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Subject	Review of C2C Alternative Northern Alignments	Project Name	Cambridgeshire Autonomous Metro
Attention	CPCA/GCP	Project No.	B237401
From	Jacobs	Status	Draft and Confidential
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## Disclaimer

The review of C2C alternative northern alignments, was prepared by Jacobs at the request of the CPCA with the purpose of developing high level northern route options to the proposed southern corridor on the Cambourne to Cambridge (C2C) route alignment.

The options and costs set out in the report are high level and aim to begin an exploration of whether a northern route would be possible – prepared for the purpose of providing indicative options for discussion. Considerably more detailed analysis would be required by the GCP if this is to be considered as an alternative route.

## 1. Introduction

Jacobs have been asked by CPCA (working in partnership with the GCP) to review a potential northern option of the current Cambourne to Cambridge (C2C) alignment to avoid the villages of Coton and Hardwick. A corridor has been identified north of the A1303/Cambridge Road and A428, and two options developed. These two routes have been assessed against the current C2C route assessment criteria with input from GCP officers.

In this report, only the section of the alignment to the east of Bourn Airfield is examined in response to some particular stakeholder issues in this area. There are two options for the alignment west of the airfield, a northern or southern route and the choice is predicated on the location adopted for the East-West-Rail (EWR) station which the CAM will integrate with. As this station location is currently not confirmed, this section of the route has not been examined in the same detail and is not commented on further.

### 1.1 Option description

The following paragraphs contain a brief description of each of the routes. A more detailed description is provided in Section 2.

**Current C2C Alignment.** This is the current C2C proposed alignment from the University of Cambridge west campus, which passes over the M11 and travels at-grade past the village of Coton to the A428 St Neots Road and along to Bourn Airfield. (see Figure 1)

**Northern Option 1** retains the western portal of the current CAM central tunnel section in its current location. The surface route then cuts through the University of Cambridge campus and over the M11 to Rectory Farm. From there the alignment heads north over the A1303 before looping round to a corridor between the south of Madingley village and the A428 and heading west to Bourn Airfield via the Scotland Farm development. (see Figure 2)

**Northern Option 2** consists of an extension of the CAM tunnel north east from the current western portal location to a new location to the north of the A1303 where it follows the same alignment to Bourn Airfield as Northern Option 1. A temporary condition is also proposed that would facilitate

connection to the road network at the portal location before the central tunnel section is complete. (see Figure 3)

### 1.2 Assessment and conclusions

An assessment workshop was held on 13 October 2020 with representation from Jacobs, CPCA, GCP and the current C2C route environmental lead. All three options were assessed against a number of relevant criteria including environment, cost, and construction complexity, with the C2C alignment being the base case. The other two alignments were assessed as being neutral, minor or significantly better / worse than the base case. A summary assessment matrix follows, with the full matrix and descriptions provided in the Appendix.

Criteria	Current C2C	Northern Option 1	Northern Option 2 <sup>(1)</sup>	
			A	B
Cost <sup>(2)</sup>	0	-	--	
Contribution to improved transport network	0	0	-	0
Impact to existing transportation	0	0	0	
Construction complexity and risk	0	-	0	--
Environmental impacts	0	-	--	
Social impacts	0	0	0	
Impacts on existing transportation networks	0	0	-	0
Stakeholder support / impacts	0	0	-	
Land and property impacts	0			
Contribution to growth	0	0	-	0
Approval and delivery risk	0	0	0	

Colour code:

Significant Improvement	++
Minor Improvement	+
Neutral	0
Minor Worsening	-
Significant Worsening	--

**Table 1 – Summary scoring matrix**

<sup>(1)</sup> For Northern Option 2, column A represents the temporary situation after the C2C works are complete but when the Central tunnel Section is still under construction. Column B represents the final state, when the entire CAM network is complete.

<sup>(2)</sup> It is worth considering costs in relation to the overall cost of CAM, particularly Option 2 which increases the length of the underground CAM Central Tunnel Section.

This review has highlighted the key differences between the routes:

**Environmental impacts:** The northern routes could potentially have impacts on:

- The setting of Madingley Hall Registered Park and Garden. (The Hall is Grade 1 listed and the Park and Garden Grade 2). Note that hall is 500m distant and gardens 250m,
- 800 Wood – adjacent to a SSSI and recently planted by the university and local schools
- The setting of and important views from the American Military Cemetery (Grade 1 Registered Park and Garden and Grade 2\* Memorial Building)
- Priority Habitats – Deciduous Woodland at White Pits Plantation

Separately, tunnel construction for Option 2 will require the disposal of additional spoil and will generate significantly more CO<sub>2</sub>, albeit that represents an increase of only 9% of the tunnelling induced CO<sub>2</sub> emissions for the scheme.

**Stakeholder impacts:** The northern routes could potentially have impacts on the stakeholders above plus Madingley Village and Rectory Farm. Tunnelling induced groundbourne vibration could have an effect on the University of Cambridge research facilities (Northern Option 2 only). In addition, the alignment may sever agricultural access for Scotland Farm, Moor Barns Farm and others to the north of the A428. It may also lead to significant impacts on cottages on Cambridge Road, Madingley.

The current C2C alignment has recognised stakeholder impacts on Coton Village, agricultural landowners between Coton and the A428 and the village of Hardwick which will not be the case if a northern alignment is adopted.

**Cost and construction complexity:** Both northern routes include additional structures when compared to the base case, including additional tunnelling for Northern Option 2 and a complicated skew bridge across the M11 on a curved alignment for Northern Option 1 which also requires an embankment 400 in length and up to 5m high between the M11 and A1303. Both Northern Option 1 and 2 include an 850m long shallow cutting in front of the American Cemetery to shield it from view as well as two crossings of the A428. Northern Option 1 also requires a complex crossing of the A1303 and extensive structures to separate it from and adjacent Highways England slip road.

In contrast the C2C alignment has a single structure across the M11 with the rest of the alignment at grade, albeit with much of this length adjacent to existing roads with associated construction traffic management complexity.

Section 4 provides further cost comparison detail and a breakdown of structures required in each option.

### 1.3 Constraints to the study

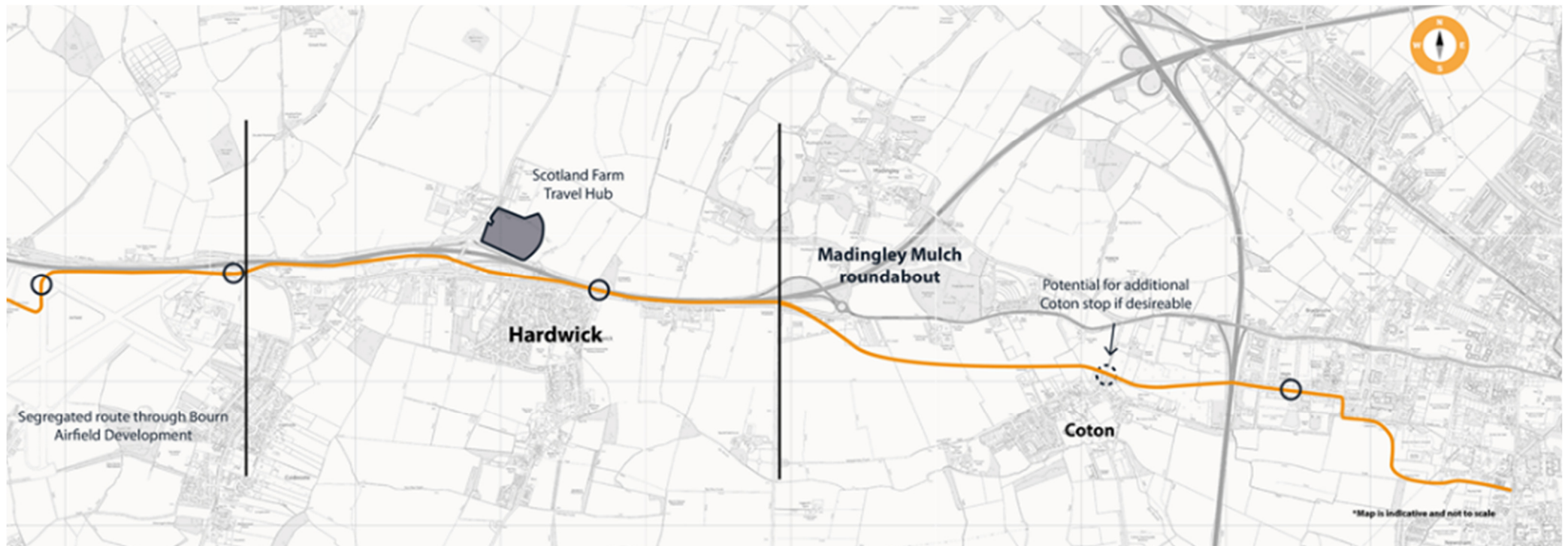
This work was intended to be a high-level study to ascertain whether there is a viable alternative northern route and for this reason there are constraints imposed upon it.

Whilst the routes have been developed and a certain number of stakeholders have been identified, it has not been possible to speak to them, so this aspect has not been examined in great detail. Since no stakeholders have been approached for their response to the alignments the assessments are made on a high-level basis. In contrast, the existing C2C alignment has developed through a concept design and has been through several rounds of public consultation and therefore stakeholder issues are well understood.

## 2. Route Option Description

### 2.1 Current C2C Alignment

The current C2C proposes a fully segregated alignment from the University of Cambridge west campus, which passes over the M11 and travels at-grade past the village of Coton to the A428 St Neots Road and along to Bourn Airfield.



**Figure 1- Alignment of the current C2C alignment.**

Notable issues that were identified by stakeholders include the proximity of the route to Coton village including associated impact on the Green Belt and proximity of the route to housing along St Neots Road in Hardwick.



### 2.2 Northern Option 1

From the proposed CAM western portal at the south-eastern corner of the University of Cambridge campus, the surface route cuts north into the campus and bears east onto Charles Babbage Way. At the eastern end of Charles Babbage Way, the road is extended over the M11 crossing on a bridge on a curved alignment to Rectory Farm. It will continue on an embankment / retaining wall north alongside the northbound off slip from junction 13 of the M11 to a bridge over the A1303 Cambridge Road.

From here, the alignment follows the A1303 / Cambridge Road, passing the American Cemetery in a landscaped cutting at a distance of approximately 200m, before turning east through the top corner of 800 Wood and crossing the A428 on a bridge. It then follows the north side of the A428, connecting to the Scotland Farm before crossing on a bridge south into the Bourn Airfield development immediately west of the turn off to Childerley Lodge.

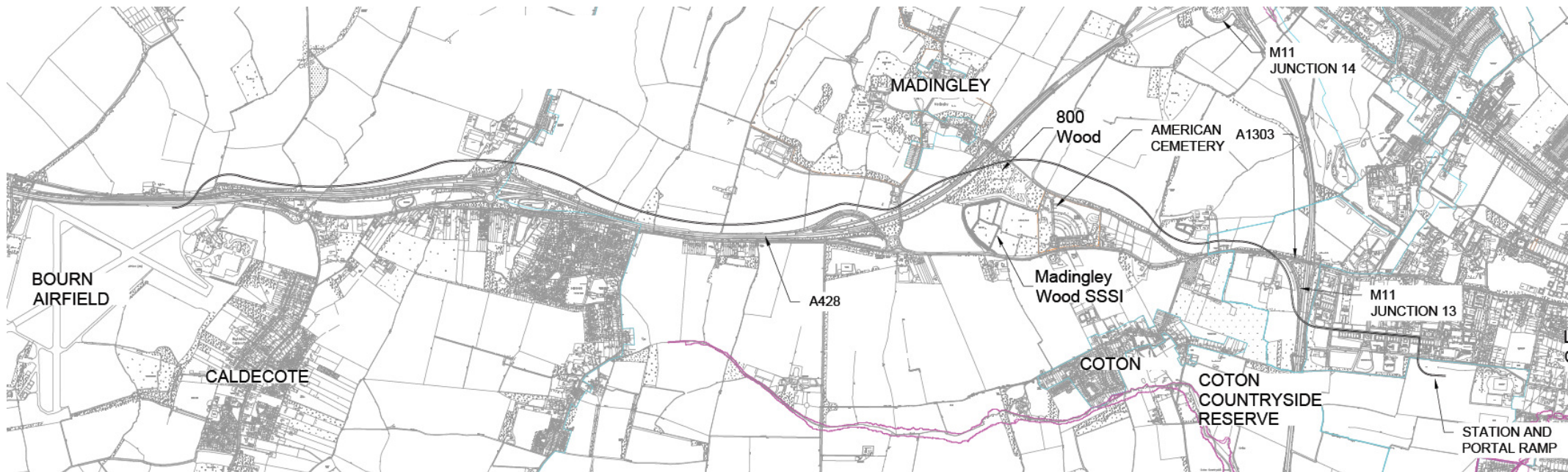


Figure 2 – Alignment of Option E- northern route with surface section through University of Cambridge campus

### 2.3 Northern Option 2

Option 2 is a sub-option to Option 1 and from the A1303 to Bourn Airfield it shares the same alignment. It consists of an extension of the CAM tunnel north west from the current western portal location – which will become a sub-surface station. The tunnel would now break ground to the west of the M11 just north of the A1303, an extension of 1.5km. From this new portal location, the alignment follows the A1303 / Cambridge Road, passing the American Cemetery in a landscaped cutting at a distance of approximately 200m, before turning east through the top corner of 800 Wood and crossing the A428 on a bridge. It then follows the north side of the A428, connecting to the Scotland Farm before crossing on a bridge south into the Bourn Airfield development immediately west of the turn off to Childerley Lodge.

There will be a programme discrepancy between the completion of the C2C works and the expected later completion of the CAM Central Tunnel Section. Therefore, a temporary connection is made at the end of the route to the A1303 to allow for the C2C route to access the wider road network until the tunnels are completed. This will also subsequently allow non-tunnel compliant vehicles to leave the segregated route when the full network is in operation.

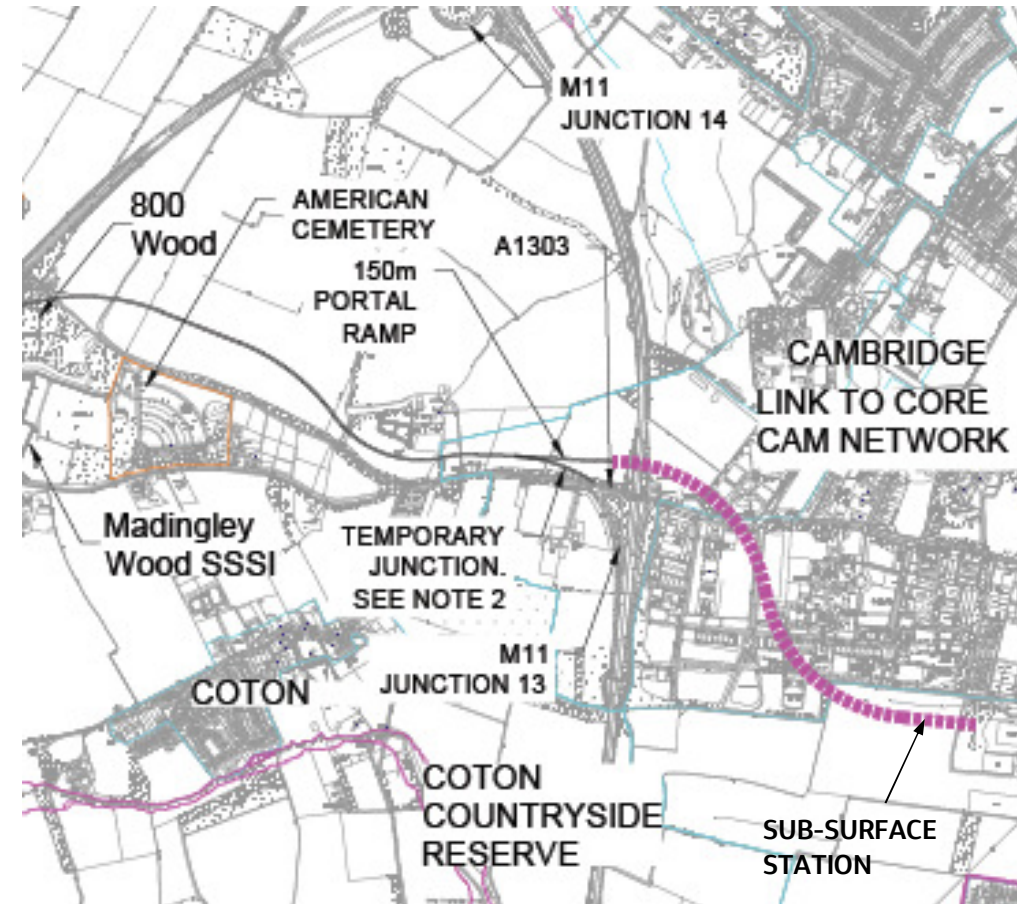


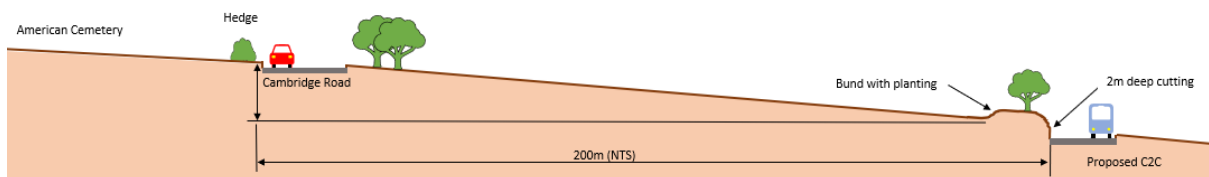
Figure 3 – Alignment of Option 2 – northern route with extension to the CAM Central Tunnel Section.

### 3. Challenges associated with northern options

As noted in Section 1.3, the northern alignments are in close proximity to a number of sensitive sites and the implications of this has yet to be tested.

#### 3.1 The American Cemetery

This is a Grade 1 Registered Park and Garden and houses a Grade 2\* Memorial Building and the land is owned by the US Government. There are currently views out over the farmland to the north and east which are interrupted by Cambridge Road, a rural single carriageway road at this point running along the boundary of the cemetery. The proposed alignment will be 200m away from the cemetery grounds and the high-level costs in this document assume it will be constructed in a false cutting.



**Figure 4 – section through alignment at American Cemetery**

It is understood that an agreement with the American Government, prevents development of the land within circa 150m of the cemetery, which would not be affected by these proposals. It is however also considered likely that any proposals to develop land in the vicinity of the cemetery will meet with stakeholder resistance.

#### 3.2 800 wood

This is a newly planted woodland in a triangle of land between Cambridge Road and the A428 and borders an existing Ancient Woodland (Madingley Wood SSSI). It was planted by the University of Cambridge in 2008, to commemorate the 800th anniversary of the university, and is not itself a designated nature conservation site or habitat. Although not designated as a nature conservation site or habitat it is thought that there will be some biodiversity connecting with the adjacent SSSI.

It is understood that local schools were involved in the planting of the trees which it is understood form part of an ongoing university research project. As such it is thought that any proposals to remove part of the wood for the alignment will be met with stakeholder resistance, although there will be a possibility to provide additional planting elsewhere along the route as a mitigation.

#### 3.3 Madingley Village

Madingley village contains a number of sites registered with Historic England, including: Madingley Hall (a Grade 1 listed building in a Grade 2 Registered Park and Garden which encompasses much of the village), Madingley Mill (Grade 2\*) and Madingley School all of which will be affected by the alignment as it crosses the A428 to one degree or another. It is considered that any proposals to construct the alignment in this area will meet with stakeholder resistance.

#### 3.4 White Pits Plantation

Both the northern options will pass directly through the middle of the White Pits Plantation. This is a wooded area of mature deciduous trees (Identified as Priority Habitat under the Natural Environment and Rural Communities Act 2006) that borders the A428 opposite the eastern end of the village of

Hardwick. It is the subject of a Tree Preservation Order and therefore construction here will require additional consents.

#### 4. Costs

A high-level review of costs has been carried out. In order to make the comparison with the existing C2C route, all three routes have been costed using the same principles. It is recognised that this may differ from the more detailed costing already undertaken for the C2C alignment, but it will be the same level of accuracy as for both northern options.

Each route has been split into its component parts and each of these has been costed on a BoQ rate principle. To these direct construction costs, contractor's preliminaries and overhead, design team fees and tender inflation are added to derive an anticipated final cost without any risk allowance or Optimism Bias. A summary of the assessed costs and the breakdown of the structures per route option are presented in the following tables:

Cost Element	Current C2C	Northern Option 1	Northern Option 2
Direct Construction Costs £m	£65.2	£87.8	£157.0
Tunnels	-	-	£64.7
Underground station	-	-	£29.8
Highway	£15.3	£16.2	£13.7
Structures	£31.2	£52.7	£39.6
Miscellaneous – culverts, CAM stop, temp works etc.. £m	£18.7	£18.9	£9.2
Indirect Construction Costs	£25.9	£34.9	£53.7
Contractor's Preliminaries	30%	30%	25%
Overhead and Profit	7.5%	7.5%	7.5%
<b>Total</b>	<b>£91.1</b>	<b>£122.7</b>	<b>£210.7</b>

**Table 2 – Anticipated final cost for the three schemes**

Note that the preliminaries for Northern Option 2 are a lower percentage as it is considered that those associated with the additional tunnelling will already be covered in the Central Tunnel Section costs.



Option	List of Structures
Current C2C	Bridges i) over M11 into UoC campu
Northern Option 1	Bridges: i) over A438 into Bourn Airfield, ii) over A438 into 800 Wood, iii) over A1303 into 800 Wood, iv) over M11 into UoC campus, Embankment / retaining wall between M11 and A1303, False cutting - environmental bund past American Cemetery
Northern Option 2	Additional tunnel section from current West Portal Location Sub-surface station at UoC (site of current West Petal) Bridges: i) over A438 into Bourn Airfield, ii) over A438 into 800 Wood, iii) over A1303 into 800 Wood. False cutting - environmental bund past American Cemetery

**Table 3 – Breakdown of structures per scheme**

### 5. Summary and Next Steps

Jacobs have been asked by the CPCA (working in conjunction with the GCP) to review the potential for an alternative northern alignment for the current Cambourne to Cambridge (C2C) scheme that would avoid the villages of Coton and Hardwick.

Following a joint assessment workshop, the two potential alignments, one fully on the surface and one involving an extension of the CAM central tunnel section were compared to the C2C route. The workshop concluded that the northern routes would alleviate concerns expressed by stakeholders in Coton and Hardwick and would introduce a number of new stakeholders who would be likely to have similar concerns.

A very high-level cost estimate indicates that the northern surface route is 35% more expensive than the current C2C route and the sub-surface route considerably more expensive than that.

#### Next steps

It is suggested that further combined work is undertaken to review the costs of all options in more detail and to understand the potential effects on the identified stakeholders. It will also become necessary to share the plans with these stakeholders including: LLF (local liaison forum), EWR the American Cemetery and the University of Cambridge.

The programme for this will be driven around relevant CPCA and GCP meetings. Specifically, the CAM Steering Group meeting of 04/11/2020 where this report will be presented and the CPCA Transport and Infrastructure Committee meeting of the same day when a summary slide will be presented. The Steering Group will be requested to ask the joint CPCA and GCP boards to advise if they wish the team to i) report back and ii) continue to the next stage.

### 6. Appendix

#### 6.1 Workshop scoring matrix

#### Comparison Table of C2C against Alternative Options

Criteria \ Options	Current C2C		Northern Option 1		Northern Option 2*	
Location and brief description	<b>C2C + connecting to East West Rail station west of Cambourne</b>		<b>UoC portal with route on west side of M11</b>		<b>Sub-surface station at UoC Campus with tunnel to portal north of A1303 and west M11</b>	
<b>Costs.</b>	Lowest CAPEX. Similar OPEX compared to other options other than C (which is higher). Shorter route with less property acquisition required.	<b>0</b>	Expected to be higher CAPEX compared to C2C, as requires additional and more complex bridges but a simpler connection to Scotland Farm P&R will make construction earlier. Embankment / ret wall required alongside M11 slip, and a bund / false cutting at cemetery. Cost of land acquisition expected to be proportional to C2C.	<b>-</b>	Very High CAPEX due to extension of tunnel; cost up to an additional £100m greater than base case. Higher OPEX due to need to maintain tunnel infrastructure and subsurface station.	<b>--</b>
<b>Contribution to Improved Transport Network</b> Journey time, reliability and experience, connectivity / interchange, highway time savings	Direct route compared to others so likely to have the shortest journey times. Access to Scotland Farm development comes via a two-roundabout configuration, which is more complex than the other options presented here.	<b>0</b>	Slightly longer journey than C2C due to increased length and low speed limit sections between west Cambridge and Madingley. Simpler access to Scotland Farm Travelhub than C2C.	<b>0</b>	Marginally longer journey times due to low speed limits east of Madingley but avoids slower route on Charles Babbage Way. Simpler access to Scotland Farm Travelhub than C2C. UoC stop on edge of campus instead of centrally on Charles Babbage Way. Consider interim phase where C2C complete and connects Madingley Road and CTS still under construction ("B")	<b>A: -</b>
						<b>B: 0</b>

<b>Impact to existing transportation</b>	Potential impact on A428 traffic at Scotland Farm roundabout system. Other crossings assumed to be at grade	0	Impact on traffic from crossings at Cambridge Road and Church Lane. Other crossings assumed to be via overbridges. Note the need to integrate at grade at the Scotland Farm roundabout.	0	Impact on traffic from crossings at Cambridge Road and Church Lane. Other crossings assumed to be via overbridges. Note the need to integrate at grade at the Scotland Farm roundabout	0
<b>Construction complexity and risk</b> Site constraints, geology, settlement, access, construction techniques required, utilities and obstructions and H&S	Requires single bridge over M11, at grade crossings and a junction to connect to Scotland Farm.	0	Requires an additional bridge and cutting north of American Cemetery, but simpler connection to Scotland Road development than C2C. Overall 3 additional major bridges compared to Option A and structure adjacent to M11 slip. M11 bridge is a skew and curved alignment.	-	Additional Station construction and requires tunnelling under UoC West Campus. Vibration and settlement issues from tunnelling need to be managed. Requires an additional bridge and cutting north of American Cemetery, but simpler connection to Scotland Road development than C2C. Overall 2 additional major bridges compared to Option A	A: 0
						B: --
<b>Environmental impacts</b> Landscape & visual, Heritage & Historic Environment, Biodiversity & Ecology, Water Resources, Waste, noise	Potential impacts on Coton village. Affects Priority Habitats- routed through Woodland Priority Habitats at Comberton Plantation (also TPO) and along M11. Visual impact from additional bridge over M11.	0	Requires construction within greenfield land west of M11. Visual impact from additional bridge over M11. Passes through the northernmost part of 800 Wood and 200m away from the American Cemetery (grade 1 Registered Park & Garden). Passes south of Madingley Hall Registered Park & Garden and Madingley Conservation Area, and south of Moors Barn Farmhouse (grade 2 listed building), and south of grade 2* listed Schlumberger Gould Research Centre.	-	Additional 1-2km of tunnel increases construction CO2 emissions, plus need to shift more spoil. Routed close to south of Madingley Hall Registered Park & Garden (grade 2) site and Madingley Conservation Area. Passes through the northernmost part of 800 Wood. Passes 200m away from the American Military Cemetery (grade 1 Registered Park & Garden, including a grade 2* listed Memorial building). Passes south of Moors Barn Farmhouse (grade 2 listed building, and tunnels close	--

			Affects Priority Habitats - Deciduous Woodlands at White Pits Plantation (TPO), along Cambridge Rd/A428 junction east of Madingley, and alongside M11 south of A1303.		to grade 2* listed Schlumberger Gould Research Centre. Affects Priority Habitats - Deciduous Woodlands at White Pits Plantation (TPO) and along Cambridge Rd/A428 junction east of Madingley.	
<b>Social impacts</b> Site use, construction impacts on community, improved provision of / access to housing / employment	Runs close to the village of Coton, including a section through the entirety of the width of the Coton Orchard. St Neots Road between Coton and Hardwick is heavily impacted	0	Potential impact on Rectory Farm, Madingley village and users of 800 Wood. Routed through 4 cottages on east side of Cambridge Road opposite 800 Wood.	0	Stakeholders impact reduced by moving portal north of A1303, although potential impact on Madingley village and users of 800 Wood. Routed through 4 cottages on east side of Cambridge Road opposite 800 Wood.	0
<b>Impacts on existing transportation networks</b> Highway, rail, bus, cycling and walking routes	Potential impact on A428 traffic at Scotland Farm roundabout system. Other crossings assumed to be at grade and will impact current traffic flows. Shared route on Charles Babbage Way.	0	Impact on traffic from crossings at Cambridge Road and Church Lane. Other crossings assumed to be via overbridges. Shared route on Charles Babbage Way	0	Impact on traffic from crossings at Cambridge Road and Church Lane. Other crossings assumed to be via overbridges.	A: -
						B:0
<b>Stakeholder support / impacts</b> Key and wider stakeholders impacts in operation / construction and benefits	Impact on Coton. St Neots Road between Coton and Hardwick.	0	Potential impact on Madingley village, users of 800 wood and American Cemetery. Need to avoid significant landscape/visual impact on American Military Cemetery.	0	Tunnelling under UoC West site will involve detailed consultation to ensure buildings that are sensitive to ground movements and vibrations are protected, i.e. scientific labs. Removes impacts on Coton area. Need to avoid significant landscape/visual impact on American Military Cemetery. Impact on west fields reduced	-
<b>Land and Property impacts</b> Land take requirements and land use	Requires land take from Rectory Farm and Coton Orchard Garden Centre.	0	Land take from Rectory Farm fields to the west of M11 westbound. Some land take from 800 Wood required. Risk to cottages on east side of Cambridge Road opposite 800 Wood and to Rectory Farm		Land required to construct portal and potentially drive tunnel from Moor Barn Farm. Some land take from 800 Wood required. Risk to cottages on east side of Cambridge Road opposite 800 Wood.	



<b>Contribution to growth</b> Connections to housing and labour market Future-proofing	Connects to Scotland Farm and Bourne developments.	<b>0</b>	No particular advantage or disadvantage to this option in terms of development, with respect to C2C.	<b>0</b>	No particular advantage or disadvantage to this option in terms of development, with respect to C2C.	<b>A: -</b>
						<b>B:0</b>
<b>Approval and Delivery Risk</b> Acceptability, risk to TWAO, Legislations and ability to construction and operate	Risk due to local stakeholder objections in Coton/Hardwick area.	<b>0</b>	Potential risk due to potential vibration impacts on UoC and objections from those north of A1303/ A428 and and from Statutory Consultees in connection to Madingley, 800 Wood and American Cemetery. Likely to remove current objections around Coton area. Multiple complex Trunk Road crossings needed.	<b>0</b>	Additional tunnelling could add 15-20 weeks to programme. Potential risk due to potential vibration impacts on UoC and objections from those north of A1303/ A428 and from Statutory Consultees in connection to Madingley, 800 Wood and American Cemetery. Multiple complex Trunk Road crossings needed	<b>0</b>

Table 1: Summary of C2C Comparison against CAM Objectives and Sub-Objectives

### Key - Comparison to C2C+

Significant Improvement

Minor Improvement

Neutral

Minor Worsening

Significant Worsening

++
+
0
-
--

Note that Northern Option 2 has been split into two phases for some of the Criteria to represent the phase at which the C2C scheme is complete and operational, but the central tunnel section is still under construction ("A") and completion of both integrated schemes ("B")