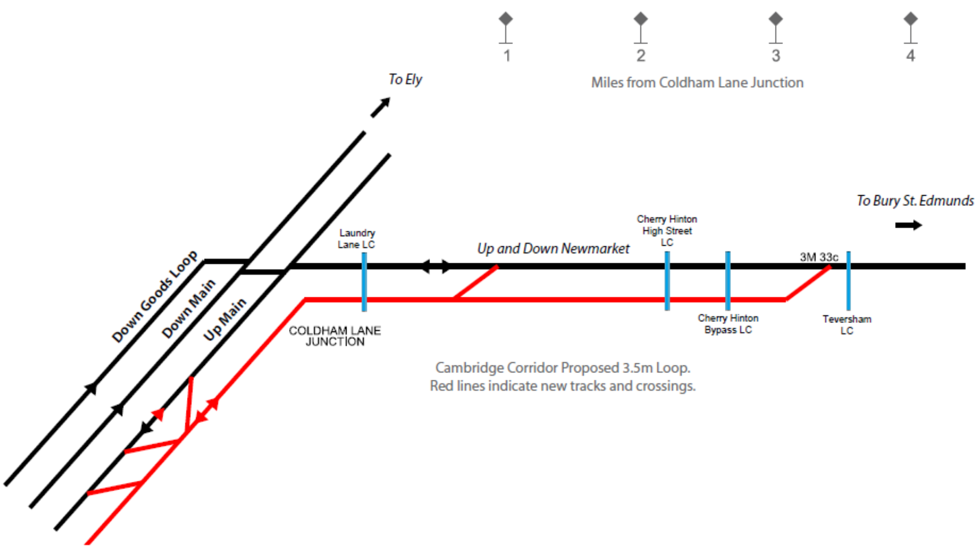
Network Rail, Cambridgeshire Corridor Study 2019

2.15 Improvements are also being considered to address passenger capacity constraints on the platforms and footbridge. As well as extending the existing footbridge to serve the new platforms, consideration is being given to the provision of a second footbridge, both to provide additional capacity and to disperse passenger movements around the station.

2.16 These developments were all considered in Network Rail's Cambridgeshire Corridor Study of 2019. While this did not consider the Cambridge and Peterborough Independent Economic Review (CPIER) forecasts of development in the region or the implications of new developments such as CAM on access to Cambridge station, it did set out where most rail demand growth was expected, based on recent trends. The corridor to the east (the Newmarket Line) is forecast to experience the strongest growth (up 7% per annum) and the line to the south (Broxbourne) the second highest (6%).

2.17 The Newmarket line is set to have a double track section of line re-instated over a 3.5 mile section eastwards from Coldham's Lane Junction, designed to support an expanded train service by 2043. These works are shown diagrammatically in Figure 2.3.

Figure 2.3 Cambridge Station Layout - Growth Scenario 1 to achieve 2033 and 2043 train service requirements



Network Rail, Cambridgeshire Corridor Study 2019

2.18 The possibility of a station being located on this line near where it passes the southern boundary of the airport site has been discussed with Network Rail who have expressed an interest in the idea. But while such a facility could improve access to the site from the east, it should be recognised that service levels on this line, which east of Teversham would remain single track, are expected to remain only around 2 or 3 trains/hour (today's service is only hourly).

2.19 The East West Rail (EWR) project has progressed since 2018, with the selection of a preferred corridor of the central section of the line between Bedford and Cambridge. This offers the prospect of an interim (and ongoing) complement to the Cambridge East transit line to Cambridge station, from which interchange would be possible onto EWR services to Cambourne, the St Neots area and places further west.

2.20 The Marshall Group Properties transport team has had discussions with Network Rail on the plan for a new transit line to serve Cambridge station from the Cambridge East development site, over the last two years and no objections have been raised at this early stage: the preferred approach going forward given plans for expansion of the station would be joint studies and development work.

2.21 Network Rail is of course also fully aware of the CAM proposals which envisage underground platforms. It also recognises that accessibility from the east of the railway to Cambridge station is inconvenient, and that the Marshall Group Properties proposals could be transformational, with a new station entrance on the east side of the railway offering access by public transport, pedestrians (including wheelchair users) and cyclists (for whom the existing cycle/foot bridge to the north of the station offers only a circuitous route).

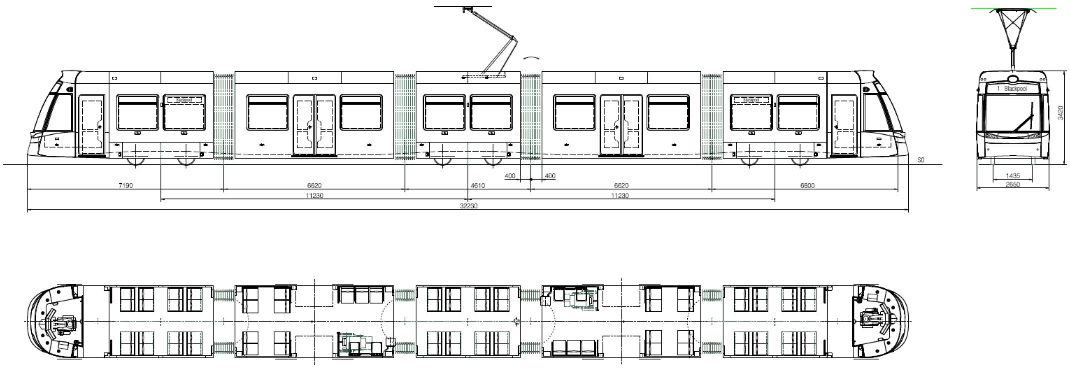
3 Engineering Parameters

Technology Assumptions

3.1 The approach, having considered in the earlier studies a very wide range of technologies and alignments, was a transit system running via a tunnel from the Cambridge East site directly to Cambridge station using Light Rail Transit (LRT) technology. LRT is a mature technology and has been used in many cities across the UK and the world. Modern LRT systems use electrically powered, bidirectional, multi-section articulated vehicles, typically 25-40m long and 2.65m wide. The vehicles have flanged steel wheels and run on steel rails usually at standard gauge (1435mm). Vehicles can run on segregated alignments, in shared running with road traffic, in tunnel and through pedestrian areas. It is important to note that Marshall is agnostic to technology at this stage..

3.2 Although Light Rail Vehicle (LRV) lengths vary, the commonest configuration currently available is a five-section articulated vehicle about 30m long. Figure 3.1 shows the 32.2m long vehicles supplied to the Blackpool Tramway as an example.

Figure 3.1 Blackpool LRV



3.3 Some LRVs are designed to be extendable by the introduction of additional body sections (although they would need to be removed from service while the additional sections are fitted). Elsewhere LRVs operate in coupled pairs to provide a higher capacity. This allows operation of paired units at peak times, with single units operating off-peak services, and maintains a single unit type throughout the fleet.

3.4 The light rail vehicles are provided with a driver’s cab at each end, together with multiple doors on both sides for rapid boarding and alighting. The internal floor level is typically 350-400mm above track level, and stations/stops are provided with low platforms of similar height to allow level boarding. LRT systems operate on a line-of-sight basis, as with other road vehicles, with their progress through road junctions controlled by conventional traffic signals which are also fitted with specific LRT aspects. On fully segregated sections, railway-type signalling may be used.

3.5 Historically LRT systems have been powered from overhead lines, usually at a voltage of 750V dc. Some modern schemes have included the use of ground level power collection systems, and there is now increasing interest in the use of battery power to allow LRVs to operate without Overhead Line Equipment (OLE), particularly in historic and visually sensitive areas. Recent developments in battery technology are increasing the range of operation without OLE, with the batteries being recharged when the LRVs are operating with overhead line or plugged in at termini. In tunnel operation and other segregated areas, LRVs can be powered from low level 'third rail' systems.

3.6 In summary, LRT is a proven, flexible, technology, which can be delivered in reasonable timescales, and which would enable a high density sustainable development in Cambridge East, linked to Cambridge Station and from there via other modes to the city centre and all parts of the Cambridge area. That said, the main design parameters – vehicle size and capacity, operating speed, acceleration and braking rates, alignment curvature and gradient criteria, safety requirements etc. are broadly similar to those of other transit technologies which would deliver a similar overall passenger capacity. As such, LRT can be regarded as an illustrative solution, to demonstrate scheme feasibility. If, by the time the project comes to be implemented, the technology has moved on, and /or if the CAM project has defined appropriate parameters for a wider Cambridge area transit system, then the scheme presented here would not require substantial modification to adopt such technology.

Alignment Criteria

3.7 The alignment and clearance criteria used in developing the route alignments set out in this report are set out below.

Parameter	Value
LRV Length	30m (nominal)
LRV width	2.65m
LRV height	3.6m (excluding pantograph)
LRV door threshold/Platform height	0.35m - 0.4m
Station/stop platform length	60m (nominal) – to allow operation of coupled LRVs
Minimum horizontal curve radius	25m
Minimum vertical curve radius	400m
Maximum gradient	6.0%/8.0%

3.8 Note that 6% maximum gradient is often specified, but many modern LRT vehicles are capable of steeper gradients. The Croydon tram system was originally designed with maximum 6% gradients, but in detailed design was modified to 8%, since the selected vehicles were capable of this, and as a result, the extent of earthworks and structures in the Addington Hills could be reduced. The Sheffield system was specified with a 10% gradient capability to deal with the hills in the city, but this did require additional motored axles compared with other LRVs. In the proposals presented in this document, a 6% maximum gradient has been taken as the base case, but the benefits of adopting 8% in key locations are also shown.

3.9 Where appropriate, the design has made reference to the UKTram document Tramway Principles & Guidance[3], which has superseded the design guidance previously issued by the Health and Safety Executive and the Office of Road and Rail for tramway and light rail systems in the UK.

Compatibility with CAM

3.10 As noted above, CAM is proposing the use of autonomous (driverless) rubber-tyred vehicles, guided by means other than conventional rails or guided bus systems, which are capable of operating on new segregated surface and underground alignments as well as on the existing busway routes. Many aspects of this technology have yet to be determined, including the vehicle size and capacity, operating pattern, service frequency, power source and control system. While there is currently much research and development being undertaken into such systems, by the public sector, academia and industry, they are currently unproven in regular public service operation. Similarly, there are as yet no established regulatory and safety systems which will govern how the emerging technologies of driverless vehicles and non rail-based guidance systems are designed, approved, constructed and operated.

3.11 The assumed use of LRT technology at this stage allows the Cambridge East transit system to be developed with confidence in both the technical solution and the likely capital and operating costs and will enable the project to be delivered in the timescales required to support delivery of the early stages of the build-out of the Cambridge East development.

3.12 Designs and design assumptions presented here are flexible in that they would allow the detailed technology to be amended as/when the proposed CAM technology is developed and proven in a suitable timespan. Or indeed, it would be possible to replace the LRT technology with a guided bus approach., albeit with the need for tunnelled sections remaining. And it is also common practice to allow an LRT right-of-way to be shared with high quality public transport (bus-based systems) where route sections overlap.

3.13 It is important to remember that the options assessed in this report are in the context of providing evidence for a range of deliverable solutions for the Local Plan evidence base and would be subject to further analysis.

3 Tramway Principles & Guidance, UKTram, 2018, https://uktram.com/wp-content/uploads/2018/07/Tramway-Principles-Guidance-Final-2.pdf

4 Engineering Design for Option T1

Background

4.1 The preferred option from the earlier studies envisage a route running in tunnel from north-east of Coldham's Lane, passing in a broad sweep beneath former quarries, then running directly below Radegund Road and Davy Road to Cambridge Station. This alignment was selected as providing a reasonably direct route from the Cambridge East development to the railway station; the large radius curves would maximise running speeds and the alignment, being mostly directly below streets, would minimise any impact on existing building foundations.

4.2 We have reviewed this tunnelled alignment and looked at surface alternatives in the same corridor, together with alternative shorter tunnel options. In this chapter, we present findings based on available evidence on the feasibility of the tunnelled sections of the scheme.

4.3 We have found that this and other tunnelled transit routes on shorter alignments could be combined with a surface transit station at Cambridge railway station, rather than an underground station. This has the benefit of significantly reducing construction costs, with little impact on operating performance, and potentially reduces interface issues at Cambridge station. Overall, this helps assure the deliverability of the stand-alone transit line. An initial surface transit station at its western end can later be connected to a wider CAM network with an underground station at the railway station, as set out in the next Chapter, where descriptions of other route and station options are also provided. In this Chapter we describe the option designated as Option T1.

Horizontal Alignment – Cambridge Station to North of Coldham's Lane

4.4 The horizontal alignment of the Option T1 route between Cambridge Station and north of Coldham's Lane is shown in Figure 4.1 with an underground terminus at Cambridge station, and Figure 4.2 with a surface terminus at Cambridge station.

Figure 4.1 Option T1 Transit Route from Cambridge Station to North of Coldham's Lane – Underground Station

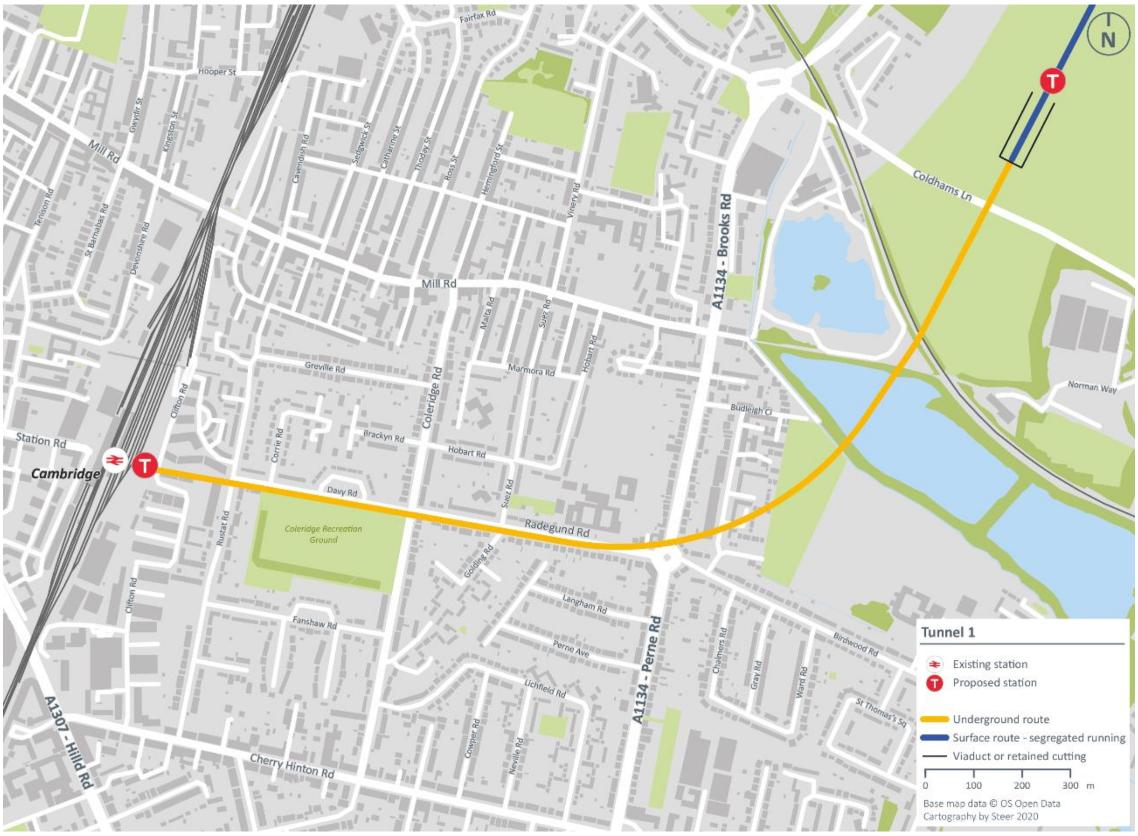
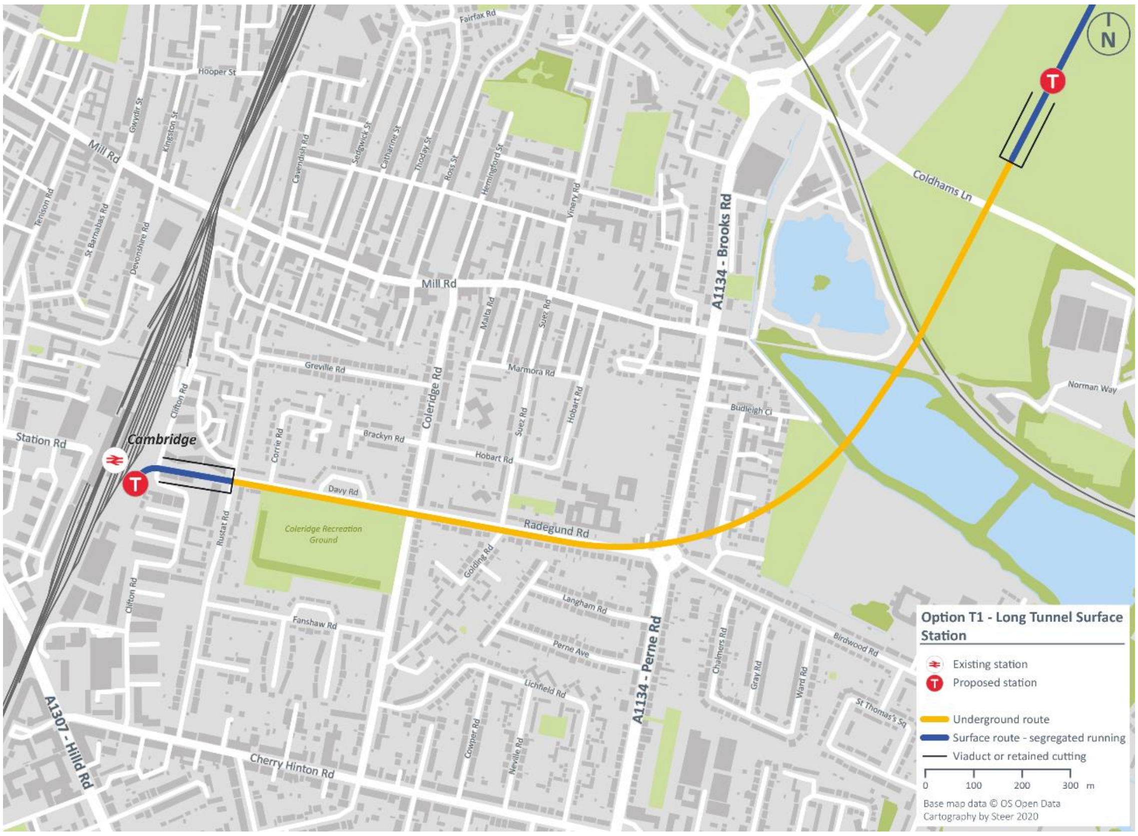


Figure 4.2 Option T1 Transit Route from Cambridge Station to North of Coldham's Lane – Surface Station



4.5 The route commences at a surface station located to the east of the existing railway station tracks and platforms, and to the south of the newly built train stabling sidings. The platform and tracks are aligned parallel to the railway tracks and platforms and located to allow for the planned additional railway island platform. This layout makes best use of the available space and anticipates a new southern footbridge to serve both the railway and transit platforms. The station would have a 60m long island platform with tracks on both sides able to accommodate paired LRVs.

4.6 North of the station the tracks would curve to the east on a minimum radius curve and cross Clifton Road at-grade under traffic signal control. The route would then descend in a retained cutting in the open land to the south of Rustat Avenue. This may need to continue for a short distance as cut-and-cover tunnel beneath the western end of Davy Road to the portal of the driven tunnel. Within the cutting and cut-and-cover tunnel the twin tracks from the station would merge to a single track before the driven tunnel portal. These structures would be designed to accommodate a second tunnel should the tunnel route be double-tracked in future.

4.7 The route then runs eastwards in tunnel below Davy Road and Radegund Road. Near the western edge of Coleridge Community College, the route starts to curve northwards on a sweeping curve, crossing beneath Perne Road just to the north of the roundabout junction with Radegund Road and Birdwood Road, under Tiverton Way and the Burnside Allotment site. The route then passes beneath Cherry Hinton Brook, below the flooded former Western Quarry, under the Cambridge to Newmarket railway line and then below another quarry, now infilled with industrial, commercial and domestic waste before passing below Coldham’s Lane. The route then rises on a 6% gradient to ground level within the Cambridge East development site.

4.8 The gradient section would comprise firstly bored tunnel, ending at a portal structure, then a length of cut and cover tunnel and finally an open retained cutting. The bored tunnel would be single track, the cut and cover tunnel and open cutting sections would be double track width, with the portal designed to allow for the later construction of a second tunnel bore.

Horizontal Alignment – North of Coldham’s Lane to Multi-modal Interchange/Newmarket Road Travel Hub

4.9 Through the Cambridge East development site the route would run at grade in a generally north easterly direction across the site. There are no particular constraints on the alignment in this area, and therefore the final alignment and stop locations will be developed as part of the overall planning for the development. It could be advantageous to construct the transit while the airport runway remains in operation, and thus the route has been realigned a short distance to the southeast to maintain sufficient separation from the runway. Figure 4.3 shows an alignment developed on this basis.

Figure 4.3 Possible Transit Route through Cambridge East Development, Compatible with Continued Runway Operation

4.10 It should be noted that this transit alignment, while notional, would require some reworking of the development layout shown. Also, the two middle stops are both located towards the edge of the main developed areas, which decreases the accessibility to the stops from the northern parts of the development.

Multi-Modal Interchange/Newmarket Road Travel Hub

4.11 The Multi-modal Interchange/Newmarket Road Travel Hub is proposed to accommodate a minimum of 2,000 vehicles and be located on the A1303 at Longfield Farm, to the north east of the main Cambridge East development. The site will provide access from the east to the development, to Cambridge Station, and if the CAM network is implemented, to the wider Cambridge area. As set out in Cambridge East: Transport Vision and Emerging Transport Strategy document, whilst the Newmarket Travel Hub would provide a role in intercepting and switching trips to sustainable modes on entry to the city, it is considered that the optimal use of the land would be that the site also integrates with other complementary land uses around it to provide broader benefits to users. Such land uses could be food and beverage outlets, parcel pick up/click and collect services, childcare, white good pick-ups, and workstations, for example.

4.12 The location here strategically intercepts traffic on a key radial route into Cambridge from the east as close to the Strategic Road Network (A14) as possible, reducing impacts on the local highway network between the site and Cambridge City Centre.

4.13 Furthermore the location is in-line with the Local Authorities aspiration to potentially relocate the current Newmarket Road Park and Ride site to this area, which, at the time of writing, is currently undergoing a public consultation process.

4.14 The multi-modal nature of this design element is intended to allow transfer between the transit system and walk/cycle, private vehicles, taxis, demand responsive transit services (DRT) and scheduled bus and coach services.

4.15 As the site will form the eastern terminus of the transit, it will require two platform faces and crossovers to allow LRVs access to and from both platforms.

4.16 The size and layout of the parking area are yet to be determined. The site should be designed to allow for expansion of the parking area as demand grows, and as/when the network is expanded as part of the wider CAM project and also have the ability to reduce in size in the far-future should car usage decrease as public attitudes and travel trends evolve.

Depot

4.17 The depot is required to provide stabling and maintenance facilities for the LRVs, together with facilities for the staff who will operate, manage and maintain the system.

4.18 The size of the depot facility is largely dependent on the number of vehicles in the fleet. Fleet requirements for various scenarios are discussed in Chapter 6. For a free-standing Cambridge East initial system operating with single LRVs, with a fleet of up to 10 LRVs, only a small site is required, with 3-5 stabling sidings and maintenance facilities sufficient for cleaning, inspection and maintenance activities. With such a small fleet it will be more economic for the less frequent maintenance activities to be undertaken off-site. An enhanced provision of key components, such as wheelsets and traction motors, would allow these to be swapped out on-site with the removed units taken for inspection, maintenance and repair elsewhere. If coupled LRVs are to be operated the fleet size doubles, and there will need to be a corresponding increase in the facilities provided, and it may then be more economic to carry out more activities on site. The depot could also potentially become a CAM depot in due course.

4.19 The depot will also be the location where drivers sign on and off (although staff shift changes may also occur at Cambridge Station), and the base for the cleaning and maintenance staff, so basic staff welfare facilities will also be required. The free-standing system will have a control room, together with a small operator and management complement. These would also normally be accommodated on the depot site, although some roles could be located elsewhere.

4.20 The depot would typically be located beyond the operating section of route, i.e. east of the Multi-modal Interchange/Newmarket Road Travel Hub, although alternative locations are also possible. If car parking is to be provided with a multi-storey facility to minimise land take, it is perfectly feasible to provide such parking decks over the LRV depot/maintenance building.

Ground Conditions

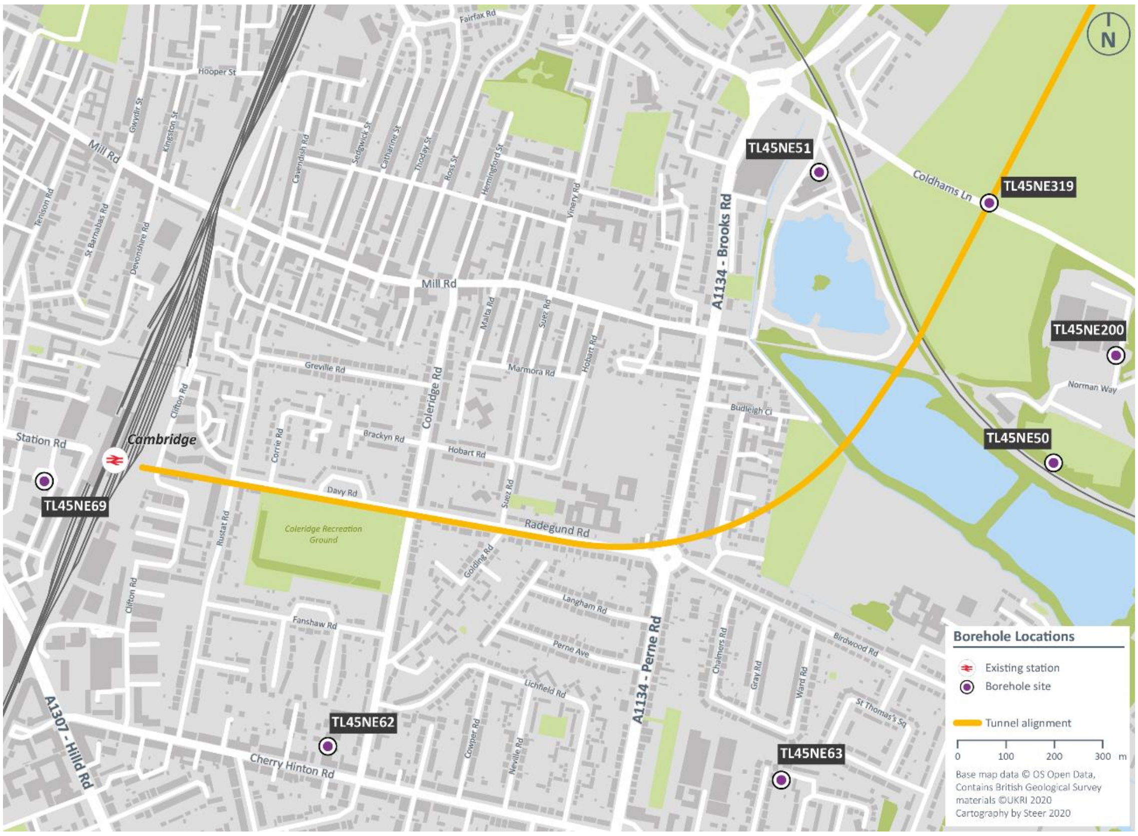
4.21 The ground conditions between Cambridge Station and east of Coldham's Lane are a major determinant of the feasibility, cost and alignment of the tunnelled section of the route.

4.22 The general solid geology of the area of interest comprises made ground and alluvial deposits at the surface, underlain by Chalk, Gault Clay and Lower Greensand. While the depths of made ground and alluvium vary across the area, the Chalk, Gault Clay and Lower Greensand are fairly consistent.

4.23 Borehole data made available by the British Geological Survey (BGS)[4] have been reviewed to assess the likely ground conditions along the proposed tunnel route. Boreholes were identified which gave details of the strata down to at least the bottom of the Gault Clay. These borehole logs were used to develop an indicative ground profile. Their locations are shown in Figure 4.4. These deep boreholes were generally bored as wells to access water in the Lower Greensand. The BGS also lists a number of shallower boreholes in the study area, generally used to establish design parameters for building foundations. These do not identify the base of the Gault Clay and are of limited use for this project.

4 British Geological Survey, GeoIndex (Onshore) map viewer, https://www.bgs.ac.uk/map-viewers/geoindex-onshore/

Figure 4.4 Borehole Locations used for Indicative Ground Profile



4.24 Table 4.1 below summarises the borehole data, giving the elevation of the base of each of the main strata. The Chalk layer is some 10-12m thick, and the Gault Clay around 37-40m thick. The base of the Lower Greensand was not encountered in any of the boreholes.

Table 4.1 – Borehole Data

Levels above Ordnance Datum (m)	Borehole Reference						
	TL45NE 69	TL45NE 62	TL45NE 63	TL45NE 50	TL45NE 200	TL45NE 51	TL45NE 319
Ground Level	15.24	12.19	10.67	15.24	15.24	9.75	14.68
Base of Made Ground/Alluvium	11.28	n/a	10.44	n/a	n/a	9.14	13.88
Base of Chalk	0.08	-1.52	-4.80	-0.08	-0.08	-0.61	1.48
Base of Gault Clay	-39.62	-38.40	-41.99	-49.00	-49.00	-40.84	NA
Lower Greensand	NA	NA	NA	NA	NA	NA	NA

4.25 In developing a longitudinal ground profile along the proposed route, the strata elevations at each borehole have been translated to the nearest point on the alignment, to give the best indication available from the existing data of the ground conditions likely to be encountered along the route.

4.26 The Gault Clay is similar to London Clay and is an excellent material for tunnelling. Indeed the presence of London Clay at suitable depths under much of London was an important factor in the early and rapid development of the London Underground network.

4.27 For this project the majority of the tunnelled route would be located in the Gault Clay.

Former Quarries (Landfill and Lake)

4.28 Either side of the Cambridge to Newmarket Railway line the route crosses former quarries from which chalk was excavated for the manufacture of cement.

4.29 The quarry to the south of the railway, known as the Western Flooded Quarry, is now a lake, that to the north (the "Biffa" quarry) has been infilled with waste.

4.30 Mott Macdonald reviewed the health, safety and environmental hazards associated with former quarries in the Coldham's Lane area in 1999[5]. Information from that report has informed this study.

Western Flooded Quarry

4.31 Ordnance Survey data shows that the water level in the Western Flooded Quarry is approximately 6.6m above ordnance datum (AOD). The Mott Macdonald report notes that the lakes are up to 8m deep, giving a base level for the lake of around -1.4m AOD. This is close to the interface between the Chalk and the Gault Clay, suggesting that all the chalk was excavated until the clay was encountered.

"Biffa" Quarry

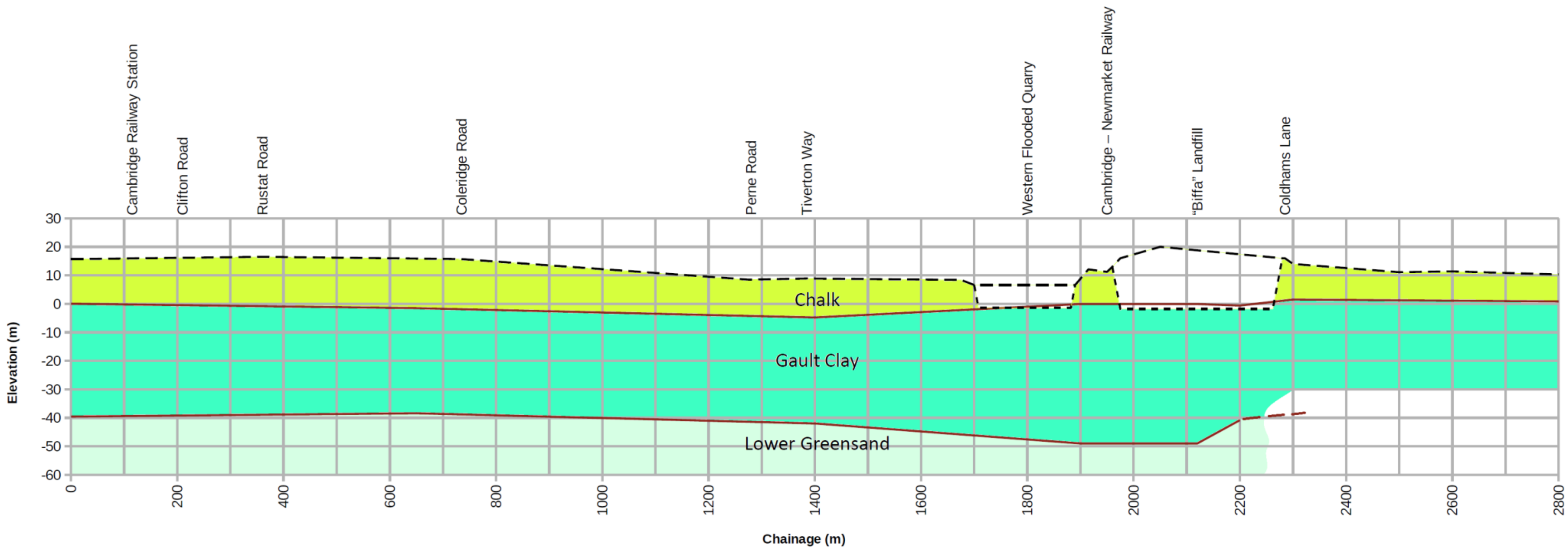
4.32 The Biffa quarry was infilled between 1978 and 1989 with industrial, commercial and domestic waste, and contains waste to depths of between 11.5m and 22.5m. A thin clay capping 0.1-0.4m thick was originally placed over the waste, but by 1999 a more substantial layer had been added. In 1999 the site was actively gassing, and a gas extraction system was installed. Since 1999 the rate of gas generation will have reduced, but it is unlikely to have ceased altogether.

4.33 The infill rises above the surrounding ground, with a maximum elevation of around 21m AOD. If these high areas coincide with the reported maximum depth of waste infill of 22.5m, then the base of the quarry will be at about -1.5m AOD, i.e. very similar to the Flooded Western Quarry, suggesting that this quarry was also worked until the clay was encountered.

4.34 Overall it is considered the quarries do not present major challenges to construction which cannot be overcome.

5 Blue Circle Site, Coldham's Lane - Review of Health, Safety and Environmental Hazards, Mott MacDonald for Cambridge City Council, March 1999

Figure 4.5. Indicative Ground Profile along the Route



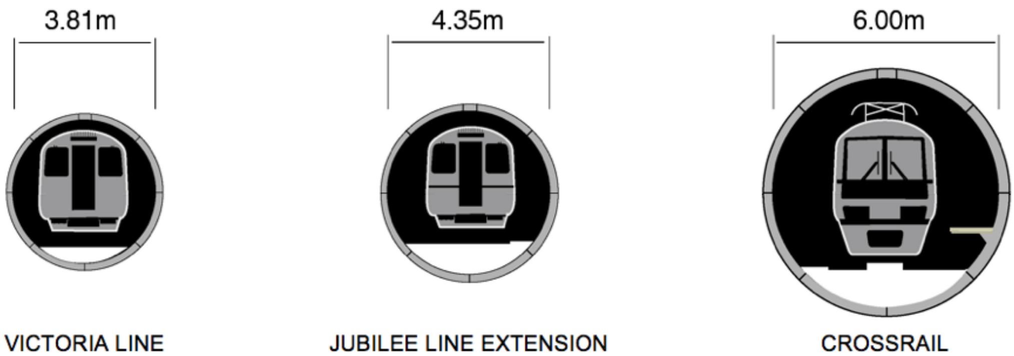
Typical Tunnel Details

Tunnel Cross Section

4.35 For a project of this type is it desirable to keep the tunnel diameter as small as reasonably practical, both for reasons of cost, and to minimise settlement of the ground above the tunnel. The minimum cover to be provided between the tunnel crown and the top of the Gault Clay also varies with diameter, so a smaller diameter would allow the tunnel level to be higher as it passes under the north-eastern edge of the landfill site, which in turn would minimise the tunnel length and allow the track to reach ground level sooner.

4.36 Historically, underground transit systems have adopted vehicles with curved roofs which are a fairly close fit to the tunnel bore. The older London Underground tube lines have a tunnel diameter 3.6 - 3.81m. In more recent years it has become standard practice to provide a continuous walkway alongside the track to allow emergency escape for passengers and access for emergency personnel. The Docklands Light Railway Bank Extension used 5.0m diameter tunnels to accommodate both the boxy vehicle profile and a walkway on one side. The Jubilee Line Extension used 4.35m tunnels with standard tube rolling stock. Current London Underground practice is to provide a passenger emergency escape walkway 0.85m wide and 2.0m high on one side of the track, and an access route for emergency personnel 0.45m wide by 2.0m high on the opposite side. This has resulted in increased tunnel sizes for other projects, as shown in Figure 4.6.

Figure 4.6 Comparative Tunnel Sizes from Other Projects

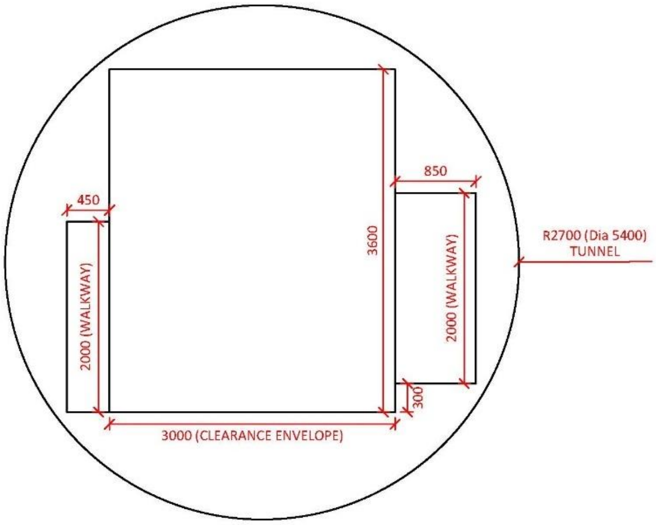


4.37 The passenger emergency walkway would be set at approximately the same level as the vehicle internal floor to allow safe and rapid exit from the vehicles, including for those with wheelchairs, buggies or other mobility impairments. The emergency services personnel access would be set at rail level (to allow access under the vehicle if required). Having two access walkways avoids any potential conflicts between departing passengers and arriving emergency personnel.

4.38 The previous study assumed a tunnel internal diameter of 5.75m. On the basis of typical light rail vehicle dimensions (but allowing a degree of flexibility for alternative vehicle types) and using London Underground requirements for evacuation and emergency personnel access walkways, a tunnel diameter of 5.3-5.4m should suffice. See Figure 4.7 below for an example cross-section of such a layout.

4.39 For the underground station at Cambridge Railway Station, described in the next chapter, platform tunnels of 7m diameter are proposed for the ends of the platforms beyond the central station box. This allows for platform widths of 3m in the platform stubs (and wider in the central area), as well as for the emergency personnel walkway on the opposite side.

Figure 4.7 Example 5.4m Tunnel Section



Trackform

4.40 Within the tunnel the light rail track form will comprise conventional flat bottomed rails. These in turn are supported by 'hedgehog' sleepers – precast concrete sleepers with projecting steel reinforcement - which are then cast into mass concrete infill in the tunnel invert. Drainage channels would be formed in the surface of the invert concrete either side of the track. At low point(s) in the alignment sumps would be provided to allow any water in the tunnel to collect and be pumped out.

Ventilation

4.41 In normal operation the passage of LRVs is expected to cause sufficient air movement to ventilate the underground tunnels and the station. Fans may be needed for smoke extraction in an emergency. Detailed modelling of the underground layout of the tunnels and station is needed to determine the size and location of fans.

Emergency Access/Escape

4.42 Emergency access points to transit tunnels are normally provided at intervals of no more than 1.5km (so that all parts of the tunnel are within 750m of an access point). Access would be available at the Rustat Road and Coldham's Lane portals. Intermediate access points require a separate shaft with access/escape stairs (and in the case of twin tunnels, separate access to each tunnel). The shaft may also be used for tunnel ventilation.

4.43 For the approximately 2.2km tunnel between Rustat Road and Coldham's Lane, one intermediate access point is required, which would need to be located between about 200m west of Perne Road roundabout and the middle of the Burnside Allotments site. Possible options are:

- open land at the front of the Coleridge Community College site;
- in the middle of the Perne Road roundabout; and
- in the Burnside Allotments site.

4.44 The option in the middle of the roundabout would need to be accessed by an approximately 50m-long side tunnel. Access points can be designed to be discrete and sensitive to the local surroundings.

Vertical Alignment - Cambridge Station to North of Coldham's Lane

4.45 An indicative vertical alignment has been developed. This is based on the tunnel being almost entirely within the Gault Clay and maintaining cover of 1.5 tunnel diameters between the tunnel crown and the top of the clay, and beneath the water filled and infilled former quarries. This clearance is typically used in tunnel design to provide safe tunnelling conditions and to minimise the effects of tunnel excavation on buildings and structures above. That said, given that over most of the tunnel length, the Gault Clay is overlain by Chalk, it may be possible to raise the tunnel level somewhat, which would reduce the depth of the intermediate access shaft.

4.46 As described above, in this version, the alignment is assumed to be at existing ground level at Cambridge Station and across Clifton Road, before descending in retained cutting to the tunnel portal. Figure 4.6 shows a profile for this section of route with a maximum gradient of 6%. This shows that between Clifton Road and Rustat Road the route drops enough to enter cut-and cover tunnel west of Rustat Road, but that the cut-and-cover tunnel would need to continue for a short distance along Davy Road before the route can enter the bored tunnel.

4.47 Figure 4.7 shows a variant profile with 8% gradient, which allows the driven tunnel portal to be reached immediately west of Rustat Road. Clearly this latter option would be significantly less disruptive during construction.

4.48 In both variants the main length of tunnel below Davy Road and Radegund Road descends on a gradient of 0.5% to a low point just beyond the Cambridge to Newmarket railway line. This nominal gradient allows any water in the tunnel to drain to a sump from where it can be pumped out to the surface.

4.49 The critical point for determination of the vertical alignment from here to the Coldham's Lane portal is the bottom of the infilled quarry. On the basis of the information above this is assumed to be at an elevation of -1.8m AOD, and it has been assumed that the quarry sides slope down at an angle of 45˚ .

4.50 The tunnel profile shown in Figure 4.8 provides 1.5 diameters' cover beneath this critical point, with the tunnel rising at 6% gradient from here to the surface north-east of Coldham's Lane. The tunnel portal would be approximately 11m below ground level and located about 240m from Coldham's Lane. This is followed by a length of cut and cover tunnel and retained open cutting, with a vertical curve to bring the gradient to approximately horizontal as the route reaches ground level. The south end of the first surface stop would need to be located at least 430m from Coldham's Lane. This is approximately 100m north of the position shown on the Option 8.1 plans in the previous study.

4.51 Figure 4.9 shows the variant profile with the same clearance beneath the infilled quarry but rising at 8% to ground level. This reduces the length of the gradient, with the tunnel portal located approximately 170m from Coldham's Lane and places the south end of the first surface stop some 325m from Coldham's Lane.

4.52 Figure 4.10 shows the profile (with 6% gradients) for the case where the driven tunnel portal is located immediately north-east of Coldham's Lane. In this case the southern end of the first surface stop could be located about 190m from Coldham's Lane. However, the tunnel drive would pass wholly or partly through the quarry infill material for a length of about 120m, and 150-200m of the tunnel to the south-west would have less than 1.5 diameters' cover to the base of the infill. Further detailed assessment of the infill material and the approach to tunnelling through it would be required to determine the feasibility and cost-effectiveness of this approach.

Figure 4.8 Option T1 Profile 6% Maximum Gradient

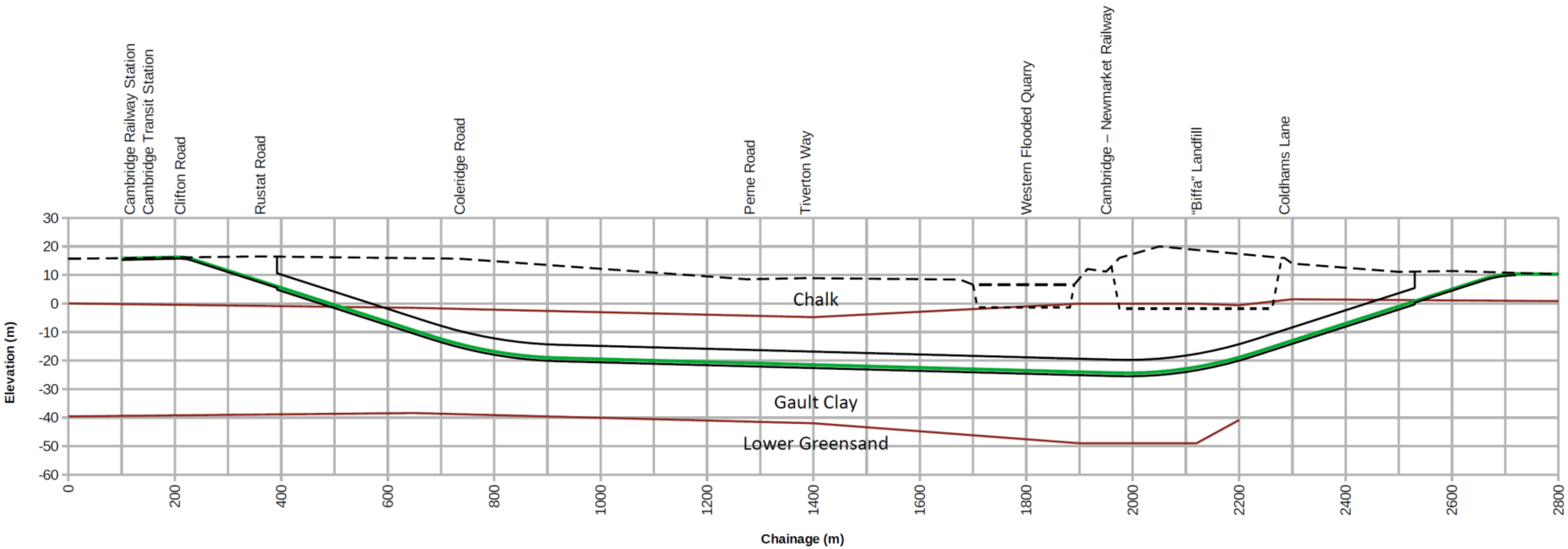


Figure 4.9 Option T1 Profile 8% Maximum Gradient

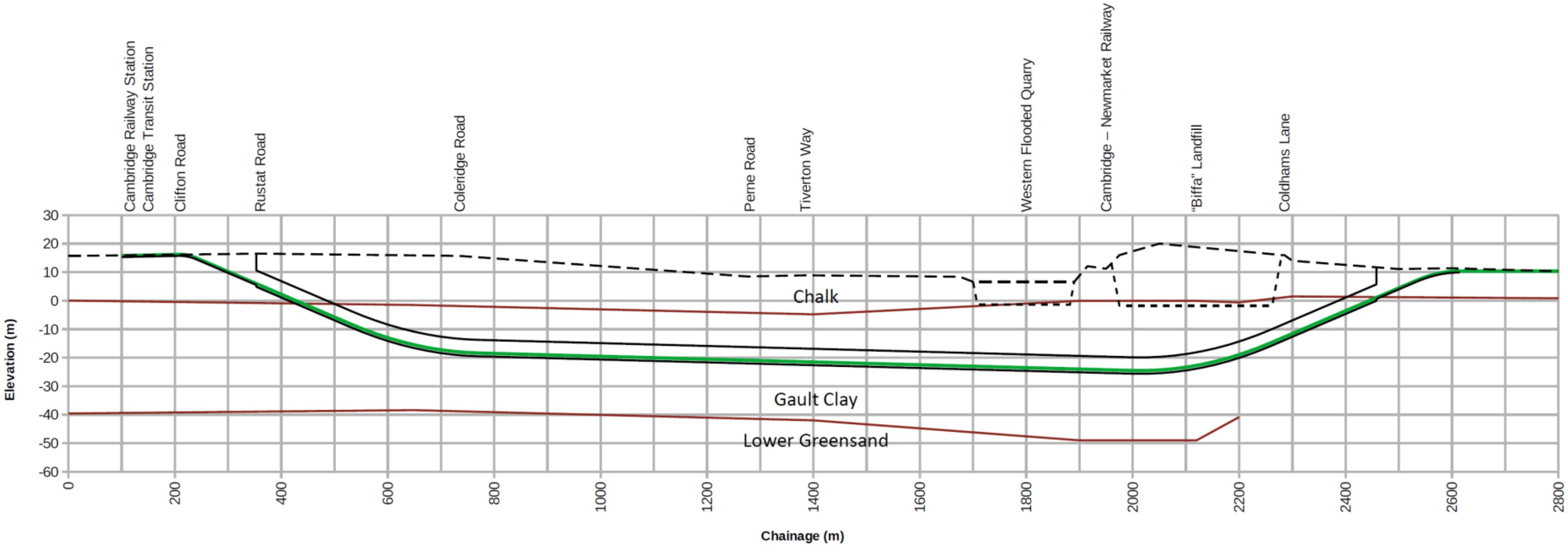
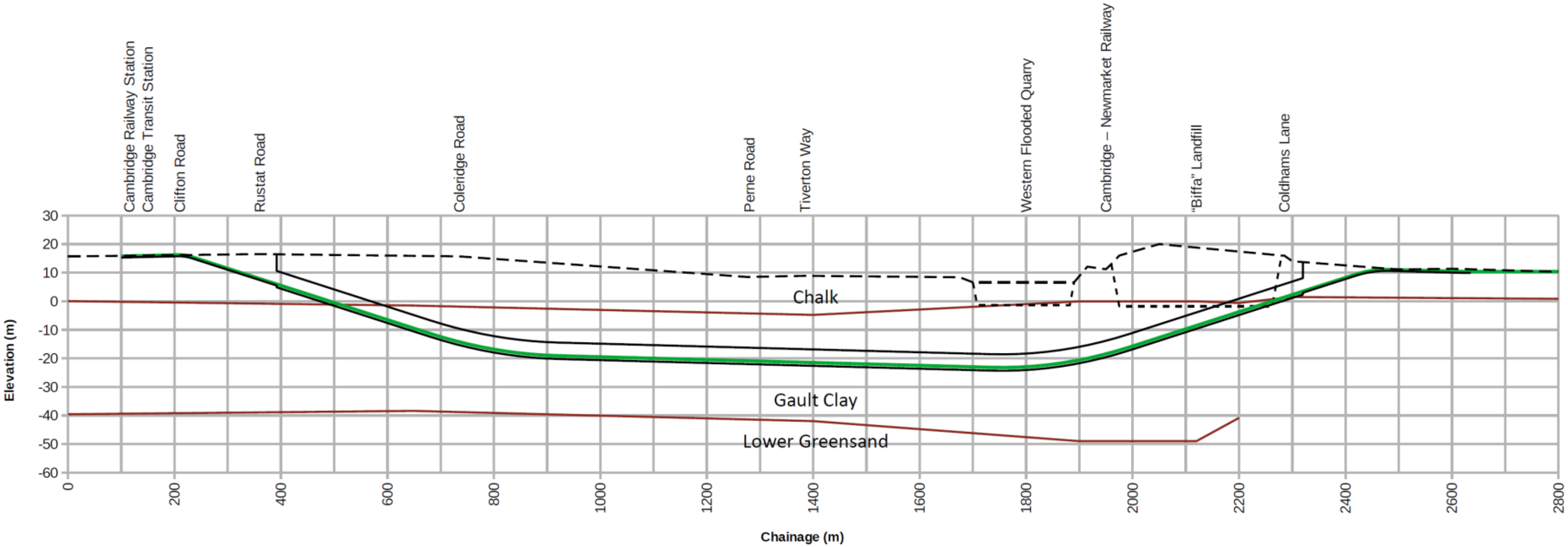


Figure 4.10 Option T1 Profile 6% Maximum Gradient, Driven Tunnel Portal Close to Coldham's Lane



Surface Stops

4.53 The stops on the surface section of the route will be simple at-grade stops. Platforms are assumed on both sides of the tracks, approximately 350-400mm high (above rail level) and 60m long, to accommodate coupled LRVs. The ends of the platforms are assumed to be sloped down to track level to facilitate access and crossing the tracks. The back edge of the platform should be blended into the level of the adjoining surface to provide easy step-free access.

4.54 Platforms are assumed to be equipped with shelters, seating, lighting, passenger information systems, public address. Depending on the fare/ticketing system to be adopted, stops may also be equipped with ticket vending and/or validation machines. Controlled access with barriers, as used on main line railway stations, are assumed not to be needed.

Surface Trackform

4.55 The trackforms to be used would be similar to those adopted on other UK light rail systems.

4.56 In areas accessible to pedestrians and at road crossings, embedded track with grooved rails are assumed to provide a flush surface. The rails would be embedded in a resilient polymer material (to provide some noise and vibration attenuation) in slots in a reinforced concrete foundation slab. The areas between and either side of the rails can be paved in a variety of materials, depending on the treatment of adjacent paved areas. Suitable materials include block paving, stone setts, asphalt, plain concrete and imprinted concrete.

4.57 In public areas not normally used by pedestrians or vehicles, grass track (where the area between and either side of the rails is grassed) could be used.

4.58 Where the route runs in full segregated alignment, not accessible to pedestrians conventional ballasted railway track could be used.

Power Supply

4.59 Conventional LRT systems are powered from an overhead line, usually operating at 750V dc. A pantograph is fitted to each vehicle to collect the power, and the return current returns via the wheels and the running rails.

4.60 Ground level power pickup systems have been used on some LRT systems, in visually sensitive areas, to avoid the need for overhead lines and supporting masts. To date these have not been as reliable as overhead line and are significantly more costly.

4.61 London’s Docklands Light Railway uses a low-level bottom-contact power rail, which is less susceptible to weather-related disruption than the top-contact third rail system used on London Underground. However, this is only appropriate for a fully segregated system.

4.62 More recently, interest has focussed on the use of battery and hybrid battery powered LRVs. Battery technology is developing rapidly, and by the time the transit system comes to be implemented, battery power may well be a viable alternative to a fully overhead line powered system. But it should be noted that the whole life carbon impact of battery based systems is in general not as attractive as the use of fully electrified systems (as assumed here), given the pace of UK electrical power generation decarbonisation The tunnel section can be provided with overhead line equipment both to power the LRVs and (if necessary) to recharge the batteries while operating underground.

4.63 Some recharging could also take place at the north-eastern terminus of the route where LRVs are likely to dwell longer than at the intermediate stops. Vehicles would also be recharged overnight at the depot when not in service.

4.64 Power will be supplied to the route from substations located along the route. The substations in turn require a suitable connection to the local grid. The availability of such supplies may be a factor in determining the substation locations. Small-scale substations would typically be located at around 1.5km intervals, meaning that for the approximately 5.5km route about 4 substations will be needed. The suggested arrangement is that one substation would be located at the depot, and another at Cambridge Station (where it may be possible to feed from Network Rail's power supply). To avoid having a substation and feed-in in the tunnel section, the next substation would be located at the tunnel portal at Coldham's Lane, with a further substation located in the middle of the development site. A free-standing transit substation, housing transformers, switchgear and other electrical equipment, would be contained within a single storey building typically about 11m by 4m. It could also be integrated with a substation serving the development and using a common power feed from the grid. This may be appropriate for the two central substations within the development site.

4.65 A full power study will be required to confirm the locations and ratings of the substations and associated switchgear and cables etc.

Signalling and Communications

4.66 Light rail transit systems are generally manually driven on a line-of-sight basis. Road crossings and junctions are controlled by conventional traffic signals, with special LRT-only aspects operating in conjunction with the normal red/amber/green signals for other traffic.

4.67 Access to the bi-directional single track tunnel section could be controlled by a railway-type signalling interlock, to ensure safe operation.

Utility Interfaces

4.68 Where the LRT route crosses utility pipes and cables it is usually necessary to either divert or protect the utility apparatus, so that the apparatus can be maintained, and to minimise disruption to LRT services should there be a failure of the utility apparatus.

4.69 For Option T1 there will be few utility impacts. The underground route will pass well below any utilities and, within the Cambridge East site, there is likely to be very little existing utility apparatus to be retained, and the new services for the development will be located away from the transit alignment. That said, it will be prudent to incorporate empty ducts across the alignment beneath the track at regular intervals, to allow for the straightforward installation of additional service pipes and cables in future.

4.70 There may be some utility impacts at Davy Road, Rustat Road, in the open area between Rustat Road and Clifton Road, and at the crossing of Clifton Road.

4.71 At Cambridge station there may be a need to relocate some railway signalling or power cables.

Safety Requirements

4.72 The safety of light rail and similar transit systems in the UK falls within the scope of The Railways and Other Guided Transport Systems (Safety) Regulations (ROGS), introduced in 2006 and amended in 2011 and 2013, with the Office of Rail and Road (ORR) being the enforcing authority.

4.73 Before ROGs Her Majesty's Railway Inspectorate (HMRI), part of the Health and Safety Executive (HSE), had responsibility for approvals before the bringing into service of new or altered railway (including light rail) infrastructure and rolling stock, but ROGS set out a self-certification procedure, based on risk assessment. The requirements for a light rail scheme are less onerous than those for main line railways and principally comprise the following:

- **Safety management systems.** ROGS give transport undertakings and infrastructure managers a duty to develop safety management systems that must meet certain requirements. However, the safety management system should be adapted to fit the size and nature of the business - for a smaller organisation a simpler safety management system should be appropriate.
- **Safety verification.** Operators must show that they have procedures in place to introduce new or altered vehicles or infrastructure safely. If there is a new or significantly increased risk to safety a project must go through a safety assurance process involving an independent competent person. Operators are responsible for making sure that a project is safe.
- **Safety certificates and authorisations**. Safety certificates (for transport undertakings) and authorisations (for infrastructure managers) should describe how the safety management system allows the transport system to be run safely. ORR's focus is on checking that safety management systems are effective and fit for the purpose they are being used for.
- **Risk assessments**. ROGS give transport operators a specific duty to carry out risk assessments and put in place the measures they have identified as necessary to make sure the transport system is run safely.
- **Cooperation**. ROGS also give operators a duty to work together to make sure the transport system is run safely.
- **Safety critical work.** Operators and their contractors have clear duties under ROGS to make sure their employees who carry out safety critical tasks are suitably competent and fit to do so. This also includes making sure these employees are not affected by fatigue.

4.74 Since ROGS places the onus on project promoters, owners and operators to develop their own safety systems and risk assessments, there are few specific requirements for safety set out in standards. Nevertheless, guidance is available from ORR, UKTram and others that draws together best practice from current and previous projects. Such guidance and practice elsewhere has informed the development of this project.

4.75 The tunnel will be accessible at the Rustat Road and Coldham's Lane tunnel portals. In addition, it is usual practice to provide intermediate access points at intervals of 1.5-2.0km (i.e. putting any part of the tunnel within 750-1000m of an access). For this project the main tunnel is a little over 2km long, and it is proposed to provide a single intermediate shaft near the mid-point. The access shaft will be provided with stairs from ground level to the tunnel but will be separated from the tunnel itself by fire doors. The shaft may also be used as part of the tunnel ventilation/smoke extract system.

4.76 Some of the possible alternative alignments discussed later in this report have shorter lengths of tunnel, and for these, no intermediate shaft is required.

5 Engineering Design for Alternative Alignments

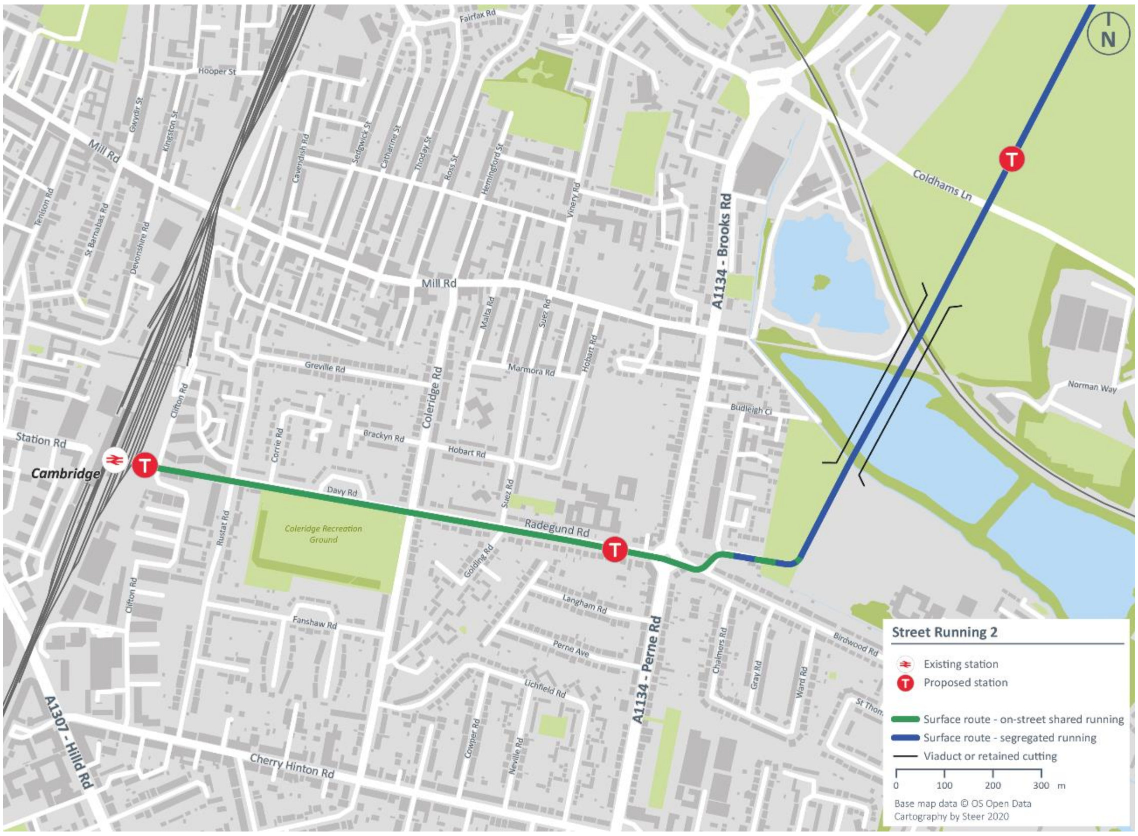
Introduction

5.1 This chapter outlines a number of alternatives – both surface and tunnelled – to the T1 transit scheme. The variations arise for the route between Cambridge Station and Coldham's Lane; North of Coldham's Lane, these alternatives would be as described above for the Option T1. All of the alternatives use the same LRT technology as Option T1, and all are capable of being incorporated into a wider CAM network. The naming of the options corresponds with that set out in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

Option S1 – Surface Alignment – Cambridge Station to North of Coldham's Lane

5.2 This alternative envisages an entirely surface operation, with no tunnelling. Its alignment from Cambridge Station would broadly follow the same horizontal alignment as the Option T1 underground route and is shown in Figure 5.1. It would be double track throughout.

Figure 5.1 Option S1 Surface Route Horizontal Alignment



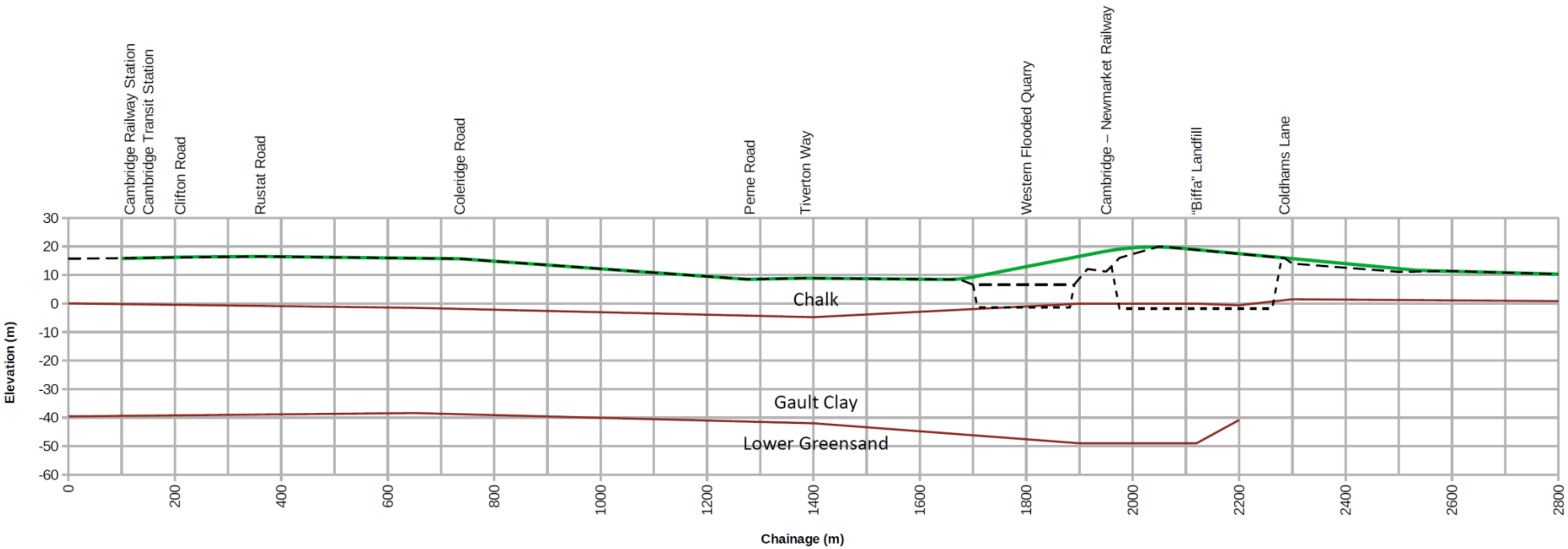
5.3 The route would start at a surface station immediately to the east of Cambridge mainline station and would then proceed across the grassed area to the south of Rustat Avenue, then continue in shared running on street along Davy Road and Radegund Road and into Birdwood Road. The mini roundabout at Rustat Road/Davy Road would be converted to traffic signals. The Perne Road roundabout would either be signalised with the transit route running across the centre of the island, or the junction could be converted to a conventional signal controlled crossroads.

5.4 From Birdwood Road the route would turn to run north then east along Ancaster Way to the Burnside Allotments site. There is some flexibility in the alignment from here to Coldham's Lane, and the impact on the allotments could be reduced by running in part through the St. Bede's School playing fields if this was for some reason preferable. The route shown runs across the allotments from Ancaster Way then broadly follows the boundary between the allotments and the playing fields to the south side of the lake.

5.5 The route would cross the flooded quarry on a viaduct rising to cross over the Cambridge to Newmarket railway, as shown in Figure 5.2. The piers of the viaduct across the lake would be supported by piles founded in the Gault Clay below the lake. Similarly, the north-east end of the structure may need foundations piled through the landfill into the clay. The viaduct, including the railway crossing, would be about 300m long.

5.6 The height of the landfill above the surrounding ground generally suits the profile of the transit route, falling towards Coldham's Lane. Some form of ground improvement will be needed to stiffen the fill material sufficiently to support the track. This section of the route should be constructed on ballasted track to allow future reprofiling should there be significant further settlement of the fill material. Alternatively, if the fill material is found to still be very loose, it may be necessary to construct a raft foundation for the track, supported by piles driven through the infill material into the underlying clay.

Figure 5.2 Option S1 Vertical Alignment across Lake and Landfill Site



5.7 The route would cross Coldham's Lane at grade under traffic signal control to enter the development site.

5.8 A stop could be located immediately to the north of Coldham's Lane. One or more intermediate stops could also be provided on the on-street section along Davy Road/Radegund Road. A single stop, west of Perne Road, serving Coleridge Community College is shown.

5.9 Due to the on-street running along roads which are currently subject to a 20 mile per hour speed limit, the traffic signal controlled junctions along the route and the possible additional stop and the much smaller curve radii on the Birdwood Road/Ancaster Way section the journey time would be some 4-5 minutes greater than for the underground section of route, and the journey times achieved in service would be more variable. The surface line would need to be double track throughout and this would be needed because of the slower journey times and the greater likelihood of service disruption to allow greater operational flexibility than is required for the single track tunnel approach

Integration with CAM

5.10 The CAM project envisages a mainly segregated alignment, with sections of shared on-street running where road traffic levels are relatively light. It is assumed that Davy Road and Radegund Road would be regarded as 'relatively lightly' used, and so acceptable for mixed traffic on-street operation. But this does breach any specification that calls for a fully segregated system.

5.11 The initial transit route Option S1 could be later incorporated into an underground central Cambridge CAM network, by replacing the initial at-grade terminus with an underground CAM station. It would be necessary to construct a ramp down from street level to the underground tunnels, and it is suggested that this could be located along the north edge of Coleridge Recreation Ground. In this area Davy Road has wide verges, and it may be possible to realign the carriageway to the north, so that most or all of the new ramp structure could be located within the highway reserve, thereby minimising or even avoiding impacts on the recreation ground.

5.12 This ramp would enable an underground junction between the transit route and the prospective CAM southern branch to be located between the tunnel portal and the underground station, allowing services on both branches to use the underground transit station at the Railway station.

5.13 Figures 5.3 and 5.4 shows an indicative route alignment and vertical profile for the option of extending the S1 surface route via a new ramp to connect to an underground station of the form described later in this chapter. Depending on the depth, location and layout of the underground station, it may be necessary for the ramp gradient to be steeper than 6% (but not more than 8%).

5.14 After completion of these works, the section of the surface route west of the Coleridge Recreation Ground would be removed.

5.15 The southern route works could be constructed while maintaining the transit service to the at-grade terminus, ensuring minimal disruption to service during the construction (although the same issues surrounding conversion to a different (CAM) technology as arise with the tunnelled route would arise with a surface option).

Figure 5.3 Indicative Alignment of Option S1 Extended to Underground Cambridge Station as part of CAM Network

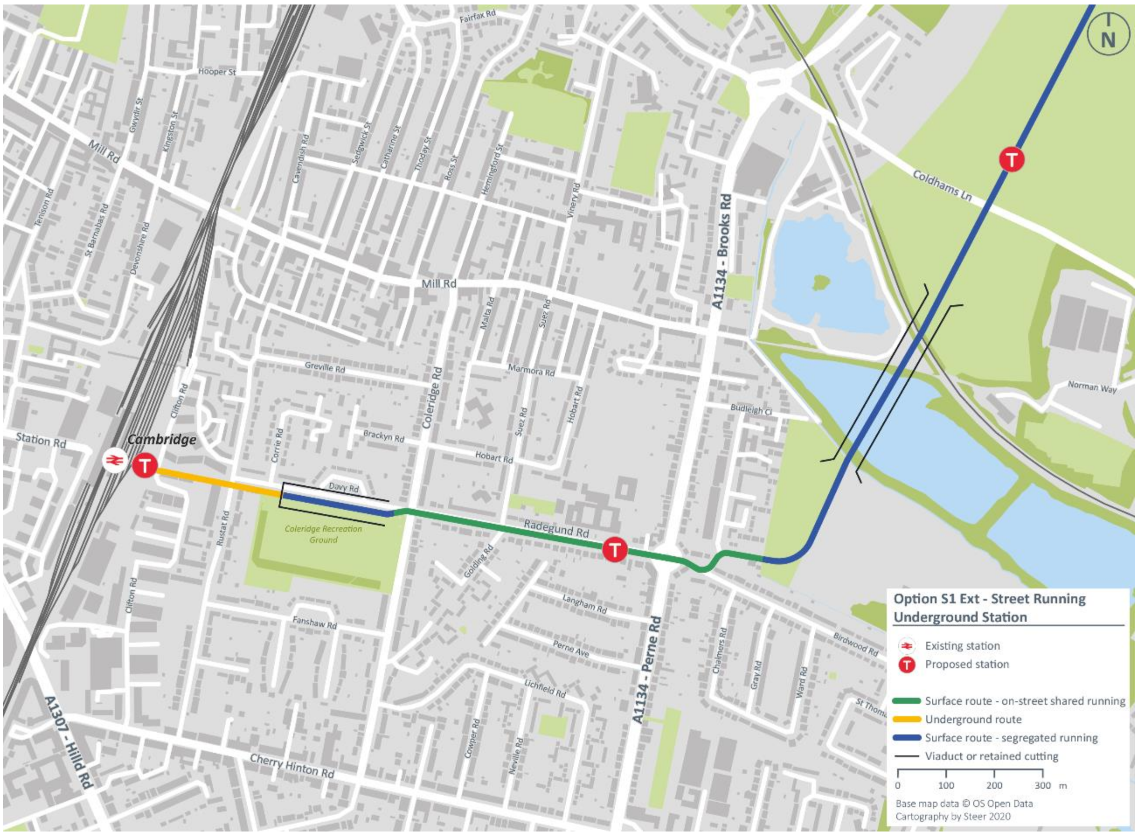
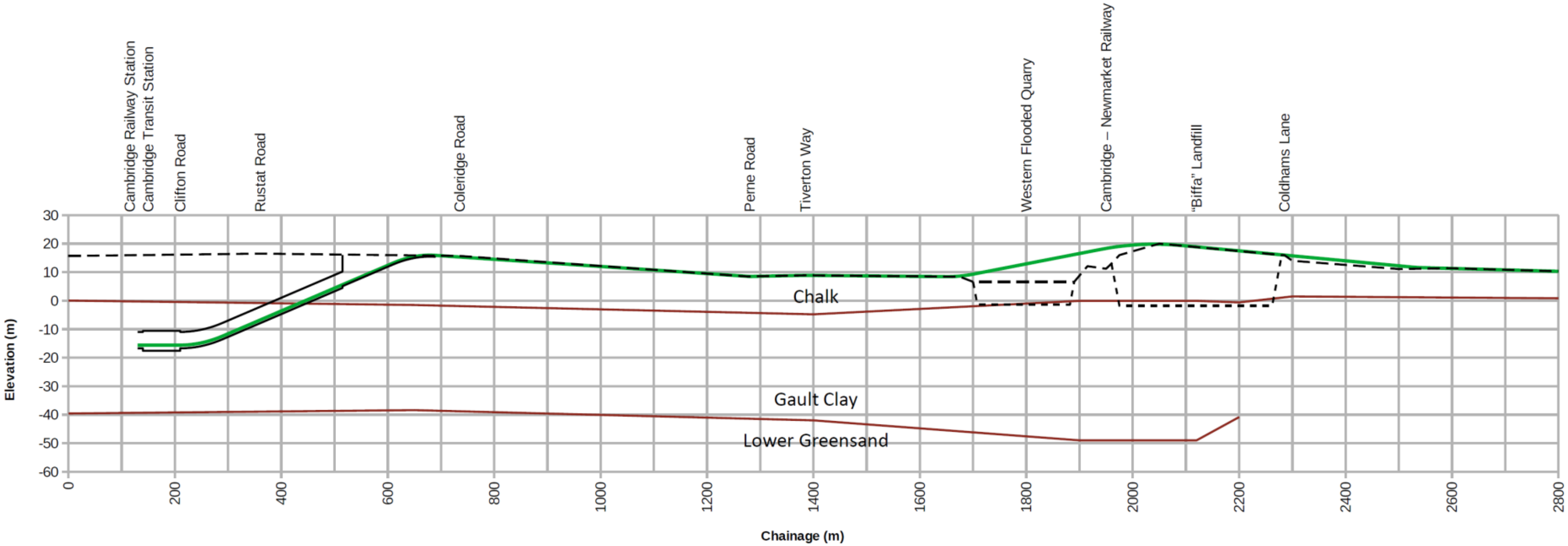


Figure 5.4 Indicative Profile of Option S1 Extended to Underground Cambridge Station as part of CAM Network



Other Surface Options

5.16 Other corridors between Cambridge East and Cambridge Station have also been re-assessed for their suitability for a surface transit option. Neither Coldham's Lane nor Mill Road corridor, while fully considered, can readily provide direct access to Cambridge station, which is considered essential to support the major urban development of Cambridge East.

5.17 Mill Road could be used to access Cambridge station if, at some future date, a comprehensive development of land on the west side of the railway south of the Mill Road bridge could be fashioned. This may well prove possible at some stage in future, but it clearly at this stage introduces an unwanted dependency into plans for Cambridge East. Mill Road itself offers a potentially very useful bus route between Cambridge East and Cambridge city centre (and indirectly, Cambridge railway station) which features in our interim plans for Cambridge East (see report on Complementary Public Transport Interventions, in Appendix B).

5.18 Mill Road is relatively narrow and supports a vibrant community-focused set of shops and businesses. If it is to be considered for a transit link, even assuming that general through traffic is precluded through bus gates and similar controls, it would need to accommodate a transit service *and* local buses *and* cyclists, along with the inevitable needs for access for servicing vehicles, taxis and emergency vehicles, as well as pedestrians and the inevitable wish for some parking, even if restricted to loading only. No priority could be afforded the Transit system in this street environment, even with through car traffic was banned, although with a modal filter a high quality bus route could be feasible. Moreover, any construction activity needed to provide for transit along this street (utility diversions, road/track-bed and electrical power supply, for example) would be inevitably disruptive to the businesses located along Mill Road.

5.19 A surface transit route along the Davy Road corridor has the virtue of leading directly to Cambridge station *and* is much more readily capable of being accommodated since the frontage to frontage distances are much wider than in Mill Road, as highlighted by the comparison shown in Figures 5.5 and 5.6, below.

5.20 As can be seen, operating transit vehicles along the Mill Road corridor would create, in some places, minimal space for other road users, including vulnerable pedestrians and cyclists not being left sufficient room for manoeuvre, making it hard to achieve high levels of safety; and uses (so meaning that on-street residents' parking spaces would need to be displaced). Transit vehicles, whether rubber-tyred or rail based. would run close to properties with associated noise and vibration impacts.

5.21 This compares to the Davy Road corridor, where along the majority of the length of the route there is sufficient space to segregate road users, and the properties are set back much further compared to the Mill Road corridor:

Figure 5.5 – Example Cross Section: Mill Road Corridor

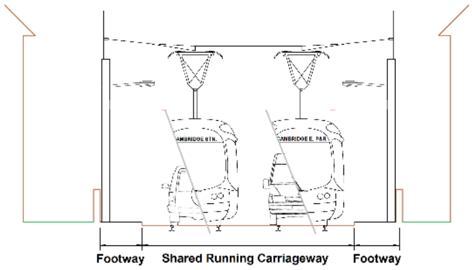
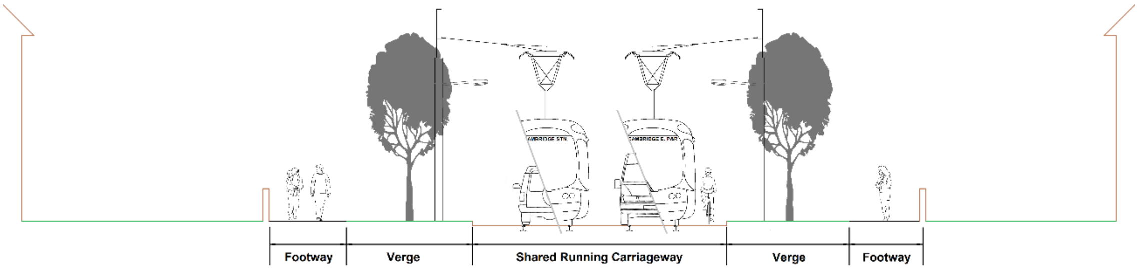


Figure 5.6 - Example Cross Section: Davy Road Corridor

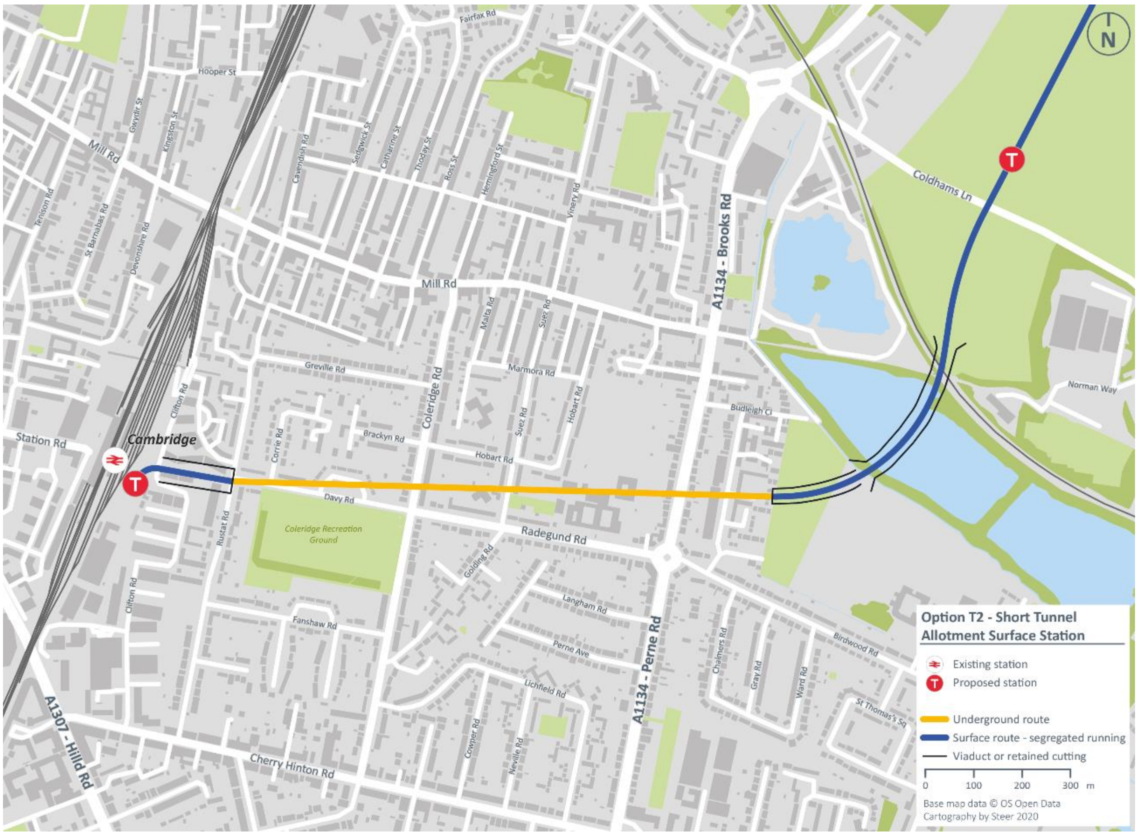


5.22 Notwithstanding the above, we believe that Mill Road along with other corridors have an important role to play in enhancing the connectivity of Cambridge East both in the early years of development and into the future when there would be a complementary function, with the Transit system in operation. These corridors are considered further in Appendix B. The transport strategy as a whole (including active modes) is set out in full in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

Tunnel Option T2

5.23 Figure 5.7 shows Option T2 which has a shorter tunnel compared with the Preferred Option (T1) It follows the same corridor as Options T1 and S1, but the shorter tunnel leads to a surface level route immediately east of the existing built up area. From the surface station at Cambridge Railway Station the route runs as Option T1 to enter a tunnel immediately west of Rustat Road and runs in tunnel a little to the north of Davy Road and Radegund Road, rising to surface within the Burnside Allotments site. From here the route turns north to cross over the lake and the Cambridge – Newmarket Railway on a viaduct and then runs at grade across the landfill site and Coldham's Lane to the development site, in similar manner to Option S1 described above.

Figure 5.7 Option T2 via Davy Road/Radegund Road /Burnside Allotments Corridor



5.24 For this option the tunnel length is such that no intermediate access shaft is required.

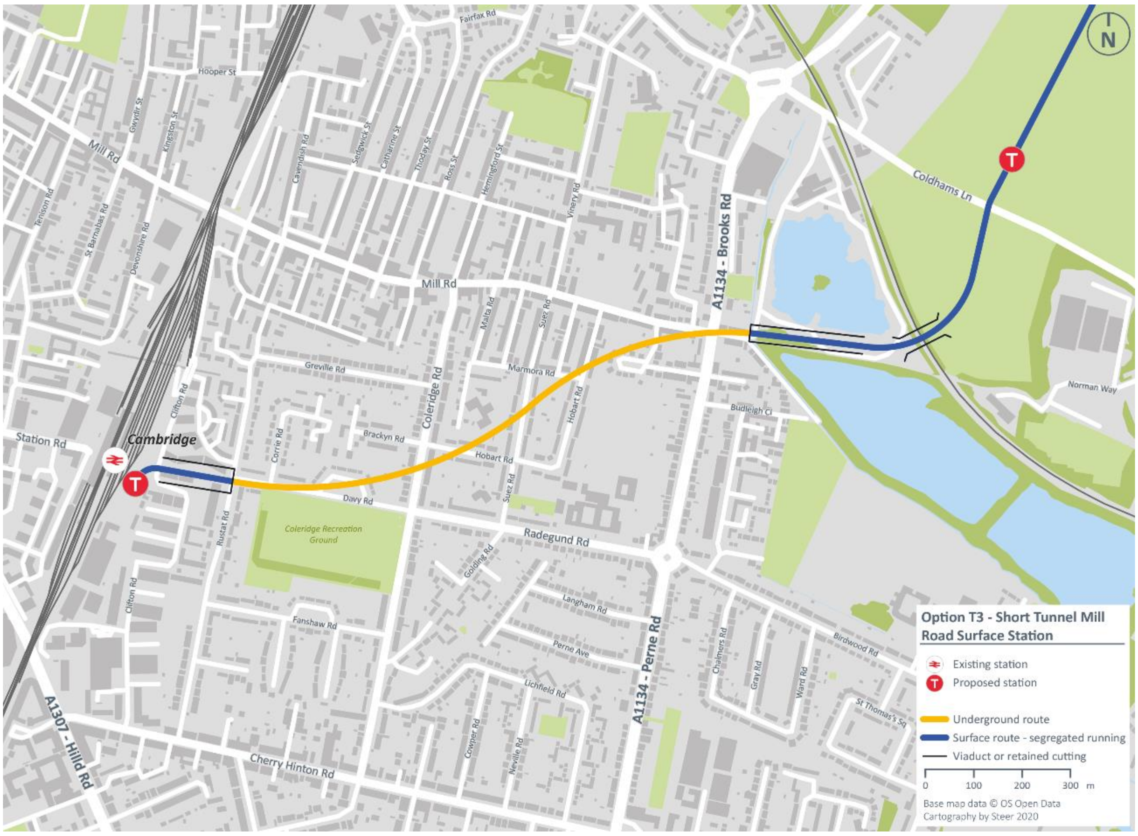
Tunnel Option T3

5.25 Figure 5.8 shows a further option in which the route in tunnel runs from the portal west of Rustat Road, but in more of a north-easterly direction, to an eastern tunnel portal located just beyond the eastern end of Mill Road, on the spit of land between two flooded quarries, adjacent to The Tins footpath. From here the route rises to cross the Cambridge to Newmarket Railway on a bridge, and thereafter continues as in the previous option. This gradient may need to be around 8% to achieve sufficient depth below ground at the tunnel portal and sufficient headroom over the railway.

5.26 This option avoids the cost of the viaduct across the lake and the adverse impact on the allotments which feature in Option T2.

5.27 As with Option T2 the tunnel length is such that no intermediate access shaft is required.

Figure 5.8 Option T3 via Mill Road Corridor



Integration with CAM – Options T1, T2 and T3

5.28 The two tunnel options T2 and T3 could be connected to an underground Cambridge Station, as part of a wider CAM network, in similar manner to Option T1, as described in the following paragraphs.

Cambridge Underground Transit Station

5.29 This section describes an underground Cambridge Station option, as it might be built for a free-standing transit system between Cambridge East and Cambridge Station, running on the surface through the Cambridge East development, then in tunnel from Coldham's Lane to Cambridge Station, i.e. Option T1. The same transit underground station concept design can apply to all options – T1.T2, T3 and S1 in place of the surface transit described above.

5.30 The choice between and underground and surface station at the Railway station will need to be examined in detail in conjunction with Network Rail in due course: it is not necessary to form a preference at this stage. Both surface and underground variants have been conceived so that they can be extended westwards and both can provide high quality onward connection and interchange facilities at Cambridge station.

5.31 The surface stand-alone variants would involve provision of the underground transit station as part of the westward extension works, but the built-out systems would be exactly the same, with the surface transit terminus taken out of use once tunnelling further west was carried out. Compatibility of all of the stand-alone route options with a future wider CAM network is discussed in Chapter 7.

5.32 Possible passenger interchange arrangements for both a surface and an underground station at the railway station are shown in Figures 5.9 and 5.10 below. In practice, any option would need to be worked up in close collaboration with Network Rail.

Figure 5.9 – Example Surface Station Plan

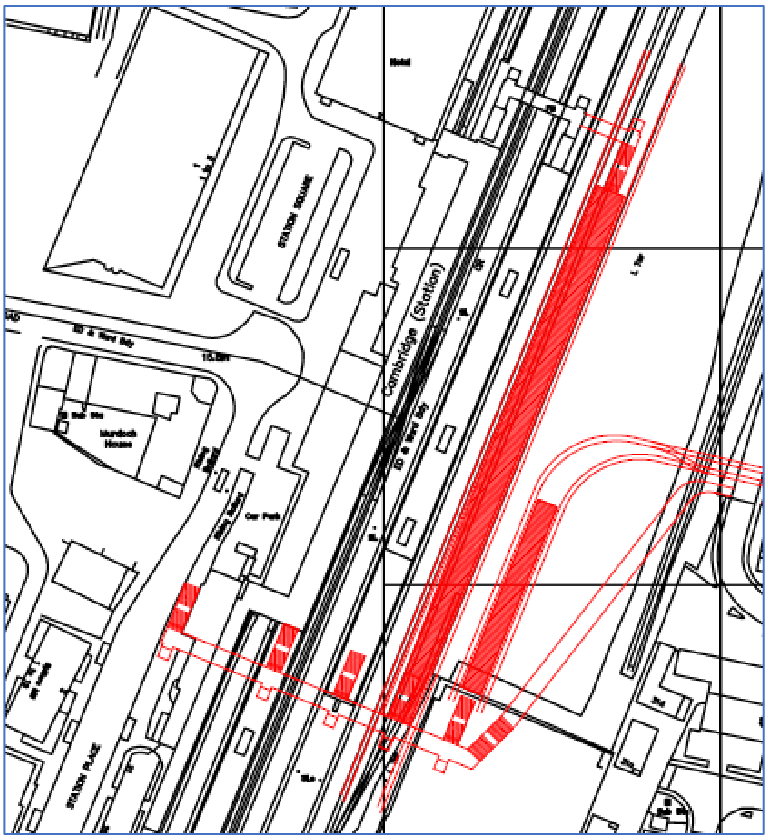
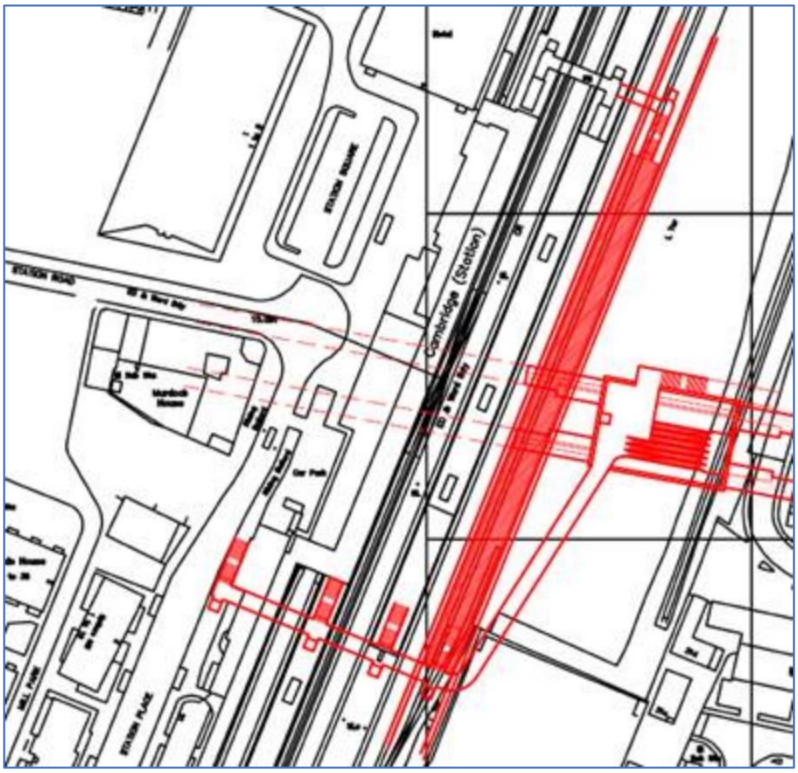


Figure 5.10 – Example Underground Station Plan



5.33 If initially built for use with a free-standing transit system linking Cambridge Railway Station to the Cambridge East development and a park and ride site alongside Newmarket Road, the Cambridge underground station would have two terminus platforms. This maximises the capacity of the single track tunnel, so that as soon as an incoming service arrives, a vehicle already in the station and with passengers boarded can depart. The station design is based on the use of 30m long light rail vehicles coupled in pairs (60m total length).

5.34 Given the constrained station site it is assumed that the central part of the station would be formed in a rectangular box excavated from the surface, but with 7m internal diameter station tunnels extending out at each end. Providing 1.5 diameters' cover to the top of the clay for these tunnels puts the platform level at about 31m below ground level. Subject to further detailed tunnel design and assessment of impacts on nearby buildings, it may be possible to raise this level, but conservative assumptions have been made at this stage. The first (approximately 16m of) excavation will be through made ground, alluvial deposits and Chalk, with the remainder being in the Gault Clay. The best interchange between the underground transit station and the mainline station would be achieved by providing a new subway under the railway between the station forecourt in Station Road and the pedestrian routes to Rustat Road/Davy Road on the east side. Direct access could then be taken from this subway up to each of the mainline station platforms (including the proposed additional island platform), and with the transit station served by a concourse at subway level. This arrangement would provide access to both stations from both sides of the railway and could also provide a pedestrian/cycle connection across the railway for wider public use. This would significantly improve accessibility both to Cambridge Station and to the Station Road area for residents living east of the railway.

5.35 However, tunnelling under the railway tracks, platforms and the main station building would be costly, and potentially disruptive.

5.36 Alternative footbridge options have been considered. The simplest option would be to extend the existing station footbridge across to the east side of the tracks. However, the footbridge would then land in the area of the recently constructed stabling sidings, and it is not clear that an acceptable access can be created. The existing footbridge is also relatively narrow and is unlikely to be of adequate capacity for the additional passenger flows from transit and the additional mainline platforms.

5.37 Network Rail is planning a second footbridge at the station. Footbridge connections right across to Station Road would need to take into account the presence of the historic main station building on the west side of the tracks, and space to land a footbridge in the central part of Platform 1/4 is constrained. A second footbridge towards the south end of the station buildings may be more feasible and could provide direct access to the transit station. The image below illustrates a modern style of footbridge (with escalators and lifts) as deployed with the Copenhagen automated metro system.

5.38 It is concluded provisionally that a subway under the railway tracks, platforms and main station building may provide a better arrangement here with a sub-surface transit station, simply because it reduces the amount of vertical transfer distance involved. Either arrangement would be equipped with lifts and escalators given the likely passenger/pedestrian volumes

5.39 The subway (or footbridge) would provide not only direct access to and between all of the station platforms (including the new island) and the transit platforms, but also, direct access to the platforms from both sides of the railway. This would also be a significant benefit to 'inner east Cambridge' for whom the existing cycle/foot bridge to the north of the station offers only very indirect access.

5.40 On the east side of the railway there would be a concourse/information office at subway level, giving access both to the station subway and to the underground station.

5.41 The subway and concourse floor level would be about 6 metres below ground level. From there down to platform level is a level difference of about 25m. This could be accomplished by two banks of escalators, each with a rise of about 12.5m, together with a single lift shaft for those in wheelchairs, with buggies or other mobility impairment. Each bank would comprise three escalators. Typically, these would be operated with two running in the direction of peak travel and one in the counter peak direction. Having three escalators allows one to be out of service for maintenance while providing service in both directions at all times. At off peak times the centre escalator may be turned off, but still available for use as a staircase.

5.42 The two banks of escalators would be arranged so that passengers make a U-turn at the intermediate landing. This places the top of the upper bank close, in plan position, to the bottom of the lower bank, The lift shaft is located nearby, so that passengers using either the escalators or the lift can be directed to a similar location at both concourse and platform level.

5.43 The space within the lower levels of the station box, not used for the escalators and lift shaft can be used for a ventilation shaft and the electrical and mechanical plant associated with the station operation. The highest level of the station box, at subway level, would house the concourse and ticket office areas. From here stairs and a ramp would rise to the level of Clifton Road. The stairs could rise directly from the concourse towards Clifton Road, but there is insufficient space for a ramp here, which would instead need to be 'folded', running first south then back north, parallel to Clifton Road.

Summary of Options

5.44 Table 5.1 below provides a summary of the key engineering and operational parameters of the various route options set out in this document.

Table 5.1 Option Summary

Option Description	Option T1 Full Length Single Tunnel	Option T2 Short Tunnel via allotments	Option T3 Short Tunnel via Mill Road corridor	Option S1 Street Running
Overall Route Length (approx.)	5.4 km	5.4 km	5.3 km	5.4 km
Length of bored tunnel (excluding approaches) (approx.)	2.2 km	1.2 km	1.2 km	-
No. of intermediate shafts	1	0	0	n/a
Length on bridge/viaduct (approx)	-	300 m	30 m	300 m
Length across landfill (approx)	-	350 m	350 m	350 m
No. of Stations	5	5	5	6
End to end run time (approx)	9 minutes	9 minutes	9 minutes	13.5 minutes
Maximum reliable service frequency	8 per hour*	12 per hour*	12 per hour*	12 per hour
Maximum capacity with 1/2 LRVs**	1600 / 3200	2400 / 4800	2400 / 4800	2400 / 4800
Vehicles in service 1/2 LRVs	4/8	6/12	6/12	8/16

* this can be increased if the track is doubled.

** passengers per hour per direction.

6 Operations

6.1 The journey time for the route has been estimated using the following parameters:

Parameter	Value
Maximum speed in tunnel and approaches	70 km/h
Maximum speed on non-segregated sections of route	50 km/h
Maximum acceleration	0.9 m/s^2
Maximum deceleration	0.9 m/s^2
Dwell time at stops	20 seconds
Delay time at Airport Way crossing	20 seconds

6.2 Transit road crossings within the development site would be controlled by traffic signals. The control system will be linked with the traffic signals so that priority can be given to transit vehicles. It is assumed that full priority would be provided at most crossings within the development site, so that transit vehicles are not significantly delayed. At the Airport Way crossing a lower level of priority is assumed, with average delays to transit vehicles of 20 seconds.

6.3 These parameters are typical of those adopted for other LRT and transit systems.

6.4 The end to end run time (i.e. the time from departing one terminus platform to arriving at the other end, including the dwell time at the intermediate stops) has been estimated at approximately 8.7 minutes from departing the platform at one end of the route to arriving at the other end, which is rounded up to 9 minutes for the purposes of further development of the operational proposals.

6.5 The critical section of route for operations is the single track tunnel section. The run time from clearing Clifton Road crossing before entering the west end of the tunnel to arriving at the next stop north of Coldham's Lane is estimated to be about 2.8 minutes.

Operating Pattern

6.6 The operating pattern at times of maximum service level is necessarily determined by the operation of the single track tunnel section.

6.7 In theory, an inbound service, departing from the Coldham's Lane stop will arrive at Cambridge Station just under 3 minutes later. Another LRV, already waiting in the opposite platform will have departed shortly before its arrival, so that it arrives at the merge of double track to single track before the tunnel portal just after the first LRV has left the tunnel. The second LRV arrives at Coldham's Lane a further three minutes later, and only then can the next inbound service depart from Coldham's Lane i.e. the minimum headway between successive LRVs is just under 6 minutes, and each LRV will spend just under 6 minutes in one of the platforms at Cambridge station, during which time arriving passengers will alight and departing passengers board.

6.8 This 6 minute headway (10 services per hour) is the theoretical maximum level of service, if all LRVs depart the stations on time and achieve the predicted journey time. In practice variations in run time will result in inbound LRVs sometimes arriving at Coldham's Lane late, or a departing service may be delayed leaving Cambridge station (e.g. a passenger obstructing the doors) and there is virtually no slack in the timetable to allow the lost time to be made up. So in this case it would be preferable to schedule a greater headway between services to allow reliable operation.

6.9 It is common practice for transit systems to operate a regular 'clock face' service, that is services depart at regular time intervals at the same minutes past each hour, even if with the headway less than about 10 minutes, most passengers don't aim for a particular timed service, but simply turn up and wait.

6.10 Options for a clock-face service are a regular 6 minute (10 per hour) or 7.5 minute (8 per hour service). The former allows a maximum of about 20 seconds of late running by an individual service, before this would impact on the following service, and this is near the limit of reliable operations. A regular 7.5 minute headway service would allow a clock face timetable to be provided and would allow an individual service to run up to nearly 2 minutes late, before its passage of the critical tunnel section would delay the following service, thus giving the system some flexibility to recover from delays.

6.11 With a 7.5 minute headway, an LRV waiting at Cambridge station cannot depart until the next service has almost arrived (7.5 minutes later) and so the layover time at Cambridge is now about 7.5 minutes.

6.12 For the 6 minute headway service, with a 9 minute run time in each direction, and a 6 minute layover at the Cambridge station end of the route, the round trip run time would be 30 minutes (and the layover at the Multi-modal interchange/Newmarket Road Travel Hub would also be 6 minutes).

6.13 Similarly, for the 7.5 minute headway, with a 9 minute run time in each direction, and a 7.5 minute layover at the Cambridge station end of the route, the round trip run time would be 30 minutes (and the layover at the Multi-modal interchange/Newmarket Road Travel Hub would be 4.5 minutes).

6.14 With a 7.5 minute headway this would require 4 LRVs (or pairs of LRVs if the capacity requires) in service and (with a 6 minute headway) 5 LRVs or pairs.

System Capacity

6.15 As part of a parallel piece of transport evidence and set out in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document, Stantec have prepared initial forecasts of person trip generation arising from the four different development scenarios. The assessment also considers the potential origins and destinations of these trips and demands on key transport corridors within and outside Cambridge.

6.16 To inform this Transit Deliverability Report, Stantec have assessed the potential for those living and working at Cambridge East to use the transit link during the three hour peak period, in the context of the wider transport strategy and the trip budget principle as set out in their report.

6.17 The three hour demand outputs provided by Stantec have been converted into a one-hour peak period using analysis of network peaks from Land North of Cherry Hinton surveys from 2016. This suggests that circa 40% of the 3-hour demand occurs within the 1-hour peak.

6.18 The initial outputs from Stantec's trip generation and distribution tool, which are conservative as they do not consider the wider patronage of the transit link for East Cambridge or surrounding development (e.g. Marleigh), or ascribe any modal advantage to Transit over conventional public transport, indicate a peak flow of 2,100 one way trips during the AM peak hour for a free-standing transit system operating between the Multi-modal Interchange/Newmarket Road Travel Hub and Cambridge Railway station only. For the case of the route forming part of an integrated city wide (CAM) network, the corresponding figure is 3,100 passengers per hour, on the link between Cambridge station and the southern boundary of the Cambridge East development.

6.19 A flow of 2,100 passengers per hour with a service of 8 LRVs per hour equates to an average vehicle load of around 260 passengers (on a free-standing transit line). Typical 30m long LRVs have a passenger capacity (seated and standing) of around 200 passengers, meaning that capacity limits would not be reached with twin-car LRT service. The build-up of Cambridge East is anticipated over a 20-25 year horizon, with transit patronage forecast to increase steadily to that point.

6.20 The use of paired LRVs would be introduced to increase capacity when required, but in the later years this level of demand would require a doubling of the tunnels to support the level of service frequency needed.

6.21 With 3,100 passengers per hour (with the full CAM network) a service frequency of 8 per hour would be very close to the peak capacity available with twinned LRVs and higher frequency and double track would be appropriate.

Fleet Requirement

6.22 There will be a requirement for spare units to cover both planned maintenance and to have a 'hot spare' available to enter service in the event of breakdown. Typically, on larger LRT systems, an additional 10-15% spare vehicles are required, with a minimum of 2 (one undergoing planned maintenance, one 'hot spare'). For the small fleet size required for this operation it is suggested that provision of two spare vehicles (i.e. 50% more than the number in service) could not be justified, and so one spare vehicle should be provided, accepting that there is a risk to system reliability in the event of significant breakdown.

7 Integration with CAM

Introduction

7.1 This chapter outlines the main civil engineering works required to integrate the initial transit route into a wider CAM network.

7.2 If CAM uses similar vehicle, power and track technology as the transit system, then it will be straightforward to extend this over the wider network as it is built, and the initial route can remain in passenger service while this is taking place, with minimal interruption to service.

7.3 CAM technology would need to be introduced, commissioned and proven on a suitable test site before its adoption for Cambridge East, in order to address any initial technical challenges, and to demonstrate satisfactory operation firstly in trial running and then in full public service. Once reliable operation has been achieved, the initial transit route can adopt the chosen CAM technology.

7.4 The choice of technology, proven in service, would need to be established prior to the pursuit of planning powers for the transit line.

Tunnel Duplication and Westward Extension

7.5 A single track bidirectional tunnel between Cambridge Station and Coldham's Lane is sufficient if the line extends no further than Cambridge station until the later years of Cambridge East development build-out but has insufficient capacity as part of an integrated city-wide network. Of course, there is always the option to construct the tunnelled section with double track from the outset. But if the transit system is built initially with a single track, then to form part of the wider network, the tunnel will need to be duplicated to provide a full twin track two-way capability. In this circumstance, it is assumed that the first tunnel would become the new eastbound tunnel, with the westbound (second) tunnel being added to the south of it.

7.6 The new tunnel would need to connect into the first stage tunnel underground. This would be done by creating an enlarged cavern around the existing tunnel, tapered in plan to encompass the area where the two tunnels meet. Historically this has been done by means of a 'step plate' junction, using successively larger rings of cast iron tunnel segments. Today, it is more likely that a sprayed concrete lining approach would be used.

7.7 As the excavation continues, temporary support would be provided to the existing tunnel, allowing services to continue to run inside the tunnel. On completion, during a possession of the track, the original tunnel lining would be removed, and the area reinstated to allow the resumption of services, into the surface Cambridge station, until these are replaced by the wider network operation.

7.8 Once the new wider network service is in operation, the west end of the original tunnel, and its ramp up to ground level could be abandoned.

7.9 In order to allow for later tunnel duplication, provision needs to have been made at the Coldham's Lane portal to allow for the later additional tunnelling work. A worksite will need to be established at the portal (for which space will need to be reserved in the initial development). This could be avoided if a twin track tunnel was constructed in the first place, but this would add to initial costs, of course.

7.10 The TBM drive for the second tunnel would start from Coldham's Lane and run towards Cambridge Station, as for the initial drive, with all tunnel spoil being removed at Coldham's Lane. Depending on the plans for the wider network, it may be possible for this TBM to pass through the Cambridge underground station and continue to drive the westbound tunnel towards the city centre and maybe beyond.

CAM Southern Branch

7.11 Current CAM plans show a southern branch joining the eastern branch to the east of Cambridge Railway Station, allowing services on both branches to run through the underground station, and on towards Cambridge city centre. It is not clear whether this would be a 'flat' junction, on one level, where outbound services for the south branch would cross inbound services on the eastern branch, or whether full grade-separation is required.

7.12 If full grade separation is required, then the new westbound tunnel may have to follow a lower profile than the first tunnel, to the east of the station, to allow the outbound connection to the southern branch to pass over the westbound tunnel. For a flat crossing the second tunnel would be at the same level as the first.

7.13 The southern branch tunnels would be connected into the eastern branch tunnels in a similar manner to that described above. Tunnelling of southern CAM branch tunnels would need to take place from the southern branch portal, working towards Cambridge Station. It is probable that it will be necessary for the southern branch tunnels to be driven from the opposite end, before connecting into the eastern branch tunnels to enable the eastern branch to remain in passenger use.

7.14 On completion of each tunnel drive, the TBM used would need to be dismantled in-situ with the components then withdrawn back through the tunnel to the driving site. The outer skin of the TBM may then have to remain in place, behind the new tunnel lining (meaning that a new outer skin would be required if the TBM is to be used for another tunnel drive).

Eastward Extension

7.15 An at-grade eastward extension of the route would be straightforward to construct. The layout of the route terminus at the Multi-modal interchange/Newmarket Road Travel Hub and the depot could be designed to allow for a future route to continue onwards to the east. The design would have to consider townscape issues as well as the existing context/environment at the time.

Depot Impacts

7.16 For Option T1 it is recommended that the depot for the line is initially sized to accommodate 5 LRVs, with provision for this to be increased to [to be provided] , to allow for expansion of the service with the line remaining as a self-contained operation.

7.17 If the line is incorporated into an integrated city-wide network, then the extended system will most likely need significantly more depot facilities. A wider benefit of the transit proposal is that it could allow new vehicles to be commissioned on a dedicated site, and then operated in trial running and public service from the planned depot. The existing eastern depot could later be reconfigured to act as a subsidiary depot and/or out-stabling facility for the wider network.

7.18 Alternatively, it may be more appropriate to operate the wider network entirely from one or more new depots elsewhere on the network, in which case the Cambridge East site would become surplus to requirements.

Phased Transit Implementation

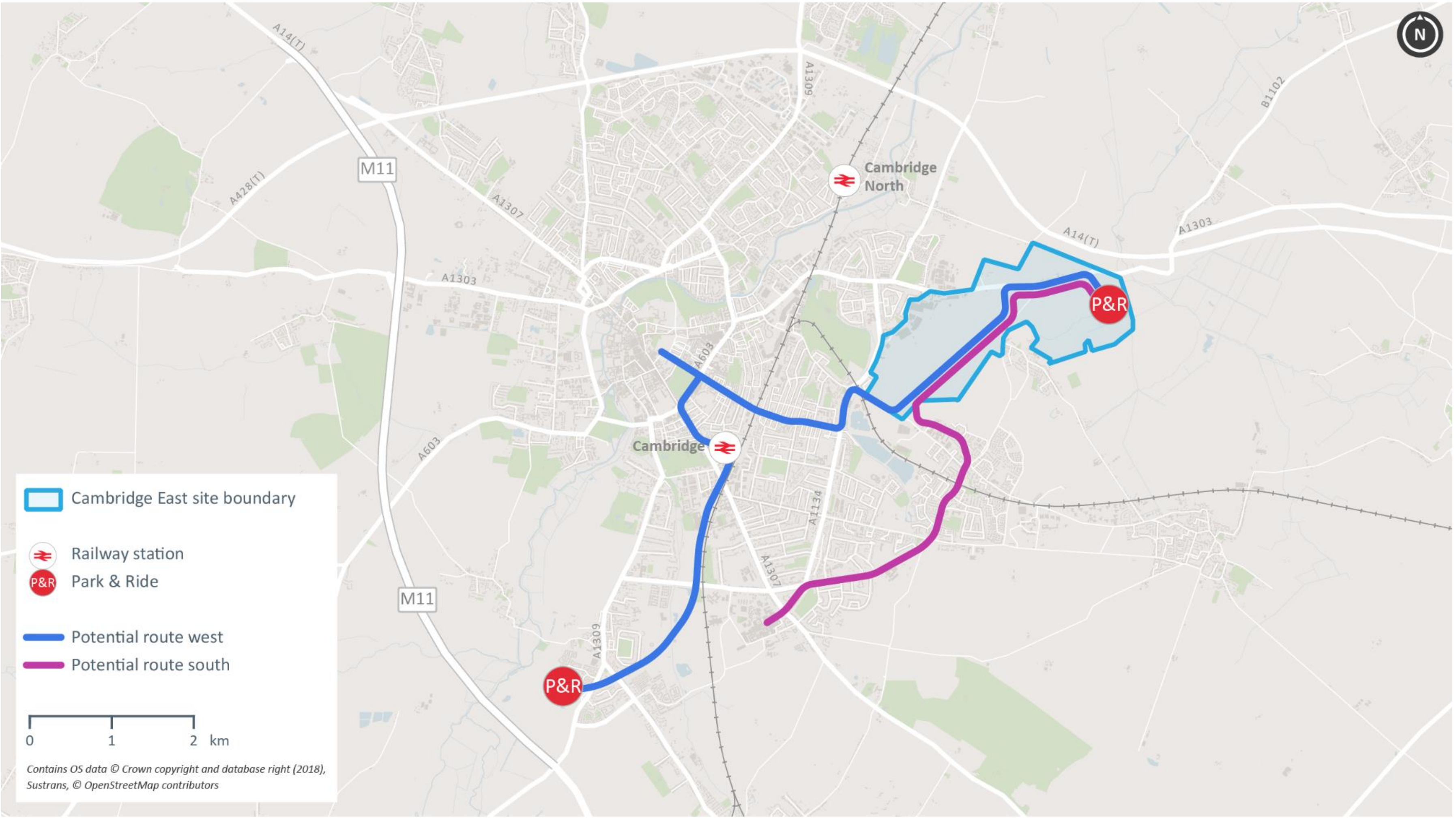
7.19 The design of the transit system lends itself to a phased implementation. The route north of Coldham's Lane across the development site could be used, in conjunction with on-street service along Coldham's Lane and onwards to the city centre and other key destinations. When the transit system is fully implemented onwards to Cambridge station, such interim services could continue to serve the development site as high quality public transport providing direct linkages to other locations in Cambridge and the surrounding area.

7.20 Sections 8 to 11 of Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document sets out a range of transport measures for providing connectivity to key destinations within and beyond the City which can be implemented in phases as Cambridge East grows. This includes active mode connections and public transport connections. The transport strategies assumed to support the different development scenarios is summarised in Stantec's report. One of the alternative high quality bus routes that could be considered within the interim stage of development at Cambridge East is illustrated below at Figure 7.1.which shows an interim high quality public transit route that uses the transit right of way through the development and Mill Road to serve a number of key destinations ahead of the transit link being completed to Cambridge station. Specifically, it envisages a high quality public transport (bus based) service that use Coldham's Lane, Mill Road, Grenville Place (serving the southern side of the city centre) before continuing southwards on Hills Road and Station Road (serving Cambridge station) and onwards on the Cambridgeshire guided busway to Trumpington/Cambridge South/Addenbrookes. Such a route would offer connectivity gains for current residents in the Mill Road catchment as well as many 'no interchange' links for residents and businesses at Cambridge East.

7.21 This route allows benefit to be derived early from the transit right of ways, helping to build use of public transport ahead of the much faster connections that the transit will allow.

The detail of such interim (and in future) complementary measures is set out In Appendix B and is summarised in Chapter 12.

Figure 7.1 – Potential Interim High Quality Public Transport Routes



8 Construction Issues

Tunnel Construction

8.1 Decisions on the most appropriate tunnelling technology to be used for the underground section of route will need to be based on detailed investigation of the ground conditions. At present, limited information is available on the stratigraphy, which has identified the thick band of Gault Clay, but the engineering properties of the clay and other information such as water pressures has not been obtained.

8.2 That said, Gault Clay is considered to be an optimum material for tunnelling, and the vertical alignments presented in this report have been prepared on that basis.

8.3 Mechanical excavation using a tunnel boring machine (TBM) is assumed to be the best option for construction of as much of the tunnel as possible – in this case from the portal at Coldham's Lane to the west end of the north tunnel at Cambridge Underground Station.

8.4 The main TBM shield has a rotating cutter mounted on the front. This cuts material from the tunnel face, which is then removed by a screw conveyor and deposited onto a conveyor belt, which takes the material back from the shield. From the end of this primary conveyor, material may be carried back to the portal either using secondary conveyor(s) or it may be carried using rail-mounted wagons or dump trucks. A cylindrical tail skin projects back from the shield. Within this is a mechanical segment erector, which takes tunnel segments brought in from the portal and erects them into a complete bolted ring. As tunnelling proceeds the shield is jacked forward against the last completed ring, until there is sufficient space to erect the next ring. As the tail skin is drawn forward, grout is injected through holes in the segments, to fill the space between the excavated ground surface and the extrados of the tunnel ring. This process is repeated as the tunnel advances. Tapered rings are used to form horizontal and vertical curves in the tunnel alignment as necessary.

8.5 For reasons of space, tunnelling would commence at the Coldham's Lane portal and proceed towards the Rustat Road portal, with spoil being removed at the Coldham's Lane end. On completion of the tunnel through to underground station, the tunnel boring machine (TBM) would be partly dismantled, with the majority of the 'train' of material removal and segment supply equipment being taken back to Coldham's Lane for removal. The TBM head would be lifted out from the portal.

Cambridge Underground Station

8.6 If an underground station were to be provided here from the outset then the main TBM would construct the northern access tunnel into the station box. The remainder of the underground works – southern access tunnel, station tunnel enlargements, overrun tunnels, underground junctions etc. would be constructed separately.

8.7 Sprayed Concrete Lining (SCL) techniques would typically be used, due to the flexibility of this method in dealing with varying tunnel sizes and intersections. Material would be removed by bucket excavator or road-header, with sprayed concrete applied after each section is excavated. Larger tunnels would be built using a series of headings, with a pilot heading typically constructed at the top or top/side of the tunnel, then successive enlargements generally working downwards and across, to the full tunnel size.

8.8 Construction of the relatively shallow pedestrian subway tunnel beneath the railway would ideally be done by excavation from the surface. But the disruption to rail services this would cause is unlikely to be acceptable. It may be necessary to jack a rectangular concrete box under the railway tracks, platforms and maybe the main station building, removing material from the face of the excavation as the jacking proceeds. This would most easily be accomplished from the eastern side. Either side of the operational railway, the subway works would be constructed in open cut.

Coldham's Lane and Rustat Road Ramps and Portals

8.9 The tunnel approach at Coldham's Lane will comprise a retained cutting approximately 200m in length and sloping down from ground level at the north-east end to about 12m below ground at the portal. The headwall will incorporate two 'eyes' – circular sections of weaker concrete through which the TBM will start cutting the tunnels.

8.10 As it is proposed to construct only a single tunnel initially, but with provision for later tunnel duplication, the portal structure will need to be wide enough to allow sufficient space for the second tunnel construction to take place while the transit is operating through the first tunnel.

8.11 The tunnel approach at Rustat Road will be broadly similar, although, as has been noted above, if a 6% gradient is used, the cut-and-cover approach will be located beneath the existing Rustat Road and Davy Road carriageways. This will inevitably mean that the construction activity here is more disruptive – the roads will need to be closed to traffic, with special arrangements made to maintain access to frontage properties. Adoption of a 'top down' construction method here would minimise the duration of the main disruption. Two lines of piles are first installed to provide the ramp walls, the roof slab is then placed, allowing the road above to be reinstated, and only then does the bulk of the excavation beneath take place.

8.12 The main TBM head would be lifted out at Rustat Road.

Worksites

8.13 The main worksite will be at the Coldham's Lane tunnel portal. Space will be needed here to accommodate the spoil handling, tunnel segment storage and handling, support equipment for the TBM, storage of other contractor's plant and equipment, site offices and parking etc.

8.14 On completion of the main tunnelling works, a smaller area of worksite will be needed to support the tunnel fitting out.

8.15 However, the full tunnelling site will need to be held back from development to allow it to be reused as/when the tunnel is duplicated. Only after that has been done can the site be made available for development.

8.16 A smaller worksite will be needed at Cambridge station site to support the construction of the station itself, a subway or footbridge crossing of the railway and the surface route works between the station and the tunnel approach.

8.17 A worksite will also be needed at the intermediate access shaft on Radegund Road. Since space here is limited, this may need to incorporate space from the Coleridge Community College grounds and/or from part of Radegund Road highway land.

Tunnel Spoil Removal

8.18 Most of the excavated material will be taken back to the Coldham's Lane portal and will be clean good-quality clay material, which may be suitable for capping landfill sites (locally or further afield) or may be used to raise ground levels elsewhere within the development site. Use within the site would minimise offsite construction traffic and would also avoid disposal costs (including landfill tax).

Supply Chain

8.19 LRT is an established technology, with a range of manufacturers of vehicles and associated systems and equipment, operating in a competitive marketplace, some located in Britain. Similarly, the civil works comprising this project are conventional and within the capability of a number of contractors.

9 Costs

Construction Costs

9.1 The pricing approach and rates adopted for cost estimate have been carried forward from those reported in 2018. This includes a "green book" allowance of 66% optimism bias to rightly reflect that this is a transit scheme that has only been developed to a preliminary design stage. The price base remains at 2018.

9.2 A significant proportion of the previously reported tunnelled option costs related to the construction of an underground station. This study has identified the opportunity for a standalone tunnelled scheme to terminate at Cambridge Station with a surface interchange. This provides opportunity for considerable savings for the western section of the route.

9.3 The headline potential project costs for the T1 transit link with an underground station at the Cambridge railway station is estimated to be c.**£643m** (2020 prices), made up of:

- Cambridge Railway Station to Portal **£508m**
- Portal to Eastern Transport Hub **£135m**

9.4 The same option but option with a surface station interchange is estimated to be c.**£460m,** made up of:

- Cambridge Railway Station to Portal **£325m**
- Portal to Eastern Transport Hub **£135m**

9.5 These summary figures are derived from a build-up of elements of the scheme, as set out in Tables 9.1 and 9.2 below:

Table 9.1 T1 Cambridge Station to Tunnel Portal - Construction Cost Estimates

Item	Estimated Cost (millions)
Route Infrastructure	£ 172.2
Prelims, Overheads and Profit	£ 34.4
Design & Management	£ 17.2
Contingency	£ 34.4
Depot	£ 5.2
Vehicles	£ 9.1
Operator procurement	£ 8.6
Testing and commissioning	£ 8.6
Network Rail costs	£ 8.6
Sub-total	***£ 298.4***
Optimism bias	£ 196.9
Land and compensation	£ 12.8
TOTAL	**£ 508m**

Table 9.2 Tunnel Portal to Eastern Interchange - Construction Cost Estimates

Item	Estimated Cost (millions)
Route Infrastructure	£ 40.4
Prelims, Overheads and Profit	£ 8.1
Design & Management	£ 4.0
Contingency	£ 8.1
Depot	£ 5.2
Vehicles	£ 9.1
Operator procurement	£ 2.0
Testing and commissioning	£ 2.0
Network Rail Costs	£ 2.0
Sub-total	***£ 81.0***
Optimism bias	£ 53.5
Land and Compensation	£ -
TOTAL	**£ 134.5**

Design Assumptions

9.6 These costs are based on the outline scheme assessed as the preferred option for providing the transit link between and eastern transport hub, NEC and Cambridge Station. The key features of the scheme are:

- 5.4km route length (Cambridge Station to new P&R site)
- 5 stops (including termini)
- An underground or surface terminus at Cambridge Station

9.7 Whilst no dedicated geotechnical investigation has been carried out to inform this study, the desktop work set out in previous section confirms previous assumption that the underlying geology in the Cambridge area is well suited to bored tunnelling techniques, with a thick band of clay at a suitable depth in the city centre and in areas to the north, south and west.

Option Cost Comparison

9.8 The comparable headline estimated costings for the options detailed in this report are set out in 2020 prices below in Tables 9.3 and 9.4.

Table 9.3 Estimated Construction Costs with Underground Station

Option	Cambridge Station to South of Airport	South of Airport to Eastern Transport Hub	Total
Option T1 – Ext Full Length Single Tunnel, Underground Cambridge Station	£508m	£135m	**£643m**
Option T2 – Ext Short Tunnel via allotments Underground Cambridge Station	£474m	£135m	**£609m**
Option T3– Ext Short Tunnel via Mill Road corridor Underground Cambridge Station	£441m	£135m	**£576m**
Option S1 Ext Street Running, Underground Cambridge Station	£411m	£141m	**£552m**

9.9 Table 9.4 below outlines the estimated costs of options above should an underground station at Cambridge Station be constructed instead of a surface station.

Table 9.4 Estimated Construction Costs with Surface Station

Option	Cambridge Station to South of Airport	South of Airport to Eastern Transport Hub	Total
Option T1 Full Length Single Tunnel rising to surface Cambridge Station	£325m	£135m	**£460**
Option T2 Short Tunnel via allotments rising to surface Cambridge Station	£303m	£135m	**£438m**
Option T3 Short Tunnel via Mill Road corridor rising to surface Cambridge Station	£267m	£135m	**£402m**
Option S1 Street Running, Surface Cambridge Station	£212m	£141m	**£357m**

10 Funding Options

DfT Guidelines

10.1 In the past UK central government grant funding could be made available for transport schemes on the basis of a strong ‘transport’ case (e.g. time savings, improved accessibility, reduced congestion). Recent funding decisions on transport schemes including Crossrail 1 and the Northern Line Extension and the Government’s position on Crossrail 2 have made it clear that:

- Government grant funding will increasingly be linked to the ability to serve wider objectives beyond transport - in particular housing growth; and
- a significant proportion of funding for major transport investment should be secured from local sources.

10.2 The purpose of this section is therefore to:

- set out the wider context to major scheme funding, including recent Government practice and expectations for how major schemes should be supported;
- explore the principles of local funding and the ‘beneficiary pays’ principle;
- set out the potential funding options available to deliver the Cambridge East transit; and
- identify the next steps to developing a suitable funding strategy.

10.3 Recent agreed urban public transport funding packages provide a useful benchmark for establishing the case for public investment in transformative transport infrastructure and, in particular, identifying and securing an appropriate funding package. Recent funding packages have included the following broad principles:

- A significant proportion of funding from local sources;
- Fares revenue and/or other income sources covering long run operating, maintenance and ideally renewal costs – i.e. a positive operating ratio;
- A mix of local funding including local authority grants and support from local businesses, developers and users; and
- Significant wider economic benefits of the project resulting in increased taxes which can help recover the central government outlay.

10.4 Earlier studies for the transit have shown that with an average fare of £2.00 the scheme’s operating costs would be covered after an initial period of deficit. A positive operating cost ratio is one of the DfT’s key requirements. The possibility of a revenue surplus in the medium to longer term would also need to be explored as it may help with financing, but it is unlikely to be a primary source for funding the Cambridge East transit.

10.5 Applying the emerging funding context to the Preferred Option for Cambridge East transit indicates that the key elements of a funding package which are discussed in the following paragraphs would most likely include a combination of:

- Government Funding linked directly to unlocking 12,000 new houses in East Cambridge;
- Borrowing against other future income streams from expected additional local taxation income; and
- Other Government and combined/local authority funding.

10.6 The Cambridge East transit will unlock significant development, including up to 12,000 homes, in a sustainable way, and is therefore a strong candidate to meet the requirements of the Government's new £10 billion Single Housing and Infrastructure Fund (SHIF) which was announced in the Conservative Party Manifesto and included in the Queen's Speech and in MHCLG's 'Planning for the Future ' document which accompanied the March 2020 Budget and stated:

> **A new £10 billion Single Housing Infrastructure Fund** – as set out in the Conservative manifesto, we will also build on this infrastructure investment with a new long-term, flexible fund which will give confidence to communities, developers and local authorities. Details of the funding will be announced alongside the Spending Review. Homes England will engage with local authorities and the wider market to build a pipeline of opportunities up and down the country .'

10.7 We understand that MHCLG is currently reviewing the previous HIF programme in order to identify lessons learnt as part of their process prior to formulating the guidance for SHIF bids. The previous HIF only awarded grants towards new infrastructure unlocking housing development. It is expected that the new SHIF will be more flexible and allow loans as well as grants. The previous HIF requirements to identify the additional development which can be supported by the new infrastructure (the 'dependent development') and to develop a five-case business model- are likely to form part of the new SHIF guidance. Also, in a similar way to HIF, SHIF bids, it is expected, will have to be submitted by a local authority with support from developers and other stakeholders.

10.8 The previous successful HIF bids provide some indication of the funds that could be available to unlock new housing in Cambridge East through a SHIF bid. The average infrastructure grant from HIF was around £4k per home but there was a very wide range. TfL's bid for the East London Line secured £80.4m for 14,000 new homes i.e.an average of around £6k per home, whereas TfL's bid for a new station on the DLR secured £290.7m for 16,800 new homes i.e. an average of around £17k per home. The sums secured by TfL suggest that it should be possible to secure £100m - £200m grant towards the capital costs of the Cambridge East transit line through SHIF, solely based on the scheme's housing content, although greater sums may be possible depending on how the allocation rules for SHIF evolve.

Other Funding Streams

10.9 Other funding streams from additional local taxation used elsewhere which will almost certainly be raised in discussions with the Government include: .

- Workplace Parking Levy;
- Community Infrastructure Levy (CIL); and
- Business Rate Supplement.

10.10 A Workplace Parking Levy and CIL are unlikely to be appropriate because they would be incompatible with the developer's funding model. A Business Rate Supplement introduced by the Mayor (possibly to fund CAM) could raise significant funds towards the transit.

10.11 A Workplace Parking Levy, as introduced in Nottingham and used to part-fund Phase 2 of the Nottingham Express Transit, typically involves a charge of £400 – 1000 per workplace car parking space. Nottingham (pop 330,000) raises approximately £9m per year through a charge of £424 per year levied on employers with 11 or more parking spaces.

10.12 Other mechanisms of funding from road users could generate additional funding but gaining public acceptance has proven thus far to be problematic. Greater Cambridge has consulted on a range of measures as part of a City Access programme, including a 'flexible' congestion charge to drive into and around Cambridge at the busiest times, and a 'pollution' charge for the most polluting vehicles. Within Cambridge, these were estimated to generate funding of £60m + per year, dependent on scheme definition. London's Congestion Charge raised £174 million net in 2017/18.

10.13 Community Infrastructure Levy (CIL) is a development levy which local authorities can introduce on residential and commercial developments to help fund the delivery of infrastructure projects. It is applied as a charge on each square metre of floor space in new buildings, with a minimum threshold of 100 square metres or a single dwelling. The levy only applies in areas where a local authority has consulted on, and approved, a charging schedule which sets out its levy rates and exceptions.

10.14 A 'Mayoral CIL' was introduced across Greater London to support Crossrail charged at between £20 and £50 per square metre of development and it generated more than its £300m target over the first four years of implementation. This is estimated to be only a fraction of the uplift in land values driven by Crossrail with real estate research suggesting that residential and commercial property values around Crossrail stations have already grown by more than £5.5bn compared to the wider London property market.

10.15 The devolution deal for the Cambridgeshire and Peterborough Combined Authority includes agreement that following the implementation of the necessary legislation, the Mayor will be given the power to place a supplement on business rates to fund infrastructure.

10.16 Where transport infrastructure generates benefits to a series of beneficiaries, funding mechanisms can be devised to capture a proportion of these benefits to fund the investment. If development is directly 'unlocked' by the Cambridge East transit, there could be the opportunity to 'allocate' a proportion of existing funding streams such as business rates/council taxes to be paid in the longer-term by such developments to fund the transit scheme. This is known as a rate 'retention'.

10.17 For instance, new developments enabled by the transit will be subject to local taxes, including business rates paid by the businesses, or council tax paid by the households. A proportion of those charges collected by the local council could be allocated to fund the transit on the rationale that neither these developments nor the increased level of economic activity and resulting increase in rateable values would come forward without the transit.

10.18 This retention could 'top slice' these taxes or retain a proportion of them within a defined area, to provide a significant additional funding stream for the transit. There are examples in the UK of such mechanisms being used to support transport infrastructure improvements, most notably the developments in Vauxhall/Nine Elms/Battersea that were enabled by the Northern Line Extension (NLE).

10.19 This mechanism would not result in additional charges to land owners/developers in the area but would instead ring-fence a proportion of tax receipts. However, it would be dependent on both central government and local approval, since it would represent a redirection of income typically paid to Government (business rates) or Councils (council tax) for local services to funding the transit.

Other Government and Local Authority Funding Sources

10.20 The Greater Cambridge Partnership (GCP) is the local delivery body for the City Deal which aims to enable 'a new wave of innovation led growth' by investing in infrastructure, housing and skills. £500m from Government and the same pledged by the GCP will provide £1 billion of funding over the City Deal period to 2035. A proportion of this fund could potentially be made available for the Cambridge East transit.

Conclusion

10.21 We can conclude that funding is likely to mainly utilise the successor to the Housing Infrastructure Fund (HIF) amongst other mechanisms identified here that include funds through the Combined Authority's devolution deal. Cambridge East transit should meet a key DfT funding criterion that includes a need to avoid an operating subsidy after an initial build up period.

11 Powers to Construct and Operate the Transit System

Introduction

11.1 Two options for securing powers to build new transit systems are available – a Development Consent Order (DCO) or a Transport and Works Act Order (TWAO). The DCO approach is only available for projects of National Significance which would require approval via a Section 35 Direction from the Secretary of State for Transport. It is very unlikely that the Cambridge East transit would be accepted as a project of National Significance but, if approval for the transit was being sought as part of the whole CAM network, then CAM might be considered to be a project of National Significance and the DCO approach could be considered. This would not necessarily be advantageous as the amount of work and therefore the cost of a DCO is far greater than for a TWAO. Designs and reports at a much higher level of detail would be required for a DCO and a shorter time period to approval certainly cannot be guaranteed. The TWAO approach is therefore recommended for the Cambridge East transit.

11.2 An order made under the Transport and Works Act 1992 (the TWA) is the recommended way for the promoters (see below) to obtain powers to construct the Cambridge East transit. The application would be made to the Secretary of State for Transport. The procedure that has to be followed allows any interested person to have their say before the Secretary of State takes their decision. They make their decision only after considering all the comments made — sometimes through a Public Inquiry. They can make TWA orders (with or without amendments) or they can reject them.

11.3 The powers that can be given in a TWA order can be very wide-ranging e.g. compulsory powers to buy land or to close streets. A TWA order can grant these powers. Building the transit could affect people's enjoyment of their property and affect the environment. Because of this, applications for TWA orders have to follow a set procedure which allows people to give their views on the proposals. The TWA does not limit who can apply for an order. This can be private companies and public authorities. Matters that can be authorised by the TWA order include:

- powers to construct, alter, maintain and operate a transport system or inland waterway;
- compulsory powers to buy land;
- the right to use land (for example, for access or for a work site);
- amendments to, or exclusion of, other legislation;
- the closure or alteration of roads and footpaths;
- provision of temporary alternative routes;
- safeguards for public service providers and others; and
- powers for making bylaws.

11.4 The powers applied for must be relevant to the scheme and may relate to matters that are necessary to support the scheme — for example, providing the park-and-ride site.

11.5 A TWA order does not in itself grant planning permission. But the organisation applying for the order can ask the Secretary of State to grant planning permission for any development described in the order. The Secretary of State would only grant planning permission if he or she decided to make the TWA order. He or she would do so at the same time as the order was made and may attach conditions to it. On the other hand, the organisation applying for a TWA order may apply for planning permission, separately, to the local planning authority.

11.6 Applications for TWA orders, and objections to them, must follow the Transport and Works (Applications and Objections Procedure) (England and Wales) Rules 2006 which can be viewed online at www.legislation.gov.uk.

11.7 The rules specify the documents which must be sent with an application. These vary according to the type of order being applied for. The typical documents needed for a proposal involving works are:

- a draft order and an explanatory memorandum
- a concise statement of the aims of the proposals
- a report summarising the consultations carried out by the applicant
- plans and cross sections
- an environmental statement
- a book of reference, including names of owners and occupiers of land to be bought compulsorily
- the estimated costs of the proposed works
- the funding arrangements

11.8 The organisation applying for the order ('the applicant') has to arrange for these documents to be available for inspection by the public, free of charge. Usually, this would be during normal office hours in the organisation's office and in local public libraries. In addition, the application documents during the objection period will be made available via a link to the website www.gov.uk/dft/twa.

Developer Involvement in Promoting TWA Orders

11.9 A number of new light rail, rail and underground lines which have been built over the last four decades in order to serve major developments in areas with poor access have been initially been progressed by work funded by developers. Examples include:

- Docklands Light Railway (DLR) Extension to Bank;
- Jubilee Line Extension;
- Crossrail to Canary Wharf; and
- Northern Line Extension to Battersea Power Station.

11.10 For all the above projects the developers funded initial feasibility and transport planning studies which were used to make the strategic, transport and economic case to the Government and public authorities. The proposals eventually became public policy with an agreed funding package including contributions from the developers.

11.11 For the DLR Extension to Bank after initial feasibility work for the Canary Wharf developers Transport for London agreed to setting up a joint team to prepare a Parliamentary Bill which was subsequently approved.

11.12 After developing initial proposals for a Bakerloo Line extension to Canary Wharf, the developers proposed a stand-alone fully automatic line from Waterloo to Canary Wharf. Bids were obtained from potential construction/operations companies and a Parliamentary Bill was prepared by the developers. The Government did not accept this Bill but agreed to an East London Rail Study which recommended the extension of the Jubilee Line.

11.13 The early plans for Crossrail (Elizabeth Line) only had one branch in east London to Stratford and Shenfield. The Canary Wharf developers funded some initial transport planning and feasibility studies setting out the options for rerouting Crossrail via Canary Wharf and then having two branches one to Stratford/Shenfield and one to serve developments on the south side of the River Thames. This proposal was not fully accepted by Government/TfL but they did agree to having two branches east of Liverpool Street with one serving Canary Wharf. The Canary Wharf Group agreed to pay for the construction of the station at Canary Wharf and the DfT agreed to pay approximately one third of the total costs. The full funding package of £15bn involved a range of sources including a business rate supplement and development levies across London through a Mayoral CIL.

11.14 Initial work on the proposal to extend the Northern Line (NLE) to Battersea Power Station was funded by the developers who recognised that only such a scheme would enable a high density 8 million sq ft development of Battersea Power Station and other developments in the surrounding Opportunity Area. The proposal was considered and recommended by a GLA/TfL funded study of transport needs for the Opportunity Area and then became included in the London Plan and the Mayor’s Transport Plan as a potential developer funded scheme. The Government agreed to the establishment of an Enterprise Zone covering the whole Opportunity Area enabling 100% of incremental business rates to be retained locally for at least 25 years and this is forecast to produce approximately £700m. A Transport and Works Order granting powers to build the NLE was approved following a Public Inquiry and the extension should be in operation by the end of 2021.

Conclusion

11.15 The transit line needs to be promoted by a public sector body with the appropriate capacity to action such a scheme. In this case, with a significant part of the scheme lying within the development, clearly close involvement of the developer will be needed. Marshall Group Properties has carried out initial development work as reported here and will continue to support the statutory authorities in progressing the transit line to support the Cambridge East development and continue to work closely with the CAM team as that project develops too.

12 Overall Conclusions

Overview

12.1 In this report, the deliverability of the proposed transit link from the Cambridge East development to Cambridge station has been assessed and can be confirmed. It would form part of a comprehensive transport strategy that includes complementary public transport measures (see Appendix B) and a programme of walk-cycle measures. These transport strategies are set out in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

12.2 The plan to provide a high quality/capacity public transport connection has long been seen as a likely pre-requisite to the success of the development, as is acknowledged in the Area Action Plan, and will enable the ambition to provide a truly exemplar development.

12.3 The requirement for a transit connection as a part of the Cambridge East development Scenarios B, C or D is derived from three factors:

- to provide an attractive alternative to car use to contain any traffic impacts arising from the Cambridge East development
- to ensure the viability of the development, capable of attracting world-class businesses
- to help make a net positive contribution to Cambridge, its residents and businesses.

Options have been examined across the full spectrum of corridors and technologies. The selected approach minimises delivery risk, is affordable, supports wider aspirations of the local authorities, and benefits established local communities.

12.4 In looking at deliverability questions here, the following aspects of the transit project have been covered:

- Evidence on the feasibility of tunnelling, using available data on ground conditions along the line of route
- An assessment of the likely approach to carrying out tunnelling work, indications of how extracted soil will be removed and work-site requirements
- Identification of surface options that could obviate the need for any tunnelling, and further options that show how shorter tunnel alignments could be adopted
- A review of demand levels and potential transit operating plans
- Updates on the proposals for CAM, noting the similarity of thinking on an eastern corridor route, and on relevant main line rail developments arising since 2018
- Identification of options which displace the need for an underground transit station at Cambridge railway station until a future Cambridge-wide system (CAM) is committed
- Forecast estimates of capital costs for constructing the various transit schemes identified
- A review of funding and consenting arrangements adopted elsewhere for equivalent proposals initiated by major developments.

Updates

12.5 CAM design development has continued over the past two years but definitive decisions on routes and technologies remain to be made. The transit line remains broadly consistent with the CAM plans and this study has identified how in practice the underground connection between the eastern and the central part and southern limb of the proposed CAM network could be constructed.

12.6 The plans for East West Rail (EWR) have progressed. The central section is intended to approach Cambridge via a station at Cambourne from the west, with the new railway looping south to approach via the new South Cambridge (Addenbrookes) station which now has planning consent. These national rail developments add to the value of the initial transit line from the development to Cambridge station because onward connectivity by rail will be significantly enhanced.

12.7 The possibility of a 'Cambridge East' station, located near the southern edge of the planned development, located on what Network Rail now plan to be a re-doubled section of railway line has been the subject of a preliminary discussion. This would have some benefits for the development, but, with much lower planned service frequencies than Transit offers, would have limited impact on demand levels for the transit line.

Findings

Tunnelling and alternatives

12.8 Based on existing borehole evidence, the preferred tunnel alignment is likely to be constructed though the medium of Gault Clay, a highly suitable medium for bored tunnelling methods of construction. The main work-site can be located on the development site itself. The design of the tunnelling has been refined and includes provision for emergency egress and ventilation needs.

12.9 While Cambridge is a small city to be considering use of tunnelling technology for its key transport facilities, existing evidence suggests that ground conditions in the area concerned is very suitable for the planned tunnelled alignment.

12.10 Moreover, alternative tunnel alignments are available. It has also been concluded in this study that it is not necessary to construct the transit station at Cambridge railway station underground, saving significantly on capital costs. This conclusion applies to each of the three tunnel alignments identified. While a surface transit station at the railway station has a lower cost and is probably more readily deliverable as first stage scheme, no conclusions have been reached on whether a first stage transit line should have an underground or a surface station at tis location. Decisions of this type must await a further stage of design development with full engagement with Network Rail.

12.11 If a surface transit station at the railway station were to be provided, it would be replaced with an underground station when the route is extended westwards to Cambridge city centre. Both underground and surface transit stations can be fully integrated with the railway station and provide a cross station route, pedestrian access to the station from the east and access from the stand-alone transit to buses and taxis for onward travel west, south and north west from the station. Both types of transit station can provide a high quality interchange.

12.12 But we have also identified that there is a viable surface route between the Airport site and Cambridge station. As with all surface schemes, this will have more significant impacts for local residents, and on established land uses. Nevertheless, no property would need be demolished to achieve a surface route.

12.13 At this preliminary stage, we judged the risks of the surface alternative to be greater than those arising from a tunnelled approach, which for the present remains therefore the preferred approach. But the existence of these alternatives substantially reduces the deliverability risks of the project, since there is no dependency on a single alignment nor on tunnelling.

Cambridge Station

12.14 Newly built (2020) stabling sidings stop short of the area where the transit platforms would be built. Plans for Cambridge station envisage that a new island platform and a second footbridge will need to be provided. The transit line will provide direct access to the station from the east on foot as well as by transit which is not currently available. It will trigger the need for a subway or, more likely, at least initially, a second footbridge, which Network Rail is already contemplating. This will help address the challenge of accommodating additional passenger flows at the station and provide step-free interchange between the transit and national rail services and other public transport services at Cambridge station.

Extendibility into a wider CAM network

12.15 A design is outlined which would allow subsequent extensions westwards to be built, with an underground transit station at the railway station before continuing to an underground city centre station and routes beyond to Cambourne/Cambridge North as part of a wider CAM network. It would also be possible to accommodate a tie-in to a CAM network southern branch that approached Cambridge railway station from the eastern side of the railway, possibly supporting through operation from south to east in advance of any central area tunnelled section of the CAM system.

Operations

12.16 The planned transit service frequencies, operating speeds and journey times and fleet size requirements have been reviewed and confirmed, as has the suitability of an initial single track section through the planned tunnel to Cambridge station. If the line is subsequently extended into a cross-city CAM network, then the tunnelled section would need to be doubled, and a preliminary design has been identified to show how that would be added in practice.

12.17 In the case of the surface option, this would need to be built with double track from the start. It would offer a slower (and less reliable) journey time. It would have an intermediate stop between the airport site and Cambridge railway station which would serve the local area.

Securing powers & funding

12.18 A number of built-out or under-construction transit lines were created in response to major land use developments in the UK. Their powers have been secured by statutory planning authorities following initial planning work funded by developers. Funding sources have typically been based on multiple public sector grant regimes and private sector contributions. The planned transit line for Cambridge East should meet DfT funding criteria that include a need to avoid an operating subsidy after an initial build-up period. Funding is likely to utilise the successor arrangement to HIF amongst other mechanisms.

Technology choices

12.19 The transit scheme remains specified here using well-established parameters for light rail transit (LRT) systems. These are likely to be more onerous and are (usually) costlier than busway-style technologies. The costs and design parameters for the CAM system are not yet known. So the approach taken is (intentionally) conservative.

Interface with the Masterplan

12.20 To reach the surface station located at the south end of the development site from the planned transit tunnel designed with the standard clearances to avoid risk of settlement of the land-fill site would require adoption of an 8% grade. This is steeper than desirable (although exists in practice on Croydon Tramlink; Sheffield Supertram has 10% grades). A more desirable 6% grade would require the station to be relocated slightly further north, but these conclusions will need to be re-visited as designs are refined.

12.21 Transit demand will be maximised by a central spine alignment with, it is suggested, three intermediate stops. The possibility of creating this to the southeast of the existing runway, should phasing require such an approach has been confirmed as feasible.

Deliverability Risks

12.22 Evidence on ground conditions and more detailed assessment of the design of the planned tunnelled section of the line reduces overall scheme buildability risks.

12.23 The identified availability of surface and alternative, shorter, tunnelling variants also reduces overall buildability risks of the preferred transit line.

12.24 Shorter tunnel options and (especially) surface schemes would be less expensive, reducing funding risks – but quite possibly increasing consenting risks because of the likely greater levels of local objections stemming from more extensive above-ground impacts.

12.25 The surface variant now identified would also result in slower and less reliable transit service, and this may detract from the marketability and value of the development. However, the extra journey time may appear modest (around 4-5 minutes), it means that the journey time from the southern-most station within the Cambridge East site is doubled.

12.26 Interface risks at Cambridge station can be further reduced by engagement with Network Rail in 2021. The transit plan has advantages for the national railway (direct access to Cambridge's premier development site; access locally from the east side; investment in cross-station facilities), but its design needs to be integrated with Network Rail plans for additional platforms and a second station footbridge.

Technology Choices Ahead

12.27 The recommended approach for securing powers to build the transit would be through a Transport and Works Act application. Experience suggests that these applications can only proceed once there is clarity on the transit technology to be implemented.

12.28 The presumption made here of using LRT technology should be kept under review. It is used here entirely to establish proof of concept and is not being promoted as a preferred solution.

12.29 The CAM system specification remains 'work in progress' with a competition launched to explore innovative design solutions. The use of low-capacity CAM vehicles (should these be proposed) would not necessarily be as acceptable in the Cambridge East context, where passenger demand levels will be relatively high.

Interim solutions

12.30 The transit line across the development site is common to each of the variants presented here. Its creation at an early stage could allow the development to proceed with an established high quality public transport corridor through the site. It could support a new bus route(s), that would use Coldham's Lane or Mill Road to access the city centre and indeed other locations across the city (as described in Paragraphs 7.18 *et seq*). The cross-site transit link could also be connected to a new station near Coldham's Lane on the Cambridge-Newmarket railway line, but as noted, train service frequencies, even when the line is re-doubled are not currently envisaged to be very high on this route.

12.31 Creation of the onward route to the station – if tunnelled – would require a worksite to be set aside at the southern edge of the development site.

Conclusions

12.32 A transit link between Cambridge East is needed for Scenarios B, C or D and its deliverability, having been tested in this study, can be confirmed. Its cost is lower than previously estimated, and identification of a valuable set of variants helps de-risk the project. A tunnelled version has fewer third party inter-dependencies and in any form, the transit connection, as a fully electrified system, can offer a major contribution to the project's wider green credentials.

12.33 The focus of the development, creating a substantive, world class, extension to the Cambridge urban landscape demands that the site can be easily accessed by the most sustainable transport systems from a wide catchment. Cambridge station has direct services from across the County and from London, Brighton. Gatwick Airport, Stansted Airport, Ipswich, Norwich, Kings Lynn & Ely, Peterborough, Leicester, Birmingham; and in future, (probably) Bedford, Milton Keynes, Oxford and Leeds. A link to Cambridge station is necessary, and this study has shown there are several ways to achieve it. A tunnelled version of the transit connection is ideal since it provides a fast and dependable connection.

12.34 Estimates of demand, as with costs, are conservative. Nevertheless, after an initial period of operating losses (which is usual in such cases) a surplus can be generated from the operation of the transit, given likely assumptions on fare levels. This may prove to be part of suitable project financing regime. Funding is likely to draw on a number of sources, including the new SHIF programme.

Appendix A

Report
December 2020

Cambridge East
Transit Patronage and Viability

Marshall Group Properties
Our ref: 23297007

steer

Report
December 2020

Cambridge East
Transit Patronage and Viability

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Contents

1 Introduction

Background

1.1 This report has been developed alongside the Cambridge East Transit Deliverability Study to detail the patronage forecasts associated with the transit link and the various development scenarios being considered.

1.2 Steer previously developed patronage forecasts for the transit link in 2018 to inform the '*Connecting New East Cambridge – a Preliminary Study*' report which considered the various alignment and technology options for providing a high-quality public transport connection to Cambridge East.

1.3 Stantec has subsequently been instructed to develop a trip generation tool for Cambridge East, drawing on similar Stantec tools for other developments around Cambridge which have been validated and approved by Cambridgeshire County Council.

1.4 The patronage forecasts presented within this report supersede those presented to date which were based on an alternative scale and mix of development and without the more detailed trip distribution information included within Stantec's tool.

1.5 This report presents forecast transit link patronage from Stantec's tool which have been developed in collaboration with and reviewed by Steer. Details of the specific forecasting methodology applied within the spreadsheet tool are presented in Stantec's 'Cambridge East Transport Appraisal and Emerging Transport Strategy' document, but some assumptions regarding the inputs to the tools are set out within this report where appropriate and relevant to the transit patronage forecasts.

1.6 It should be noted that the Stantec tool has been developed in the absence of the benefit of using the Cambridge Sub-Regional Model (CSRM2). The trip generation, distribution and demand forecast work will be refined through the use of CSRM2 at a later stage.

2 Development Assumptions

Scenarios

2.1 Four development scenarios are being considered as part of the evidence base work supporting the inclusion of Cambridge East within the Local Plan. From a transport and movements perspective and for quantifying the number of passengers expected to use the transit link, the key inputs for each scenario are detailed in **Table 2.1**.

Table 2.1: Development Scenario Assumptions

Development Scenario	Homes	Jobs
A	9,500	4,000
B	9,500	28,000
C	12,000	38,000
D	12,000	38,000

2.2 There are other differences between the scenarios across land uses including education, retail, leisure and health which generate subtle differences with regard to the internalisation of trips from each scenario. However, the quantum of homes and jobs as presented above are most useful and sufficient to differentiate between the scenarios and the resulting patronage with each scenario.

2.3 Initial trip forecasting work completed by both Steer and Stantec for Scenario A determined that a standalone transit link is neither viable nor the appropriate transport solution for the scale and nature of development in Scenario A. Scenario A has therefore been excluded from further analysis within this report.

Transit Connections

2.4 Previous trip forecasting work carried out by Steer considered two transit scenarios. One assessed the patronage associated with a standalone transit connection – a link between the Newmarket Road Travel Hub east of the development, passing through Cambridge East and terminating at Cambridge station. The other assessed a transit link as an integrated leg of a wider Cambridge Autonomous Metro (CAM) network. For each transit scenario the following demand assumptions were used:

- **Cambridge East to Cambridge station** – demand to Cambridge station as an interchange with rail/bus and serving the immediate CB1 business area.
- **Cambridge East to Cambridge station and beyond via CAM** – demand to Cambridge station and other areas proposed to be served by CAM including Addenbrooke's and the Biomedical Campus, City Centre, West Cambridge and the Cambridge Science Park.

2.5 Following the updates to the development scenarios and the significant increase in job provision since the original transit work by Steer, Stantec produced revised trip generations and distributions. This work found higher demand for travel from outside Cambridge, particularly from the dispersed areas of population to the north and north-west. If the CAM were to come forward, this connectivity would be addressed by linking Cambridge East to developments on both the north and west sides of Cambridge and would accommodate growth associated with these higher growth scenarios. However, if CAM cannot be assumed to be committed for the purposes of the Local Plan evidence base, the Stantec work identified a requirement for a significant public transport intervention in Scenarios B, C and D to accommodate the additional demand .

2.6 Most of the public transport demand generated from the north of Cambridge is derived from a combination of Milton Park & Ride, Cambridge North Area, Guided Busway and Waterbeach and this is what drives the potential case for the further significant public transport intervention. Demand from north of Cambridge by rail is likely to be accommodated by interchange between rail and the planned transit link to Cambridge East at Cambridge station, and direct north-east on-street bus routes may accommodate some further part of the demand

2.7 It is however important to consider the demand associated with a Cambridge North High Quality Public Transport (HQPT) connection as the Stantec tool assumes that this demand would translate into trips on the northern section of the transit link, via interchange at the planned new eastern (Newmarket Road) travel hub.

2.8 As such, the following two schemes were tested by Stantec for each development scenario (B-D):

Cambridge East to Cambridge station transit link + a Cambridge North HQPT connection

- The Stantec tool implies that all Cambridge North demand (with the exception of rail) would use a complementary HQPT northern route connection using services that would extend over the Cambridge East surface corridor across the development site and interchange to transit at the Newmarket Travel Hub.
- Demand via Cambridge station is a combination of demand from interchange with rail, local to station and CB1 area, P&R from Trumpington, Babraham and Sawston and future East-West Rail.
- P&R ‘through’ trips from eastern travel hub to Cambridge station.

Full CAM network incorporating the Cambridge East to Cambridge station transit link

- Connectivity to north, south, west and central Cambridge is delivered by CAM.
- All Cambridge North demand is routed via Cambridge station.
- P&R ‘through’ trips from eastern travel hub increase with the connectivity CAM provides.

2.9 The demand forecasts associated with these two transit scenarios are considered in the following sections.

3 Transit Demand

Demand Assumptions

3.1 The anticipated user demand for the transit link as it passes through the Cambridge East site has been projected by aggregating anticipated demand from three potential user groups:

- **Trips originating or ending within Cambridge East** – those generated by the development itself.
- **Trips transferred from the existing (but expanded and relocated) Park and Ride** – these include 'through trips' which are projected to use the transit link as a means of accessing Cambridge station, the CB1 employment area and destinations beyond.

3.2 It is acknowledged that there would be some demand for the transit link through the development for internal trips, e.g. those travelling from the north to the south of Cambridge East. Whilst this shorter distance is likely to be beneficial to the overall patronage and viability of the transit link, the Stantec patronage forecasts at this stage only consider those transit trips to/from the development site as only these are relevant to overall test of deliverability at Cambridge East, i.e. that the scale of external trip making falls within a trip cap, as established in Stantec's Cambridge East Transport Appraisal and Emerging Transport Strategy document.

3.3 It is also the case that the potential for additional transit demand from existing communities including Cherry Hinton, Teversham and Barnwell, and future developments including Land North of Cherry Hinton and Marleigh is not considered within the demand forecasts. There is likely to be significant demand generated from these areas given the direct connectivity provided which will further improve the overall patronage and viability of the transit link.

3.4 It should be also noted that when considered as a standalone link, the transit patronage forecasts assume no trips between Cambridge East and the city centre. Whilst there are wider GCP proposals to improve the Newmarket Road corridor to the city centre for public transport, it is likely that some demand, particularly to the south of the city centre will be generated on the transit link instead, with good interchange opportunities provided at Cambridge station.

3.5 For these several reason, the demand forecasts for the transit link presented within this section are therefore considered conservative and this has been noted in the Transit deliverability Study.

Overall Demand

3.6 The transit link demand (inbound and outbound) forecast for the three development scenarios (B-D) during the AM peak hour for both a standalone transit link to Cambridge station and a transit link integrated as part of the full CAM network is presented in Figure 3.1 and Figure 3.2 respectively.

3.7 The 3-hour demand outputs provided by Stantec have been converted into a one-hour peak period using analysis of network peaks from Land North of Cherry Hinton surveys from 2016. This suggests that circa 40% of the 3-hour demand occurs within the 1-hour peak.

3.8 A key observation from the Stantec forecasting when compared to previous analysis is that the directional transit link flows are not as balanced, particularly along the section between the southern edge of the development and Cambridge station. The development scenarios B-D being assessed now are much more heavily weighted towards employment uses, in particular a higher density of jobs per sqft of commercial floorspace is now assumed. This contributes to the predominance of inbound passengers to Cambridge East during the AM peak, a feature that is accentuated by the assumption of no travel from the Newmarket Road Travel Hub or development to the city centre uses the Transit line.

3.9 As a result of the increased employment offer and other uses to be provided on site, such as education facilities, the resulting internalisation of outgoing trips from the Stantec tool in the AM are higher than assumed previously, equating to around 51-55% of outbound trips during the 3hr AM peak period.

Figure 3.1: Standalone Transit Demand – AM Peak Hour

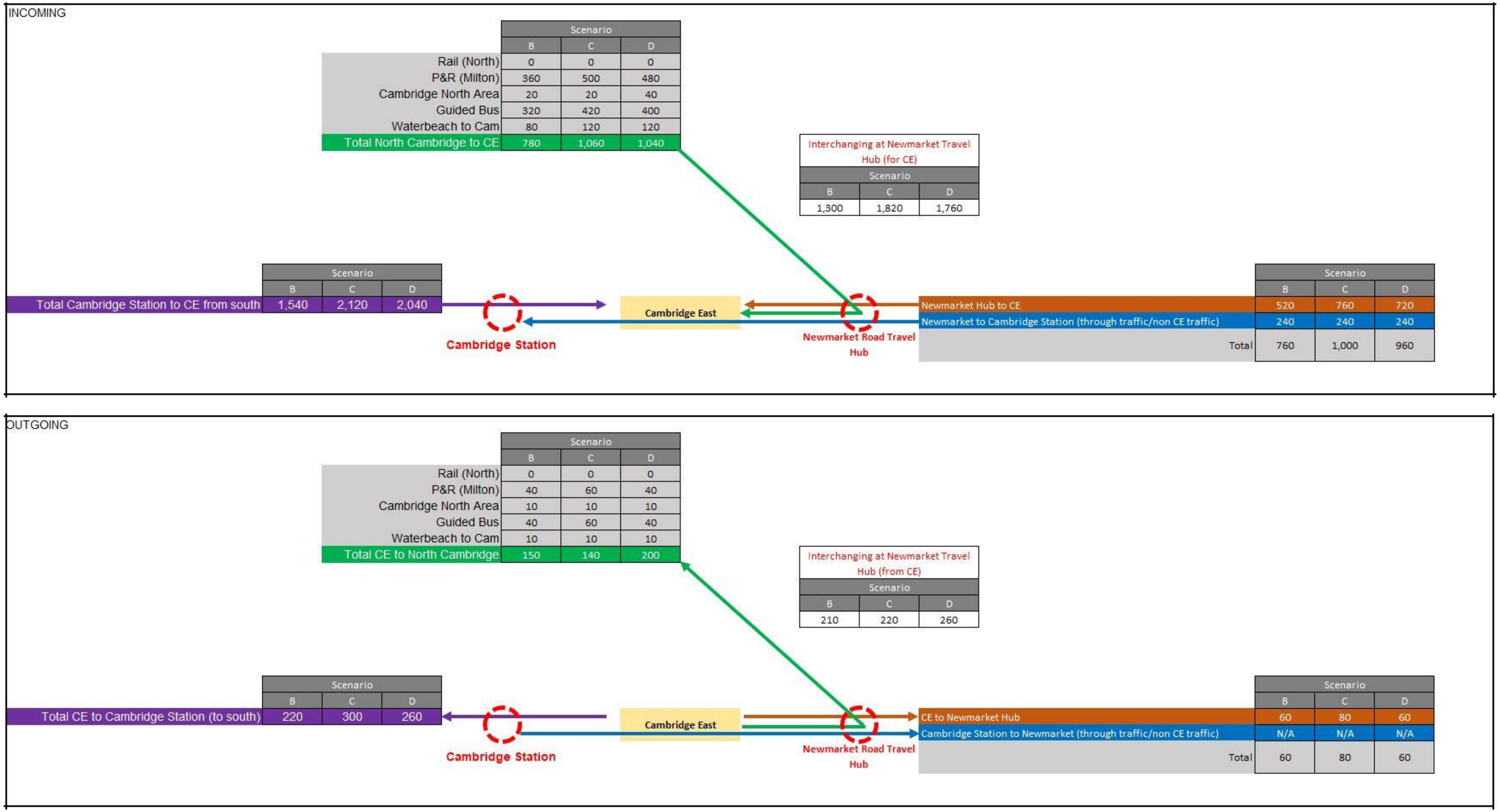
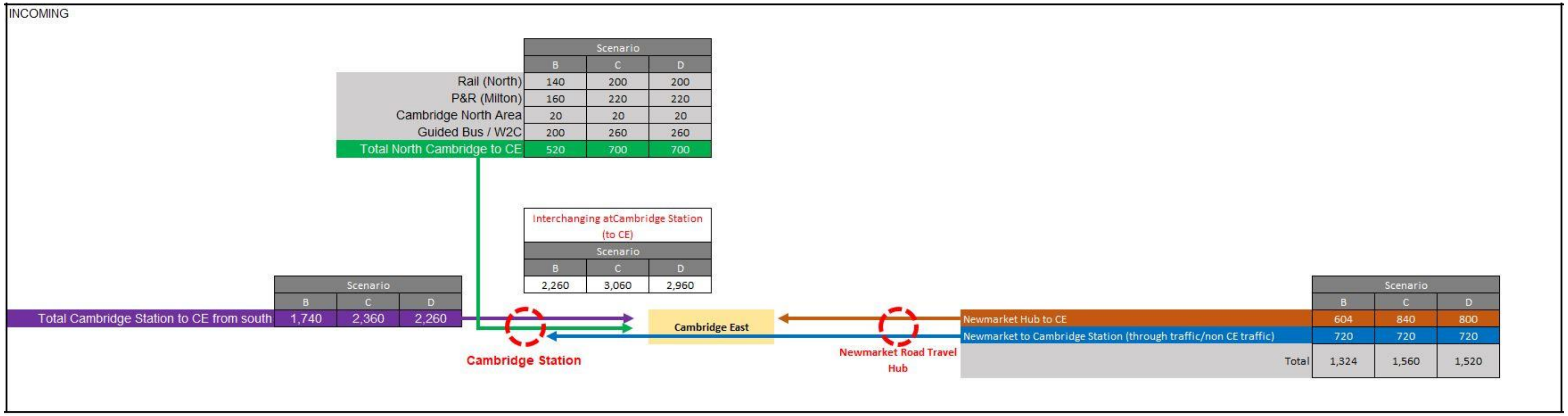
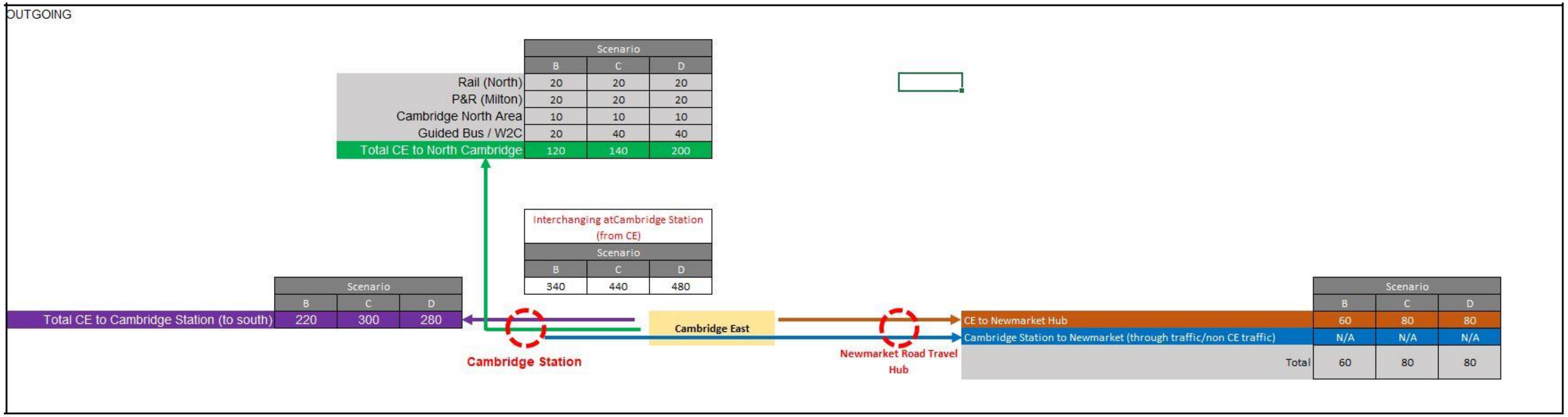


Figure 3.2: Transit Link Integrated with CAM Demand – AM Peak Hour





Standalone Transit Demand Summary

3.10 As shown in Figure 3.1 and to inform the analysis which follows in section 4, the peak hour transit trips associated with the transit link, both between Cambridge station and the southern boundary of Cambridge East and between Cambridge East and the eastern travel hub interchange are shown in Table 3.1.

Table 3.1: Standalone Transit Demand – Link Flows AM Peak Hour

Scenario	Between Cambridge Station and CE			Between CE and Eastern Travel Hub		
	Northbound	Southbound	Two-Way	Northbound	Southbound	Two-Way
B	1,540	460	2,000	210	1,540	1,750
C	2,120	540	2,660	220	2,060	2,280
D	2,040	500	2,540	260	2,000	2,260

3.11 The demand on the transit line between the eastern travel hub and Cambridge East is greater during this scenario than the full CAM scenario as it is assumed in the Stantec tool that all Cambridge North demand would use a north-west HQPT route and interchange at the travel hub for onwards travel by transit, whereas the connectivity provided by CAM would route all Cambridge North demand via Cambridge Station to/from Cambridge East.

Transit Link Integrated with CAM Demand Summary

3.12 As shown in Figure 3.2, the peak hour transit trips associated with the same links shown above are summarised in Table 3.2, which assumes that the transit link forms part of a wider CAM network. To reiterate, the flows here relate to Cambridge East demand and trips from the Newmarket Road Travel Hub only. They do not consider the patronage associated with other developments, or indeed potential CAM trips from/to the east beyond the travel hub which will result in higher patronage.

Table 3.2: Transit Link Integrated with CAM Demand – Link Flows AM Peak Hour

Scenario	Between Cambridge Station and CE			Between CE and Eastern Travel Hub		
	Northbound	Southbound	Two-Way	Northbound	Southbound	Two-Way
B	2,260	1,060	3,320	60	1,320	1,380
C	3,060	1,160	4,220	80	1,560	1,640
D	2,960	1,200	4,160	80	1,520	1,600

Phasing

3.13 The Stantec patronage forecast presented above represents a 2051 future year, which assumes that the full development is completed and occupied by this date. In relation to cumulative development this is consistent with the CPIER growth levels of housing and jobs to 2051. The jobs and homes assumed in Stantec's tool reflect CPIER's upper scenario on job growth. Larger scale transport schemes are included in the tool where they are judged likely to be in place and are significant enough to have a bearing on the tool, i.e. new EWR train services over the central section (St Neots, Cambourne etc) to Cambridge station, Cambourne to Cambridge public transport route, Waterbeach to Cambridge better public transport project, Cambridge South East Transport study, Greenways and Chisholm Trail.

3.14 While 2051 provides a useful future baseline which aligns with the CPIER growth assumptions, it is acknowledged that the assumed build/take up rates for all development scenarios leads to a protracted delivery period beyond 2051 and up to 2062.

3.15 The assumptions informing the viability testing which follows in the next section are derived from the following delivery programme and rates provided by Bidwells.

Table 3.3: Development Scenario Delivery Programme

Scenario	Land Use	Units/Jobs	Years	Start	Finish
B	Residential	9,500	18	2031	2049
	Commercial	28,000	23	2036	2059
C	Residential	12,000	23	2030	2053
	Commercial	38,000	21	2035	2056
D	Residential	12,000	29	2031	2060
	Commercial	38,000	26	2036	2062

3.16 To understand how the patronage assumptions in Figure 3.1 and Figure 3.2 relate to the residential and commercial uses and respective delivery programme, the following breakdown of patronage has been used to differentiate between the sources of transit demand.

3.17 These represent the breakdown of all external inbound and external outbound trips within the Stantec tool and attribute trips to the appropriate uses accordingly.

Table 3.4: Breakdown of External Transit Trips by Land Use

Scenario	Inbound Trips (External)		Outbound Trips (External)	
	% associated with homes	% from other uses	% associated with homes	% from other uses
B	7%	93%	84%	16%
C	4%	96%	74%	26%
D	4%	96%	74%	26%

3.18 The assumptions set out above inform the viability testing which follows in the next section.

4 Viability Testing

4.1 This section presents the forecast annual build-up of transit demand based on the patronage forecast provided by Stantec and set out in previous sections. At this stage, this is intended to provide an initial viability appraisal and as such a series of ranges are provide, both for the assumed transit link fare and also for the assumed operating expense (OPEX).

4.2 As identified in previous sections, patronage forecasts are based on early Stantec outputs and will be verified through more detailed testing at a later stage. They are also conservative in that only Cambridge East and Newmarket Road Travel Hub demand is considered. Demand associated with other developments and that associated with increased CAM connectivity will be worked into the modelling and viability testing at a later stage.

Assumptions

4.3 In addition to the assumptions set out in the previous section, the following have been applied in developing the transit link viability testing.

Annualisation

4.4 Based on previous work, factors have been applied to the AM peak hour flows to determine the annual patronage forecast. The peak to daily conversions are derived from TRICS trip rates for both residential and commercial uses, whilst the daily to weekly conversions assume weekday trips only for commercial uses and some weekend patronage for residential uses. The conversion factors which have been applied are set out in Table 4.1

Table 4.1: Annualisation Conversion Factors

Conversion Factors	Residential	Commercial
AM Peak Hour (Two-Way) to Daily	7.9	8.8
Daily to Weekly	6	5
Weekly to Annual	52	52

OPEX and Revenues

4.5 An OPEX model for a transit link with tunnelled connection to Cambridge station was developed in 2018 to inform the ‘Connecting New East Cambridge’ study. This provided an estimated cost of between £5.5m to £6.5m depending on the operating model which is still considered a robust estimate.

4.6 To estimate forecast revenues, both a £1.50 and £2 average fare rate have been assessed which provides a useful benchmark against other transit schemes within the UK. These fares have been applied to all forecast demand generated on the transit link, whether directly Cambridge East trips or through trips from the Travel Hub. The fare rate is considered inelastic for the purpose of this analysis, so has no direct bearing on assumed patronage.

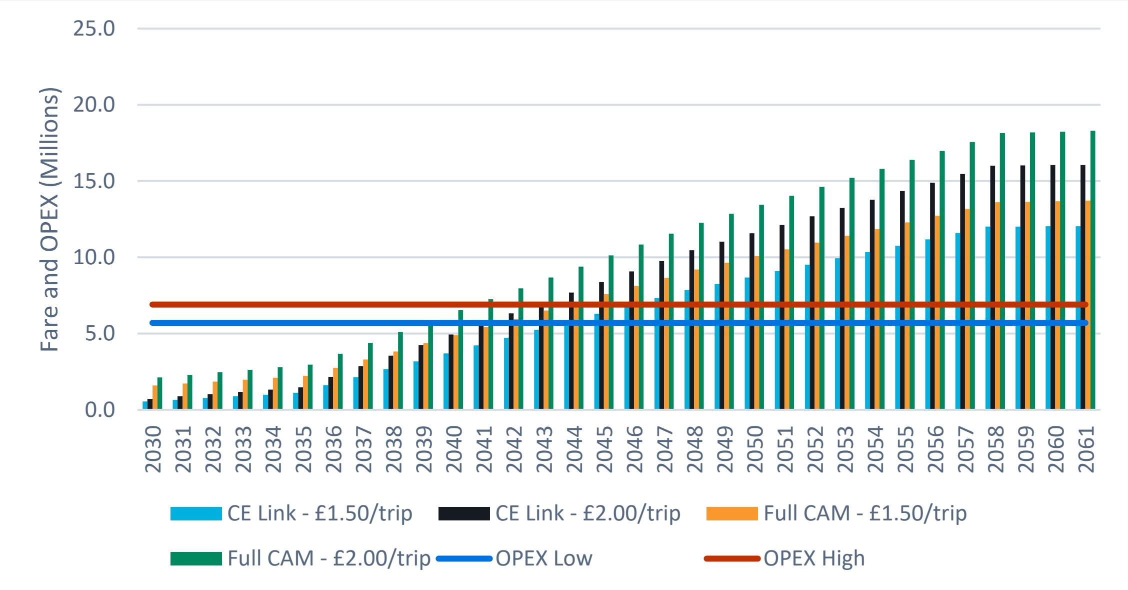
4.7 It is noted that in a full CAM scenario, with transit trips beyond Cambridge station, the fare could increase with distance travelled, nevertheless the fare range used is a good barometer for assessing revenues associated with the link between the Travel Hub and Cambridge station.

Results

Scenario B

4.8 Figure 4.1 presents the revenues associated with the transit link in development Scenario B with both a standalone transit link 'CE Link' and a transit link integrated as part of a 'Full CAM' network.

Figure 4.1: Potential Annual Revenue/OPEX comparison – Scenario B



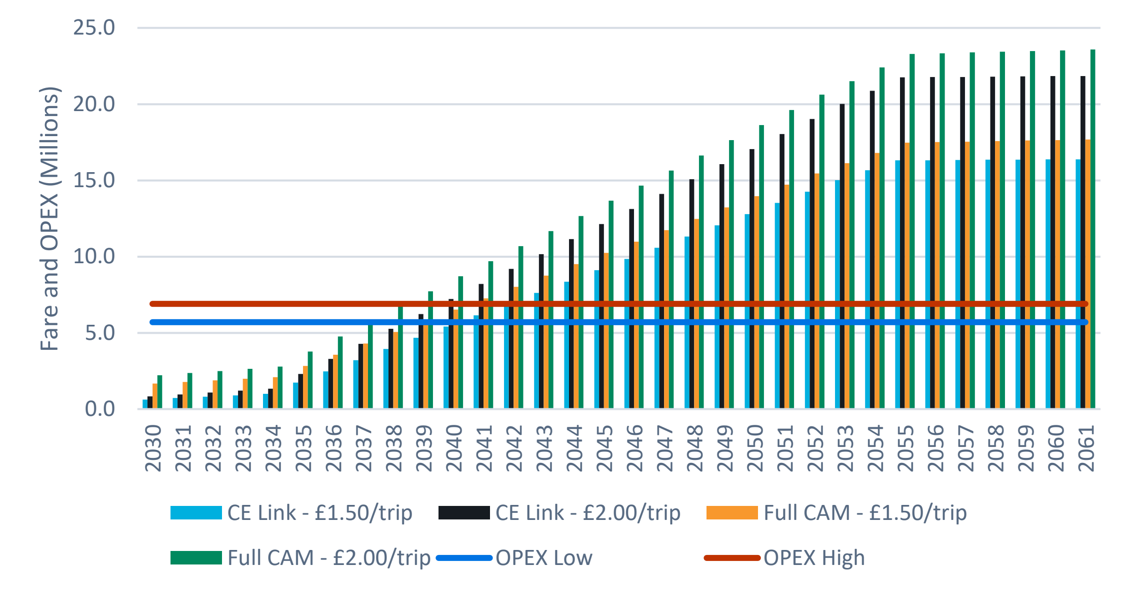
4.9 The chart shows that with an assumption of a full city-wide CAM network, revenue exceeds operating costs on the eastern link between 2039-44 depending on the fare rate and OPEX assumed, with a useful surplus produced in later years.

4.10 If the CE link is considered as a stand-alone scheme, with a £2 average fare, the transit would break even (revenues exceeding operating cost) between 2041-43, and future year surpluses would be valuable. But at a £1.50 average fare rate, the line would operate with a deficit until around 2046.

Scenario C

4.11 Based on the assumptions presented in previous sections, the same analysis has been carried out for Scenario C as presented in Figure 4.2, which includes a greater quantum of housing and jobs and assumes a shorter overall delivery timescale when compared to Scenario B.

Figure 4.2: Potential Annual Revenue/OPEX comparison – Scenario C



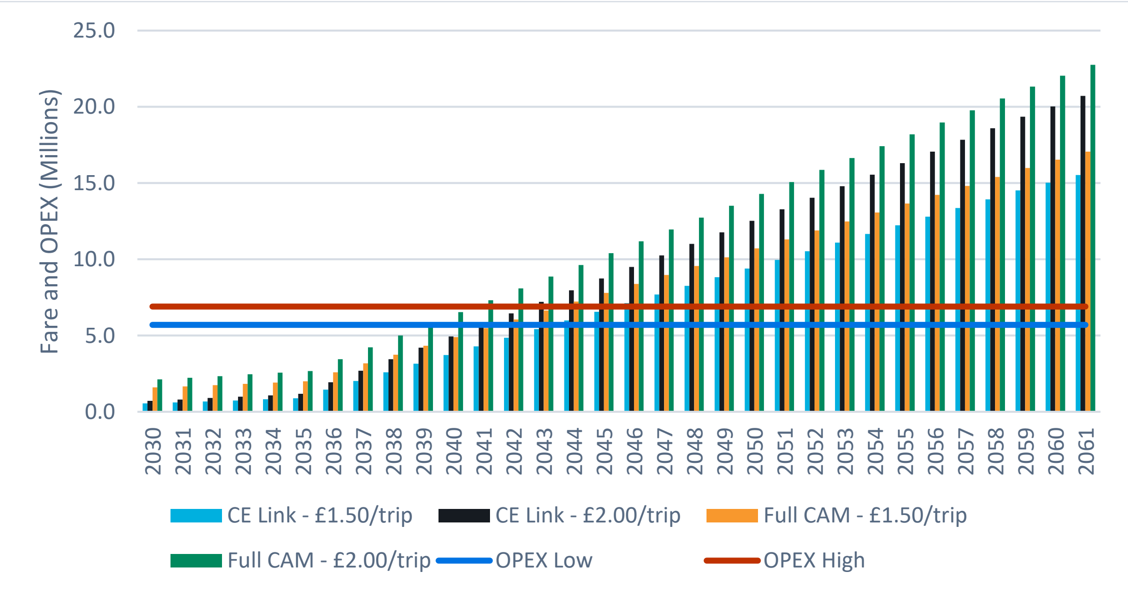
4.12 The chart shows that with an assumption of a full city-wide CAM network, revenue exceeds operating costs on the eastern link at either a £2 fare/trip or £1.50/trip between 2037-40, approximately 2-4 years earlier than Scenario B. A significant surplus would be produced thereafter.

4.13 If the CE link is considered as a stand-alone scheme, with a £2 fare, the transit would break even between 2039-40, approximately 2-3 years before Scenario B. At a £1.50 fare rate, the line would break between 2041-42, around four years before Scenario B.

Scenario D

4.14 The same analysis has also been carried out for Scenario D as presented in Figure 4.3, which includes a similar quantum of housing and jobs as Scenario C but on a protracted delivery programme.

Figure 4.3: Potential Annual Revenue/OPEX comparison – Scenario D



4.15 Whilst generating similar revenues to Scenario C by the end of the delivery programme, the protracted timescales means that the break even point is also extended, meaning the transit link would require more subsidy in earlier years.

Benefit of Employment and Residential Uses

4.16 To understand the relative importance of both residential and employment uses, simple calculations to derive the transit 'revenue per job' (Table 4.2) and 'revenue per resident' (Table 4.3) figures have been derived based on both a standalone link and a link integrated with full CAM for Scenario C. This assumes full build out of the development.

Table 4.2: Transit Annual Revenue per Job – Scenario C

	Annual Employment Transit Trips	Jobs	Annual Trips per Job	Revenue Per Job	
				£1.50 fare	£2.00 fare
Transit Link	9.0m	38,000	237	£355	£475

Table 4.3: Transit Annual Revenue per Resident – Scenario C

	Annual Residential Transit Trips	Number of Homes	Annual Trips per Home	Annual Trips per Resident (2.5 people per home)	Revenue Per Resident	
					£1.50 fare	£2.00 fare
Transit Link	1.3m	12,000	108	43	£65	£85

4.17 As shown in the tables above, from a revenue perspective, the employment use is significantly more beneficial than residential use. There are however benefits of having a good mix between employment and residential uses to help better balance the flow on the transit link, which helps to reduce the net operating costs and is important for the viability of the transit operation.

Park and Ride

4.18 The overall demand associated with both a standalone transit link and a link integrated with a Full CAM system also accounts for 'through' trips, which are those generated by future users of the Newmarket Road Travel Hub (or 'park and transit'). This demand also accounts for a proportion of existing car trips which could be expected to transfer to 'park and transit' for onward connections to particular destinations in Cambridge.

4.19 This 'park and transit' demand has been kept consistent across the Scenarios assessed above, as shown in Table 4.4.

Table 4.4: Transit Annual Demand (passengers [millions])

Scenario	Demand	Standalone Transit Link (East Cambridge to Cambridge Station)	Transit Link Integrated with Full CAM
B	Development Demand	7.5 (93%)	7.5 (84%)
	Park and Transit Demand	0.6 (7%)	1.7 (18%)
	Total	**8.1**	**9.2**
C	Development Demand	10.1 (95%)	10.1 (88%)
	Park and Transit Demand	0.6 (5%)	1.7 (14%)
	Total	**10.7**	**11.8**
D	Development Demand	9.7 (95%)	9.7 (87%)
	Park and Transit Demand	0.6 (5%)	1.7 (15%)
	Total	**10.3**	**11.4**

4.20 As shown above, the 'park and transit' demand accounts for up to 18% of total transit demand within any development scenario. As expected, the attractiveness of 'park and transit' and the eastern travel hub becomes more attractive when the transit link is considered as part of a wider CAM network with the Cambridge-wide connectivity that provides.

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Appendix B

Report
December 2020

Cambridge East
Complementary Public Transport Interventions

Marshall Group Properties
Our ref: 23297007

Report
December 2020

Cambridge East
Complementary Public Transport Interventions

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Contents

1 Introduction

Context

1.1 In developing its plan for Cambridge East, Marshall Group Properties preference and hope is that CAM will come forward and they will continue to work collaboratively with all parties to this end. In a separate report "Cambridge East Transit Deliverability Study" part of the evidence submitted for the Local Plan, a standalone transit line was identified, linking the site with Cambridge railway station. It would only be promoted on a stand-alone basis if CAM was not proceeding, or if it might be delivered in a timescale that could prohibit the timely delivery of Cambridge East, in which case, the transit link could form a first phase of CAM.

1.2 This report sets out possible further complementary public transport interventions that would support the development of Cambridge East, supplementing and adding detail to the strategies set out in Stantec's "Cambridge East: Transport Vision and Emerging Transport Strategy" document. Some of these interventions would support early and interim stages of the build-out; others would come in later either before or after the planned transit link. Having this flexibility ensures that development delivery can be guaranteed with suitably scaled and affordable transport solutions and reflect the level of progress made with the CAM project. These same solutions can then be further developed or become superseded by more strategic interventions over time and as the need arises.

1.3 The requirement for suitable complementary public transport connections associated with the development arises from:

- The need to provide an ***attractive alternative to car use***, alongside active travel and other measures including planned infrastructure investments, to ensure that the traffic impacts of the Cambridge East development on the surrounding highway network are contained to acceptable levels
- The need to ensure the ***viability of the development***, consistent with the ambition to provide a worthy extension to the city of Cambridge, capable of attracting world-class businesses and achieving high values on residential properties
- The need to contribute to the wider development aim of making ***a net positive contribution to Cambridge***, its residents and businesses
- The need to ensure that, in respect of transport, the plan for Cambridge East is consistent with all of the ***environmental goals*** set for it, including the creation of a net zero development.

1.4 These complementary public transport measures form part of the overall suite of available measures for the transport strategy for the Cambridge East development set out by Stantec in their Cambridge East: Transport Vision and Emerging Transport Strategy document.

1.5 This, study and the Stantec work builds on the work carried out by the Greater Cambridge Partnership in their examination of ways to improve access from the eastern side of Cambridge to the rest of the city – especially the city centre.

1.6 While the GCP work is not intended to address the issue of the planned Cambridge East development, Marshall Group Properties has worked closely with the GCP and its Eastern Access study team throughout and is fully supportive of the emerging conclusions. The proposals reported here are consistent with the GCP work and can be seen as an extension of the Eastern Access study emerging findings.

Anticipated Trends

1.7 Complementary public transport facilities will be the focus of this report. However, it is important to note the role that active travel will play in a successful delivery of this site. Walking and cycling are at the forefront of the Transport Strategy and will be promoted and enabled as far as possible as the 'go-to modes of choice' for those that are able to use such modes and for journeys of appropriate distances.

1.8 The build-out of the development is likely to cover a multi-decade period lasting to 2050 and beyond . The overall transport strategy therefore anticipates the likely shifts and developments in technology which will likely affect the way people choose to live, their life-styles and associated travel behaviour, set in the context of an intensification of measures that will allow the city – and the country – to adapt to the imperatives set by climate change.

1.9 These changes, in respect of transport provision plans, anticipate how Cambridge as a whole, and the surrounding area, will evolve with the development of the most sustainable development in the sub-region, which is the Cambridge East plan. This means allowing for at least the following:

- The full de-carbonisation of all public transport vehicles – so all buses to be zero emission/presumed electrically powered
- Full deployment of personal IT support available for people of all ages and abilities to enable secure and safe navigation
- Arrangements for charging systems (fares) that allow for seamless transfer between the most appropriate travel modes (including on the local part of the national rail network which is expected to expand significantly with stations in west Cambridge (Cambourne) and possibly East Cambridge (Coldham's Lane) joining Cambridge North and South and of course, Cambridge [central] stations to form a pan-Cambridge rail network).
- All of these modes designed for use by mobility impaired travellers.

Options Examined

1.10 The report considers public transport connectivity challenges and possible solutions around the compass from Cambridge East: North, East, South and West in turn.

2 Connections to the North

Introduction

2.1 In this direction, the focus is on high quality public transport interventions between Cambridge East and the North/North East Cambridge development cluster from which a number of existing and planned transport links converge. These onward links serve a number of largely residential developments to the north and west of Cambridge which are the source of anticipated significant levels of demand for journeys to work in Cambridge East, particularly in Development Growth Scenarios B, C and D.

2.2 The options to the North/North East are being considered for progressive implementation and require collaborative planning between those responsible for the North/North East and East Cambridge developments.

Option NE1

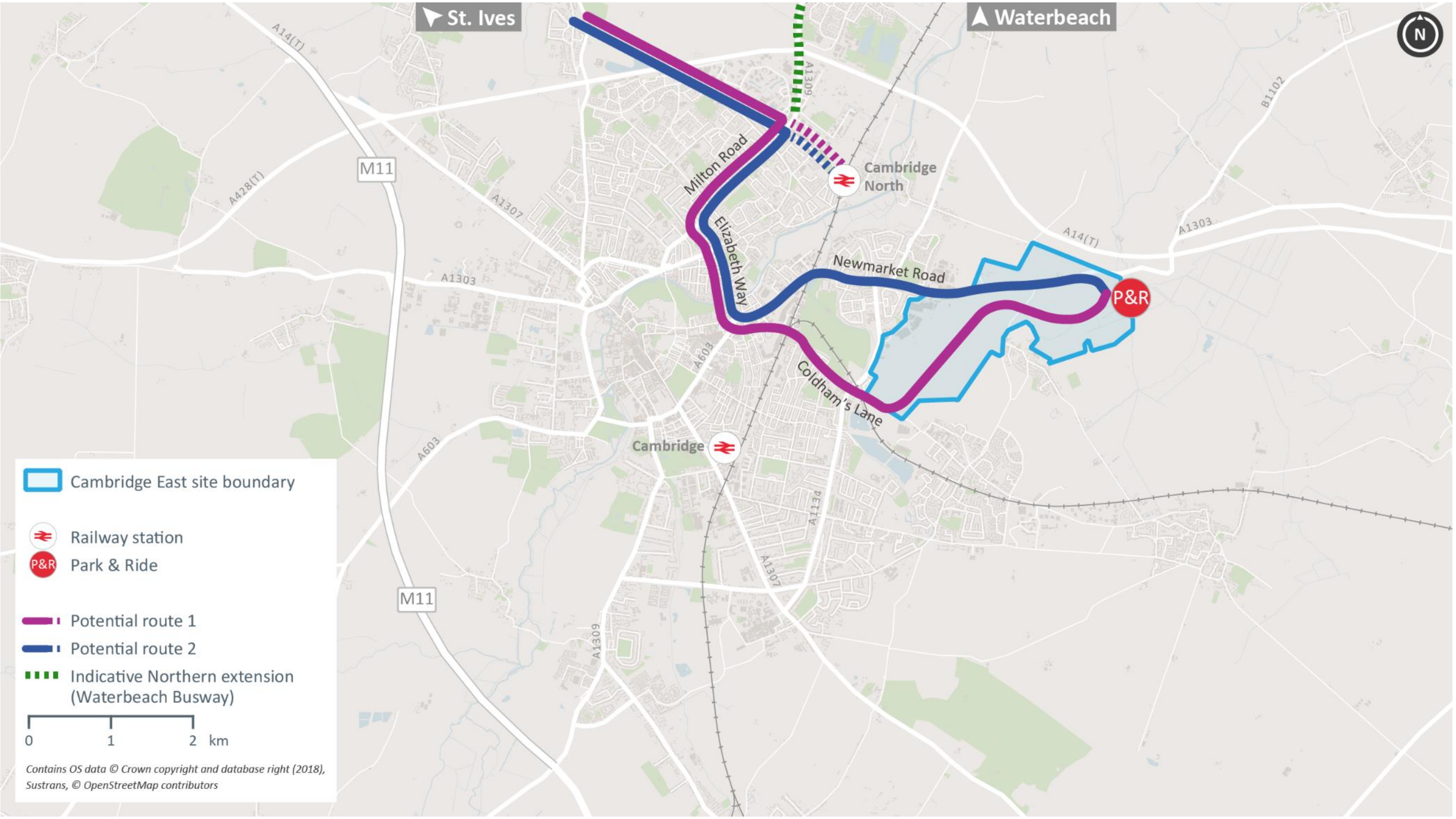
2.3 The first option (NE1) makes use of the existing highway network, building on the improvements examined in the Cambridge Eastern Access and Waterbeach to Cambridge busway studies. These proposals have been the subject of work by the Greater Cambridge Partnership (GCP) and were subject to public consultation in 2020.

2.4 Option NE1 is a variant of Stantec's Option N4 as set out in their Cambridge East: Transport Vision and Emerging Transport Strategy document and would extend bus services from the St Ives busway (and the Waterbeach route, if it is adopted) over existing roads (Milton Road – Elizabeth Way – Newmarket Road) to provide a direct connection from places north and north west of Cambridge and Cambridge Science Park directly to Cambridge East. There could also be a short route that would use the very last section of the busway between Milton Road and Cambridge North, but this would add little further in terms of connectivity, other than to/from railway services at Cambridge North.

2.5 There are alternative service routings available for such an extension of service, although none are particularly direct. As an example, east of the River Cam, routes could follow either Newmarket Road or Coldham's Lane. The enhancements under examination by the GCP as part of the access studies could help improve journey times significantly over these routes. Option NE1 is illustrated in Figure 1 below.

2.6 This could be an important first stage in establishing an orbital high quality public transport system for Cambridge, but it is appreciated that such an arrangement is less favoured by public transport operators over city centre-base hub and spoke approaches. Each route illustrated in Figure 1 could be extended through the East Cambridge development to a terminus at the re-located Park and Ride facility (Newmarket Road Travel Hub) which would help drive operator revenues and secure service provision.

Figure 1 – Option NE1 – Potential Route Alignments



2.7 Option NE1 extends services over existing highways, using whatever bus priority measures are available as a result of the GCP studies. They could provide a journey time of *circa* 20-25 minutes between Cambridge North and the Cambridge East development. Services will, however, likely be subject to traffic congestion in peak periods in the absence of any traffic restraint measures such as pricing. But the services would provide useful direct connections from Huntingdon/St. Ives and potentially Milton Road P&R as well as Waterbeach and the Science Park to the Cambridge East development, all without the need for intermediate transfer.

2.8 This forms a possible early addition to the public transport accessibility of Cambridge East, but viability of services may need operating subsidy, at least through an early years' start-up period. Such routes would be subject to development of suitable service plans and agreement with bus operators. The latter would likely be contingent on approvals of development in North East Cambridge as well as Cambridge East.

2.9 Option NE1 should form an early part of the overall Transport Strategy for Cambridge East as an alternative to Stantec Option N4 in their Cambridge East: Transport Vision and Emerging Transport Strategy document covering at least the early years of development. In its absence, a significant portion of travel to Cambridge East would involve cross city journeys requiring bus to bus transfers in the city centre. It will therefore add to the array of measures that will contain adverse road traffic impacts.

2.10 It would provide a solution for a smaller scale residential-led scheme for Cambridge East (Scenario A, for example) where it would provide access to employment at the Science park and other north-side centres; or for the early phases of a more substantial mixed use scheme where greater inward trips are forecast in the longer term

Option NE2

2.11 Option NE2 (Option N5 in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document) provides new infrastructure to support services between Cambridge East and the North East Cambridge area. It would therefore require significant levels of build-out of both developments and support from both developments. It could be construed as an extension of the St Ives busway and/or an additional/complementary part of the planned CAM network (should a tunnelled link parallel to the railway corridor not be delivered) – that is to say, part of a wider regional solution. See Figure 2 for the potential route alignment.

2.12 The route envisaged stays close to the established A14 corridor, crosses the River Cam and Ely-Cambridge railway line on new bridges before turning south to reach Cambridge North station. Here either there could be interchange with busway services arriving from the north west, or, better, after reversal, services would continue onwards on the established and possibly further new segregated busway facilities to the north and north west of Cambridge.

2.13 In Figure 2, this scheme is shown as an extension of the transit link from Cambridge railway station to Cambridge East. As such, of course, it could form part of the wider CAM network in due course. It would provide a faster connection between north and east development centres than services operating on a mix of existing streets and established busways as in Option NE1. It could support services from North Cambridge and places to the north and west of Cambridge to Cambridge East, and, provided it had compatible technology, onwards to Cambridge station in tunnel.

2.14 The scheme has been assumed to follow the CAM and Transit Line aspiration for attractiveness and hence, in consideration of alignment and likely delivery costs, the same need for fast reliable journey times and technology that includes an electrified power system and other features have been assumed.

2.15 The costs of NE2, which is *c* 5 km long, on this basis are summarised in Table 1. These have been developed using the unit rates and assumption that have been applied to the eastern section of Cambridge station link, which in themselves are consistent with the order of costs adopted for CAM, with a suitable allowance for the complications of a viaduct crossing of the River Ouse and the railway line. Overall, the costs are estimated at £170m at 2020 prices.

Table 1: NE2 Link Cost

Item	Estimated Cost
Surface route Infrastructure including design and engineering contingency	£103m
Vehicles (assuming 8 bespoke clean technology vehicles for shuttle service)	£4m
Procurement and establishing operation	£3m
Optimism Bias (@66%)	£60m
Total	**£170m**

2.16 Other variants of this option could use high quality public transport technology, as a complement to Transit /CAM without adopting its technology. While such an approach could use the transit infrastructure through the Cambridge East development site, it could not continue onwards south/west in tunnel. But it would carry a lower capital cost, while remaining fully compatible with busways beyond Cambridge North. This is choice between high quality public transport and Transit/Cam technology that can be made a later stage for this potential scheme

2.17 When NE2 is constructed, it could be envisaged that most of the NE1 bus routes would be removed, in effect transferred to the new faster alignment. There would be no intermediate stops on the busway/transit infrastructure – although there might be a case for a facility to serve Fen Ditton.

2.18 Although the route shown in Figure 2 would link Cambridge and Cambridge North railway stations, this is incidental to its primary purpose which is to provide attractive public transport connectivity directly between Cambridge East and other major employment and residential areas including, North Cambridge, Cambridge Science Park and more distantly located existing and emerging population centres including those along the current guided bus corridor.

2.19 No engineering feasibility and detailed environmental assessments have yet been made of this proposal and so it must be regarded as an indicative scheme only at this stage. However, following on from earlier high level assessments and understanding of local issues, the alignment looks to minimise its environmental impact by running close to the A14 and crossing the River Cam adjacent to the existing A14 bridge, in an area considered less environmentally sensitive, avoiding the more sensitive Ditton Meadows section, based on a desktop review of designations.

Other Alignment Options

2.20 More direct alignment options, such as that shown in Figure 3, have also been considered. They would be unlikely to be acceptable because of their impact on Ditton Meadows and/or Stourbridge Common which are places of great value to the local communities. Stourbridge Common is also classified by the Council as a Local Nature Reserve.

Figure 2 – Option NE2 – Potential Segregated Route Alignment

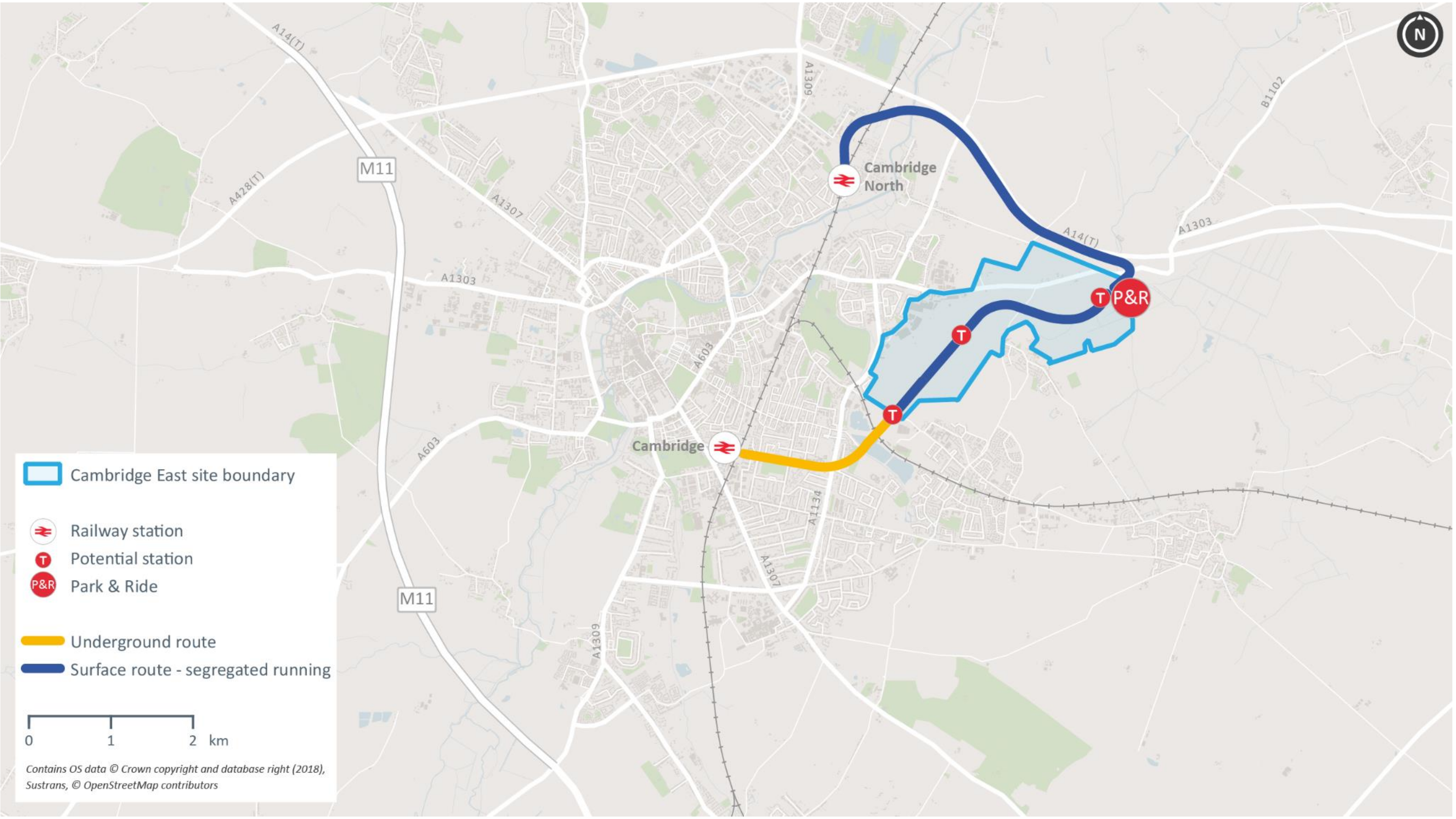
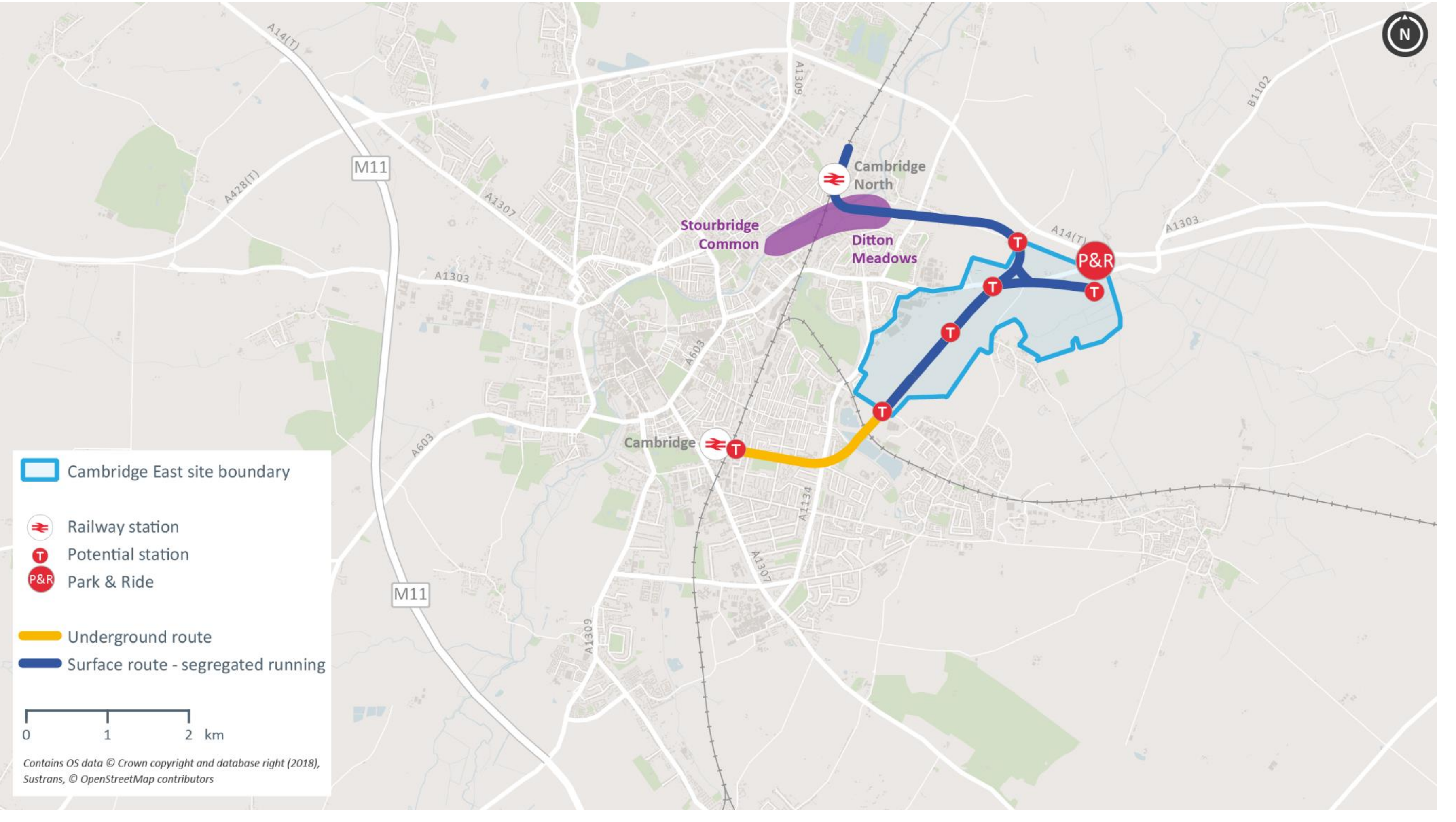


Figure 3 – More direct, but rejected Route Alignments



2.21 Both Options NE1 and NE2 would offer advantages to the North East Cambridge developments, and indeed existing residents and businesses by offering a direct connection to the planned Park & Ride at Cambridge East.

2.22 There may be scope to provide a possible solution to the constraints of the problematic Fen Road level crossing to the south of Cambridge North station as shown in Figure 4 below, possibly allowing this to be removed altogether. For example, the western segment of this link and bridged section over the River Cam could be made available for general road traffic.

Figure 4 – Fen Road Level Crossing

2.23 The alignment of NE2 next to A14 is preferred because it reduces (but doesn't eliminate) adverse impacts on the Green Belt . But it would provide excellent public transport links to the Science Park and other planned developments at North East Cambridge.

2.24 It would incorporate and support services from west and north of Cambridge, expanding the catchment of places with direct access to Cambridge East, and offering equivalent benefits to potential Cambridge NE developments.

2.25 It should be noted that if/when the current CAM network is implemented in full, incorporating the planned link from Cambridge East to Cambridge railway station, there would be direct, fast and frequent transit services from Cambridge East via the city centre to Cambourne, and other destinations to the west of Cambridge and to Cambridge North, Huntingdon/St Ives/Waterbeach. This would replicate the key linkage that this connection provides. For this reason, any decision on proceeding with NE2 needs to await developments with the CAM project.

3 Connections to the East

Introduction

3.1 In this direction, the focus is on high quality public transport (including rail) and active travel interventions along the eastern corridor out of Cambridge, including Cambridge East, and connections further afield to Newmarket, taking in to account current proposals for enhancements along this corridor.

Eastern Access

3.2 The Eastern Access initiative is being promoted by Greater Cambridge Partnership is currently out for consultation. It is one of four corridor projects that aim to provide better public transport and active travel routes, such as walking and cycling, offering better connections and alternatives to car use for growing communities to the north, south east, east and west of the city.

3.3 Following a period of public engagement in the summer of 2020 GCP has developed a number of options to improve transport to the east of Cambridge for those who live in or travel in the area. These options, which include public transport, walking and cycling proposals, remain at an early stage.

3.4 The options are split into two phases, with Options 1.1 and 1.2 being more achievable in the shorter period and the remaining three options, 2.1, 2.2 and 2.3, recognised as needing longer timescales. The valuable work in the Eastern Access study has helpfully informed the proposals presented here – although, of course, the access study could not anticipate that Cambridge East would proceed.

3.5 The options examined by the Greater Cambridge Partnership are summarised below:

- **Option 1.1:** Newmarket Road improvements – this could include bus lanes, cycle lanes and improved facilities for pedestrians.
- **Option 1.2:** Newmarket Road Improvements + Park & Ride Relocation - this could include bus lanes, cycle lanes and improved facilities for pedestrians, equestrians and people using scooters as well as relocating the Newmarket Road Park & Ride site further out of the city
- **Option 2.1:** High Quality Public Transport Route via Coldham's Lane – this could include an off-road route for public transport vehicles connecting to the city via Coldham's Lane
- **Option 2.2:** High quality Public Transport Route via the Tins – this could include an off-road route for public transport vehicles connecting to the city via the Tins and Mill Road
- **Option 2.3:** Long Term Rail Opportunity – this could include new and reopened stations as well as a more frequent train service.

Railway Options

3.6 The Newmarket to Cambridge Railway Line runs in a broadly east-west direction to the south of the Cambridge East site. Under current Network Rail plans, it is expected that the current railway, which is single track, would be re-doubled for a distance of 3.5 miles from its junction with the main line north of Cambridge station.

3.7 A potential option that could be explored would be to add an additional station on the existing alignment that could form a useful link for trips to/from the east, such as Newmarket and Bury St Edmunds. But service frequencies are expected to increase from the present hourly service only to perhaps 3 trains/hour, reflecting the longer distance nature of the route. While a new station on the line would therefore be helpful for improving access from Newmarket and other places served by this railway, the level of service anticipated cannot provide a substitute for the connection needed to Cambridge railway station that is the objective of the proposed transit link.

Other Options

3.8 Newmarket Road acts as a bus corridor east out of the city, with services operating on the A1303 through Bottisham to Newmarket and also via Bottisham, the Swaffhams and Burwell before continuing to Newmarket. There are also proposals to improve connectivity for cyclists within east Cambridge itself through the GCP's Cambridge Eastern Access Study. Further details of the GCP Cambridge Eastern Access Proposals are set out in Section 8 of Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

3.9 There is an hourly rail service operating east from Cambridge Central Station to Newmarket and Bury St Edmunds and beyond. The capacity of this line is limited as it is only a single track and there is also limited capacity at Cambridge Station.

3.10 East West Rail Phase 3 (Eastern Section) has the potential to influence travel in the area in the future. The remit of this is to improve frequencies east of Cambridge towards Ipswich and Norwich. However, this is unlikely to be delivered within timescales to 2030 as it is at the early stages of consideration by the East West Rail Consortium and no route options have yet been published. However, as already set out in the consultation for the GCP's Cambridge Eastern Access study, East West Rail Phase 3 could potentially include improving the capacity of the existing railway line east out of Cambridge. If a stop were provided at Cambridge East, this would offer a direct, more frequent service from the towns to the east of the city into and out of Cambridge.

3.11 In addition, the current proposals for CAM envisage an outer route extending from the Newmarket Road Travel Hub towards Newmarket and Mildenhall. No connectivity is currently proposed to Bury St Edmunds so this would continue to only be accessible by rail and long-distance bus service.

3.12 The main focus of the strategy to the east focuses on maximising the ability to capture and switch trips to sustainable modes by providing a range of connectivity options from a relocated and enlarged Newmarket Road Travel Hub.

3.13 As the origins of those travelling to Cambridge East from outside the city to the east are dispersed, one option to be explored is private coach services could be offered based on the home destinations of their employees and subsidised by employers within the site so that services can be tailored specifically to demands, rather than corridors. This also means that employees are not required to drive to the Newmarket Road Travel Hub to get to their workplace from east of the city.

3.14 In addition to connectivity east outside the City, there are measures within the east of Cambridge which have already been set out in earlier sections that would provide access to the Cambridge East site from other locations within the east of the city. These options include:

- Relocation of Newmarket Road Park and Ride and expansion and upgrading of the Travel Hub
- Delivering high quality public transport services from the Newmarket Road Travel Hub towards Addenbrookes, Cambridge North the Rail Station and the City Centre.

4 Connections to the South & West

Introduction

4.1 In this direction, the focus is on high quality public transport interventions along various routes to the south and west of the Cambridge East site connecting to the Station and other Park and Ride sites to maximise integration of modes.

Connections South

Option S5 - High Quality Public Transport Service from relocated Newmarket Road Travel Hub to Addenbrookes via Cherry Hinton.

4.2 As shown in Figure 5 (the purple line), this option includes the provision of a high-quality public transport service from the relocated Newmarket Road Travel Hub, through Cambridge East and via Cherry Hinton to Addenbrookes and the Cambridge Biomedical Campus.

4.3 Alternative routes and extensions that could be explored in the future exist. For example, if a modal filter is installed on Coldham's Lane, a service could capitalise on this connection and route via the A1134 to Addenbrookes rather than via Cherry Hinton. Additionally, once Cambridge South Station is delivered, service extensions could be explored from Addenbrookes to Cambridge Station or onto Babraham Road Park and Ride. This would allow people travelling into Cambridge East from Babraham to access a direct public transport service, rather than having to interchange at Cambridge Station. A route alternative could also be explored east of Cherry Hinton to provide connectivity to Tesco and Peterhouse Technology Park / Capital Park.

Option S6 – Babraham Park and Ride Expansion

4.4 With the additional demand from outside the city in the larger scenarios, Cambridge East would support an expansion of the Park and Ride as well as the other schemes in the area aimed at intercepting trips from the south and switching them to public transport before entering the City.

4.5 Another possibility could be that if a surface station were built adjacent to Cambridge Station as the western terminus of the transit link (from the east), then this could potentially be extended southwards staying east of the railway line (towards Hills Road) to create an east-south direct through-running transit route, with a connection built southwards

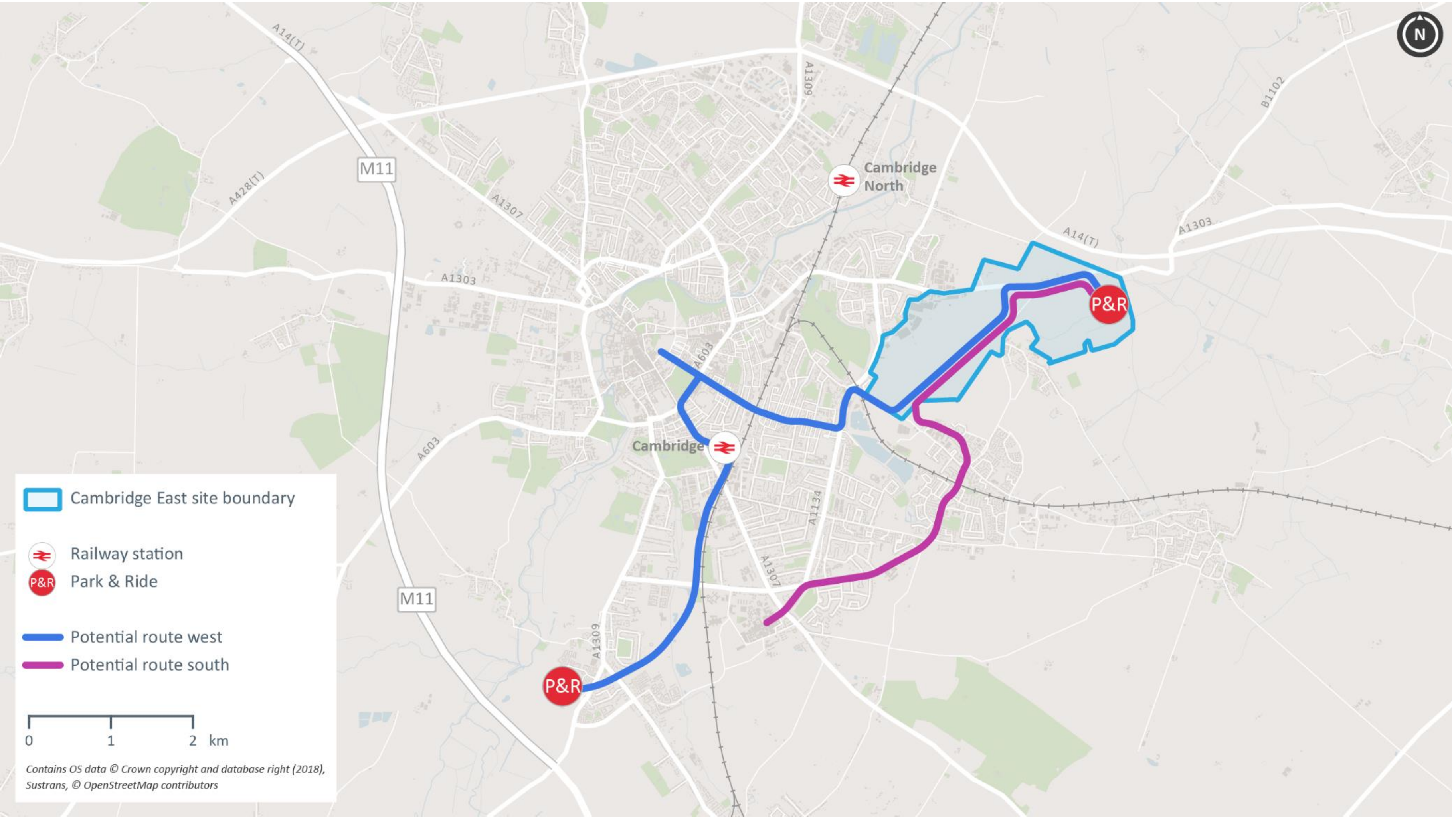
Connections West

4.6 The Transit Deliverability Study outlines detailed appraisal of the main public transport intervention to connect the Cambridge East site to Cambridge Station. It notes that the current plans for the central section of East West Rail provide, with the very fast connection by transit from Cambridge station into the development site a single-transfer fast journey from Cambourne and the St Neots area. If the CAM scheme is delivered as currently envisaged, it will provide direct and fast connectivity east-west across the city centre.

4.7 In the early years of Cambridge East development, it is likely that connectivity would be achieved using new bus-based networks to connect the Cambridge East site westward to the city centre. Such approaches, which might use for example Mill Road as a key bus route from Cambridge East to the city centre are described in the Transit Deliverability Report. Such schemes could include buses having priority through the Cambridge East site along the proposed transit route, before joining the highway network at a location on the western side of the Cambridge East site to connect with a suitable corridor such as Mill Road. This is shown on Figure 5 below and corresponds with Option SC13 as shown in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

4.8 A suitable route for bus access to Cambridge railway station is harder to achieve without a somewhat circuitous route. One option is to follow Mill Road, before a left turn at Parker's Piece and another onto Hills Road to approach the station from the west. Another would use Cherry Hinton and Hill's Road from the south which would be an extension of Option SC13 as shown in Stantec's Cambridge East: Transport Vision and Emerging Transport Strategy document.

Figure 5 – Example Routes to the South and West



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