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Mass Transit Feasibility Study

Final Draft Early Phase Options Report

Version 3

March 2019

West of England Authorities (B&NES, BCC, NSC, SGC and WECA)

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Document Title: Draft Early Phase Options Report
Revision: Version 3
Date: March 2019
Client Name: West of England Authorities (B&NES, BCC, NSC, SGC and WECA)
Author: Jacobs/Steer
File Name: Draft Mass Transit Feasibility Study Report (FINAL DRAFT 20190305)

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Document History and Status

Revision	Date	Description	By	Review	Approved
V1	Nov 2018	Draft Report (sections 1-5)	Jacobs		
V2	Jan 2019	Draft Report – full sections	Jacobs/Steer	DC	BS
V3	Mar 2019	Final Draft report	Jacobs/Steer	PB	BS

FINAL DRAFT

Executive Summary

This feasibility study has been commissioned by the West of England Authorities (through Bristol City Council) to explore the feasibility and viability of a mass transit system in the Greater Bristol area. This study will evaluate both underground and overground route options and, where appropriate, will provide sufficient evidence that route options are worth pursuing further. The study also provides recommendations of the next steps to developing a comprehensive transport appraisal for the options. This work builds on and complements the October 2017 Jacobs (formerly CH2M)/Steer Davies Gleave) pre-feasibility study on the viability of a light underground system and incorporates the evidence from that to consider the potential for mass transit within the construct of whether the system should be under- or overground.

Four corridors have been defined for investigation:

- South Bristol and Bristol Airport;
- North Bristol and North Fringe;
- East Bristol and East Fringe; and
- Hicks Gate/Keynsham[1]

The West of England region is already expected to experience growth in travel demand, resulting from committed and planned economic and housing growth, both within and into the Bristol urban area from neighbouring authorities. The increase in traffic demand in the urban area poses significant challenges, to the viability and continued growth of the region.

The aim of this study is to determine whether the prospects for the mass transit system are reasonable in delivering sufficient demand, considering potential alignment issues (both overground and underground) and identify many transformative opportunities for the WECA central urban area and the wider region. Further work into the construction and operation of options has been undertaken to help inform whether it would still represent value for money.

Key corridors in Bristol's urban area are characteristically long and, in many places, narrow, when compared to the majority of other UK cities who have reintroduced overground (street-running) trams in recent decades. When considering the routes, a key factor taken into consideration has been the potential impacts on the current street scenes and what the impact of the route would be in terms of place making and generation of an enhanced public realm.

This report considers that there remains a good case for continuing the development of the defined options to a point that the impacts and benefits can be fully understood and quantified. The work undertaken shows a mass transit system will provide major opportunities for unlocking significant growth in housing and stimulating the economy in the wider West of England urban conurbation and is likely to result in unprecedented wider economic impacts. The outcome would be enhanced public transport connectivity and fully connected interchange facilitates, which would be transformational in terms of how people live and travel around the sub-region.

There are considerable differences between the over- and under-ground schemes that include:

- the level of development (housing and employment unlocked);
- the ease of delivery and acceptability (in terms of construction and general traffic impacts); and
- the level of funding to be assembled to deliver the scheme.

The overground proposal is clearly the most affordable scheme being around 20% of the capital expenditure to construct than underground proposals, however the user benefits and development opportunities enabled by the scheme are also reduced proportionately. Whilst beneficial in terms of

[1] It should be noted that mass transit extensions to Bath are to be considered as part of the Bath Transport Study and the next phase work.

FINAL DRAFT

transport user benefits and mode share, overground mass transit proposals would also have significant adverse impacts on communities, street scenes and existing transport infrastructure. There would be considerable impacts on general traffic on three out of the seven main roads into Bristol, not only during construction but also during operation. Further work and major additional traffic and environmental modelling, including later year future horizon scenarios are required to determine whether the direct and consequential impacts are acceptable. The measures required to maintain local access for communities will also need to be mitigated along the impacted mass transit corridors.

In contrast whilst an underground option would require substantial capital expenditure that could be difficult to secure, the development (both housing and employment) opportunities enabled by the scheme are also considerably more substantive. These proposals also have generally positive impacts on communities, the environment and transport infrastructure, with adverse impacts primarily as a result of the movement of excavated and construction materials and the construction of stations, vent shafts and tunnel portals.

The outcomes of the study suggest that the system has the potential to cover its operating costs and the value for money of the options are comparable to other infrastructure schemes of similar size scope and impact. It is however the wider economic benefit potential to the region which is key and transformational, this would drive the regional West of England economic area to a level only currently experienced in the London and south east area within the UK.

The study considers the potential to support the required level of funding for the options, focusing on funding and financing options. Funding of the scheme remains a reasonable prospect yet will be a challenge, as both are very large-scale infrastructure projects and require a consequentially high-level of investment.

The new transport network will lead to an increase in the land value across much of the urban area, which can be captured by specific mechanisms defined. Local funding potential is not likely to be able to cover the entire cost of the project, therefore alternative funding measures will need to be considered to close the funding gap. Additional mechanisms could also be introduced at the transport-enabled development areas, such as retention of a proportion of local taxes.

The outcome of the study provides sufficient evidence to recommend that the mass transit system scheme options should continue to be considered further to enable a preferred option to be identified. Key considerations for further work, include: developing the modelling for construction and operation, for both over- and underground options, requiring initial construction programme development; further refinement of demand forecasting; stakeholder engagement planning; further development of options and potential hybrid options; and testing of additional funding mechanisms, particularly the appetite for local taxation measures.

FINAL DRAFT

Indicator			Underground (light-rail)	Underground (tram)	Underground (BRT)	Overground (BRT)
Demand	Annual 'initial' (no development)		38.8m			19.9m
	Annual 'base'		42.3m			20.7m
	Annual 'base' with sensitivities		54.7m			25.2m
	Annual 'base' with high optimism scenario		63.0m			25.2m[2]
Development and jobs unlocked	Housing	'base'	31,000			15,500
		aspirational	43,000			21,500
		high optimism (inc. indirect)	c.61,000			21,500
	Land value uplift[3]	'base'	£480m			£240m
		aspirational	£668m			£334m
		high optimism	£868m			£334m
	Jobs	'base'	26,000			13,000
		aspirational	52,500			26,000
		high optimism (inc. indirect)	c.65,000			26,000
	GVA[4]	'base'	£5bn			£2.5bn
		aspirational	£10bn			£5bn
		high optimism	£11bn			£5bn
Impacts of construction	Third party land impacted		Stations and portals to be located in places to avoid impact on dwellings, where reasonably practicable			Indicative Medium - high (200-350 properties)
	Indicative impact to businesses (loss of GVA/turnover) directly affected on corridors		Limited adverse impact on corridors, predominantly in vicinity of stations, vent shafts and portals.			Significant adverse impact on corridors, indicative three-year impact: GVA – c. £55-94 million, Turnover – c. £200-340 million
	Impact to existing transport network		Limited adverse impact on highways during construction, predominately impacts due to construction traffic (HGVs) and removal of excavated materials Bus network management likely required Induced rail demand			Reallocation/partial closure of three key arterial routes into Bristol c. 80 permanent and 20 partial local road closures Bus network management likely required Segregated pedestrian and cycle provision along alignments
	Public Realm/sense of place		Limited impact on high streets and local community during construction. Potential for redevelopment around station locations, including public realm enhancements			Significant impact on high streets and local community during construction, including removal of on-street parking Potential for redevelopment on corridors, public realm enhancements etc.
	Deliverability		Impacts of construction need to be developed further – local impacts			Impacts of construction need to be developed further - local impacts
	Public acceptability		Cost is likely to be a factor in public acceptance of the system, particularly if local taxation is identified to part-fund. However construction and operational impacts are not likely to be unacceptable to the wider public.			Although a lower capital cost option than underground, the construction and operational impacts on the existing highway network, along with demolitions required to implement the system are likely to be unacceptable to those directly impacted as well as the wider public.
Capital Cost			£4.75bn	£4.75bn	£4.62bn	£0.78bn
VfM 'base'			Poor	Poor	Low	Low
VfM with WEI			Low	Low	Medium	High

Summary of comparators for short-listed options

2 Overground is unlikely to have the level of transformational impact as an underground system, due to the constraints of an above ground network predominantly utilising existing alignments. Therefore the 'high optimism' scenario has not been included for the overground option, with the sensitivities scenario reported.

3 Land value uplifts reflect the number of dwellings enabled by mass transit – given the need for wider investment in other infrastructure to unlock the housing, it would be wrong to attribute all the dwellings to the mass transit system. However, it is clear that without the mass transit investment it will not be possible to unlock this development, therefore it has been considered as gross value uplift for mass transit enabled development, but we recognise that further infrastructure would be needed,

4 GVA impacts reflect the number of jobs enabled by mass transit – given the need for wider investment in other infrastructure to unlock the jobs, it would be wrong to attribute all the jobs to the mass transit system. However, it is clear that without the mass transit investment it will not be possible to unlock these jobs.

FINAL DRAFT

Contents

FINAL DRAFT

FINAL DRAFT

Appendices

Tables

FINAL DRAFT

Figures

FINAL DRAFT

Acronyms and Abbreviations

BANES	Bath and North East Somerset Council
BCC	Bristol City Council
BCR	Benefit cost ratio
bph	Buses per hour
DfT	Department for Transport
DPD	Development Plan Document
GBATS	Greater Bristol Area Transport Model
HE	Highways England
JLTP3	Joint Local Transport Plan 3 for West of England
JLTP4	Draft Joint Local Transport Plan 4 for West of England
JSP	Joint Spatial Plan
JTS	Joint Transport Study
NPPF	National Planning Policy Framework
NPV	Net present value
NSC	North Somerset Council
PVB	Present value benefits
PVC	Present value costs
SDL	Strategic development location
SGC	South Gloucestershire Council
SOBC	Strategic Outline Business Case
SSSI	Sites of Special Scientific Interest
TBM	Tunnel boring machine
tph	Trains per hour
VfM	Value for Money
WebTAG	DfT online Transport Analysis Guidance
WECA	West of England Combined Authority
WoE	West of England

FINAL DRAFT

Introduction

This feasibility study has been commissioned by the West of England Authorities, through Bristol City Council, to explore the feasibility and viability of a mass transit system in the Greater Bristol area. This study will evaluate both underground and overground route options and, where appropriate, will provide sufficient evidence that route options are worth pursuing further. The study also provides recommendations of the next steps to developing a comprehensive transport appraisal for the options. This work builds on and complements the October 2017 Jacobs (formerly CH2M)/Steer Davies Gleave) pre-feasibility study on the viability of a light underground system and incorporates the evidence from that to consider the potential for mass transit within the construct of whether the system should be under- or overground.

1.1 Background

The West of England region is already expected to experience growth in travel demand, resulting from economic and housing growth, both within and into the Bristol urban area from neighbouring authorities. The increase in traffic demand in the urban area poses significant challenges, to the viability and continued growth of the region.

The Joint Transport Study (JTS, 2017) and emerging Joint Local Transport Plan 4 (JLTP4) have been developed to tackle these challenges, with proposed enhancements to the rail network, new Metrobus routes to serve new corridors and other interventions to core bus routes. However, a clear challenge is caused by the high volumes of traffic entering the urban area. In order to tackle this, the JTS recommends a number of mass transit routes are needed to cater for existing and future transport demand. This includes routes between Bristol city centre and:

- South Bristol and Bristol Airport;
- North Bristol and North Fringe;
- East Bristol and East Fringe; and
- Hicks Gate/Keynsham, with future links towards Bath.

The JTS states: "*there is a strong ambition for a higher-capacity mass transit system to serve key corridors, including Bristol city centre to the North Fringe, East Fringe and South Bristol / Airport. A mass transit network would form an integral part of the future public transport system and it will be critical to plan for effective interchange with the bus network, MetroBus, rail network and Park & Ride. This will be critical in enabling a much higher proportion of journeys to be made by public transport and in encouraging mode shift from cars on the most congested corridors in the Bristol urban area".*

This study considers the viability for a mass transit system serving the wider Bristol urban area.

1.2 Summary of previous study

Mass transit, in various guises, has been mooted for the West of England for over 30 years, in numerous Plans and Policy documents. The previous 2017 underground study is summarised below, with Appendix A providing a brief summary of the key previous proposals for mass transit systems in the West of England region.

1.2.1 Previous 2017 underground study

Following identification in the JTS, Jacobs (formerly CH2M)/Steer Davies Gleave were commissioned by Bristol City Council (as lead authority) to explore the viability of a light underground system in the Greater Bristol area. The study focused on technology options, build costs, operational costs and funding options. Key benefits of the proposal were also highlighted, along with possible interventions.

FINAL DRAFT

The study involved the investigation and assessment of underground options for three corridors (see Figure 1.1) from Bristol city centre to:

- Line A – A38 North, including approximately 9km of tunnel and 11 underground stations;
- Line B – A420 Emersons Green, including approximately 10km of tunnel and 11 underground stations; and
- Line C – South Bristol to Airport, including approximately 9.5km of tunnel and 7 underground stations.

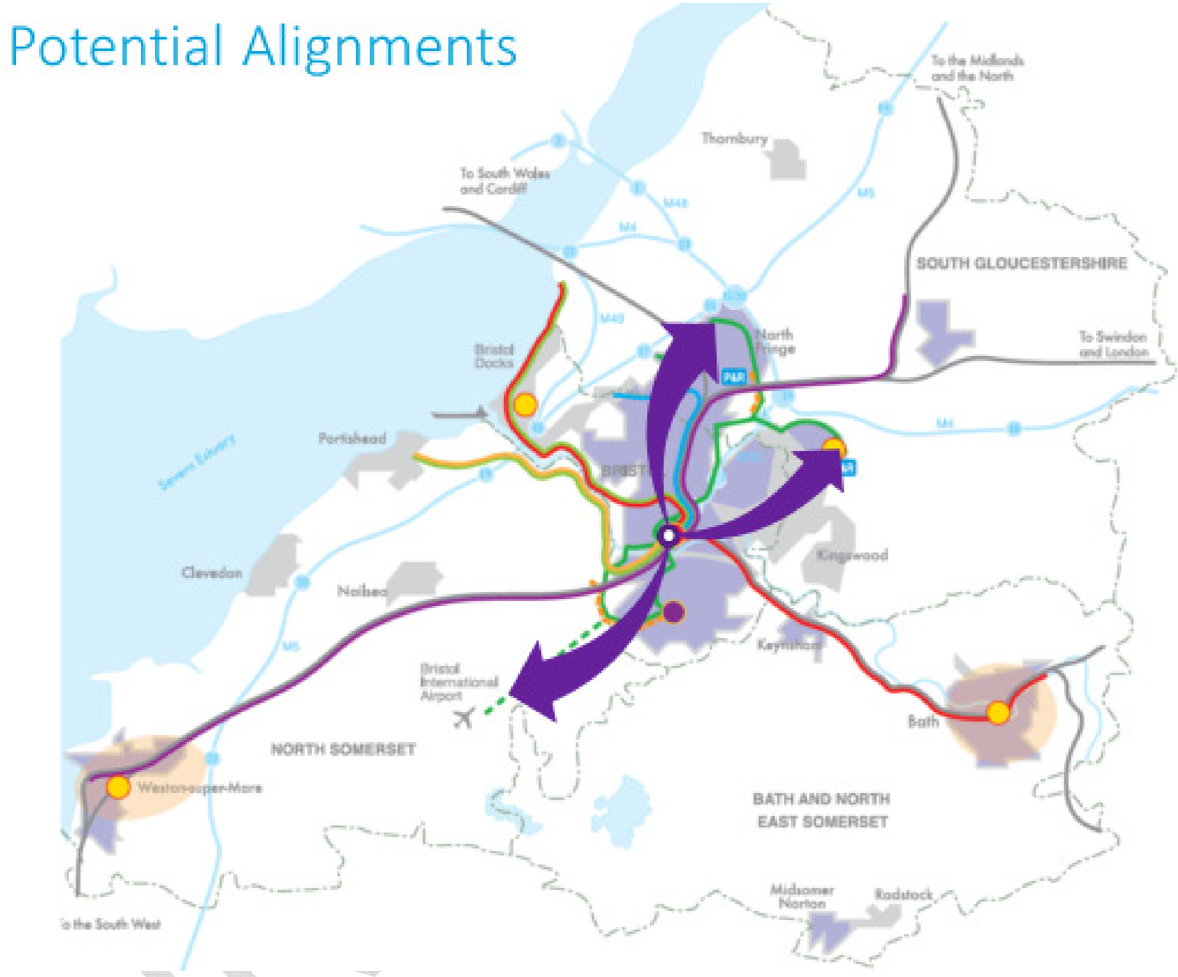


Figure 1.1: Previous underground study – potential underground alignments for consideration

Technology options considered those options that were currently available, along with their ability to deliver the level of service and capacity required (based on approximately 3,000 passengers per hour, per direction). Options included both autonomous and operator-based operations.

The study concluded that it will likely result in significant enhanced public transport connectivity for areas currently poorly served by public transport. It noted that any new rapid transit system would need to align with the developing MetroBus network to ensure connectivity between modes.

Based on experience of other systems, the study also surmised that an underground metro would also have an impact on land values along the route and lead to increased delivery of housing stock, densification and/or acceleration of the delivery rate. This would positively impact on employment sites along the route which could also be densified, as a result of better public transport accessibility for employees and thus require lower levels of parking.

The study assessed the funding opportunities to support a WECA & NSC underground metro. It focused on potential funding generated locally from third parties (i.e. not local grant funding) and present funding scenarios. The study presented a high-level range of potential funding sources and notes that there is a reasonable chance that more than 50% of the capital requirement of the metro (excluding financing costs and optimism bias for capital costs) could be generated from various combinations of these local funding options.

The high-level study report informed Bristol City Council, as the Lead Authority, of whether this form of transport is a viable option to be considered further as part of a wider and more detailed assessment of rapid transit route options for the various corridors.

1.3 Structure of this report

Table 1.1 outlines the structure of this mass transport feasibility study report.

Table 1.1: Structure of report

No.	Chapter title	Contents of chapter
2	Strategic context	Future vision for growth Fundamental step change in public transport Policy context Measures for success
3	Understanding the current situation	Description of study area Current travel demand Existing transport problems
4	Understanding the future situation	Future land uses and policies Changes to the transport system Future travel demand Future transport problems
5	Generating and sifting options	Approach to option generation Results of option generation Approach to option sifting Results of option sifting
6	Mass transit development and assessment	Approach to option development Demand forecasting Options development Options assessment Economic appraisal
7	Funding/Financial case	Funding Financing Closing the funding gap
8	Next Steps	Further option development Delivery

FINAL DRAFT

2 Strategic context

2.1 Future vision for growth

Bristol is currently one of the fastest growing economies outside London and authorities within the West of England have plans for growth in the wider region to 2036 and beyond. These have been outlined in the Joint Spatial Plan (November 2017) and will be delivered as part of the emerging respective Local Plans and Joint Local Transport Plan 4 (JLTP4).

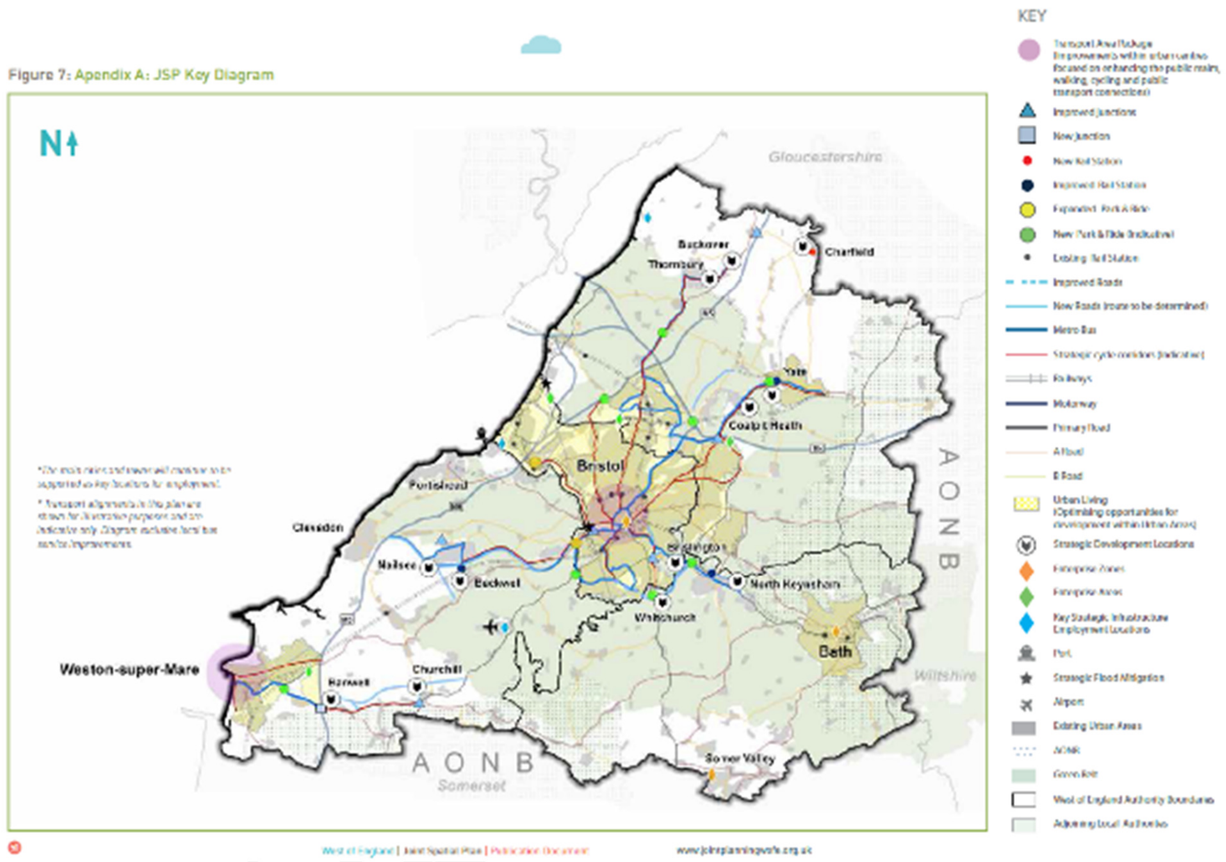


Figure 2.1: Joint Spatial Plan – key growth locations

However, in order to continue to support economic growth post 2036, as well as being a competitive region for employment and as a place to live within the UK, a step-change in public transport provision is required to assist in facilitating sustainable travel and improve air quality.

There are currently overarching network issues around the West of England urban area, which can impact and have consequences on the rest of the transport network and the wider South West region. All major routes in the West of England urban area are congested in the AM and PM peak periods and in many cases throughout the day, with considerable tensions between modes for existing road space. The recent removal of the tolls on the Severn Bridges is likely to further exacerbate congestion issues in the region on strategic and local routes, as it will be cheaper by car for return travel between southern areas of Wales and the West of England.

Without a transformative step-change in public transport provision in the West of England, traffic congestion will be an increasing constraint on economic growth preventing housing and employment aspirations of the region in the short-term and especially post the current 2036 planning horizon.

Bristol Airport have published a draft masterplan for consultation (December 2018) to outline their growth plans up to the mid-2040s. Currently serving approximately 7.5million passengers per annum (mppa), this airport aims to grow demand to 20mppa by the mid-2040s. For both passengers and staff at the Airport, improved public transport connectivity between the wider conurbation and this regional transport hub is essential to ensure growth can be achieved.

The West of England authorities and Network Rail have plans to improve rail services within the region, as part of MetroWest, this along with inter-regional improvements to the rail network will increase rail passengers, particularly at Bristol Temple Meads. Forecast passenger growth is expected to rise to 20 million passengers per annum by 2030.

2.1.1 Enhanced development

In order to be able to deliver JSP-projected growth, the West of England authorities have embraced the Urban Living strategies, which include densification of committed or allocated development sites within existing urban areas. The four main methods of delivering these opportunities for maximising the potential of existing land in urban areas include:

- Change of use – from non-residential brownfield land to residential
- Identification of underutilised land, with potential for residential or mixed-use development
- Identification of mechanisms to ensure more certainty over large windfall sites
- Increasing the density of development

The Urban Living strategy is currently proposed to be delivered within the constraints of the existing and proposed transport infrastructure, along with the mitigations proposed to enable the delivery of these developments by 2036. However the implementation of a mass transit system, whether over- or underground, could further unlock potential opportunities for densification and previously unfeasible locations within Bristol urban area.

The land value uplift and increased connectivity provided by a mass transit system will provide more opportunities for economic growth of the region and to continue to be a competitive location for highly skilled employment.

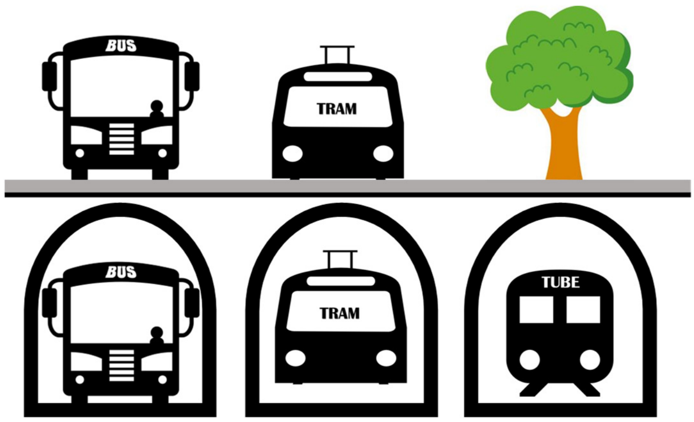
Post-2036 aspirations of Bristol and the wider West of England region, in terms of economic growth and regional competitiveness within the UK, requires planning and policy development (including for major transport infrastructure) now.

FINAL DRAFT

2.2 Fundamental step change in public transport

What is Mass transit?

Mass transit is a public transport system which operates in an urban (or metropolitan) area with high capacity and frequency, often typified by full segregation from other traffic (either over- or underground with shared technology capabilities).



A mass transit system would provide a high capacity, fast, frequent and reliable service, with the ability to transport large numbers of people more sustainably over short and medium distances, across Bristol urban area, on fixed alignments.

It would provide a limited-stop service with direct interchange opportunities to other public transport modes (heavy rail, metrobus, coach and conventional bus network) to further encourage mode shift from car travel.

Mass transit provides a high capacity, fast, frequent and reliable service. Characteristics of mass transport, including indicative capacity, speed and frequency of existing mass transit system examples are outlined in Table 2.1, as well as existing/emerging West of England public transport provision.

System	Type	Operating capacity (pph)	Avg. Speed (mph)	Frequency (tph/bph)
London Central Line	LUL	32,000	20	35
London Northern Line	LUL	17,000	20	26
Toulouse Metro	VAL	10,000	20	60
Renne Metro	VAL	8,000	20	45
Tyne & Wear Metro (core network)	Light rail	2,500	19	9
Sheffield Supertram (core network)	Tram	3,000	13	12
Manchester MetroLink (core network)	Tram	2,000	11	10
M2 Metrobus	BRT	600	14	6
Bristol Airport Flyer	BRT/Bus	350	~18	6
Parsons St/Bedminster to BTM	Heavy Rail	~650	15	2
Bath Spa to BTM	Heavy Rail	~2,000	50	6
Local Bus (A38N existing)	Bus	2,000	6	~22
Cars on Single Carriageway Road (e.g. A38N, A38S, A420)	Road	1,500	6	-
3.5m cycle lane (max capacity)	Cycle	14,000	9	-
3.5m footpath (max capacity)	Walk	19,000	3	-

*Indicative figures based on AM peak hour operation (inbound)

High Capacity Mass Transit (London Central Line, London Northern Line, Toulouse Metro, Renne Metro): Very high speed; Very high capacity; Very high frequency

Mass Transit (Tyne & Wear Metro, Sheffield Supertram, Manchester MetroLink): High speed; High capacity; High frequency

Rapid Transit (M2 Metrobus, Bristol Airport Flyer, Parsons St/Bedminster to BTM, Bath Spa to BTM): Very high/High speed; Lower capacities and/or frequencies (some with potential to increase)

Other modes (Local Bus, Cars, cycle lane, footpath): Lower speeds; Varying capacity

Table 2.1: Indicative capacity, speed and frequency of existing mass transit examples, with existing/emerging West of England public transport provision

2.3 Policy context

The proposals for the mass transit system are identified for post-Joint Spatial Plan timescales, which is outside the scope of current and proposed regional policies, although delivery would need to begin pre-2036. There is a need to be mindful of planning horizons for delivery and begin development of strategic planning policy for post 2036. However, there are several important current strategic policies that have informed the development of the proposals described in this report. These are identified below.

2.3.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF)[5] sets out the Government's planning policies and how these are expected to be applied. The Framework must be taken into account in local plans and is a material consideration in planning decisions. It must therefore be reflected in developing the transport proposals in this study. In particular:

- **Paragraph 162** states that local planning authorities should work with other authorities and providers to assess the quality and capacity of infrastructure for transport and its ability to meet future needs.
- **Paragraph 165** highlights the importance of the economic, social and environmental dimensions of sustainable development and that significant adverse impacts on any of these dimensions should be avoided.
- **Paragraph 182** refers to the examination of local plans and states that the local authority should submit a plan for examination which it considers is sound, namely that it is positively prepared, justified, effective and consistent with national policy.

2.3.2 Joint Spatial Plan and Local Plans

The West of England Joint Spatial Plan (JSP)[6] is a prospectus for sustainable growth to help the region meet its housing and transport needs for the period to 2036. The JSP is the first such joint planning approach in the UK, which takes into account cross-boundary effects within the West of England. The JSP sets out the policies and principles that have been applied in identifying future housing and employment needs and the most sustainable locations for future development.

5 https://www.gov.uk/government/publications/national-planning-policy-framework--2

6 https://www.jointplanningwofe.org.uk/consult.ti/JSPPublication/consultationHome

FINAL DRAFT

The JSP is a strategic statutory development plan document (DPD) for the West of England. It is being prepared jointly by, and will cover, the four Unitary Authorities of Bristol, Bath and North East Somerset, North Somerset and South Gloucestershire. On adoption as a DPD, it will carry full weight in the planning system and provide the higher level strategic planning policy framework for each authority's new Local Plan for the period 2016 to 2036.

The JSP supports the delivery of 82,500 new jobs and 105,600 new homes by 2036, of which 61,400 homes are existing commitments and the JSP makes provision for 44,200 new homes. Of this, 17,300 homes will be in Strategic Development Locations (SDLs), 16,600 through Urban Living, 6,900 through small windfall sites and 3,400 in non-strategic growth. There are proposed packages of transport mitigation for JSP developments, which are outlined in the Joint Transport Strategy (2017) and further developed in the emerging Joint Local Transport Plan 4 (2019).

The SDLs will be brought forward as allocations through each authority's new Local Plan. New site-specific allocations and policy designations in Local Plans will need to be in conformity with the JSP. Work has commenced on preparing the four Local Plans based on the current JSP proposals, although these will not be finalised until after examination and adoption of the JSP. Local Plan consultations will be undertaken throughout 2018 and 2019 and will include the proposed transport schemes required to support delivery of the Local Plan allocations, including the SDLs.

2.3.3 Joint Transport Strategy (2017)

The JTS sets out the strong ambition for a fully-segregated, higher-capacity mass transit system in the West of England region, serving key corridors, including Bristol city centre to the North Fringe, East Fringe and South Bristol including the Airport. The system should focus on the corridors with the highest potential passenger flows and the ability to facilitate interchange with other public transport services including, conventional bus, MetroBus and rail services.

Corridor specific objectives were identified in the JTS[7], which have been summarised below:

- Provide high-quality, convenient and frequent public transport services with shorter and more reliable journey times.
- Encourage modal shift to public transport for journeys made by car
- Improve public transport connectivity between central Bristol along the proposed corridors
- Provide additional capacity on the public transport network to accommodate the forecast increase in travel demand
- Support planned residential and employment growth in central Bristol and the wider West of England

2.3.4 Joint Local Transport Plan 4

The West of England local authorities are currently (at the time of writing) in the process of developing a new Joint Local Transport Plan (JLTP4) for the area. This will cover the period to 2036 and will therefore align with the Joint Spatial Plan and Joint Transport Study. The draft JLTP4 is out for consultation in early 2019.

JLTP4 will consider the recommendations of the Joint Transport Study and develop a long-term transport policy framework that is consistent with the Joint Spatial Plan. It will develop a long-term investment programme shaped by a set of objectives and outcomes. Table 2.2 outlines the objectives and outcomes relevant to this study.

7 https://www.jointplanningwofe.org.uk/gf2.ti/-/757442/31727269.1/PDF/-/JTS_Final_Report__Appendix_A.pdf

Objectives	Outcomes
Support sustainable economic growth	Improved efficiency and reliability on local, national and international transport networks
	Delivery of new houses and jobs, identified through the JSP, is supported
	Access opportunities to employment growth areas is provided for all
	The high-quality transport network generates inward investment
	Congestion and demand on the network is better managed through technological advances
Enable equality and improve accessibility	Connectivity is increased and transformed, enabling seamless "door-to-door" movements of people and goods
	Low carbon transport and opportunities for reducing the need to travel are maximised
	New public transport systems, smarter ticketing and faster payment options are enabled
Address poor air quality and take action against climate change	NOx, particulates and carbon emissions are reduced
	Air quality in the AQMAs is improved
	Air quality remains better than national standards outside the AQMAs
	The transport network is resilient and adaptable
	Technological advances to improve air quality and monitoring are embraced
Contribute to better health, wellbeing, safety and security	There is a step change in the number of healthy, low carbon walking and cycling trips
	There is a continued reduction in the number of road casualties on the transport network
	Road safety for transport users is improved, particularly for those most at risk
	Personal safety on the transport network is improved, and there is less crime and fear of crime
Create better places	Journey experience is enhanced through an integrated and connected transport network
	Streetscape, public spaces and urban environments are enhanced
	The transport network supports neighbourhood renewal and the regeneration of deprived areas

Table 2.2: Draft JLTP4 objectives

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The draft JLTP4 report states that "the delivery of mass transit schemes will be transformative for trips within the West of England, whilst also having the potential to shape the scale and pattern of employment and housing growth. A mass transit network could dramatically improve journey times across the Bristol and Bath urban areas, achieving reliable connections between Bristol city centre and the urban fringes and Bristol Airport; and Bath gaining easier and faster movement in and around the city." An additional feasibility study will be required to explore potential options for mass transit linking Bristol to Bath, as well as the urban area within Bath itself.

2.3.5 Approach

As an early phase option report, this feasibility study looks to demonstrate that consideration has been given to the case for intervention, assessment of options, technical feasibility, costs, benefits, impacts, potential strength of business case and affordability of the proposed transport schemes. It is not a formal business case: this will be prepared at a later date following consultation and development of the scheme options.

The focus of this report is on the development of the strategic and economic case based as much as possible on committed levels of development, as required by WebTAG[8]; however due to the opportunities for the transformative nature of development proposals in the West of England, the business cases will also be considering proposals from committed development (JSP and Local Plans), as well as enhanced development prospects for densification and unlocking of further sites. The potential funding options of these proposals and deliverability are discussed later in this report.

[8] www.gov.uk/government/publications/webtag-transport-appraisal-process

2.4 Measures for success - need for intervention and scheme objectives

In order to be able to develop and assess options for a mass transit system and to make the strategic case for such a transformational scheme, objectives and measures for success need to be defined.

2.4.1 Need for intervention

The invention is required because:

- Existing congestion is contributing to the stagnation of productivity of the West of England region.
- Poor public transport connectivity across wider Bristol area, non-competitive journey times with car-based travel.
- Future growth planned as part of JSP proposals and committed developments would intensify congestion and associated traffic-related issues, without a fundamental shift in public transport provision additional future growth over that of the JSP is not likely to be achievable.
- A transformative step change in delivery of improved sustainable transport options in the West of England and encourage mode shift from single occupancy cars in particular.
- For post-2036 transport network capacity, there is a need to start planning new infrastructure to achieve timeframes.

More information on the existing and future transport situations and possible scenarios within the study area and wider region are included in the next chapters (3 and 4 respectively).

2.4.2 Scheme objectives and outcomes

The JTS objectives have been reviewed, in line with the draft JLTP4 objectives, as well as tailored to account for the further growth aspirations and potential development opportunities unlocked as a result of such a transformative public transport scheme, this is to enable the region to continue to grow and meet its full potential. As such the key scheme objective for this study is:

To provide a high-quality mass transit solution that provides a step change in public transport connectivity in the West of England, unlocking significant housing and employment growth over and above the growth outlined in the Joint Spatial Plan.

A solution that:

- Provides **a step change in public transport connectivity** and passenger journey experience in the region, with strong links to other modes of transport including rail, bus and air transport hubs.
- Provides **regeneration and housing growth** in adjacent neighbourhoods, including opportunities to improve the public realm.
- Provides **significant additional economic growth in the region**, connecting people to existing and proposed employment sites and unlocking employment sites.
- Delivers significant **mode shift to sustainable transport modes**, from private car, to help tackle congestion.
- Contributes to **better health** through increased physical activity, improved safety, and improved air quality.
- **Reduces inequality** in the region.

2.4.3 Measures for success

Traditionally in transport economic cases, journey time savings are one of the key benefits for transport infrastructure schemes, whether improving connectivity or reducing congestion. Although important, this is not the main aim of the proposed mass transit system, as it would benefit transport choice, connectivity and congestion levels. One of the main aims of this proposed scheme is to unlock further development opportunities, as such the value for money (VfM) should not only be taken on transport benefits alone, but on the potential opportunities for further development.

FINAL DRAFT

Impacts on the local economy, fundamentally transforming the way people travel, potential to unlock housing growth, employment growth and overall vibrancy of the city region are paramount to capturing what only mass transit can bring to the region. This creates the need for different VfM indicators such as cost/house, cost/job, regional GVA, for example.

Therefore Table 2.3 below presents measures for success for each objective.

Table 2.3: Measures of success

Objective	What do we need to do to achieve this	How will we measure our success
Provides a step change in public transport connectivity and passenger journey experience in the region, with strong links to other modes of transport including rail, bus and air transport hubs.	• Protect and improve multimodal options. • Provide improved pedestrian opportunities. • Where relevant, provide improved access to local rail station. • Integrated ticketing opportunities. • Reduce volumes of slow-moving traffic.	• Uptake of non-car modes, could be through TravelWest surveys • Uptake and monitoring of any integrated smart ticketing systems implemented
Provides regeneration and housing growth in adjacent neighbourhoods, including opportunities to improve the public realm.	• Make travel to, from and within Bristol urban area more attractive. • Improve accessibility to committed housing sites. • Ensure that design considers built environment from an early stage and mitigation is built into the overall design.	• Quantification of the number of new dwellings served by the intervention • Quantification of additional housing development unlocked as a result of the intervention. • Expressed as numbers per £ invested.
Provides significant additional economic growth in the region, connecting people to existing and proposed employment sites and unlocking employment sites.	• Improve accessibility to key employment areas, such as Bristol City Centre to enable employees to more easily access jobs. • Make travel to, from and within Bristol urban area more attractive • Ensure that design considers built environment from an early stage and mitigation is built into the overall design	• Quantification of the number of new jobs served by the intervention • Quantification of additional employment development unlocked as a result of the intervention. • Expressed as numbers per £ invested.
Delivers mode shift to sustainable transport modes, from private car, to help tackle congestion.	• Provide improved quality cycle parking, routes and connections. • Provide improved pedestrian opportunities. • Reduce volumes of slow-moving traffic. • Reduce 'shock wave' stop start effects on corridors	• Use of any cycle infrastructure provided • Uptake of non-car modes, could be through TravelWest surveys • Traffic volume and speed data
Contributes to better health through increased physical activity, improved safety, and improved air quality	• Provide improved quality cycle parking, routes and connections. • Provide improved pedestrian opportunities. • Reduce volumes of slow-moving traffic and congestion hotspots.	• Use of any cycle infrastructure provided • Use of any pedestrian infrastructure provided • AQ monitoring results
Reduces inequality in the region	• Provide improved access to areas with high levels of multiple deprivation • Make travel to, from and within Bristol urban area more attractive • Removing barriers to travel and consideration of cost of travel	• Uptake of non-car modes, could be through TravelWest surveys, particularly within % of households in areas identified within the indices of multiple deprivation

FINAL DRAFT

3 Understanding the current situation

3.1 Introduction

The overarching network issues around Bristol, which is at the centre of the West of England transport network, where transport issues in the city often have consequences for the rest of the West of England and the wider South West region. Many of the major routes in the Bristol urban area are congested, particularly within the AM and PM peak periods, including the main arterial roads and the ring road. However, the majority of corridors also act as local high streets, in certain locations, where there is limited space available to provide additional capacity due to constraints such as servicing, enhanced public realm and on-street parking and loading. These high streets are valuable in maintaining the local identities and a sense of place within communities the route travels through.

3.2 West of England

3.2.1 Background

The West of England covers an area of 1,343 km^2. It has a growing population which currently stands at 1.1 million people (Bristol totals 617,280[9]), around 90% of which live in urban areas. There is a critical need to sustainably boost the housing supply (particularly affordable housing) whilst implementing efficient transport infrastructure to support this population growth and future developments.

The West of England economy is worth over £31 billion a year, with average GVA per capita (£30,167 in 2016) above the national average (£24,519 in 2016 when excluding city of London).

Latest figures detail the south-west of England to have a full-time employment rate of 79.1%[10], with unemployment rate at 2.7% - the lowest recorded region for the three months ending August 2018. More specifically, 22% of the population are employed within the high-tech economy, being above the national average, which is supported by 44% of the population having attained a level 4 qualification or above. However, even with the wider prosperity of the region, there are high levels of inequality where individuals and communities are within the top 20% of most deprived areas in the region, some of which are within the top 10% most deprived wards nationally.

3.2.2 Challenges

Transport is one of the key challenges in the West of England, with increasing congestion and high car use. A growing economy is further exacerbating the congestion levels, by increasing the volume of travel (and associated traffic) on the network.

Congestion and traffic levels also impact on air quality in the region, with around 300 deaths a year in Bristol linked to air pollution (represents about 8.5% of deaths in the administrative area of Bristol). The main pollutants of concern within Bristol urban area are nitrogen dioxide and particulate matter. In the locations that exceed the nitrogen dioxide air quality objectives, over 80% of this pollution has been shown to be from local traffic sources[11].

3.3 Network

3.3.1 Congestion and resilience

The wider Bristol conurbation suffers from severe congestion across the urban area, with some of the slowest average traffic speeds outside of central London. Key arterial routes are often found to be congested in AM peaks (0730-0930), with average inbound speeds of 6mph.

[9] Source 2011 Census, based on the usual residents by built up area

[10] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/regionallabourmarket/october2018

[11] https://www.bristol.gov.uk/documents/20182/32675/Bristol+City+Council+2018+Air+Quality+Annual+Status+Report+ASR/3d5c287b-f379-e484-7924-2aa02fc8bb0a

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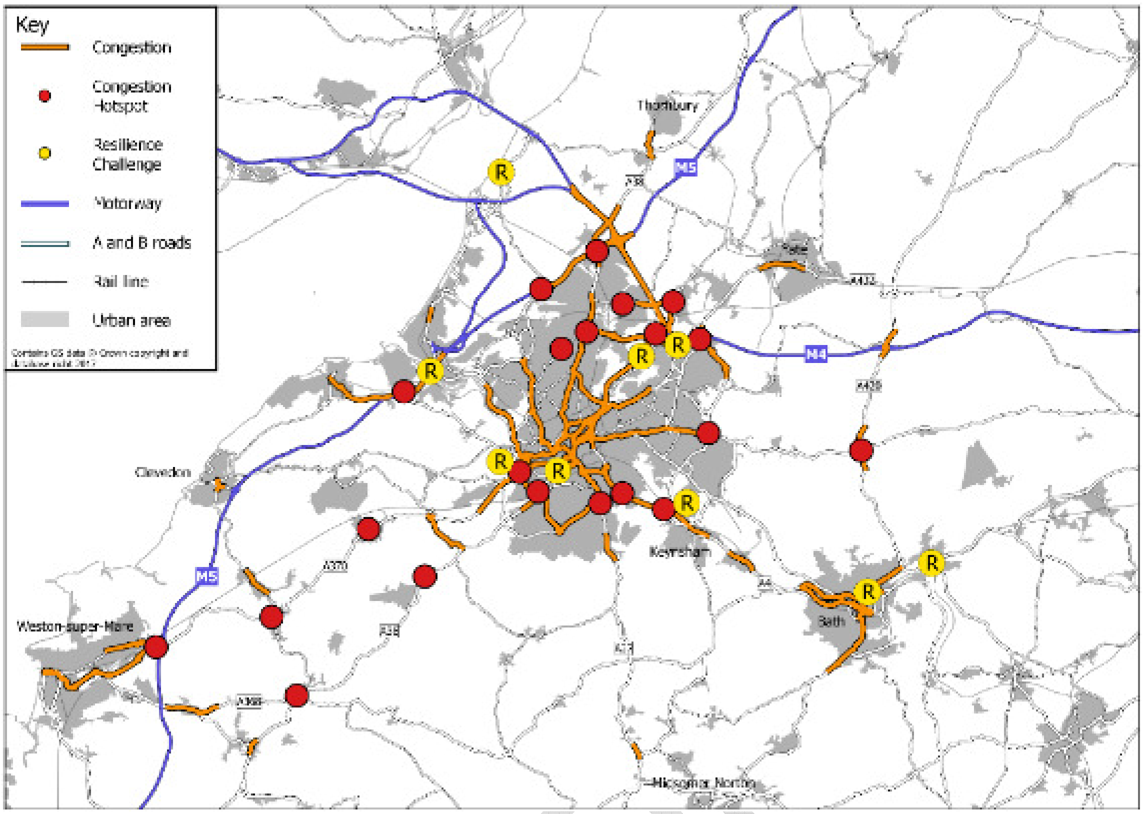

Source: Figure 3.5, JTS 2017

Figure 3.1: West of England primary congestion and resilience issues

Not only is Bristol urban area congested, but the strategic road network surrounding Bristol also suffers from severe congestion in the AM and PM peaks. The traffic confluence of the M5 and M4 corridors is further exacerbated by the number of local trips on the strategic road network.

3.3.2 Current travel demands

Analysis of 2011 Census data concerning method of travel to work for the West of England details that bus travel accounts for 6.7% (Bristol authority area accounts for 9.6%) of use. Although there has been a 30% increase in number of trips made by bus in the last decade[12], bus patronage numbers and level of service has been seen to stagnate in recent years, with congestion thought to be one of the main causes of this, as buses are often subject to the peak period congestion and delay along with general traffic, particularly where there is limited bus priority measures.

Two-thirds of commuting trips are made by car-based travel. If Bristol and the wider West of England want to deliver their growth plans, more needs to be done to encourage mode shift to more sustainable modes of travel.

The City of Bristol has a good track record with commuters walking (19%) and cycling (8%) to work, both above national averages, however journey distance often precludes this option for people working within Bristol and commuting from surrounding authorities. Approximately 2% of commuting journeys are by rail.

Table 3.1 outlines the 2013 base total demand (person trips) by mode for the GBATS4 model area. This gives an indicative level of demand for the study area and has been used to develop future do minimum and do something scenarios in the demand forecasting assessment.

[12] JTS, 2017 - https://www.jointplanningwofe.org.uk/gf2.ti/-/757442/31727173.1/PDF/-/JTS_Final_Report.pdf

Table 3.1: GBATS4 2013 Base – total demand (person trips) by mode

Total demand mode (person) trips	AM Peak (3-hours)	Inter-peak hour (average hour)	PM peak (3-hours)
Car	264,700	76,200	222,000
Bus	33,800	9,600	24,900
Rail	24,700	3,200	21,800
PT Total	**58,500**	**12,800**	**46,700**
Total	**323,200**	**89,000**	**268,700**

3.3.3 Existing public transport provision

Local rail services

A characteristic of the Bristol area is the number of local rail links provided by longer distance services, in particular regional and inter-regional services. Fast connections between major centres are provided by longer distance services, with non-stop connections between Bristol and Bath provided by Great Western Railway London trains and links between Parkway and Temple Meads provided by Cross-Country services.

The local connections to and across Bristol is generally hourly on any one line, but this is not uniform. It is worth noting the variation in calling frequencies at different local stations:

- Filton Abbey Wood has four/five trains-per-hour to Bristol;
- Stapleton Road and Lawrence Hill have two/three trains-per-hour;
- Stations to Weston-super-Mare and on the Severn Beach line as far as Avonmouth see one/two trains-per-hour;
- Patchway, Yate and intermediate stations (Oldfield Park, Keynsham etc.) on the Bath and Westbury lines have one train-per-hour; and
- Severn Beach has a less than hourly service to Bristol

Bristol Temple Meads is the busiest railway station in the south west region. Office of Road and Rail data reported in 2016/17 Bristol Temple Meads station received circa 11 million entries/exits, along with a further 1.5 million interchanges.

Bus services

Many of the key bus routes within Bristol urban area, often travelling from surrounding authority areas, utilise key arterial corridors to access the city centre or key attractors like Southmead hospital. Predominantly local bus routes services operate from Bristol city centre, through residential areas to the main attractors on the outskirts of Bristol urban area (i.e. Cribbs Causeway, Southmead, Hengrove), or to settlements in South Gloucestershire (i.e. Yate, Thornbury), North Somerset (i.e. Clevedon, Nailsea, Weston-super-Mare) and Bath and NE Somerset (i.e. Bath, Midsomer Norton, Radstock). However there are a number of local cross-city centre routes serving key movements to Southmead hospital, UWE and Cribbs Causeway. Specific services and frequencies on the proposed corridors have been identified in relevant sections below.

The first two of three new Metrobus services have been launched in Bristol between Emersons Green and the city centre (m3 in May 2018) and Long Ashton Park & Ride and the city centre (m2 in September 2018). The remaining service (m1) opened in January 2019 and runs along routes throughout the city centre area between Cribbs Causeway and Hengrove. Metrobus is designed to fit in with rail and existing bus services and is connected to the city's traffic signal system so that it can take advantage of bus priority at junctions.

3.4 Corridors

3.4.1 Route 1 – South Bristol and Airport

Land use, socio-economic and demographic context

The A38 is a key arterial road, linking Taunton in the south west, cutting across the Mendip Hills and through the current study area to Bristol city centre. It then continues northwards towards Gloucester and the Midlands. It also provides the key access route to Bristol Airport.

The A38(S) is a busy corridor, often with increased volumes of traffic during peak periods, resulting in congestion, particularly in the central area of Bristol. The route is predominantly a single-lane carriageway, with speed limits ranging from 30mph to the national speed limit (60 mph).

The main land use is primarily agricultural (when travelling beyond Highridge) followed by small settlements and Barrow Gurney reservoir up to Bristol Airport. From Highridge towards Bristol centre is predominately residential, with a mix of densities and interspersed with retail (particularly along West Street and within Bedminster).

The city of Bristol is very diverse culturally, economically and socially. Unlike much of the West of England, Bristol city's population is skewed towards a younger age profile, with a high population of 20- and 30-year olds. However south Bristol has levels of high deprivation with particular areas (Bishopsworth/Hartcliffe) just south of the A38(S) - being in the top 20% most deprived in the West of England, along with low levels of car ownership (within the top 20% of non-car households in West of England).

Key destinations (in no particular order) along this corridor include:

- Bristol airport
- Long Ashton Park and Ride
- Bristol Temple Meads and Parsons Street railway stations
- Ashton Gate
- Imperial retail park
- South Bristol community hospital
- Potential A38(S) Park and Ride
- Hengrove Park
- Parson Street gyratory
- Bedminster

Congestion

Congestion is predominately tidal along the A38(S) in the AM and PM peaks, inbound to the city centre in the AM and outbound from the city centre in the PM peak. There are peak delays throughout the corridor but particularly around the following locations:

- the roundabout between Bridgwater Road (A38) and Kings Head Lane;
- Parsons Street gyratory, particularly the junction between Bridgwater Road (A38) and Bedminster Road; and
- Malago Road through to Bedminster Parade and the Bedminster Bridge roundabout.

Consistent delays are often observed along West Street and Parsons Street gyratory, as well as within the city centre itself.

FINAL DRAFT

Current travel demand considerations

A38(S) is a key arterial route between North Somerset and Bristol city centre, as well as the strategic road network. Key trip attractors along the A38(S) include Bristol Airport.

Bristol Airport and the separate business operations it facilitates directly employ circa 3,000 staff (2015), The BIA Travel Plan referenced in the BIA Master Plan (2006-2030[13]) outlines that 93% of staff commute by car (single occupant) with 3.9% travelling as a car passenger, along with bus-based commuting at 2.5%. The Plan stated that the unconstrained demand for staff car parking is estimated to be 1400 vehicles, which was reduced to 1200 spaces as part of the Travel Plan.

Existing public transport provision

Bus routes[14] that serve the A38(S) corridor include those that provide connections between city centre and Bristol Airport (six buses-per hour), as well as frequent cross-city services between Hengrove Park and Ashton Vale in the south of Bristol to Cribbs Causeway, Henbury and Aztec West to the north of Bristol and into South Gloucestershire.

Key railway stations along this corridor include Bedminster and Parson Street, both stations are served by one train per hour with two trains per hour in peak times (in direction of peak movement – AM inbound/PM outbound).

3.4.2 Route 2 – North Bristol and North Fringe

Land use, socio-economic and demographic context

The A38(N) corridor runs through the centre of Bristol from south of the city, northwards through Filton and Patchway, linking to the M5 at junction 16, before continuing north past Thornbury. The corridor consists of urban, mainly residential areas until passing through Almondsbury, where it becomes more rural. This route is single carriageway from the centre of Bristol to Filton Roundabout, where the road then becomes dual carriageway. After the junction with the M5 the A38 becomes single carriageway again.

There are many large commercial and manufacturing premises, such as Rolls Royce and Airbus, in the Filton area, along with Aztec West Business Park close to the M5. Sections of the A38(N) are characterised by independent and chain businesses, particularly along A38(N) Cheltenham/Gloucester Road between Bearpit and Filton. Within the wider area there is a mix of residential properties of differing densities, medical facilities (including Southmead hospital), a university, schools and businesses.

Key destinations (in no particular order) along this corridor include:

- Aztec West
- Cribbs Causeway
- Cribbs Patchway new neighbourhood
- Southmead Hospital
- Bristol Royal Infirmary
- Cabot Circus
- University of West of England
- University of Bristol
- Bristol Temple Meads, Montpelier/Redland and Filton Abbey Wood railway stations
- Bristol bus station

[13] https://www.bristolairport.co.uk/~/media/files/brs/about-us/bristol-airport-master-plan.ashx?la=en
[14] Taken from TravelWest – July 2018 (daytime service frequency)

FINAL DRAFT

- Filton Abbey Wood (MoD)
- Filton airfield (potential Arena site)
- Potential A38(N) and/or Almondsbury Park and Ride
- Memorial Ground

Congestion

Congestion is not typically tidal along the A38(N) in the AM and PM peaks, delays are identified both inbound and outbound in the AM peak, with more pronounced delays outbound in the PM peak. There are peak delays throughout the corridor but particularly around the following locations:

- Filton roundabout (A38 and A4174);
- M5 junction 16 (Almondsbury) and A38/Bradley Stoke Way; and
- A38 Gloucester Road and Kellaway Avenue.

Consistent delays or slow-moving traffic are often observed along Gloucester Road (the high street between The Arches and Memorial Stadium) and Filton roundabout (A38 and A4174), as well as within the city centre itself.

Current travel demand considerations

A38(N) is a key arterial route between South Gloucestershire and Bristol city centre, as well as the strategic road network. Key trip attractors along the A38(N) include Southmead hospital and Aztec West.

Existing public transport provision

Bus routes that serve the A38(N) corridor include those that provide connections between city centre and Cribbs Causeway (ten buses per hour) University of West of England (six buses per hour), as well as frequent cross-city services between Hengrove Park and Ashton Vale in the south of Bristol to Cribbs Causeway, Henbury and Aztec West to the north of Bristol and into South Gloucestershire.

Key railway stations along this corridor include Montpelier and Patchway, both with one/two trains per hour, and Filton Abbey Wood (five trains per hour).

3.4.3 Route 3 – East Bristol and East Fringe

Land use, socio-economic and demographic context

The A420 runs from the St Philips area of Bristol, east through Kingswood out towards Cadbury Heath and Warmley. This corridor is predominately residential, with retail and businesses also located along the A420, particularly through Kingswood town centre. The A420 is a constrained route, mainly due to the characteristics of the single carriageway, with sparse on-street parking and shops and residential developments in close proximity to the highway.

The A420 cuts across the Bristol to Bath Railway (Cycle) Path. Managed by the Avon Frome Partnership, the path is a 13-mile off-road route – along a former railway line between the cities of Bristol and Bath. The path provides numerous links to the residential areas of East Bristol and East Fringe and is open to walkers and cyclists, providing an integral commuting route, attractive leisure path and an important wildlife corridor.

Key destinations (in no particular order) along this corridor include:

- Emersons Green/Science Park
- Staple Hill
- Kingswood
- Temple Gate Enterprise Zone

FINAL DRAFT

- Bristol Temple Meads station
- Lawrence Hill station
- Emersons Green/Lyde Green Park & Ride
- Potential J18a Park and Ride
- Cadbury Heath

Congestion

Congestion is predominately tidal along the A420 in the AM and PM peaks, particularly in the proximity of the city centre, through Lawrence Hill to the junction with the A431. Consistent delays or slow-moving traffic are often observed, at the following locations, which are further exacerbated in peak times:

- A420 Church Road through Lawrence Hill
- The Fountain junction (A420 Church Road/A431 Summerhill Road);
- Kingswood town centre; and
- A420 Deanery Road /A4174.

Current travel demand considerations

A420 is a key local arterial route between South Gloucestershire and Bristol city centre. Key trip attractors along the A420 include Kingswood town centre and Emersons Green/Science Park.

The A420 (then A4174) is a key route for the Bristol and Bath Science Park, Emersons Green. This is a 59-acre site, which is expected to be fully developed by 2033 and employ 6000 people. The site is host to high-tech industries including aerospace, software development, engineering and specialist technical solutions.

Existing public transport provision

Bus routes that serve the A420 corridor include those that provide connections between city centre and Cadbury Heath (ten buses per hour), as well as some cross-city services from Keynsham/Bath to key attractors in north Bristol (Southmead Hospital and Cribbs Causeway).

Only one railway station is located along this corridor, Lawrence Hill with a service frequency of five trains per hour.

3.4.4 Route 4 – Hicks Gate/Keynsham

Land use, socio-economic and demographic context

The A4 runs from the city centre to the south east of Bristol, continuing towards Keynsham and Bath. The A4 provides access to Bristol Temple Meads railway station, Brislington Park & Ride and Keynsham. For individuals travelling from towns such as Keynsham and Saltford, as well as areas within the city such as Brislington, the A4 is a main route into Bristol city centre. The corridor is a mixture of single carriageway as well as dual carriageway, with speed limits ranging from 30 mph up to 70 mph on dual carriageway sections such as the Keynsham bypass.

Residential areas of Knowle, Totterdown and Brislington are located along the A4, with the A4 in Brislington providing access to an industrial estate and several large retail premises, as well as to local convenience shops, restaurants and cafes.

Keynsham is another key destination – home to 16,000 people. This historic market town is served by Keynsham railway station. There is currently a heavy rail link between Keynsham and Bristol with no intermediate stops (10-minute journey). The high street supports the surrounding villages with an array of independent and chain retail and businesses.

FINAL DRAFT

Key destinations (in no particular order) along this corridor include:

- Brislington Park & Ride
- Hicks Gate (potential relocation of Brislington Park & Ride)
- Island development site/St Philips Marsh Enterprise Zone
- Bristol Temple Meads and Keynsham railway stations
- Broad Walk shopping centre
- Longwell Green
- Keynsham

Congestion

Congestion is predominately tidal along the A4 in the AM and PM peaks, inbound to the city centre in the AM and outbound from the city centre in the PM peak. There are peak delays throughout the corridor but particularly around the following locations:

- Between Keynsham and Brislington;
- Junction of A4 and West Town Lane;
- Bristol Temple Meads, Temple Gate and Victoria Street; and
- Junction of A37 Wells Road and A4 Bath Road.

Consistent delays are often observed through Brislington, between West Town Lane junction and Emery Road junction, as well as within the city centre itself.

Current travel demand considerations

A4 is a key arterial route between Bath and North East Somerset and Bristol, particularly between Bath and Bristol city centres. Key trip attractors along the A4 include Bath city centre, Keynsham and Broadwalk shopping centre.

Existing public transport provision

Bus routes that serve the A4 corridor include those that provide connections between city centre and Bath (five buses per hour), as well as frequent cross-city services from Broomhill/Keynsham/Bath to key attractors in north Bristol (Cribbs Causeway) and to Bristol Airport from Bath. A route from Brislington Park & Ride also serves this corridor.

Only one railway station is located along this corridor, Keynham with a service frequency of one/two trains per hour.

FINAL DRAFT

4 Understanding the future transport situation

4.1 Introduction

Major strategic changes are proposed for the West of England, in terms of housing and employment delivery, as well as future transport provision in the next 20 years. With committed development and JSP proposals, an ambitious programme of schemes has been outlined to facilitate the travel demand resulting from new developments and employment opportunities.

The transformative prospects of a mass transit system in Bristol, in terms of enhanced public transport provision and the resultant development opportunities enabled are not considered in this section of the report (these are outlined in section 6).

4.2 Future land use and policies

4.2.1 Committed developments

There are a number of committed developments within the West of England, ranging from smaller-scale infill developments to larger new neighbourhoods like Cribbs/Patchway New Neighbourhood (CPNN) and Bristol Airport Masterplan.

Bristol

Bristol City Council's Housing Delivery Plan (2017-2020)[15] outlines that the adopted Bristol Local Plan has allocated 226 hectares of land for mixed use housing development, which can accommodate over 8,000 new homes.

The Local Plan site allocations document (July 2014)[16] provides further detail as to specific sites, in terms of location and size of developments. Those sites identified along the mass transit corridors (within Bristol City Council boundary) have been summarised in Table 4.1 below.

Table 4.1: Bristol Local Plan – site allocations (corridor specific)

Corridor	Total land for housing (hectares)	No. of dwellings
Corridor 1 – South Bristol and Airport	41.4	1,667
Corridor 2 – North Bristol and North Fringe	15.9	740
Corridor 3 – East Bristol and East Fringe	2.0	250
Corridor 4 – Hicks Gate/Keynsham	16.2	756
Total	**75.5**	**3,413**

The 2018 Draft Bristol Urban Living Supplementary Planning Document (SPD)[17] includes future areas of focused urban living development. These are illustrated in Figure 4.1 below.

[15] https://www.bristol.gov.uk/documents/20182/361915/BCC+Housing+Delivery+Plan+2017+to+2020
[16] https://www.bristol.gov.uk/documents/20182/34540/BD5605%20Site%20Allocations_MAIN_text%20V8_0.pdf/46c75ec0-634e-4f78-a00f-7f6c3cb68398
[17] https://bristol.citizenspace.com/growth-regeneration/ul-spd-draft/user_uploads/urban-living-spd-consultation-draft-feb-2018-2.pdf

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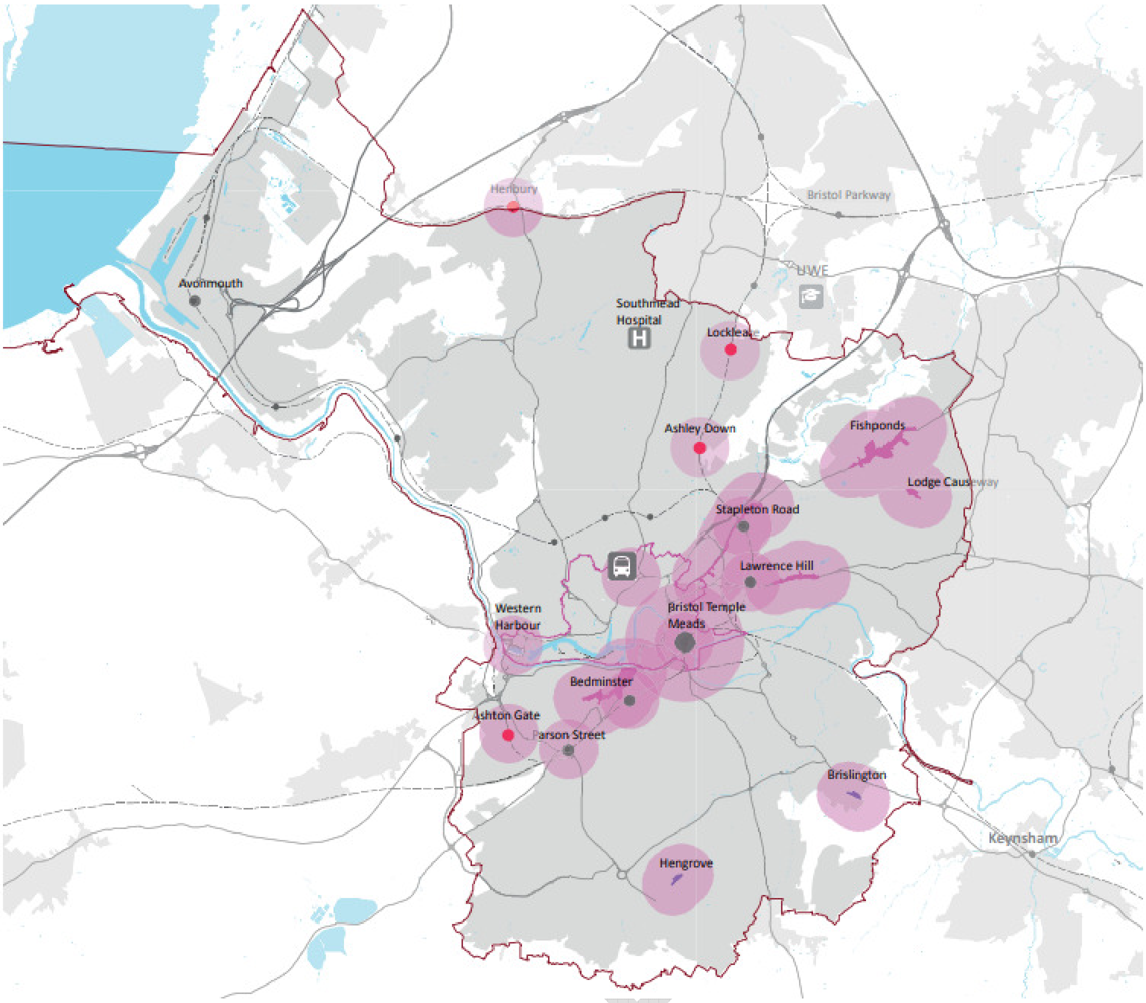

Figure 4.1: Draft Urban Living SPD – future focus for Urban Living

South Gloucestershire

The Cribbs/Patchway New Neighbourhood will involve the development of 5,700 new dwellings and 50ha of employment land within the Northern fringe of Bristol by 2027[18]. This is expected increase traffic congestion on the A38(N), A4018 and connecting roads[19].

The East of Harry Stoke New Neighbourhood also lies within the north fringe of Bristol and proposes to build approximately 2000 new homes, with a range of community facilities and services by 2027[20].

These are illustrated, as core strategy allocated developments, in Figure 4.2 below.

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18 http://www.southglos.gov.uk/documents/CPNN-DH-Feasibility.pdf
19 http://www.southglos.gov.uk/Documents/Cribbs%20Patchway%20Exhibition%20material.pdf
20 http://www.southglos.gov.uk/documents/Appendix-B-2016-January-Adoption-EoHS-Development-Framework.pdf

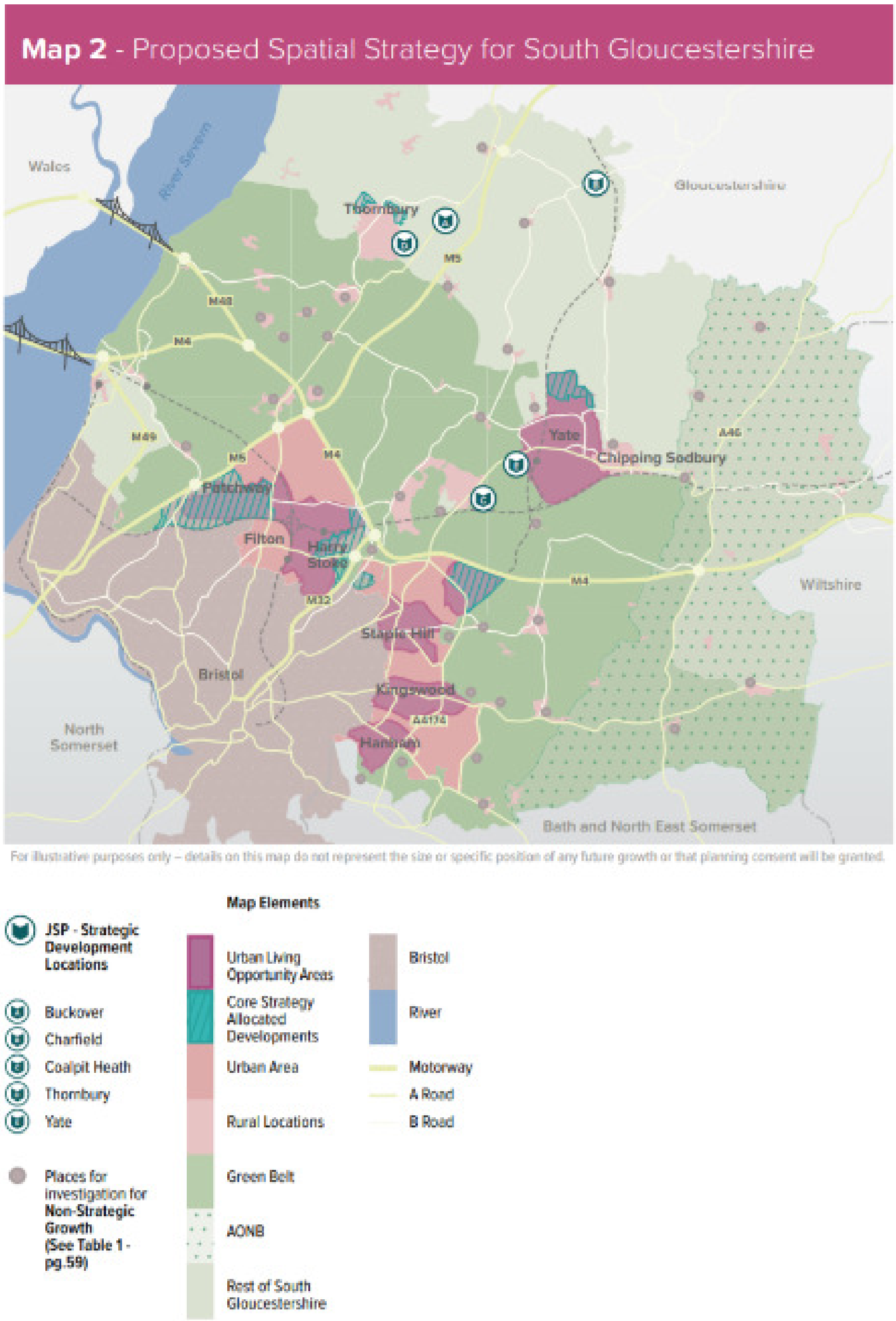

Figure 4.2: Emerging South Gloucestershire Local Plan (2018-2036)[21]

Bath and North East Somerset

BANES Council is currently preparing a new Local Plan. The new Local Plan 2016-2036 Issues and Options document was published for comment in November 2017. The document will undergo further rounds of consultation before formal adoption.

The adopted Core Strategy for BANES outlines a requirement for 12,956 houses which includes both the local plan delivery shortfall (1996-2011) and demographic need (2011-2029). 2,150 of these houses are to be provided in Keynsham, of which 1,600 will be provided through strategic sites.

[21] Taken from SGC Local Plan consultation document - https://consultations.southglos.gov.uk/consult.ti/NewLocalPlanFeb2018/consultationHome

1,600 new jobs will also be created between 2011 and 2029 primarily by increasing the stock of office floorspace in Keynsham, complemented by an extension to the Broadmead/ Ashmead/Pixash industrial Estate.

Strategic sites in Keynsham are located to the south west and east of the town (Figure 4.3), and the Core Strategy states that "*land is removed from the Green Belt to the south west and east of the town and allocated for development in order to provide additional employment floor space and housing*".

Within the Core Strategy, land has also been removed from the Green Belt at East Keynsham and safeguarded for possible development in the future. Development of this land will be permitted only when allocated for development following a review of the plan.

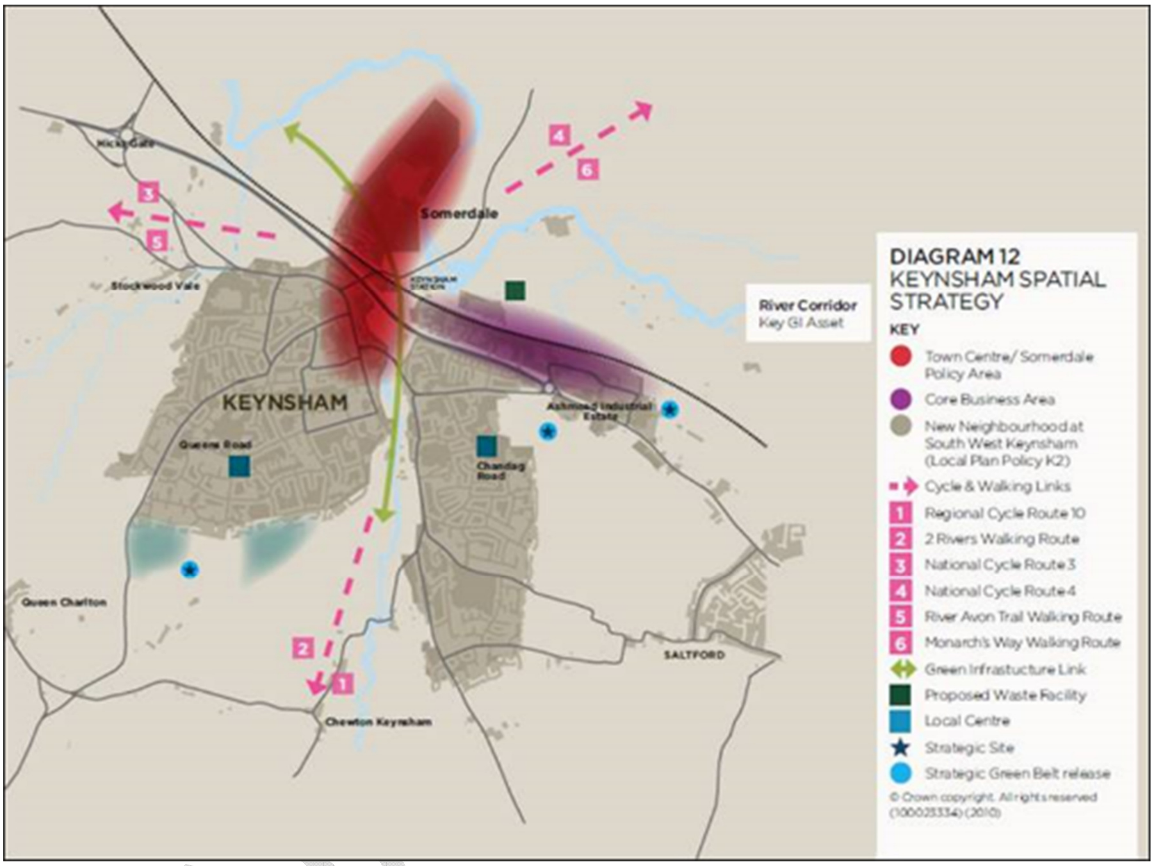

Figure 4.3: Keynsham Spatial Strategy (Core Strategy 2011-2029)

North Somerset Council

Bristol Airport has developed a Masterplan (2006-2030) to meet growing business and leisure flight demand across the South West of England, recognising regional and wider benefits;

- Employment forecast to rise (from 3,802 jobs in 2015 to 5,686 jobs in 2030)
- Reflects on environmental impacts of the airport growth
- Recognises growing demand for leisure travel by residents within the airport catchment area

Bristol Airport is the UK's ninth busiest airport, and the fifth busiest outside London, serving more than eight million passengers in 2017. Planning permission is already in place for facilities to handle up to 10 million passengers per annum, and £160 million has been invested in infrastructure improvements since 2010.

Forecasts indicate that up to 12.5 million passengers could use Bristol Airport by 2030 (passenger numbers totalled 5.2 million in 2005). The Masterplan includes a preliminary assessment of how the airport might develop further to meet this expectation.

Bristol Airport is currently developing a revised draft Masterplan ‘Towards 2050’, which includes a Charter for Future Growth in five key areas: aviation, economic impact, green belt, sustainable growth and surface access. The draft Masterplan is due for consultation in late 2018/early 2019.

4.2.2 Joint Spatial Plan

The JSP supports the delivery of 82,500 new jobs and 105,600 new homes by 2036, of which 61,400 homes are existing commitments and the JSP makes provision for 27,600 new homes in Strategic Development Locations (SDL) as well as 16,600[22] new homes through Urban Living developments. Figure 4.4 illustrates the wider regional proposals of the JSP, including locations of SDLs and Urban Living developments.

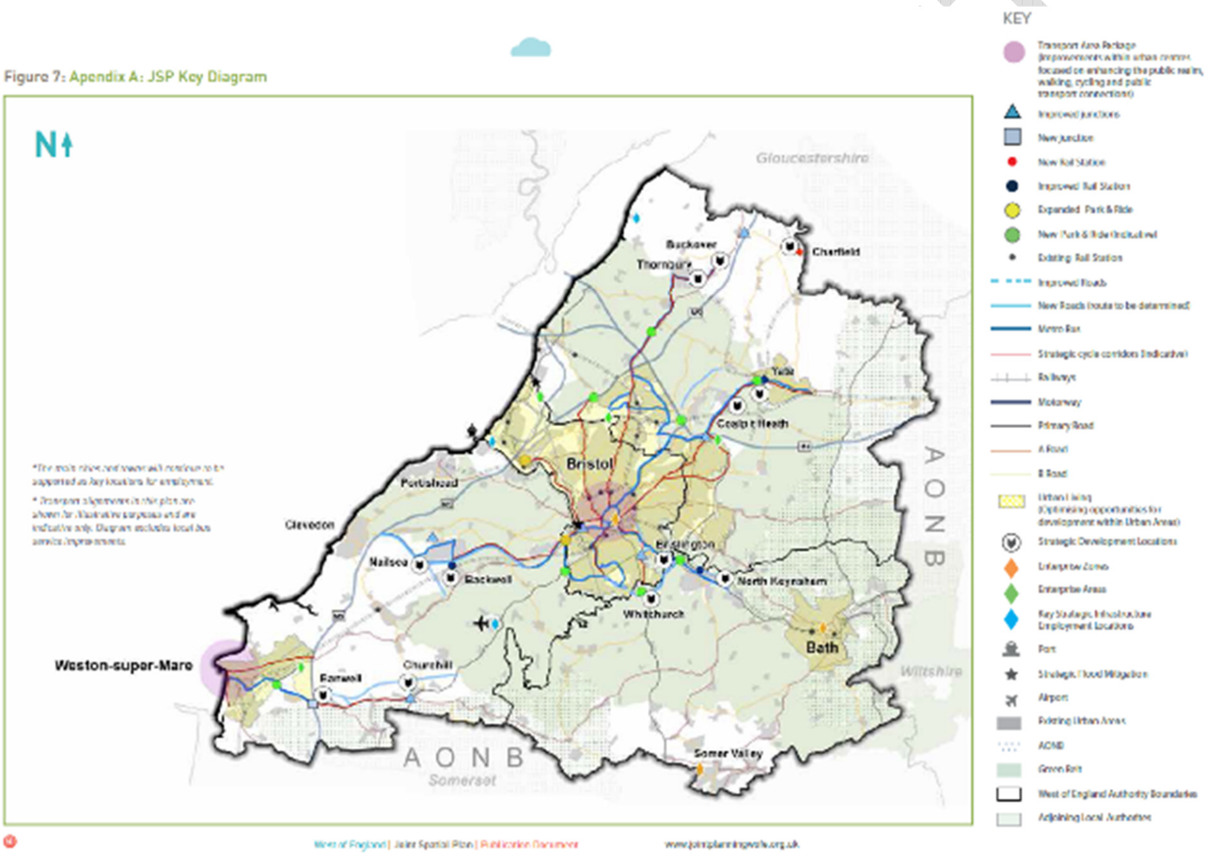

Figure 4.4: Joint Spatial Plan key diagram

The JSP outlines four main methods of delivering Urban Living developments, with ‘opportunities for maximising the potential of existing land in urban areas resulting from:

- The change of use of non-residential brownfield land to residential – where the previous use is no longer required or residential use would result in the more efficient use for the land.
- Identifying land which is currently underused and has potential for residential development or mixed-use development.
- Identification of mechanisms to ensure more certainty over the delivery of large windfall sites.
- Increasing the density of development on allocated or existing sites by reappraising and increasing their development potential in line with new thinking on urban living’.

[22] JTS states 14,600 new homes under Urban Living – with breakdown coming from JTS.

Urban Living is a central plank of the JSP which commands a high degree of public support and is a highly sustainable element of the strategy.

The JSP also supports the delivery of 82,500 additional jobs in the West of England between 2016 and 2036 and seeks to enable access to employment opportunities for all through the spatial distribution of development.

The following Strategic Development Locations will be delivered during the plan period:

- Keynsham, Bath and North East Somerset
- Whitchurch, Bath and North East Somerset
- Land at Bath Road, Brislington, Bristol
- Charfield and Buckover, South Gloucestershire Council
- Banwell and Churchill, North Somerset Council

Those SDLs relevant to proposed mass transit corridors have been detailed further below.

Keynsham, Bath and North East Somerset

The Joint Spatial Plan for North Keynsham requires the development of 1,500 new homes (including affordable housing provision), 50,000sqm of employment floorspace (which could provide around 1,600 jobs), a new school, local centre and potential for a new marina. Creation of a new local centre is necessary to provide a focal point for the new community with an appropriate range of small-scale retail services and facilities.

It is proposed that the development will be delivered along with the completion of key transport infrastructure including the North Keynsham multi modal link road from Avon Mill Lane to the A4, Keynsham rail station improvements and a Metrobus (high quality public transport) route from Bristol to Keynsham on the A4 corridor.

Other transport requirements include pedestrian and cycle connections (including to the Bristol to Bath cycle path), a high frequency local bus service through the site and off-site junction improvements.

Land at Bath Road, Brislington

The relocation of Brislington Park and Ride to land near Hicks Gate roundabout within Bath and North East Somerset will enable the creation of a new neighbourhood within Bristol. Development in this area should comply with the following strategic principles and infrastructure requirements:

- Provision of at least 750 new homes;
- The provision of key transport infrastructure in advance of development including;
  - relocation of Brislington Park & Ride to land near Hicks Gate Roundabout within Bath and North East Somerset;
  - widening of the A4 strategic road network corridor to provide public transport infrastructure inbound and outbound

Charfield and Buckover, South Gloucestershire Council

The Joint Spatial Plan has also identified a series of strategic locations for growth outside the Bristol, Bath and Weston urban areas. In South Gloucestershire, the Plan identifies development at settlements to the north of the M4 at Charfield and the Buckover Garden Village to the east of Thornbury.

Charfield has been recognised as an area with high levels of car dependence, with infrequent and long journey times by bus to Yate and North Bristol. A re-opened station at Charfield could be served by trains extending from Yate to Gloucester, which would improve rapid access to the North Fringe and Bristol. This should be planned alongside improved rail services from Gloucestershire to Bristol.

FINAL DRAFT

The Buckover Garden Village is set to be developed on land either side of the A38 (east of Thornbury). The garden village should comply with the following key strategic objectives and infrastructure requirements:

- Provision of 3,000 dwellings (including affordable homes)
- Provision of and support for a range of retail, community and cultural facilities
- Provision of 11ha of employment land
- Provision of delivery of, or contributions to a strategic transport package, as required

Banwell and Churchill, North Somerset Council

Land to the north west of Banwell is set to accommodate a new Garden Village. The key strategic principles and infrastructure requirements are as follows:

- 1900 dwellings – with own character and sense of identity;
- Creation of a new local centre to provide a focal point for the new community with an appropriate range of small-scale retail, services and facilities;
- Creation of new footpath and cycleways connecting the Garden Village to Banwell;
- Delivery of bus service improvements to Weston-super-Mare and Bristol including potential for MetroBus;
- Provision of two primary schools one of at least 2.4ha and the other 3.4ha to be located to maximise safe accessibility from surrounding communities by walking and cycling

Land to the north west of Churchill and Langford is set to accommodate a new Garden Village. The key strategic principles and infrastructure requirements are as follows:

- 2675 dwellings including affordable housing, an additional 125 dwellings are estimated beyond 2036;
- An interconnected and multi-functional network of green infrastructure will be established;
- Protection and enhancement of local heritage assets and their settings, including Churchill Court unregistered park and garden and listed buildings at Churchill Green and Front Street;
- Creation of a new local centre to provide the heart of the new community with a range of retail, employment, services and facilities.
- Identification of around 7.4ha of employment land. Employment land to be located in close proximity to new highway link and will provide business opportunities in the B Use Class.

4.3 Future changes to the transport system

There are numerous transport schemes outlined for the wider West of England region, particularly within Bristol urban area. Some are committed/proposed as part of development proposals or JLTP3 schemes, however the majority are proposed as part of the West of England Joint Transport Strategy (uncommitted at this stage) and in the forthcoming JLTP4.

4.3.1 Committed development

At the end of 2018, the tolls on the Severn Bridges were removed, making it cheaper to commute by car from southern areas of Wales to Bristol and vice versa. This will likely increase the traffic levels on the strategic and local routes from the Severn Bridges within the wider West of England region, having implications on the existing congested routes, particularly in the peak periods.

Bristol Temple Meads railway station

Forecast passenger growth at Bristol Temple Meads is expected to rise to 22 million by 2030. Network Rail have a programme of signal and station upgrades planned in and around Bristol Temple Meads station, with signal upgrades facilitating more services between Bristol and London. Station upgrade plans include additional ticket barriers (£3million in October 2018) and a further requirement of £40million investment for the renovation of the historic roof (in the next five years).

Future development of the station and local area, as part of Bristol's forthcoming masterplan, also includes the requirement for capacity improvements to provide better access in and around the station.

MetroWest

MetroWest involves proposed improvements of railway lines and services across the West of England region, including the proposals for new stations. The proposals have been put forward by the West of England Councils who, working alongside Network Rail, want to see the network proposals brought forward in the next Great Western Franchise.

Phase 1 involves service enhancements between Bath, Bristol and Severn Beach, opening the Portishead railway line to passenger services (with a new station at Portishead and Pill) and improvements to existing railway stations (accessibility and branding). Phase 2 involves opening the Henbury railway line (new stations at Henbury, North Filton and Ashley Down) and increasing service provision to Yate.

4.3.2 West of England Joint Transport Study

The JTS aims to provide long term direction for the transport system within the West of England up to 2036. The draft JLTP4 is scheduled for consultation in early 2019. The JTS includes plans for the four quadrants of West of England (see figures below), including the following proposals.

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North-west

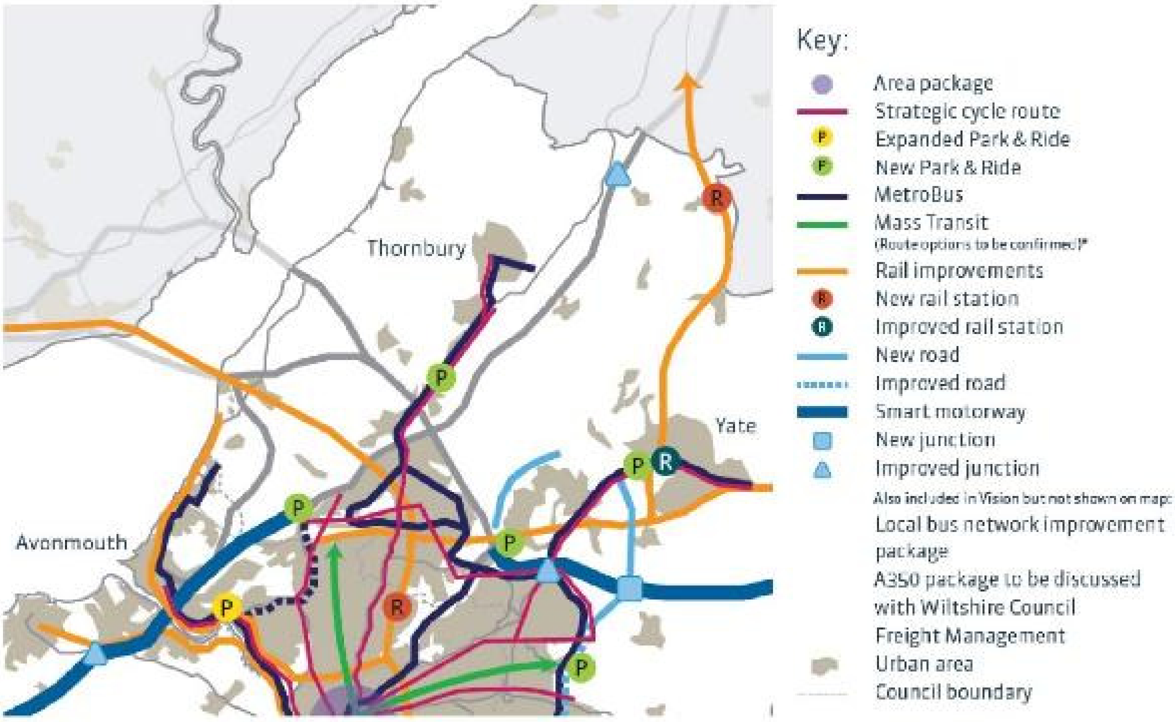

Figure 4.5: JTS transport proposals for North West Area (Source: JTS 2017)

Along with the provision of a proposed mass transit corridor (this study), the north-west area proposals include:

- New Metrobus services and strategic cycling route on A38(N), as well as new Metrobus route to serve Severnside and an expanded Portway Park & Ride
- Improvements to M5 junction 14
- New Park & Ride sites including: A38(N), A4018 and M32

These main schemes will be complemented by reopening of railway stations, further improvements to local rails services and better rail connections between Bristol and South Wales.

North-east

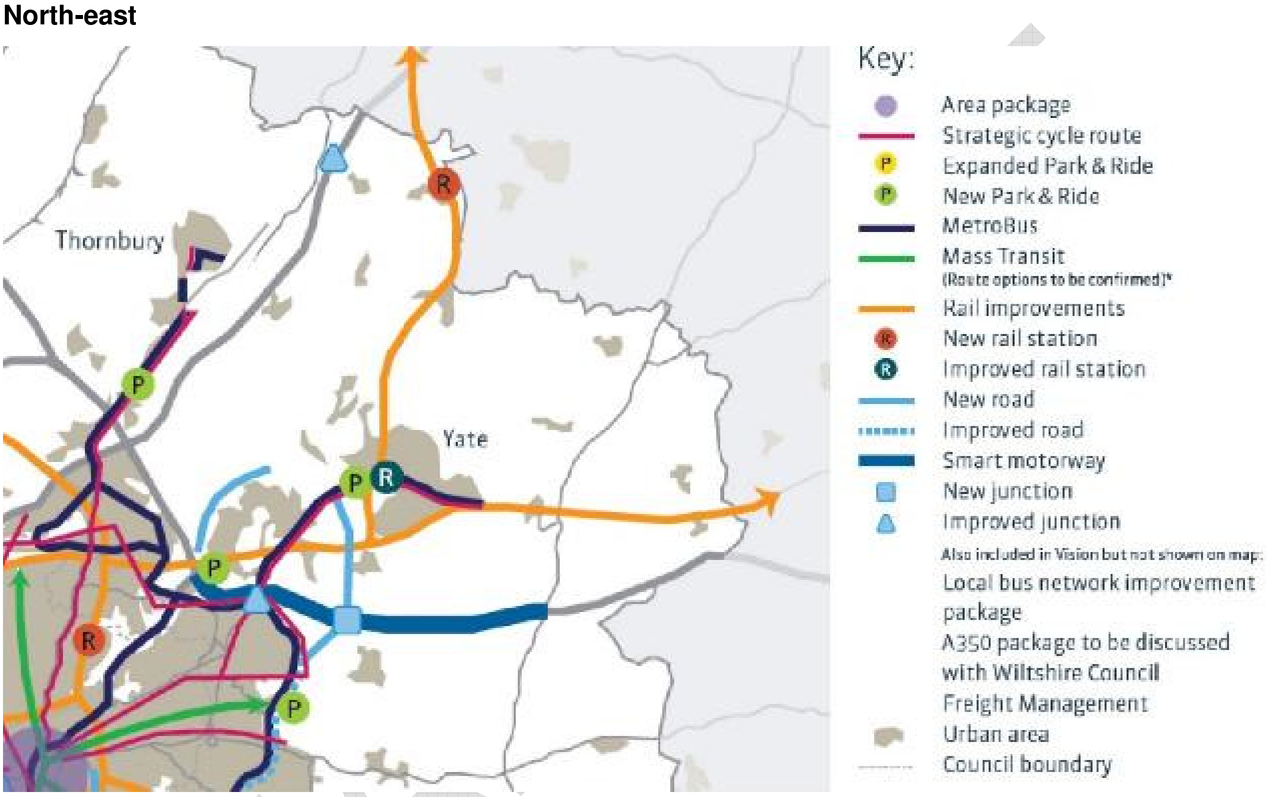

Figure 4.6: JTS transport proposals for North East Area (Source: JTS 2017)

Along with the provision of a proposed mass transit corridor (this study), the north-east area proposals include:

- A new motorway junction on the M4 (junction 18a), which aims to manage traffic issues at the M32 junction 1 and improve connections to Yate
- New Park & Ride sites including: M32, A432 and A38(N)
- A Winterbourne bypass on the B4058 to improve highway capacity for Metrobus improvements on the A432 between Yate and Bristol
- Improved facilities at Yate railway station
- Orbital Metrobus connections aim to improve access to employment

The JTS also aims to improve active travel within the area and includes plans for new strategic cycling routes within Bristol, which will extend to neighbouring towns such as Yate.

South-east

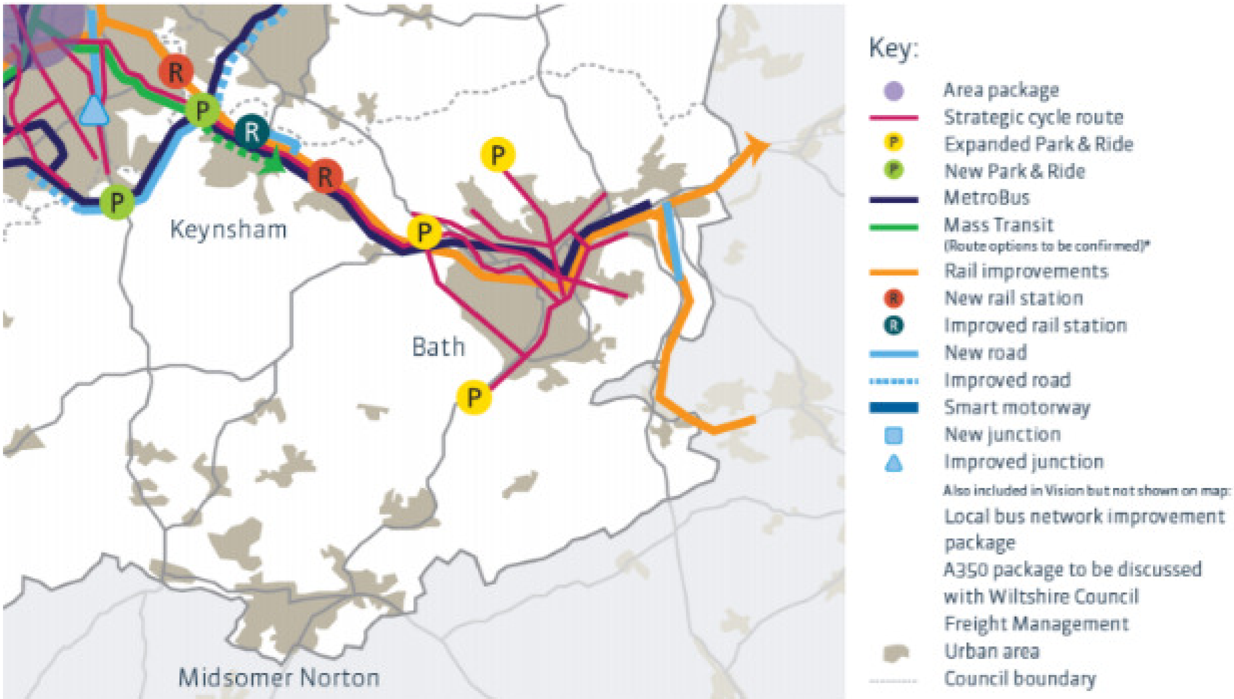

Figure 4.7: JTS transport proposals for South East Area (Source: JTS 2017)

Along with the provision of a proposed mass transit corridor (this study), the south-east area proposals include:

- A network of new and expanded Park & Ride sites on the edge of Bristol urban area, along with expanded Park & Ride sites in Bath
- New highway link from A4 to Avon Mill Lane link
- Metrobus proposals
- A new strategic cycle route between Bath and Bristol
- Improved multimodal orbital connectivity around south Bristol

These main schemes will be complemented by reopening of railway stations, existing station upgrades, further improvements to local rails services and better rail connections between Bristol and Bath.

South-west

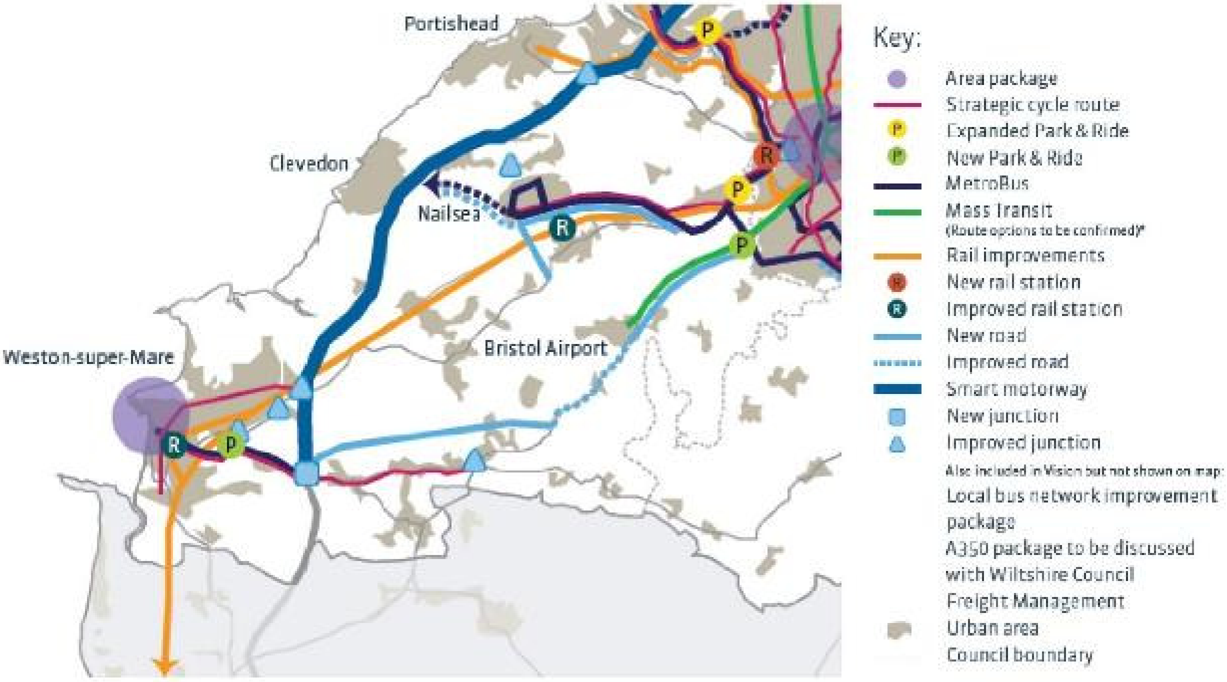

Figure 4.8: JTS transport proposals for South West Area (Source: JTS 2017)

Along with the provision of a proposed mass transit corridor (this study), the south-west area proposals include:

- Weston-Super-Mare transport package
- A new strategic corridor from M5 to Airport and Bristol
- A multi-modal transport corridor (including Metrobus) connecting Nailsea and Bristol
- Improved orbital connectivity around south Bristol
- New Park & Ride sites including A38(S) and Weston-Super-Mare, as well as an expanded Long Ashton Park & Ride

4.3.3 Bristol's Draft Transport Strategy 2018

Bristol's draft Transport Strategy[23] was recently consulted on (September-November 2018) and discusses the measures proposed and the potential transformative opportunities in the way people move around Bristol. It also includes considerations for potential funding mechanisms to assist in revolutionising the transport system, as it cannot be covered by existing sources of funding alone.

The draft Transport Strategy suggests potential new funding sources, including workplace parking levies and road user/congestion charging. The consultation included questions as to whether respondents would be supportive of charging measures. The consultation response document is due out in spring 2019.

This study further investigates and discusses potential funding sources in chapter 7 later in the report.

[23] https://bristol.citizenspace.com/growth-regeneration/bristol-transport-strategy/

4.3.4 Uncommitted schemes

Clean Air Action Plan

Bath and North East Somerset and Bristol City Council are both developing Clean Air Action Plans, for Bath and Bristol respectively, which could tackle air pollution through a wide range of measures, such as:

- more investment in public transport and cycling;
- changes in traffic management;
- greater use of existing regulatory powers such as taxi licensing; and
- ways to support and encourage a shift to cleaner vehicles.

These measures may also include the creation of a Clean Air Zone (CAZ) to ensure the city is meeting legal limits for levels of nitrogen dioxide. As the implementation of a CAZ, is currently uncommitted in both Bristol and Bath, it has not been considered in the future baseline for this study. However, if one were to be implemented, it would have direct implications on the current public transport network, including the potential opportunity to provide an improved service quality on some existing bus routes within Bristol and Bath. It would also likely affect mode share, impacting on car drivers and therefore the potential for more people to use sustainable modes to travel.

Draft Airport Masterplan

The UK Government is making decisions on national and regional transport strategies for the next two decades. A new Master Plan, published in December 2018 by Bristol airport, aims to assist decision-makers in the development of this policy framework.

With increasing demand for air travel and Britain's place in the world changing, the Airport have identified a need to serve circa 20 million passengers a year by the mid-2040s (another significant increase from 12.5 million projected by 2030 in the current master Plan).

This further expansion plans provide a vision for the airport's future which is shared across the region and delivers what customers want in a way which is sensitive to the environment and local communities.

4.4 Future travel demand and transport-related problems

The existing network congestion and delays across the West of England, particularly in urban Bristol will be further exacerbated by the proposed housing and employment growth up to 2036. The West of England region is already expected to experience growth in travel demand both within and into the Bristol urban area.

Initial modelling carried out as part of the JSP and JTS has identified that the additional housing and employment development envisaged will add pressures on several key corridors including the A4, A38(N), A38(S) and A420, with trips to/from central Bristol, key attractors and proposed developments in Bristol and areas in surrounding authorities. Transport proposals to mitigate this growth, with regards to infrastructure upgrades and service uplifts, have been identified in the JTS (2017), and the forthcoming draft JLTP4.

The increase in traffic demand across Bristol's urban area will pose significant challenges. In order to enable the wider West of England region to continue to grow and remain a competitive location for employment, more needs to be done to improve the public transport offering, particularly to encourage mode shift to non-car-based modes – not only to reduce congestion and delays on the network, but to reduce carbon and NOx emissions to improve air quality.

Table 4.2 outlines the 2036 do minimum scenario, along with the 2013 base total demand (person trips) by mode for the GBATS4 model area. This gives an indicative level of demand for the study area and has been used to develop future do something scenarios in the demand forecasting assessment.

FINAL DRAFT

Table 4.2: GBATS4 2036 future do minimum scenario and 2013 Base – total demand (person trips) by mode

Total demand mode (person) trips	2013 Base			2036 Do Minimum		
	AM Peak (3-hours)	Inter-peak (average hour)	PM peak (3-hours)	AM Peak (3-hours)	Inter-peak (average hour)	PM peak (3-hours)
Car	264,700	76,200	222,000	267,000	77,000	224,100
Bus	33,800	9,600	24,900	44,100	11,900	32,500
Rail	24,700	3,200	21,800	28,000	3,700	24,700
PT Total	**58,500**	**12,800**	**46,700**	**72,100**	**15,600**	**57,200**
Total	**323,200**	**89,000**	**268,700**	**339,100**	**92,600**	**281,300**

FINAL DRAFT

5 Generating and initial sifting of options

5.1 Approach to option generation

The JTS and the emerging JLTP4 sets out policy identifying the opportunities a mass transit system could bring to the West of England region, along with potential corridors for investigation and assessment. The previous Metro Study (CH2M/SDG 2017) developed the underground options for three corridors: North Bristol and North Fringe; South Bristol and South Fringe; and East Bristol and East Fringe.

The scope of this study is to further consider the feasibility of a mass transit system in Bristol, looking at both above and below ground options for the three corridors from the original pre-feasibility study and including the additional A4 corridor for consideration.

Initial options have been proposed based on the following:

- Previous/existing studies and proposals;
- Engagement with local authority officers (client group);
- Scheme objectives;
- Accessibility and capacity of corridors;
- Key destinations and attractors - employment, healthcare, retail/entertainment, housing;
- Land use planning aspects;
- Enhanced development prospects;
- Existing infrastructure provision;
- Potential interchange opportunities; and
- Fit with existing local, regional and national programmes and strategies

5.2 Results of option generation

The generation of the long-list potential corridor options identified five underground alignments (technology to be confirmed) and 14 overground alignment options (26 options when accounting for mode – street-car/bus rapid transit, tram or tram-train technology solutions). Table 5.1 summarises the long-listed alignment options considered within this study. Figure 5.1 illustrates the overground alignment options, with Figure 5.2 illustrating the underground alignment options.

FINAL DRAFT

Corridor	Option	Description	Mode
1: South Bristol and Airport	1 UG	Underground route from Bristol Temple Meads via Bedminster, Hengrove Park, Hartcliffe, South Bristol Link to Airport	TBC
	1 OG	Overground route from Bristol Temple Meads via A38(S), Parsons Street, Bedminster, South Bristol Link (Park and Ride) to Airport	Bus/BRT, tram
	1b OG	Overground route from Bristol Temple Meads via Redcliffe Hill, Cumberland Road/Coronation Road, AVTM, South Bristol Link (Park and Ride) to Airport	Bus/BRT, tram
	1c OG	Overground route from Bristol Temple Meads via Hengrove Way, Knowle, Hartcliffe, South Bristol Link (Park and Ride) to Airport	Bus/BRT, tram
	1d OG	Overground route from Bristol Temple Meads via heavy rail alignment to Parsons Street and overground to Airport (BSWEL)	Tram-train
2: North Bristol and North Fringe	2 UG	Underground route from Bristol Temple Meads via Cabot Circus, Bus Station/BRI, A38(N) Gloucester Road, Southmead Hospital, CPNN, Aztec West, and M5/M4 Park and Ride	TBC
	2 OG	Overground from Bristol Temple Meads via A38(N) Gloucester Road, Southmead Hospital, CPNN, Aztec West and M5/M4 Park and Ride	Bus/BRT, tram
	2i OG	Overground from Bristol Temple Meads via A38(N) Gloucester Road, Southmead Hospital, CPNN, Aztec West and M5/M4 Park and Ride, with extension to Thornbury	Bus/BRT, tram
	2b OG	Overground from Bristol Temple Meads via Bristol supertram route	Tram
3: East Bristol and East Fringe	3 UG (EG)	Underground route from Bristol Temple Meads via Kingswood, Staple Hill to Emersons Green/Science Park	TBC
	3 UG (LG)	Underground route from Bristol Temple Meads via Kingswood to Cadbury Heath/Longwell Green	TBC
	3 OG (EG)	Overground route from Bristol Temple Meads via Kingswood, Staple Hill to Emersons Green/Science Park	Bus/BRT, tram
	3 OG (LG)	Overground route from Bristol Temple Meads via Kingswood, Walmley (A4174) to Longwell Green	Bus/BRT, tram
	3b OG	Overground route from Bristol Temple Meads via Bristol Bath Railway (Cycle) Path to Emersons Green	Bus/BRT, tram
4: Hicks Gate/Keynsham	4 UG	Underground route from Bristol Temple Meads via Brislington to Keynsham Railway Station	TBC
	4 OG	Overground route from Bristol Temple Meads via A4 to Brislington and Hicks Gate (Park and Ride)	Bus/BRT, tram
	4a OG	Overground route from Bristol Temple Meads via A4 to Brislington, Hicks Gate (Park and Ride) and Keynsham	Bus/BRT, tram
	4b OG	Overground route from Bristol Temple Meads via Old Market Street, A4, Callington Road Link and Hicks Gate (Park and Ride)	Bus/BRT, tram
	4bi OG	Overground route from Bristol Temple Meads via St Phillips Marsh, Avon Street, Callington Road Link and Hicks Gate (Park and Ride)	Bus/BRT, tram

Table 5.1: Long-list alignment options

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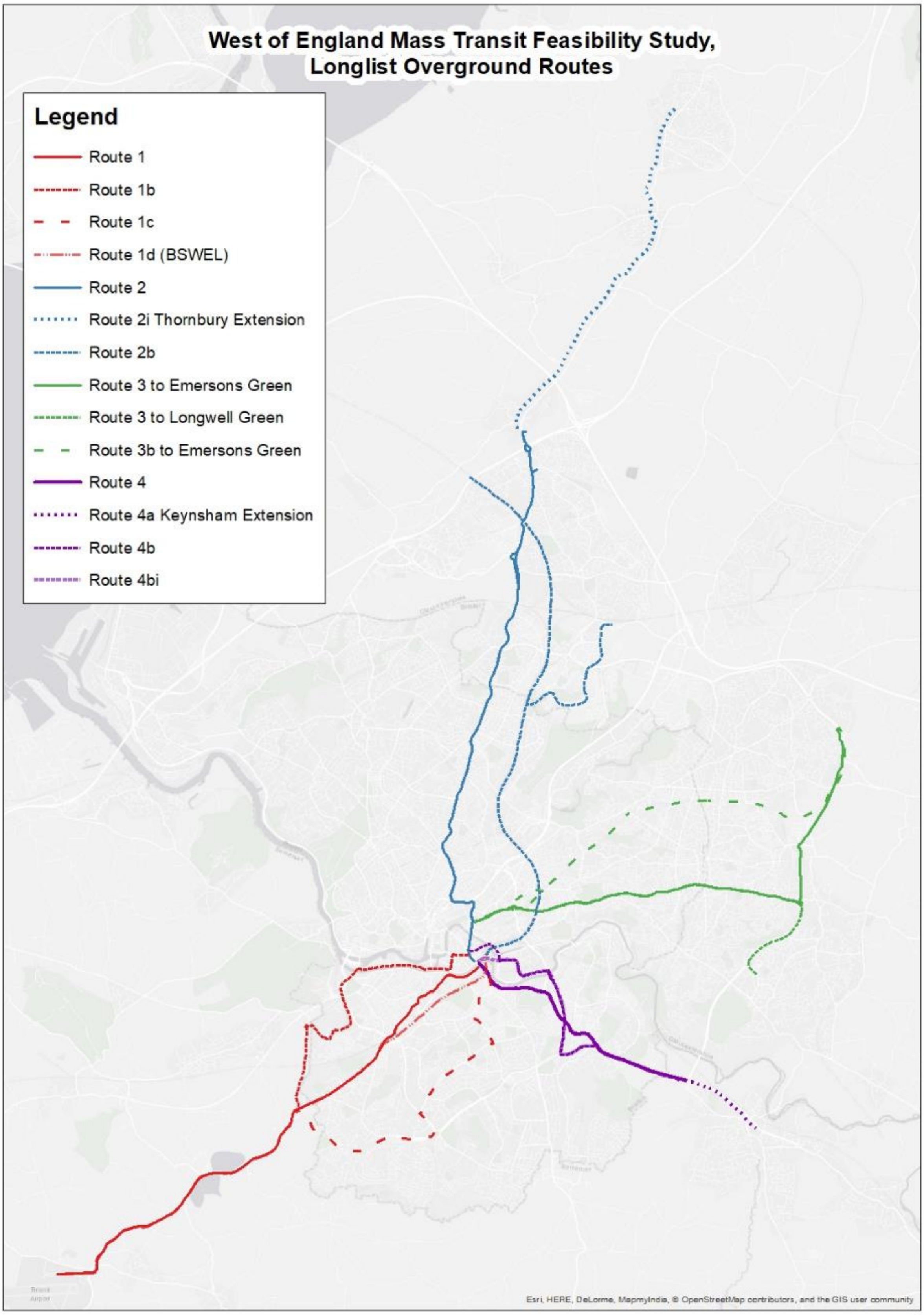

Figure 5.1: Overground long-list alignment options

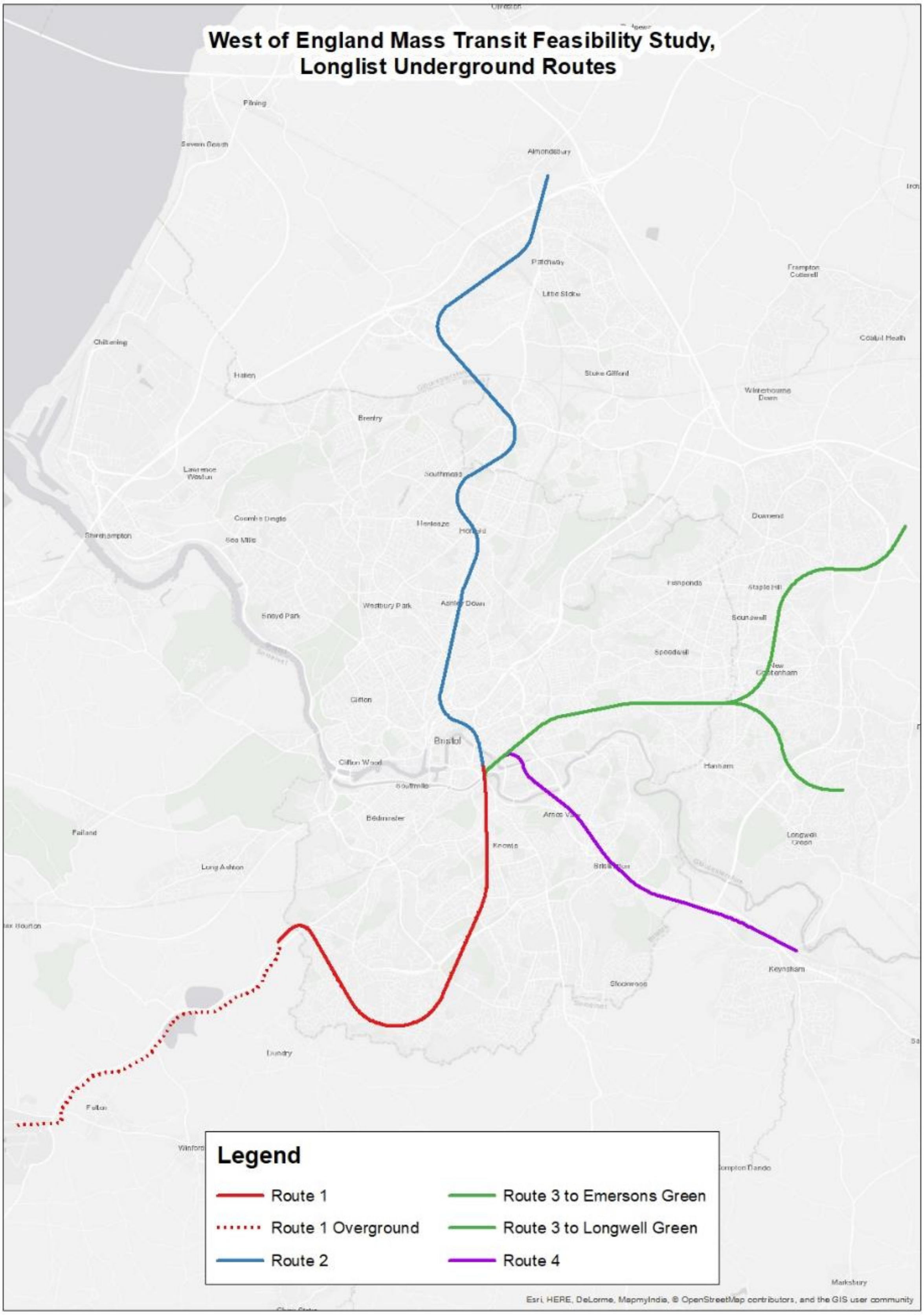

Figure 5.2: Underground long-list alignment options

5.3 Approach to option sifting

All scheme options have undergone a robust but proportionate sifting process to identify a short-list of the schemes that justify more detailed development and consideration. The DfT '*Transport Analysis Guidance: The Transport Appraisal Process*'[24] outlines the approach to be taken for the initial sifting of options.

It states that '*an initial sift should… be undertaken to identify any 'showstoppers' which are likely to prevent an option progressing at a subsequent stage in the process'*. The process involves discarding options that:

- '*would clearly fail to meet the key objectives identified for intervention;*
- *do not fit with existing local, regional and national programmes and strategies, and do not fit with wider government priorities; and*
- *would be unlikely to pass key viability and acceptability criteria (or represent significant risk) in that they are unlikely to be:*
    - *deliverable in a particular economic, environmental, geographical or social context e.g. options which would result in severe adverse environmental impacts which cannot be mitigated against or where the cost of doing so is too high;*
    - *technically sound;*
    - *financially affordable; and,*
    - *acceptable to stakeholders and the public.*'

The initial long-list of the mass transit feasibility study has been sifted against scheme objectives, transport business cases and deliverability (based on the available information at the time of sifting)– in terms of feasibility, constructability, impacts during construction and operation, environmental considerations and land and property impacts. Table 5.2 summarises the multi-assessment criteria used for the sifting. There are a number of criteria not included in this stage of the sifting, this is due to the appropriateness of the principles at this stage of the study. These categories are to be utilised at a later stage of the option development and assessment, to inform preferred option selection.

Sifting has been undertaken to identify feasible options to take forward for further development, including demand forecasting, outline design and economic assessment. Detailed costing, demand forecasting and economic analysis was not undertaken at this stage. Indicative level of demolitions and population catchments were included for different options, where appropriate.

This chapter provides a summary that sits alongside the long-list sifting table (Appendix B) to provide reasoning behind short-listing, discarding or why options have not been taken forward at this stage.

FINAL DRAFT

[24] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/431185/webtag-tag-transport-appraisal-process.pdf

Criteria			Ranking
Strategic Fit (study objectives)	Economic Growth	Connectivity to existing areas of employment	(✓✓) (✓) (Θ) (X) (XX)
		Connectivity to proposed areas of employment	
		Unlocking new employment sites	
	Transport connectivity	Accessibility to key attractors/destinations	
		Connectivity/interchange with other public transport	
		Dispersal from stations	Not included at this stage
		Fit with anticipated demand	
		Indicative BCR	
		Connectivity to BTM and Bristol Airport	(✓✓) (✓) (Θ) (X) (XX)
	Support housing & regeneration	Connectivity to existing areas of housing	
		Connectivity to proposed areas of housing	
		Unlocking new residential sites	
		Opportunities to improve public realm	
	Sustainable growth	Increase in public transport connectivity levels	
		Stimulates mode shift from private car	
	Reduce inequality	Provide improved connectivity from and to areas of high deprivation	
		Improved travel opportunities for specific/vulnerable groups	
	Promote health	Increases safety of the transport network	Not included at this stage
		Increases perceived and actual security	
		Promotes physical activity	(✓✓) (✓) (Θ) (X) (XX)
Deliverability	Land and Property	Availability/acceptability of sufficient land (construction)	
		Availability/acceptability of sufficient land (permanent)	
		Property take (construction)	
		Property take (operation)	
		Difficultly in acquiring land	
		Land cost/compensation	
	Feasibility	Engineering complexity	
		Cost	£ ££ £££
		Impact of construction	(✓✓) (✓) (Θ) (X) (XX)
		Construction site access	
		Construction risk/acceptability	
		Construction timescales	# of years[25]
	Operations	Degree of operational complexity	(✓✓) (✓) (Θ) (X) (XX)
		Indicative operating cost	£ ££, £££
	Environment & heritage	Heritage	(✓✓) (✓) (Θ) (X) (XX)
		Landscape	
		Amenity	
		Ecology	
		Noise & air quality (construction)	
		Noise & air quality (permanent)	
		Archaeology	Not included at this stage

FINAL DRAFT

25 Timescale assumption that planning and land acquisition is complete, does not including testing and commissioning

<table>
<tr><th colspan="3">Criteria</th><th>Ranking</th></tr>
<tr><td rowspan="5">Transport business cases</td><td colspan="2">Strategic case</td><td rowspan="2">(✓✓) (✓) (Ɵ) (X) (XX)</td></tr>
<tr><td colspan="2">Economic case</td></tr>
<tr><td colspan="2">Commercial case</td><td>Not included at this stage</td></tr>
<tr><td colspan="2">Financial case</td><td rowspan="2">(✓✓) (✓) (Ɵ) (X) (XX)</td></tr>
<tr><td colspan="2">Management case</td></tr>
<tr><td rowspan="6">Showstoppers - WebTAG</td><td colspan="2">Does not meet the key objectives identified for intervention</td><td rowspan="6">RAG, predicated from above categories and sifting assessment</td></tr>
<tr><td colspan="2">Does not fit with existing local, regional and national programmes and strategies, and with wider government priorities</td></tr>
<tr><td rowspan="4">Unlikely to pass key viability and acceptability criteria (or represent significant risk) in that they are unlikely to be:</td><td>Deliverable in a particular economic, environmental, geographical or social context e.g. options which would result in severe adverse environmental impacts which cannot be mitigated against or where the cost of doing so is too high</td></tr>
<tr><td>Technically sound</td></tr>
<tr><td>Financially affordable</td></tr>
<tr><td>Acceptable to stakeholders and the public</td></tr>
</table>

Table 5.2: Long-list sifting criteria

5.4 Results of sifting

All the options (Table 5.1) have been considered qualitatively against multi-assessment criteria (Table 5.2) including, the defined study objectives (strategic fit), deliverability factors and transport business cases. The long list sifting table has been appended (Appendix B), with a RAG categorisation against the factors identified in the DfT transport appraisal process which assist in identifying showstoppers that are likely to prevent the option progressing at a subsequent stage for further assessment and costing.

Table 5.3 below summarises the long-list sifting results and outlines the options taken forward for further assessment, those not taken forward at this stage, as well as those paused pending outcomes of other separate studies and not considered further in this study. It should be noted that those options not taken forward at this stage are not discounted from being considered as part of any future study, if appropriate.

Figure 5.3 and Figure 5.4 illustrate the shortlisted overground and underground alignment options respectively.

FINAL DRAFT

Corridor	Option	Description	Mode	Sifting result	Comments
1: South Bristol and Airport	1 UG	Underground route from Bristol Temple Meads via Bedminster, Hengrove Park, Hartcliffe, South Bristol Link to Airport	TBC	Taken forward	• High cost option
	1 OG	Overground route from Bristol Temple Meads via A38(S), Parsons Street, Bedminster, South Bristol Link (Park and Ride) to Airport	Tram	Not taken forward at this stage	• Economic impact of construction • Implications of construction - extended closures for utility works, as well as civils construction work • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction
			Bus/BRT	Taken forward	• Impact of construction less severe than tramway, mainly due to limited requirement for additional utility works and civils. • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction
	1b OG	Overground route from Bristol Temple Meads via Redcliffe Hill, Cumberland Road/Coronation Road, AVTM, South Bristol Link (Park and Ride) to Airport	Bus/BRT, tram	Not taken forward at this stage	• Does not deliver scheme to more populated residential areas (limited demand from residential/intermediate stops), main residential population along route is Spike Island inwards to city centre, which is within walking/cycling distance • Focuses on end to end journey (city centre to airport) and not enhanced development priorities of the study objectives. • Economic impact of construction • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction
	1c OG	Overground route from Bristol Temple Meads via Hengrove Way, Knowle, Hartcliffe, South Bristol Link (Park and Ride) to Airport	Bus/BRT, tram	Not taken forward at this stage	• Option delivers access to south Bristol residential area, however it is not a direct service, with implications on journey times • Impact of construction and operation on residential streets • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction

FINAL DRAFT

Corridor	Option	Description	Mode	Sifting result	Comments
	1d OG	Overground route from Bristol Temple Meads via heavy rail alignment to Parsons Street and overground to Airport (BSWEL)	Tram-train	Paused pending further information from BSWEL study	• Does not deliver on mass transit scheme objectives with regards to providing high-frequency mass transit (BSWEL has identified availability of 4tph using tram-train) • Do not have enough information from BSWEL study at the time of sifting. Option paused to be able to provide more information regarding: – Heavy rail alignment availability (approx. 1000m is not available – constraint on line) and limited access to residential and employment between Parson Street and Bristol temple Meads – Constraints at Bristol Temple Meads, limited capacity for a mass transit frequency service on the heavy rail network • Opportunity being taken forward through BSWEL study.
2: North Bristol and North Fringe	2 UG	Underground route from Bristol Temple Meads via Cabot Circus, Bus Station/BRI, A38(N) Gloucester Road, Southmead Hospital, CPNN, Aztec West, and M5/M4 Park and Ride	TBC	Taken forward	• High cost option
	2 OG	Overground from Bristol Temple Meads via A38(N) Gloucester Road, Southmead Hospital, CPNN, Aztec West and M5/M4 Park and Ride	Tram	Not taken forward at this stage	• Economic impact of construction • Implications of construction - extended closures for utility works, as well as civils construction work • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction
			Bus/BRT	Taken forward	• Impact of construction less severe than tramway, mainly due to limited requirement for additional utility works • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction

FINAL DRAFT

Corridor	Option	Description	Mode	Sifting result	Comments
	2i OG	Overground from Bristol Temple Meads via A38(N) Gloucester Road, Southmead Hospital, CPNN, Aztec West and M5/M4 Park and Ride, with extension to Thornbury	Bus/BRT, tram	Not taken forward at this stage	• Economic impact of construction • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions • Cost of extension to Thornbury is prohibitive in terms of: – increase construction and operating costs considerably without the accompanying increase in revenue (driven by demand) – impacting on journey times and operational performance (i.e. PVR requirement) • Engineering concerns of shared carriageway layout of extension – traffic concerns, speed limit reductions and maintaining access rights, as well as access over/under/through M5 junction • Feeder service likely to be able to provide the link to Thornbury to mass transit station/Park & Ride facility.
	2b OG	Overground from Bristol Temple Meads via Bristol supertram route	Tram	Not taken forward at this stage	• Alignment along Filton is not available due to filton four-tracking and the requirement for a high frequency service (i.e. 8-12tph) could not be accommodated in this area. • Impact on stakeholders/Network Rail • Does not link to key attractors (Southmead Hospital, CPNN, Gloucester Road) • Similar alignment to existing rail services and potential implications on availability for MetroWest Phase 2 proposals
3: East Bristol and East Fringe	3 UG (EG)	Underground route from Bristol Temple Meads via Kingswood, Staple Hill to Emersons Green/Science Park	TBC	Taken forward	• High cost option • Demand forecasting and feedback from SGC to further refine EG or LG as destination for alignment
	3 UG (LG)	Underground route from Bristol Temple Meads via Kingswood to Cadbury Heath/Longwell Green	TBC	Taken forward	• High cost option • Demand forecasting and feedback from SGC to further refine EG or LG as destination for alignment
	3 OG (EG)	Overground route from Bristol Temple Meads via Kingswood, Staple Hill to Emersons Green/Science Park	Bus/BRT, tram	Not taken forward at this stage	• Economic impact of construction • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions (considerable level of demolitions), impact on sense of place during construction

FINAL DRAFT

Corridor	Option	Description	Mode	Sifting result	Comments
	3 OG (LG)	Overground route from Bristol Temple Meads via Kingswood, Walmley (A4174) to Longwell Green	Bus/BRT, tram	Not taken forward at this stage	• Economic impact of construction • Acceptability to stakeholders and the public - closure of roads for construction, impact and level of demolitions (considerable level of demolitions), impact on sense of place during construction
	3b OG	Overground route from Bristol Temple Meads via Bristol Bath Railway (Cycle) Path to Emersons Green	Bus/BRT, tram	Not taken forward at this stage	• Constructability issues – – practicality due to cutting (land take due to need to replace/create retaining walls and structures), likely requirement to replace road and footbridges along alignment – very limited access from highway network for removal/importation of materials – construction works over NR filton bank railway line – connection from Bristol to BBRP would impact on operation of the household waste transfer depot – Pedestrian and cycle routes that cross the railway path or use part of it would have to be closed for significant durations during construction and be better managed/controlled during operation • Impacts on ecology/environment – Linear park, designated as strategic green infrastructure and SCNI, biodiversity and quality of life impacts – Likely impact on 1000+ trees • Acceptability to stakeholders and the public - closure of cycle path for construction and impacts of operation on accessibility and use – Sustrans own some sections of the route, which would require CPO. Could become a national issue – 2008 BRT proposals protest – petition signed by 8,000 people in a month – Currently over 1 million walking and cycling trips per year • Single-way working would be required due to constraints at the tunnel, which would reduce resilience and frequency of this section of the route
4: Hicks Gate/Keynsham	4 UG	Underground route from Bristol Temple Meads via Brislington to Keynsham Railway Station	TBC	Taken forward	• High cost option

FINAL DRAFT

Corridor	Option	Description	Mode	Sifting result	Comments
	4 OG	Overground route from Bristol Temple Meads via A4 to Brislington and Hicks Gate (Park and Ride)	Bus/BRT, tram	Not taken forward at this stage	• Impact of construction • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction • Served by route 4a, which links to Brislington (key area of deprivation and for redevelopment) which extends to Keynsham (additional demand) and opportunities to link with future Bath study for mass transit.
	4a OG	Overground route from Bristol Temple Meads via A4 to Brislington, Hicks Gate (Park and Ride) and Keynsham	Bus/BRT, tram	Taken forward	• Impact of construction • links to Brislington (key area of deprivation and for redevelopment) which extends to Keynsham (additional demand) and opportunities to link with future Bath study for mass transit. • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction • Assumption that Callington Road Link is available for reassignment of general traffic
	4b OG	Overground route from Bristol Temple Meads via Old Market Street, A4, Callington Road Link and Hicks Gate (Park and Ride)	Bus/BRT, tram	Not taken forward at this stage	• Impact of construction • Mostly served by route 4bi – which also serves the enterprise zone. • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction • Political acceptability of using Callington Road Link
	4bi OG	Overground route from Bristol Temple Meads via St Phillips Marsh, Avon Street, Callington Road Link and Hicks Gate (Park and Ride)	Bus/BRT, tram	Taken forward	• Impact of construction, although less of an impact on utilities than compared to route along A4. • Link through enterprise zone and to Hicks Gate (as a PT interchange, as well as Park and Ride), with enhanced development opportunities. • Acceptability to stakeholders and the public - closure of roads for construction, impact of demolitions, impact on sense of place during construction • Political acceptability of using Callington Road Link

Table 5.3: Results of long-list sifting

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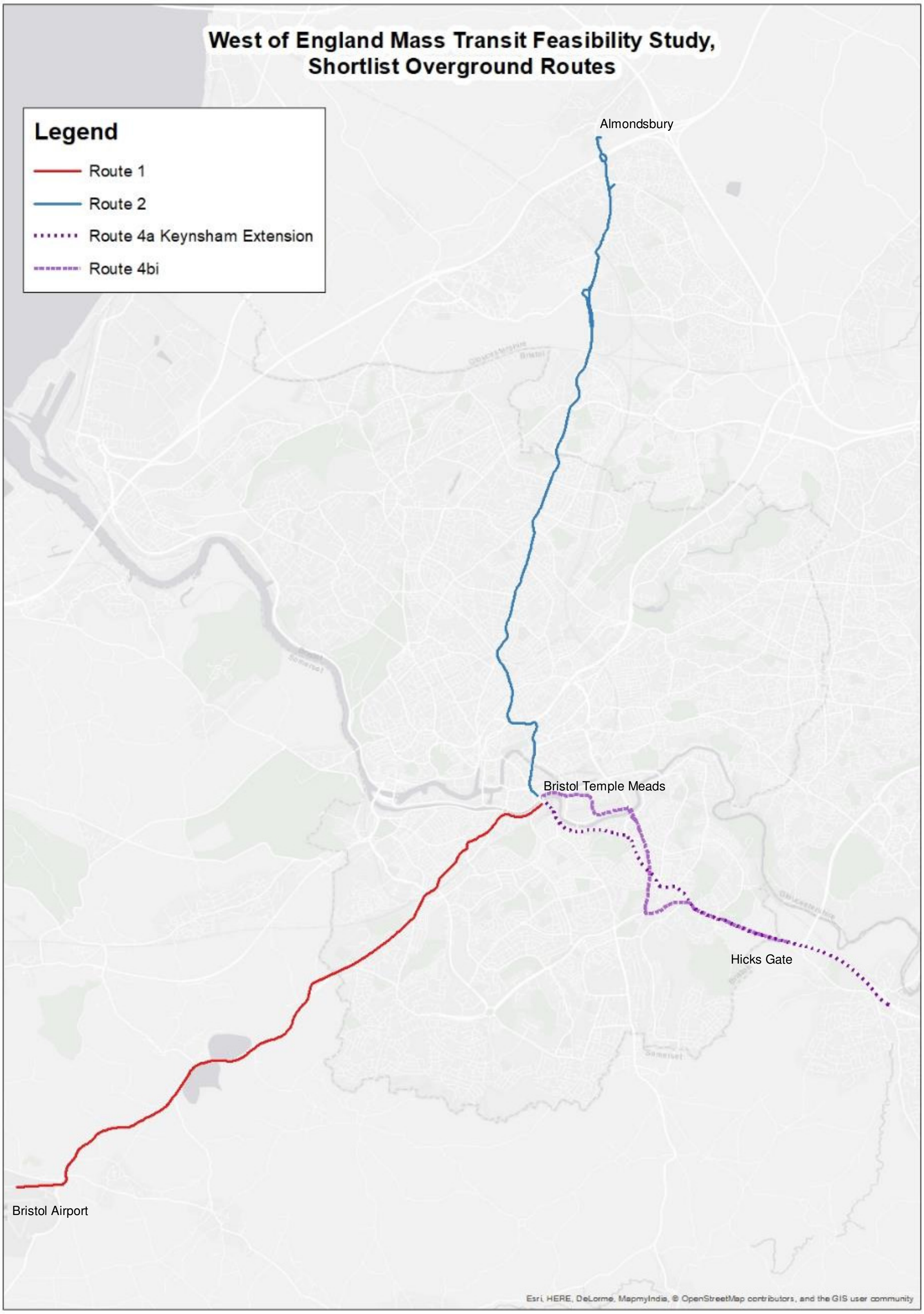

Figure 5.3: Overground short-listed options

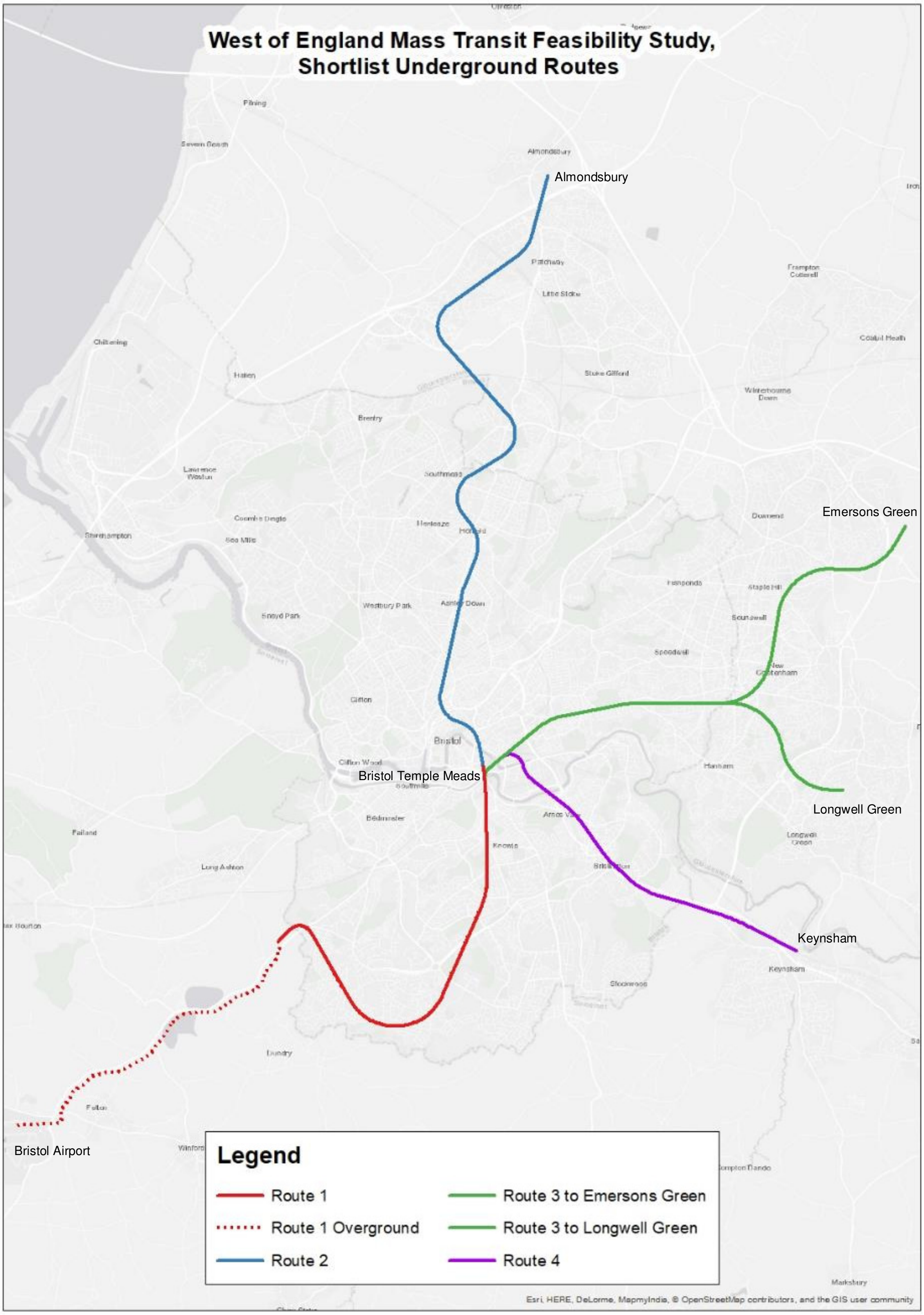

Figure 5.4: Underground short-listed options

6 Option development and assessment

6.1 Introduction

The aim of the previous Metro pre-feasibility study (2017) was to determine, at a high-level, whether the prospects for the mass transit system would deliver sufficient demand and its construction and operation would represent value for money.

This study further refines and progresses the high-level assessment undertaken to decide whether it is feasible to take forward the development of a potential mass transit system in serving Bristol and the wider area, both from an engineering and an economic appraisal perspective. This includes investigating the feasibility of both overground and underground options.

The aim of this study is to further determine whether the prospects for the mass transit system would deliver sufficient demand, potential alignment considerations (overground and underground) and transformative opportunities for Bristol and wider West of England regions. Further work into the construction and operation of options has been undertaken to help inform whether it would still represent value for money.

This section of the report outlines the modelling and demand forecasting approaches undertaken as part of the feasibility study. It presents the results from the demand forecasting along with discussing the shortlisted corridors and network, in terms of scheme design development and associated costings.

Assumptions underpinning this high-level demand forecasting and options development are stated within this report, where relevant.

6.2 Approach to option development and assessment

This section builds on the findings of the pre-feasibility study undertaken in 2017 to determine the potential for a mass transit system in Greater Bristol, which focused on an underground solution.

The pre-feasibility study used a catchment-based approach for an underground solution, followed by a number of sensitivity tests around the central forecast.

Since then, as part of this feasibility study, the catchment-based approach has been refined therefore resulting in a more robust forecast, whereby:

- Included an additional corridor (corridor 4) to Hicks Gate/Keynsham;
- Comparison between underground and overground options and technologies;
- Produced demand forecasts and economic appraisal assessments for options, including of individual corridors;
- Refined assessment of capacity requirements;
- Refined approach to demand layers (forecasts originating from Airport, Park & Ride and induced rail demand); and
- Development-led additional demand.

It should be noted that the forecasting techniques used constitute a high-level assessment of demand which allows comparison between routes and options, however these will require further refinement and development with more detailed modelling as the scheme develops.

FINAL DRAFT

6.2.1 Demand forecasting and modelling approach

The framework and approach described has been used to develop forecasts for different modes (underground and overground) and route network options. The approach is catchment-based: it uses input data for the existing modes from the West of England multi-modal demand model (GBATS4) and utilises abstraction rates for a number of defined demand 'layers' to forecast demand.

These layers grow incrementally around the alignment, based on distance, and also include additional demand generated by Bristol Airport, induced rail demand to Temple Meads, unlocked developments (enhanced development opportunities) and the proposed Park & Ride sites. The key principles underpinning the forecasting approach are described below.

Sensitivity tests around the 'base' demand have been undertaken, to account for more optimistic assumptions. Beyond this, a further scenario has been developed to consider the impact of a substantial uplift in trips rates resulting in fundamental changes to the public transport provision, along with optimistic enhanced development assumptions. This scenario has not been used for the economic appraisal, but to investigate the level of additional development that would need to be accommodated within the region, to inform future policy development.

6.2.1.1 GBATS4 input data for existing transport modes

Forecast transport demand and generalised journey cost/time[26] information has been taken from the Greater Bristol Area Transport Strategy (GBATS4) model, which is used for the forecasting of major transport proposals in the West of England.

GBATS4 models highway, bus and rail movements across three time-periods (AM peak hour, interpeak hour and PM peak hour), in 2021 and 2036 future year models. Information was extracted for all modes and all periods for 2036. This provided the future 'baseline' or 'do minimum' level of demand, for do minimum public transport and car demand. The forecast year for the do minimum scenario (2036) accounts for the interventions considered as part of the Joint Spatial Plan (JSP).

6.2.1.2 Catchment-based forecast

A catchment-based approach has been developed to forecast demand for different options. This forms the core element of the forecasting approach, as it provides the transparency and flexibility required to consider multiple mode and route options, as well as sensitivities and scenarios.

The scope area has been divided into 21 sectors, which are common to the underground and overground options. Trip data was aggregated directly to the sector system and catchment areas extracted (by catchment area within each sector); journey time information was aggregated to sectors using trip-based weighting. Assumptions could then be applied to trip totals to estimate transfers to mass transit services.

As well as trip matrices aggregated to sectors, potential trips were 'assigned' to mass transit lines, albeit in this context mass transit lines are represented by sector-to-sector movements, this approach allows de facto line loadings and on-off movements to be assessed. For each combination of origin and destination pair GBATS data provided the demand and the Generalised Journey Time (GJT), for both car and existing public transport users.

The catchment-based approach is based on the following incremental 'layers':

- A first forecast for the demand originating within a 500m catchment band either side of the alignment, i.e. a 1km wide corridor;
- Consideration of a second forecast up to a 750m catchment band[27] either side, an additional 250m band incremental either side to the initial layer, i.e. a 1.5km wide corridor; and

[26] The Public Transport Generalised Journey Time is taken from the available EMME skims and consists of in-vehicle time, a weighted "wait time" and a weighted "access/egress" time.

[27] The 750m band is as the crow flies, therefore this represents a 1km walk distance either side of the alignment, i.e. 2km wide walk-distance corridor.

FINAL DRAFT

- Further consideration of the demand originated in the rest of each sector zone (to account for those outside the 1.5km wide corridor, but still within commutable distance to stations).

6.2.1.3 Additional demand segments

In addition to those three 'layers', consideration of other bespoke demand segments have been included, particularly those that are additional to those explicitly represented in the catchment-based approach. These are:

- Park and Ride (P&R) demand – there are aspirations to build new or enhance existing/proposed P&R sites at the end of each of the proposed mass transit corridors, which would allow the attraction of a greater proportion of current car users.
- Rail demand – accounts for a proportion of users travelling from out of scope areas, who would be inclined to use the heavy rail services to Temple Meads then interchange to the proposed mass transit system to travel within the scope area.
- Airport demand – Bristol airport is beyond the area represented in detail within GBATS.
- Additional demand generated by induced additional housing and employment, this has considered two sources –
    - intensification of housing density and employment activity along proposed corridors (predominately around potential station locations), as the mass transit proposals involve a fixed mode, this allows developments to connect to the spine of the system; and
    - Brownfield/greenfield development, where land is available along the corridors.

6.2.1.4 GBATS underground test scenario

An initial test run was conducted, in which the underground mass transit option has been coded and run within GBATS. This has been used to confirm the catchment-based approach, providing a sense-check and benchmark, against which the catchment-based forecasts can be assessed and ensure the underlying demand and generalised cost assumptions are consistent between the two approaches.

6.2.1.5 Sensitivity testing and benchmarking

Sensitivity scenarios have been developed to examine the impact of growth scenarios, policy initiatives and other sensitivities on mass transit demand.

Four sensitivity tests have been undertaken to reflect potential interventions that may take place alongside the construction of the underground or overground system. These tests are:

- *Bus network management*: this test takes into account the conversion of the currently deregulated (competitive) bus system into a more managed network to reduce competition between operators and to allow for a more coordinated timetable between bus and mass transit. It has been modelled as an uplift to demand transferred from public transport to mass transit by a 15% within the 750m and rest of the sector catchment band.
- *Car constraint*: this test represents additional constraints to car to access central Bristol, for instance through a congestion charge or workplace parking levy. It has been modelled as a 30% increase in all demand abstracted from cars.
- *Aspirational development*: this test considers more optimistic assumptions for the uplift factors applied to those areas with potential for additional housing or employment. Those areas with high potential have been assumed to generate 50% additional households or jobs (25% in the core scenario) and those with medium potential to generate an additional 20% (10% in the core scenario).
- *Induced demand*: In the current analysis there is no allowance for brand new trips induced by the effect of a step change intervention that would affect the mobility patterns in the region, increasing the propensity to travel of the population. This has been modelled as a 10% increase in all the demand abstracted from public transport and car, except for Park & Ride and airport demand.

FINAL DRAFT

A benchmarking exercise has also been conducted, comparing key metrics for Bristol against existing similar systems in the United Kingdom, to understand the order of magnitude of our demand forecasts.

6.2.2 Underground

Further to the option sifting process, four main corridors were shortlisted and taken forward into the demand forecasting assessment. These routes include:

- South route to Bristol Airport, presented as line 1;
- North route to Almondsbury, presented as line 2;
- North east route(s) to Emersons Green/Longwell Green, presented as line 3; and
- South east route to Keynsham, presented here as line 4.

Through the demand forecasting analysis, further shortlisting of the two sub-corridor options (Emersons Green or Longwell Green) for line 3 (north-east route) has identified the best performing option in terms of demand. Emersons Green alignment option (3.8 million annual passengers) generates the greater level of demand when comparing to Longwell Green alignment option (3.3 million annual passengers), as well as connecting to key employment location at Bath and Bristol Science Park. Therefore, for assessment purposes, the Emersons Green alignment has been taken forward for further development.

It is assumed, for the purpose of the demand forecast that the South (line 1) and North East (line 3) lines are a continuation of one another, as are the North (line 2) and South East (line 4) lines, and therefore it is considered that the operation between those is uninterrupted.

Figure 6.1 below illustrates the four routes taken forward for further assessment and the zones used in GBATS4 to model the existing transport demand.

6.2.3 Overground

Further to the option sifting process, three main corridors were shortlisted and taken forward for the demand forecasting assessment. These routes are:

- South route to Bristol Airport, presented here as line 1;
- North route to Almondsbury, presented here as line 2;
- South East route to Hicks Gate/Keynsham, presented here as line 4.

Figure 6.2 below shows the short-listed corridors that have been considered and the zones used in GBATS to model the existing transport demand. However as noted the option shortlisting process, the north east corridor (line 3) was not taken forward due to engineering constraints and public acceptability concerns, therefore it is not included in the figure nor the subsequent analysis.

Two options for the south-east route have been shortlisted. However further engineering work following shortlisting (discussed later in this report) has identified the preclusion of the extension of the segregated overground mass transit options between Hicks Gate and Keynsham. Therefore both overground options consider Hicks Gate as the mass transit system terminus in terms of demand forecasting, but with the potential for feeder services providing the continued link to Keynsham.

FINAL DRAFT

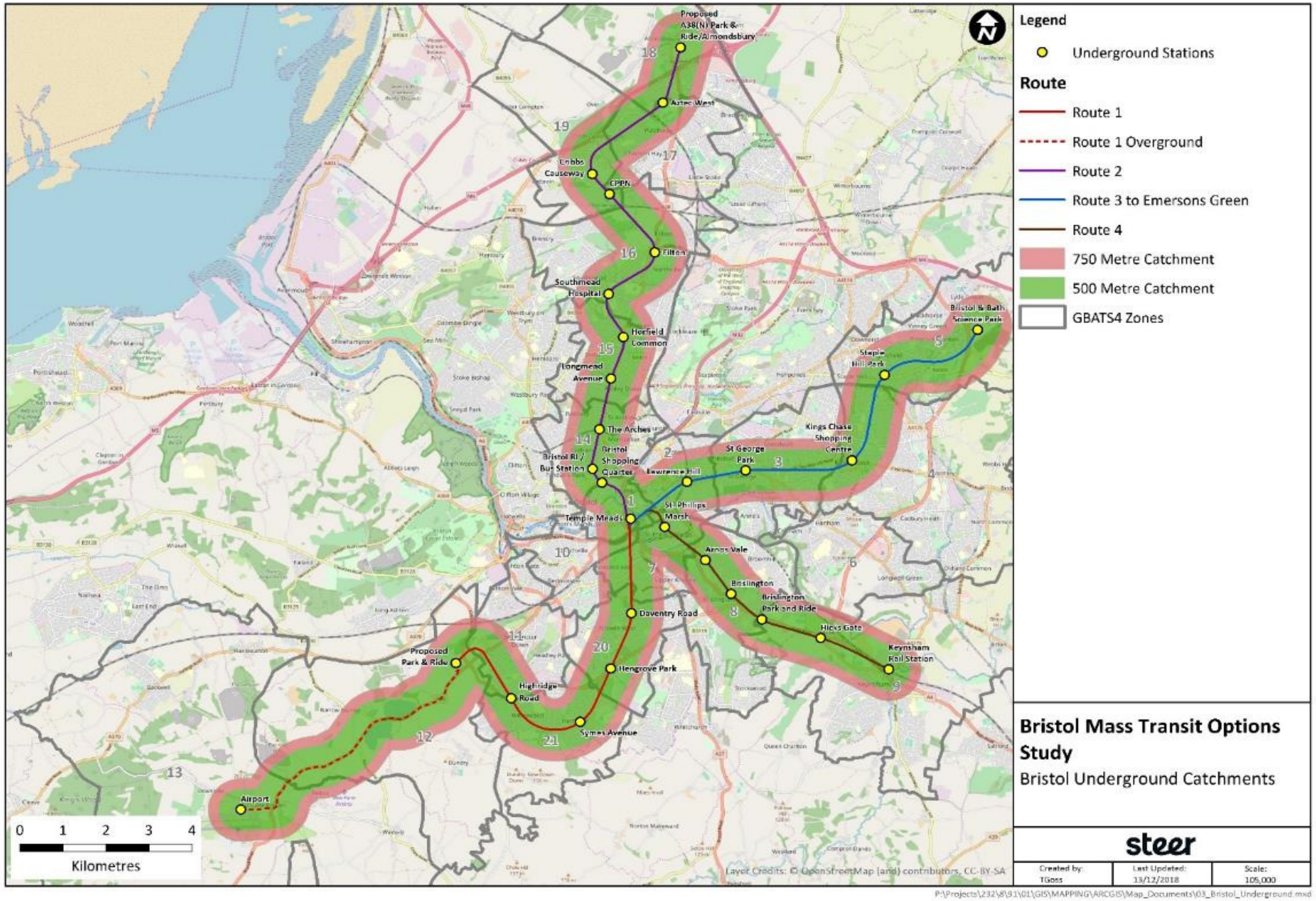

Figure 6.1: Underground shortlisted corridors and GBATS zones

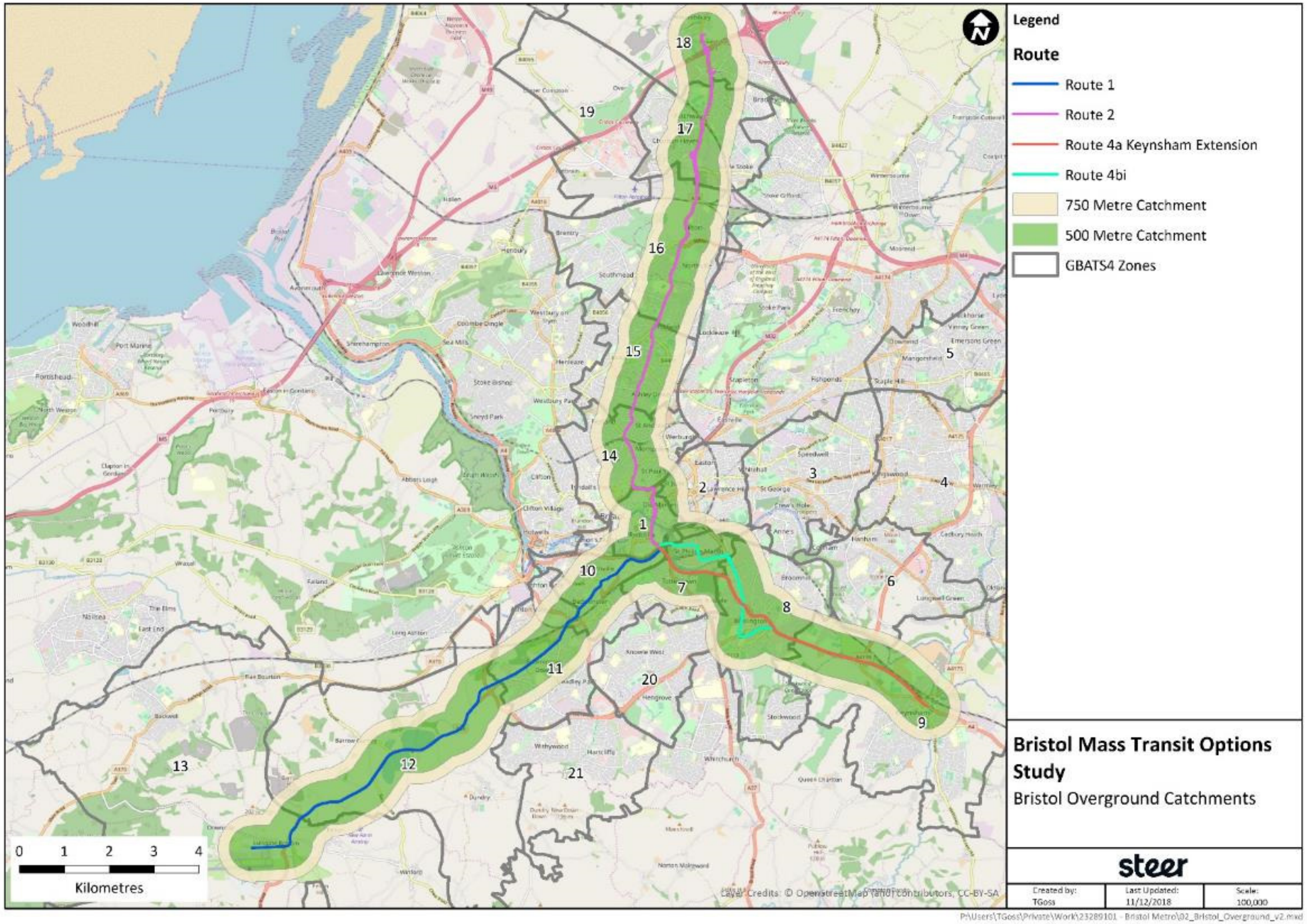

Figure 6.2: Overground corridors and GBATS zones

6.3 Demand forecasting

6.3.1 Introduction

This section summarises the demand forecasting results, from the assessment following the approach identified above.

6.3.2 Underground – annual forecast demand

One of the key objectives of the mass transit system is to unlock significant housing and employment growth within the region. This is a fundamental consideration when investigating demand, however prior to understanding what level of development is enabled by a mass transit system, the 'initial' annual demand has been calculated for the proposed underground system (four corridors) and is outlined in Table 6.2 below. This includes the induced rail, Park & Ride and airport demand.

Table 6.1: Underground 'initial' annual forecast demand (2036)

Demand 'layer'	'Initial' annual demand (million passengers)
500m capture band	14.0
Additional demand up to 750m capture band	5.5
Additional demand up to Rest of the Sector	4.1
Induced rail demand	1.0
Park and Ride	8.2
Airport	6.0
Total	**38.8**

Based on the approach summarised above, the 'base' calculated annual forecast demand including the core additional development assumed to be enabled by the proposed underground system (four corridors)is outlined in Table 6.2 and illustrated in Figure 6.3.

Table 6.2: Underground 'base' annual forecast demand (2036)

Demand 'layer'	'Base' annual demand (million passengers)
500m capture band	14.0
Additional demand up to 750m capture band	5.5
Additional demand up to Rest of the Sector	4.1
Induced rail demand	1.0
Core additional development	3.5
Park and Ride	8.2
Airport	6.0
Total	**42.3**

FINAL DRAFT

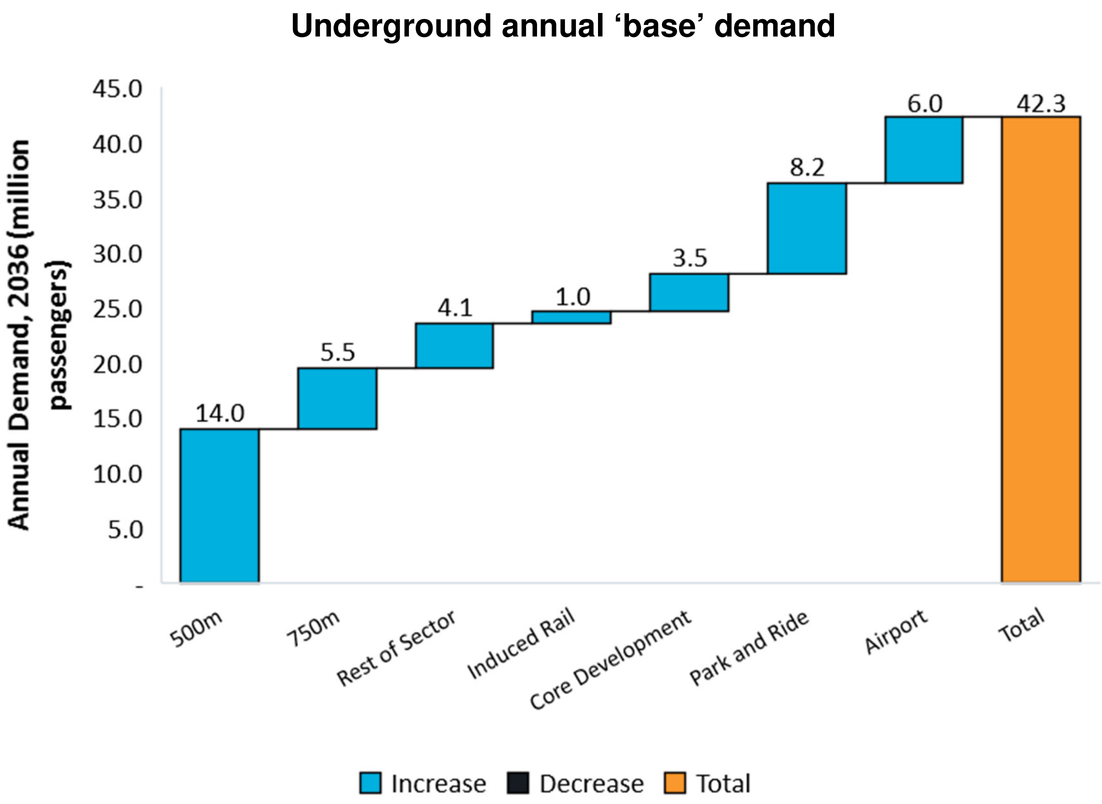

Figure 6.3: Underground annual 'base' demand (2036), by demand 'layer'

The 'base' demand has been generated for each of the four routes proposed for the underground system. The breakdown by line is based on demand within the AM peak, therefore the demand originating from the city centre to all the other zones has been isolated (as Central in table below), which is considered contra-peak. This is shown in Table 6.3 and Figure 6.4 below.

Table 6.3: Underground annual 'base' demand by line (2036), in million passengers

Line	500m	750m	Rest of Sector	Induced Rail	Core dev	Park and Ride	Airport	Total
1: South	2.6	1.0	0.8	0.2	0.7	1.9	6.0	**13.2**
2: North	3.1	1.2	0.9	0.2	0.8	2.4	-	**8.6**
3: North East	3.8	1.5	1.1	0.3	1.0	2.0	-	**9.6**
4: South East	3.5	1.4	1.0	0.2	0.9	2.0	-	**8.9**
Central	1.0	0.4	0.3	0.1	0.3	-	-	**2.0**
Total	**14.0**	**5.5**	**4.1**	**1.0**	**3.5**	**8.2**	**6.0**	**42.3**

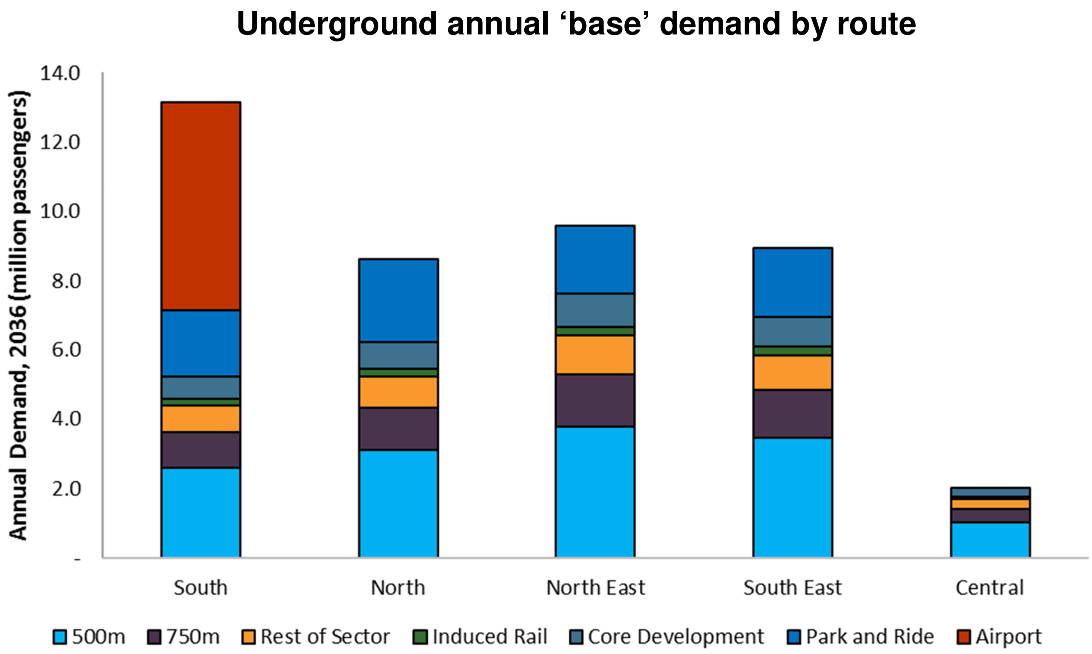

Figure 6.4: Underground annual 'base' demand by line (2036), in million passengers

The most utilised route would be the south corridor (line 1) to the airport, with the airport-induced demand accounting for more than half of its total annual demand. Following that, the other three lines perform at similar levels, with varying degrees of demand induced by each 'layer', in particular the Park & Ride demand.

Annual demand generated within the 500m catchment area represents a 33% of the total annual demand, with 13% being generated in the additional band up to a 750m catchment area, 10% in the rest of the sector, 2% is additional rail demand, 8% through core additional development, 19% via the Park & Ride facilities and the remaining 14% from the forecast airport demand.

Comparison with pre-feasibility study

Comparing the annual forecast 'base' demand to the pre-feasibility study for an underground mass transit system undertaken in 2017, which only included three lines (it did not consider the south-east line), the total annual demand in the forecast year was 35.5m annual passengers. Excluding that line in our current study, the three remaining lines would amount to 33.4m annual passengers.

The reason for this change is that a more refined approach has been employed to estimating demand. This has involved the use of 'layers' (for instance, considering the capture band masking based on pro-rated population). It also accounts for a different service frequency assumption. The assumption of this study is for an initial service frequency of every six minutes (10 per hour), whereas the 2017 study assumed a service frequency of every three minutes. The change in frequency has been identified as an initial service frequency for capacity requirements for the system, with the potential for frequencies to be adjusted in line with a ramp-up in patronage as demand grows. This frequency assumption has been used for demand forecasting, revenue and rolling stock calculations.

Benchmarking

A benchmarking exercise has been undertaken, through which the demand generated by the proposed underground mass transit system has been compared with other similar systems elsewhere in the United Kingdom.

In order to provide a fair comparison with existing systems, the 2036 proposed mass transit demand has been rebased to 2018 (assuming an annual demand growth of 3.0%, consistent with economic appraisal).

Several benchmarking comparisons have been made, with the annual passengers per route kilometre summarised in Figure 6.5 below.

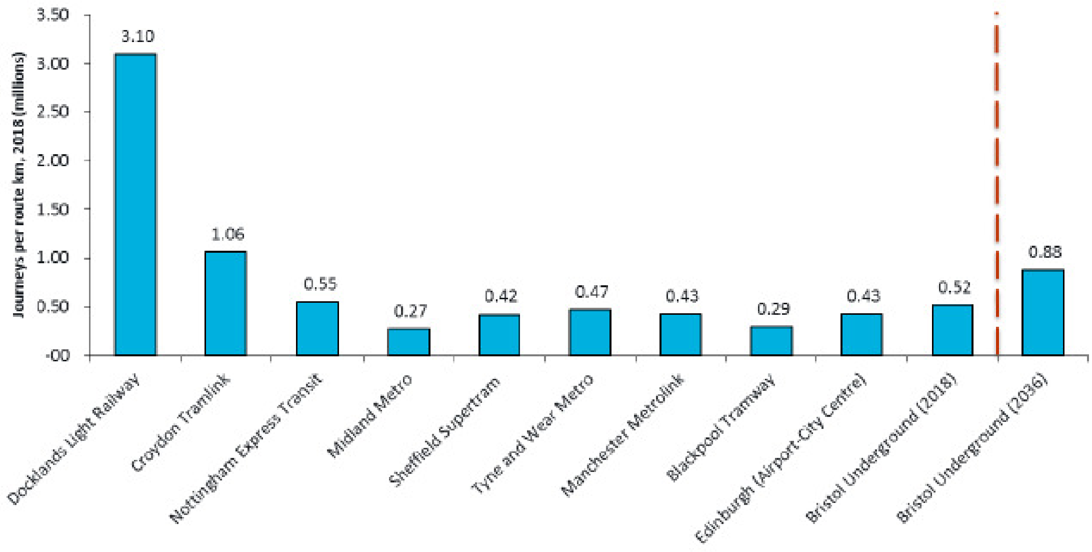

Figure 6.5: Benchmark of annual journeys per route kilometre, 2018

Sensitivity tests

Table 6.4 shows the impact in annual 'base' demand of the four sensitivity tests around an assumed 'base' case which considers the 750m capture band, induced rail demand, the construction of the Park & Ride facilities and the additional airport demand.

Table 6.4: Underground sensitivity tests – annual demand

Scenario	Increment	Annual Demand	% Change
'Base'	-	42.3m	-
Bus network management	1.8m	44.1m	4.2%
Car constraint	6.3m	48.6m	14.9%
Aspirational development	2.2m	44.5m	5.2%
Induced demand	2.5m	44.8m	5.8%
All sensitivity tests	**12.8m**	**55.1m**	**30.1%**

In total, demand generated by the mass transit system, if all four sensitivity tests are aggregated, would amount to circa. 55 million passengers per annum. This has been used to test the high growth scenario as part of the economic appraisal.

Peak hourly demand

An hourly demand breakdown by line has been produced, based on the AM peak, to inform the required capacity to be provided by the mass transit system. Tests have been undertaken for both inclusion and exclusion of the airport demand in this analysis as usually time of the peak of airport demand peak does not match underground peak times. Therefore, it has been assumed that 30% of the daily airport demand coincides with the AM peak.

FINAL DRAFT

Table 6.5: AM peak hourly demand analysis by line

Demand	Line					Total
	South	North	North-east	South-east	Central	
AM peak hour	1,866	2,002	1,971	1,888	263	7,990
AM peak hour exc. airport	1,653	2,002	1,971	1,888	263	7,548

The impact of the sensitivity tests across the peak hourly demand has also been estimated. In any case, and taking into account potential future growth in demand, it is estimated a maximum hourly demand for the proposed mass transit system would be between 2,000 and 3,000 passengers per hour in the AM peak.

A further scenario has been developed to consider the impact of a substantial uplift in trips rates resulting in fundamental changes to the public transport provision, along with optimistic enhanced development assumptions. This scenario has not been used for the economic appraisal, but to investigate the level of additional development that would need to be accommodated within the region, to inform future policy development.

The optimistic development assumptions include for c.61,000 houses and c.65,000 jobs enabled as a result of the mass transit system. Table 6.6 summarises the total demand increments. Further summary information is available in Table 6.34 later in this section.

Table 6.6: Summary of total annual demand scenarios

Demand	Underground
Annual 'base'	42.3m
Annual 'base' with sensitivities	54.7m
Annual 'base' with high optimism scenario	63.0m

FINAL DRAFT

6.3.3 Overground – annual forecast demand

One of the key objectives of the mass transit system is to unlock significant housing and employment growth within the region. This is a fundamental consideration when investigating demand, however prior to understanding what level of development is enabled by a mass transit system, the 'initial' annual demand has been calculated for the proposed overground system (three corridors) and is outlined in Table 6.7 below. This includes the induced rail, Park & Ride and airport demand.

Table 6.7: Overground 'initial' annual forecast demand (2036)

Demand 'layer'	Annual 'initial' demand (million passengers)
500m capture band	6.3
Additional demand up to 750m capture band	2.9
Additional demand up to Rest of the Sector	2.2
Induced rail demand	0.3
Park and Ride	3.8
Airport	4.5
Total	**19.9**

Based on the approach summarised above, the 'base' calculated annual forecast demand and including the core additional development assumed to be enabled by the proposed overground system (three corridors) is outlined in Table 6.8 and illustrated in Figure 6.6.

Table 6.8: Overground 'base' annual forecast demand (2036)

Demand 'layer'	Annual 'base' demand (million passengers)
500m capture band	6.3
Additional demand up to 750m capture band	2.9
Additional demand up to Rest of the Sector	2.2
Induced rail demand	0.3
Core additional development	0.8
Park and Ride	3.8
Airport	4.5
Total	**20.7**

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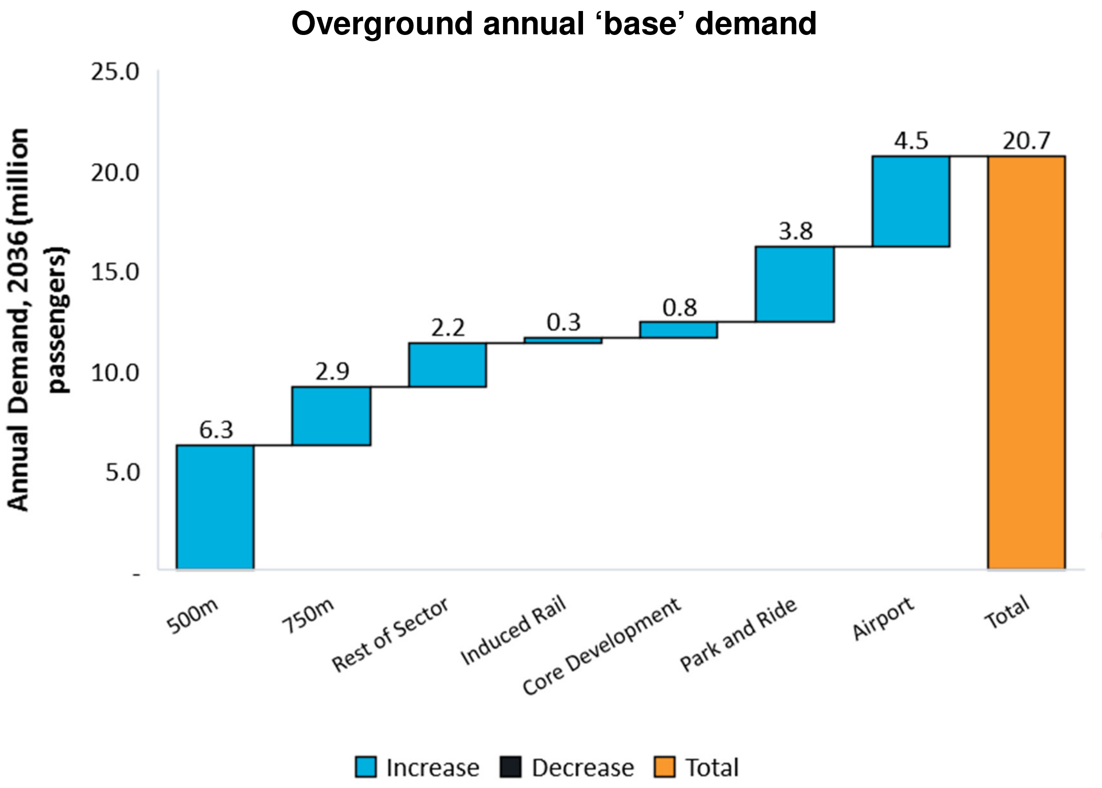

Figure 6.6: Overground annual 'base' demand (2036), by demand 'layer'

The 'base' demand has been generated for each of the three routes proposed for the overground system. The breakdown by line is based on demand within the AM peak, therefore the demand originating from the city centre to all the other zones has been isolated (as Central in table below), which is considered contra-peak. This is shown in Table 6.9 and Figure 6.7 below.

Table 6.9: Overground annual 'base' demand by line (2036), in million passengers

Line	500m	750m	Rest of Sector	Induced Rail	Core dev	Park and Ride	Airport	Total
1: South	1.2	0.6	0.4	0.1	0.2	1.0	4.5	**7.9**
2: North	2.5	1.2	0.9	0.1	0.4	1.5	-	**6.4**
4: South East	1.9	0.9	0.7	0.1	0.3	1.4	-	**5.2**
Central	0.6	0.3	0.2	0.0	0.0	-	-	**1.3**
Total	**6.3**	**2.9**	**2.2**	**0.3**	**0.8**	**3.8**	**4.5**	**20.7**

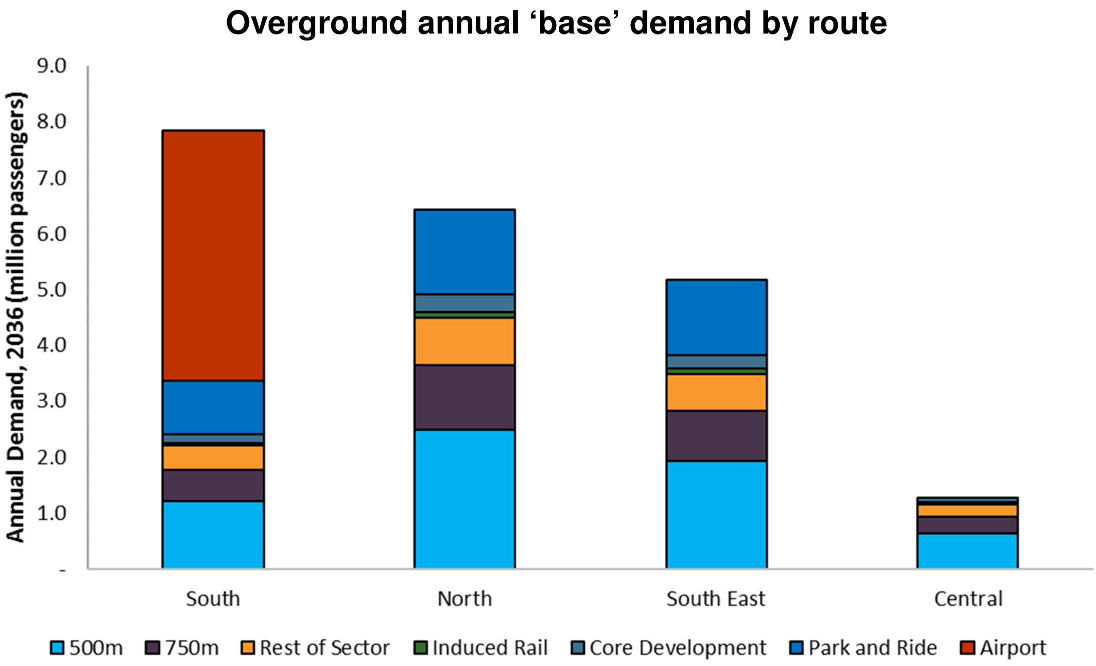

Figure 6.7: Overground annual 'base' demand by line (2036), in million passengers

The most utilised route would be the south corridor to the airport, with the airport-induced demand accounting for more than half of its total annual demand. Excluding that, the best performing line is the north line, then the south-east line and finally the south line (without airport demand).

Annual demand generated within the 500m catchment area represents a 30% of the total annual demand, with 14% being generated in the additional band up to a 750m catchment area, 11% in the rest of the sector, 1% is additional rail demand, 4% is linked to the core additional development, 18% via the Park & Ride facilities and the remaining 22% from the forecast airport demand.

Benchmarking

A benchmarking exercise has been undertaken, through which the demand generated by the proposed overground mass transit system has been compared with other similar systems elsewhere in the United Kingdom.

In order to provide a fair comparison with existing systems, the 2036 proposed mass transit demand has been rebased to 2018 (assuming an annual demand growth of 3.0%, consistent with economic appraisal).

Several benchmarking comparisons have been made, with the annual passengers per route kilometre summarised in Figure 6.8 below.

FINAL DRAFT

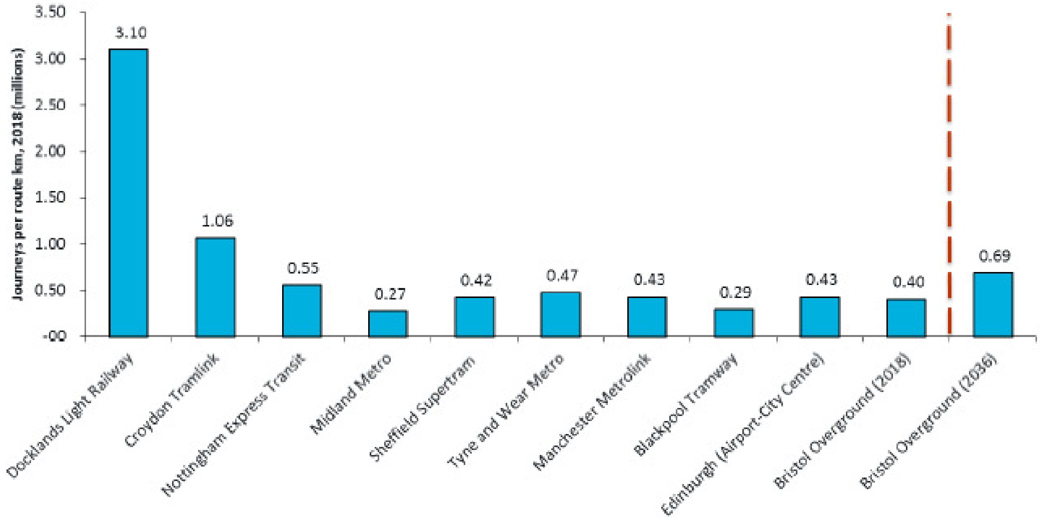

Figure 6.8: Benchmark of annual journeys per route kilometre, 2018

Sensitivity tests

Table 6.4 shows the impact in annual demand of the four sensitivity tests around an assumed 'base' case which considers the 750m capture band, induced rail demand, the construction of the Park & Ride facilities and the additional airport demand.

Table 6.10: Overground sensitivity tests – annual demand

Scenario	Increment	Annual Demand	% Change
'Base'	-	20.7m	-
Bus network management	1.2m	22.0m	5.9%
Car constraint	1.7m	22.4m	8.1%
Aspirational development	0.6m	21.3m	2.9%
Induced demand	1.2m	21.9m	5.6%
All sensitivity tests	**4.7m**	**25.4m**	**22.5%**

In total, demand generated by the mass transit system, if all four sensitivity tests are aggregated, would amount to circa. 25 million passengers per annum. This has been used to test the high growth scenario as part of the economic appraisal.

Peak hourly demand

An hourly demand breakdown by line has been produced, based on the AM peak, to inform the required capacity to be provided by the mass transit system. Tests have been undertaken for both inclusion and exclusion of the airport demand in this analysis as usually time of the peak of airport demand peak does not match underground peak times. Therefore, it has been assumed that 30% of the daily airport demand coincides with the AM peak.

Table 6.11: AM peak hourly demand analysis by line

Demand	Line				Total
	South	North	South-east	Central	
AM peak hour	1,014	1,460	1,226	182	3,881
AM peak hour exc. airport	821	1,460	1,226	182	3,689

FINAL DRAFT

The impact of the sensitivity tests across the peak hourly demand has also been estimated. As discussed previously, it is unlikely that all sensitivity tests will materialise at the same time. In any case, and taking into account potential future growth in demand, it is estimated a maximum hourly demand for the proposed mass transit system would be between 1,400 and 1,800 passengers per hour in the AM peak.

6.3.4 Summary of demand forecasts

The following Table 6.12 summarises the demand forecasts undertaken for both underground and overground.

Table 6.12: Summary of annual demand forecasts for underground and overground options (millions)

Demand 'layer'	Underground annual demand (million passengers)	Overground annual demand (million passengers)
500m capture band	14.0	6.3
Additional demand up to 750m capture band	5.5	2.9
Additional demand up to Rest of the Sector	4.1	2.2
Induced rail demand	1.0	0.3
Core additional development	3.5	0.8
Park and Ride	8.2	3.8
Airport	6.0	4.5
Total 'base' demand	**42.3**	**20.7**
Total with all sensitivities	**55.1**	**25.4**
Total 'high optimism' scenario	**63.0**	**25.4**[28]

[28] Overground is unlikely to have the level of transformational impact as an underground system, due to the constraints of an above ground network predominantly utilising existing alignments. Therefore the 'high optimism' scenario has not been included for the overground option, with the sensitivities scenario reported.

FINAL DRAFT

6.4 Option development

In order to understand the impact of constructing a mass transit system along the corridors defined as part of this study, concept designs have been undertaken for both the above and below ground scenarios that have been short-listed as part of the long-list sifting. Capital costs have been informed by the previous 2017 study, along with concept designs. Technology options have been discussed below, with operating assumptions and associated high-level rolling stock capital costs identified.

6.4.1 Underground

Introduction

Following the outcome of the initial West of England Underground Metro Study (2017) which proposed three routes to include A38(N) to Almondsbury, A38(S) to Bristol Airport and the A420 corridor to Emersons Green, this mass transit study has been expanded to include a fourth corridor along the A4 to Hicks Gate and Keynsham.

The proposed corridors have been further developed, including revisiting the number and location of stations, distances and alignments to account for key attractors and proposed/enhanced development opportunities.

At this stage of the study the technology options have not yet been confirmed, therefore three technology options have been used for rolling stock assumptions (BRT, tram and light-rail) but tunnelling and stations have assumed DLR-style technology for a conservative cost case.

Design assumptions

The designs, developed as part of this study, have been progressed from the previous West of England Metro Study (2017). Design and tunnelling assumptions have been taken from the previous study.

Underground stations are proposed approximately every 2km except in Bristol city centre where stations could be provided more frequently, depending on key locations/attractors. Although operating technology (BRT, tram or DLR-style vehicles) has not yet been confirmed, a conservative case has been assumed for the station spaces, which have been planned using London Underground standards and according to station planning standard S1371, including:

- Platform lengths designed at 63m in line with the LUL station planning standard, which require platforms to be 3m longer than the longest train.
- The running tunnels are assumed to have a 5.2m internal diameter (ID) with 0.4m thick tunnel lining meaning their outside diameter (OD) is approximately 6m.
- Ventilation shafts to be provided at 1km spacings.

No specific third-party land assumptions have been assumed at this stage for tunnel portals, vent shafts or station buildings. A 10% uplift in capital scheme cost has been included within the cost estimates to allow for securing appropriate land to build and operate the proposed system. This uplift also includes the cost of securing Park & Ride sites at the terminal point of each corridor. There is an opportunity to utilise the sites identified as tunnel portals and site compounds to be converted into Park and Rides sites post construction to avoid further land purchase and disruption.

Risks

The following key risks highlighted below apply to each of the corridors identified, based on the level of design, information received from other studies along the corridors and investigation carried out. This list is not exhaustive:

- Mixed / poor ground conditions and high-water levels;
- Historic mine working;

FINAL DRAFT

- Environmental considerations - Sites of Special Scientific Interest such as Pen Park Caves, Protected Species;
- Risk of TBM breakdown during long drives in difficult ground;
- Tunnel alignment contains unacceptable sharp curves;
- Damage to buildings and river walls from tunnel settlement;
- Damage to utilities from settlement;
- Impact on sensitive land; and
- Location of sites for portals and vent shafts not acceptable with stakeholders and residents.

Operating assumptions

Operating technologies have not yet been sifted for underground. Therefore, for rolling stock considerations, three technology options have been considered, these are by no-means the only options, but provide a range of costs which demonstrate lower (BRT) and higher (tram or DLR-style light rail) cost technology options. At the current time, it has been assumed that the mass transit system would be operated with one rolling stock option. Next steps for further work would be to understand if different technology solutions for corridors (more than one rolling stock option) is feasible.

Peak vehicle requirements for a 6-min frequency service, based on route kilometres, assumed operating speeds and an indicative layover time, have informed the rolling stock requirements at this stage of the study, along with a contingency in the number of vehicles required (to account for maintenance and operational spares). These have been costed using benchmarked costs from other UK-based systems and include contingency. A capacity sense-check has been carried out for peak demand.

Rolling stock capital costs have been included in the overarching summary of capital costs for the network in Table 6.13.

6.4.1.1 Route 1 – Bristol city centre to South Bristol and Airport

The corridor commences at Bristol Temple Meads railway station and continues south for approximately 9km to the A38/South Bristol Link, connecting station locations as Daventry Road, Hengrove Park, Symes Avenue, Highridge Road. It has been assumed that a 4,000 space Park & Ride facility/interchange station is located at A38/South Bristol Link, where the route continues south above ground for a further 6.8km to Bristol Airport. There are two options for above ground alignments, online and offline, which are discussed in section 6.4.2.1 below. No stations have been proposed between the A38/South Bristol Link and the Airport, due to limited patronage possibilities; however passive permission can be included to cater for future opportunities for development.

Figure 6.9 illustrates the indicative alignment described above and identified for this study.

A link from Bristol Temple Meads to the Airport is also being considered as part of the Bristol South West Economic Link study (BSWEL) which has been jointly commissioned by North Somerset Council, Bristol Airport and Somerset County Council to undertake a strategic transport review, which will identify road and rail improvements. At the time of issuing this study the results of the BSWEL study have not been released.

Key considerations for this route are linking Bristol Temple Meads via the wider mass transit network with the south of the city and Bristol Airport. The proposed alignment also serves to connect areas of multiple deprivation in the south with the city centre and employment opportunities in the central and north areas of Bristol.

Capital costs for this corridor have been estimated at **£1.12bn** (2018 prices), which include assumptions for land, client costs and contingency.

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6.4.1.2 Route 2 – Bristol city centre to North Bristol and North Fringe

The corridor commences at Bristol Temple Meads railway station and continues north for approximately 14km, linking Callowhill Court (Broadmead), Bristol bus/coach station/Bristol Royal Infirmary, The Arches (Montpelier Station), Longmead Avenue, Horfield Common, Southmead Hospital, Filton, Cribbs Patchway New Neighbourhood, Cribbs Causeway, Aztec West and terminating in the vicinity of an assumed 4,000 space Park & Ride/interchange site, north of M5 J16 at Almondsbury.

Figure 6.10 illustrates the indicative alignment described above and identified for this study.

Key considerations for this route are linking Bristol Temple Meads via the wider mass transit network with the north of the city. The proposed alignment connects Bristol Temple Meads and Bristol bus and coach station, Bristol Royal Infirmary and Southmead hospital and the new development at Cribbs Patchway New Neighbourhood (CPNN) and employment opportunities at Aztec West. The alignment has avoided Pen Park Hole which is a Site of Special Scientific Interest whilst linking to CPNN and Cribbs Causeway Shopping Mall.

Capital costs for this corridor have been estimated at **£1.55bn** (2018 prices), which include assumptions for for land, client costs and contingency.

6.4.1.3 Route 3 – Bristol city centre to East Bristol and East Fringe

As outlined above, the demand forecasting for the two sub-options for corridor 3 (to Emersons Green or to Longwell Green) was used to determine the route to progress as part of the option development. In terms of demand, Emersons Green sub-option provides access to a larger population and links to a key employment area (Bristol and Bath science park). Therefore this sub-option has been included within the option development and assessment for this feasibility study.

The corridor commences at Bristol Temple Meads railway station and continue approximately 10km north east to Emersons Green, linking Lawrence Hill (railway station), St Georges Park, Kings Chase Shopping Centre, Staple Hill Park and terminating at Bristol and Bath Science Park, with an assumed 4,000 space Park & Ride/interchange site (potential to expand existing Lyde Green Park & Ride facility).

Figure 6.11 illustrates the indicative alignment described above and identified for this study.

Key considerations for this route are linking Bristol Temple Meads via the wider mass transit network with the employment opportunities in the north east of the city.

Capital costs for this corridor have been estimated at **£1.05bn** (2018 prices), which include assumptions for for land, client costs and contingency.

6.4.1.4 Route 4 – Bristol city centre to Hicks Gate and Keynsham

The corridor commences at Bristol Temple Meads railway station and continues south east for approximately 7.5km, linking St Philips Marsh, Arnos Vale, Brislington, current Brislington Park & Ride site (identified for development), with an assumed 4,000 space Park & Ride/interchange site at Hicks Gate (assumed to be expansion of the proposed Hicks Gate Park & Ride) and terminating at Keynsham railway station (no portal assumed, with terminal remaining underground due to land restrictions).

Figure 6.12 illustrates the indicative alignment described above and identified for this study.

Key considerations for this route are linking Bristol Temple Meads via the wider mass transit network with the south east of the city, as well as an alternative to the direct (lower frequency) rail service from Keynsham. Opportunities for linking to employment developments at St Philips Marsh Enterprise Zone, along with employment and residential opportunities around the existing Brislington Park and Ride. The proposed Park and Ride site at Hicks Gate will provide interchange opportunities for residents across the wider region.

Capital engineering costs have been identified for the corridor of **£0.87bn** (2018 prices), which include assumptions for for land, client costs and contingency.

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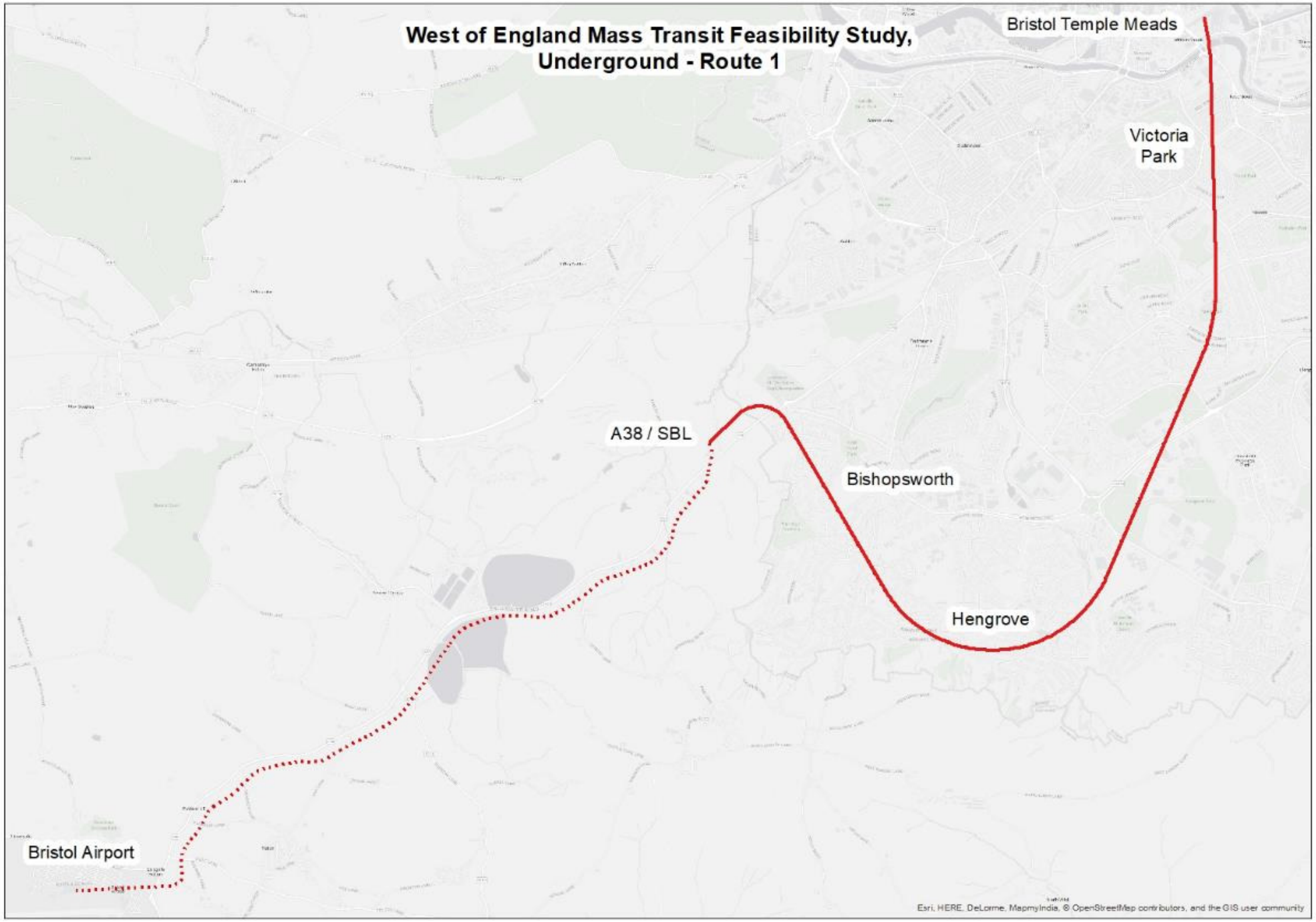

Figure 6.9: Corridor 1 (underground) – South Bristol and Bristol Airport

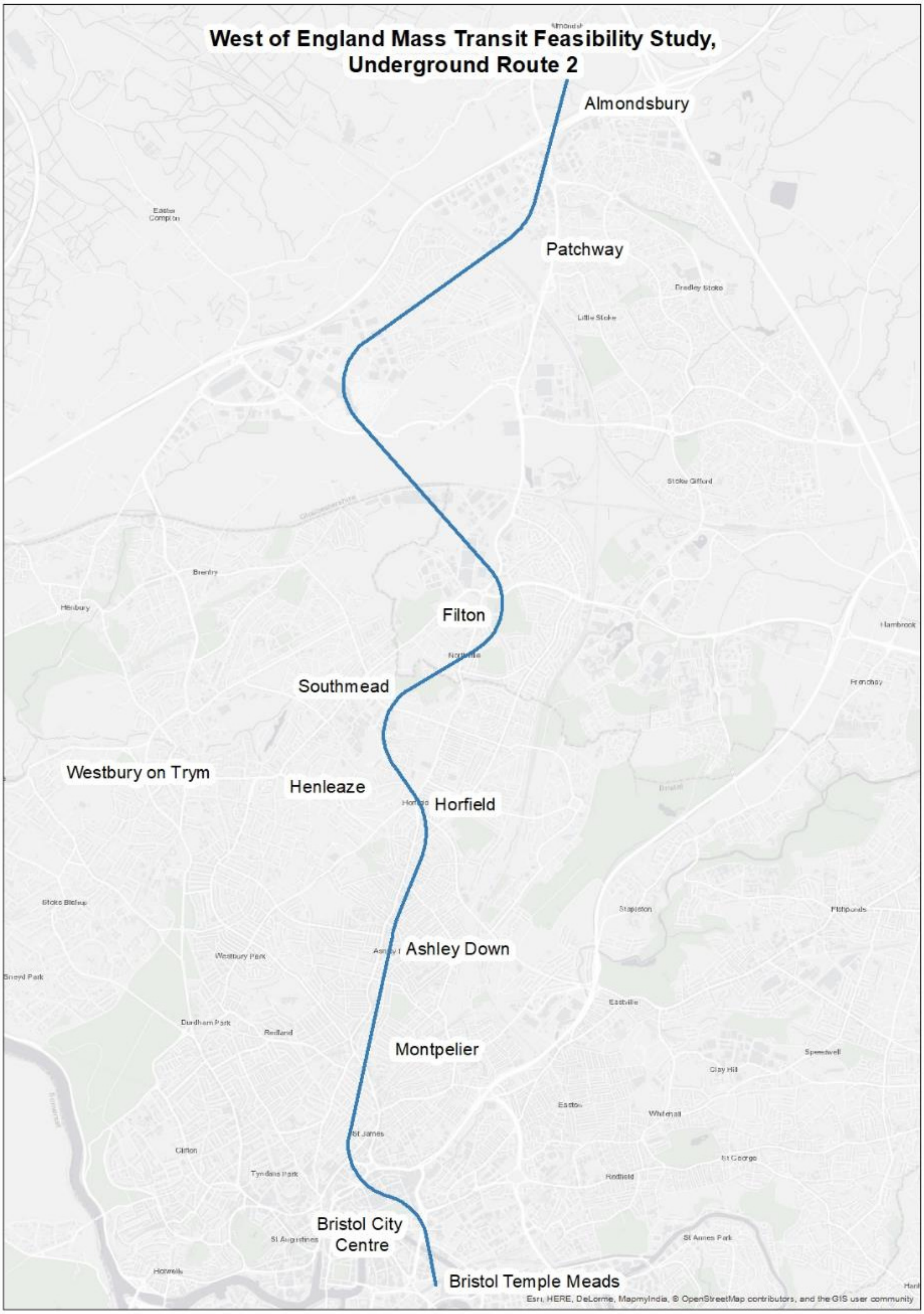

Figure 6.10: Corridor 2 (underground) – North Bristol and North Fringe

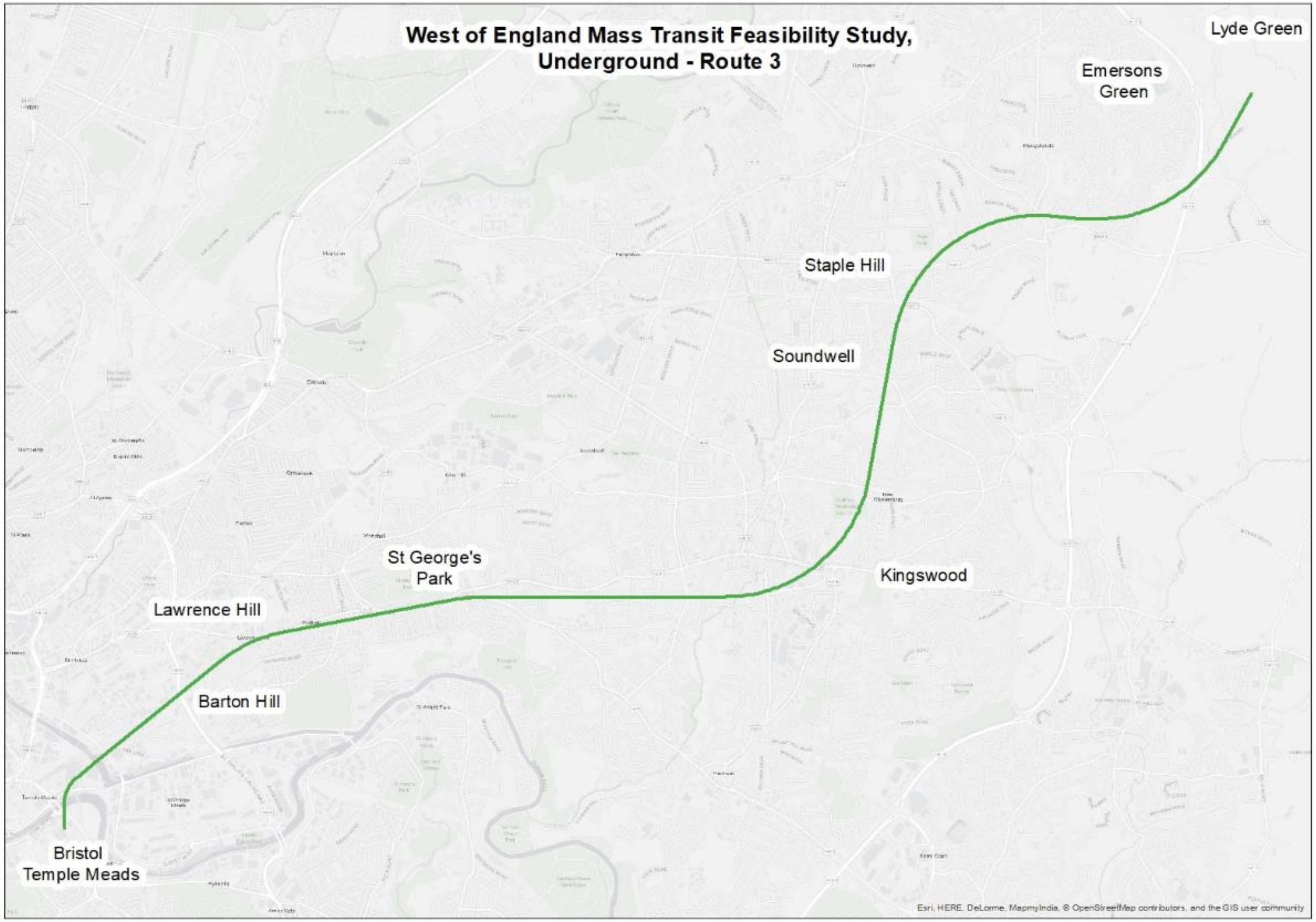

Figure 6.11: Corridor 3 (underground) – East Bristol and East Fringe

Figure 6.12: Corridor 4 (underground) – Hicks Gate/Keynsham

6.4.2 Overground

Introduction

Following the long-list sifting, three corridors have been identified for further development and assessment. The options not taken forward for further assessment were done so on predominantly deliverability and acceptability criteria, see section 5 (and Appendix B) for further information on the sifting process. The impact of implementing an overground option on corridor 3 was considered to be so severe that this has not been taken forward for further consideration as part of this feasibility study.

As with the below ground options, the exact technology has not yet been confirmed, therefore two technology options have been used for rolling stock assumptions and cross sections to establish the impact as a conservative case. However following long-list sifting, the impacts of tram were considered to be unacceptable on corridors 1 and 2, due to the extended construction timescales.

Corridor 4 has been shortlisted for both tram and bus/BRT as part of the option development, in terms of design, due to the availability of the Callington Road Link, which could be used for either the mass transit alignment, or for general traffic if the A4 is considered as a mass transit corridor. The opportunity to develop a hybrid solution, which can combine technology options, can be explored and will be considered at the next stage of scheme development. Corridor design options have been assessed utilising both bus/BRT and tram, with the tram option having the slightly greater impact in terms of land requirement. The primary difference between the proposed options is construction programme and impact as tram technology requires extensive pre-construction works to facilitate statutory utility relocation and infrastructure requirements.

Therefore the entire overground network technology option taken forward at this stage is street-car/(BRT/bus. This can be kerb-guided, optically guided or standard operation without guidance but within segregated corridors to ensure resilience along the proposed routes.

It should also be noted that following further engineering design after the long-list sifting process, it has not been possible at this stage to extend the above ground option to Keynsham railway station due to physical constraints. The limited availability of land and securing the alignment between Keynsham bypass and the railway create difficulties in facilitating access to the existing station without severe impact on properties. It is therefore proposed at this stage to link Keynsham town centre and/or railway station over ground by feeder services to Hicks Gate.

Design assumptions

The designs have been based on indicative cross sections, see Appendix C (Drg Ref: 673846.EA.03.01-05-010 onwards), which have been developed to quantify minimum widths required to safely allow a double movement of a mass transit vehicle within certain street environments.

The main corridor cross section alignments of the scheme have not been developed beyond the conceptual minimum cross-sectional extents, showing the minimum mass transit centre line radii on curves and hence have not been subject to any further design. All design undertaken as part of this study is on Ordnance Survey Base mapping. Due to the feasibility stage of this study, extent of the network and the level of design required topographical surveys have not been undertaken.

This conceptual layout also shows the impact of running the indicative mass transit corridors through the Greater Bristol area showing the additional third-party land and buildings likely to be required to accommodate its infrastructure. In addition to the minimum requirement for safe two-way operation of a mass transit vehicle, consideration has been given to footway, cycleway and loading provision, where appropriate.

The minimum section identified incorporates minimum acceptable widths for each user, based on UK standards, where applicable, and existing design standards adopted by Bristol City Council in terms of footway, cycleway and loading/parking bays.

FINAL DRAFT

It is assumed that on the majority of the corridors the mass transit route is segregated from traffic movements, with assumptions made with regard to permanent closure of roads to traffic. These have been used to provide a high-level indication as to impacts on the highway and associated disbenefits for the economic assessment. However these impacts require further testing in detail and incorporation into a wider strategic model. Access to properties affected by closures has been retained.

Stops

The study has assumed mass transit stops approximately every 500-750m. The implementation of stops will be located to minimise disruption and impact on third party property, where reasonably practicable, therefore have not been defined on the current designs.

Cycleway

Where mass transit corridors are free from general traffic, it is anticipated that these corridors will become a focus for commuter cyclists. A local example of this is the Bristol to Bath railway (cycle) path which has up to 1,000 pedestrian/cycle users in the AM peak. This greenway link provides a direct traffic-free route from the A4174 Ring Road into the centre of Bristol.

In UK cities where cyclists and mass transit systems share the same road space, there have been a number of high profile incidents. For tramway conflicts, there have been cases where cyclists have either fallen from their bikes when the wheels get caught in the trackway, or bike tyres slipping on the wet rail tracks. On BRT/bus alignments, the conflicts are likely to be between the BRT vehicles and cyclists, with regards to speeds and need for overtaking – which can impact on reliability.

In reviewing the existing cycle infrastructure associated with various mass transit systems in the UK, the design team, in agreement with the client group, have opted to provide a safe, segregated corridor for all users. This translates into a design where all modes of vulnerable road users (pedestrians, cyclists), along with loading bays are segregated from each other to avoid vehicle/pedestrian/cycle conflicts, as far as reasonably practicable, which in turn provides resilience against journey time delays. Therefore these issues have been taken into account for the concept design exercise completed to inform this study.

Constructability Description

Based on lessons learned from other UK mass transit schemes, a continuous approach to construction will be deployed, wherever possible, avoiding the need to excavate twice.

A major part of the works involved in building a mass transit system is the clearing of obstructions above and below the corridor path including all required utility diversions. Public utilities in or under the highway should, where possible, be accessible while the mass transit vehicles are operating.

For a tram corridor any access covers should have their nearest edge at least 500 mm from the edge of the swept envelope. Where pipes and cables have to pass under the track, they should be ducted or sleeved before the tracks are laid, to facilitate maintenance or renewal. Although not necessary for BRT (bus) based systems it can be considered good practice to upgrade and relocate utilities, where required, to reduce the likely impact of failure due to time-served equipment which in turn will impact on service reliability.

Risks

The following key risks highlighted below apply to each of the corridors identified, based on the level of design and investigation carried out. This list is not exhaustive:

- Third party land requirement;
- Relocation of existing utilities;
- Existing Grade I & Grade II Listed structures, along with Locally Listed structures causing width restrictions; and
- Significant disruption caused by construction and subsequent operation.

FINAL DRAFT

Operating assumptions

Following the short-listing of options, BRT technology is the predominant rolling stock consideration. At the current time, it has been assumed that the mass transit system would be operated with one rolling stock option. Next steps for further work would be to understand if different technology solutions for overground corridors (more than one rolling stock option) is feasible, particularly with corridor 4 short-listing tram as a technology option.

Peak vehicle requirements for a 6-min frequency service, based on route kilometres, assumed operating speeds and an indicative layover time, have informed the rolling stock requirements at this stage of the study, along with a contingency in the number of vehicles required (to account for maintenance and operational spares). These have been costed using benchmarked costs from other UK-based systems and include contingency. A capacity sense-check has been carried out for peak demand.

Rolling stock capital costs have been included in the overarching summary of capital costs for the network in Table 6.13.

6.4.2.1 Route 1 – South Bristol and Airport

Corridor description

For the purposes of this description, the corridor has been split into two sections: between Bristol Temple Meads and A38/South Bristol Link; and A38/South Bristol Link to Bristol Airport. This is because there are two options for the A38/South Bristol Link to the Airport – an online and an offline option.

Figure 6.13 illustrates the indicative alignment described above and identified for this study.

Bristol Temple Meads and A38/South Bristol Link

The Bristol city centre to A38/South Bristol Link Road section of the corridor commences at an assumed 4,000 space Park & Ride/interchange site adjacent to the A4174 South Bristol Link Road/A38 Bridgewater Road (Lime Kiln Roundabout) and continues east, for approximately 5.25km, towards Bristol along the A38 Bridgwater Road using Bedminster Down Road, West Street, East Street, Bedminster Parade, A370 York Road where this route is assumed to join Corridor 4 from Bristol Temple Meads to Hicks Gate Roundabout, near Keynsham.

The corridor is predominately made up of corridor section reference BW-A1, which is shown in Appendix C (drawing reference 673846.EA.03.01-05-010). This 17.95m wide section diagram has been configured to allow for on-street dual mass transit vehicles with intermittent loading/on street parking areas within the corridor (general through-traffic has been removed with restricted local access only), 3m wide segregated cycleway and adjacent footways of varying width.

The effect of applying this 17.95m wide section along the proposed corridor has a considerable impact on third-party land, a number of residential/commercial buildings would also be affected by these measures.

To shorten and improve the overall journey time of the mass transit vehicles, it is proposed to restrict the general traffic movements onto the mass transit corridor, which will require appropriate infrastructure, enforcement measures and technology. This will allow the mass transit vehicles unobstructed movement along the corridor due to the removal of queuing traffic and other obstructions. For the current proposal there will be approximately:

FINAL DRAFT

- 28 permanent road closures on the corridor;
- six partial road closures allowing local access to the 10 cul-de-sacs and residential/commercial properties; and
- two new signal junctions to allow for cross movements[29].

Potential mass transit stops are currently proposed for the assumed Park & Ride/interchange site adjacent to the A4174 South Bristol Link Road/A38 Bridgewater Road (Lime Kiln Roundabout), with further stops at approximately 500m intervals into the city centre. The precise location of these stops has not been determined at this stage but will align with the key destinations along the corridor: Parson Street railway station; Bedminster shopping district (East Street); Bedminster Bridge; and Bristol Temple Meads/city centre. Intermediate stops will be incorporated at convenient locations with little or no impact on third parties wherever possible.

A38/South Bristol Link and Bristol Airport (online)

This online option of the Bristol Airport to A38/South Bristol Link Road corridor commences at the Airport, where the mass transit stop will be located below ground near the terminal building to reduce the delays associated with an above ground network. In addition, this will have less impact on existing Airport facilities such as parking, access and potential alternative land use.

The tunnel portal would be located near to the A38 which gives the mass transit vehicle the ability to re-join the above ground infrastructure along the A38 northwards to the assumed 4,000 space Park & Ride/interchange site adjacent to the A4174 South Bristol Link Road/A38 Bridgewater Road (Lime Kiln Roundabout).

The route is approximately 6.9 km and is predominately made up of corridor section reference BW-K1, which is shown in Appendix C (drawing reference 673846.EA.03.01-05-018). This 23.10m wide section diagram has been configured to allow for a bi-directional A38 general traffic lanes and a fully segregated bidirectional mass transit corridor adjacent. This corridor section allows for no on-street parking which matches the current provision, along with 3m wide verge/footway.

The effect of applying this 23.10m wide section along the proposed corridor has a considerable impact on third-party land, a number of residential/commercial buildings would also be affected by these measures.

The A38 between the Airport and the assumed A38/South Bristol Link Park & Ride site is a rural local strategic road with a minimal number of priority junctions directly serving the rural locality. As such, it is proposed to retain all the existing priority junctions which will be enhanced allowing priority for the mass transit corridor.

Potential mass transit stops are currently proposed for the Airport and A38/South Bristol Link Park & Ride only, due to limited potential patronage. However passive permission can be included to cater for any future development opportunities as they emerge.

A38/South Bristol Link and Bristol Airport (offline)

This offline option of the Bristol Airport to A38 South Bristol Link Road corridor commences at the Airport, where the mass transit stop will be located below ground near the terminal building to reduce the delays associated with an above ground network. In addition, this will have less impact on existing Airport facilities such as parking, access and potential alternative land use.

The tunnel portal would be located near to the A38 which gives the mass transit vehicle the ability to re-join the above ground infrastructure running parallel with the A38 northwards to the potential Park & Ride site adjacent to the A4174 South Bristol Link Road/ A38 Bridgwater Road (Lime Kiln Roundabout).

The route is approximately 6.8 km and is predominately made up of corridor section reference BW-E1 which is shown in Appendix F (drawing reference 673846.EA.03.01-05-014). This 13.95m wide

[29] No assumptions have been included for the upgrade of existing signal junction infrastructure along the corridor, including life-expired infrastructure.

FINAL DRAFT

section diagram has been configured to allow for a bidirectional mass transit corridor with a 4m wide shared foot/cycleway adjacent. The potential for provision of the offline corridor will significantly reduce the impact on the existing A38 alignment and operation between the Airport and A38/SBL, with minor intervention required where roads currently accessing the A38 will need treatment to maintain access. The effect of applying this 13.95m wide section along the proposed corridor has an impact on third-party land. Further investigation is required regarding landownership of agricultural land to minimise 'land sterilisation'

Potential mass transit stops are currently proposed for the Airport and South Bristol Link Road Park & Ride only.

FINAL DRAFT

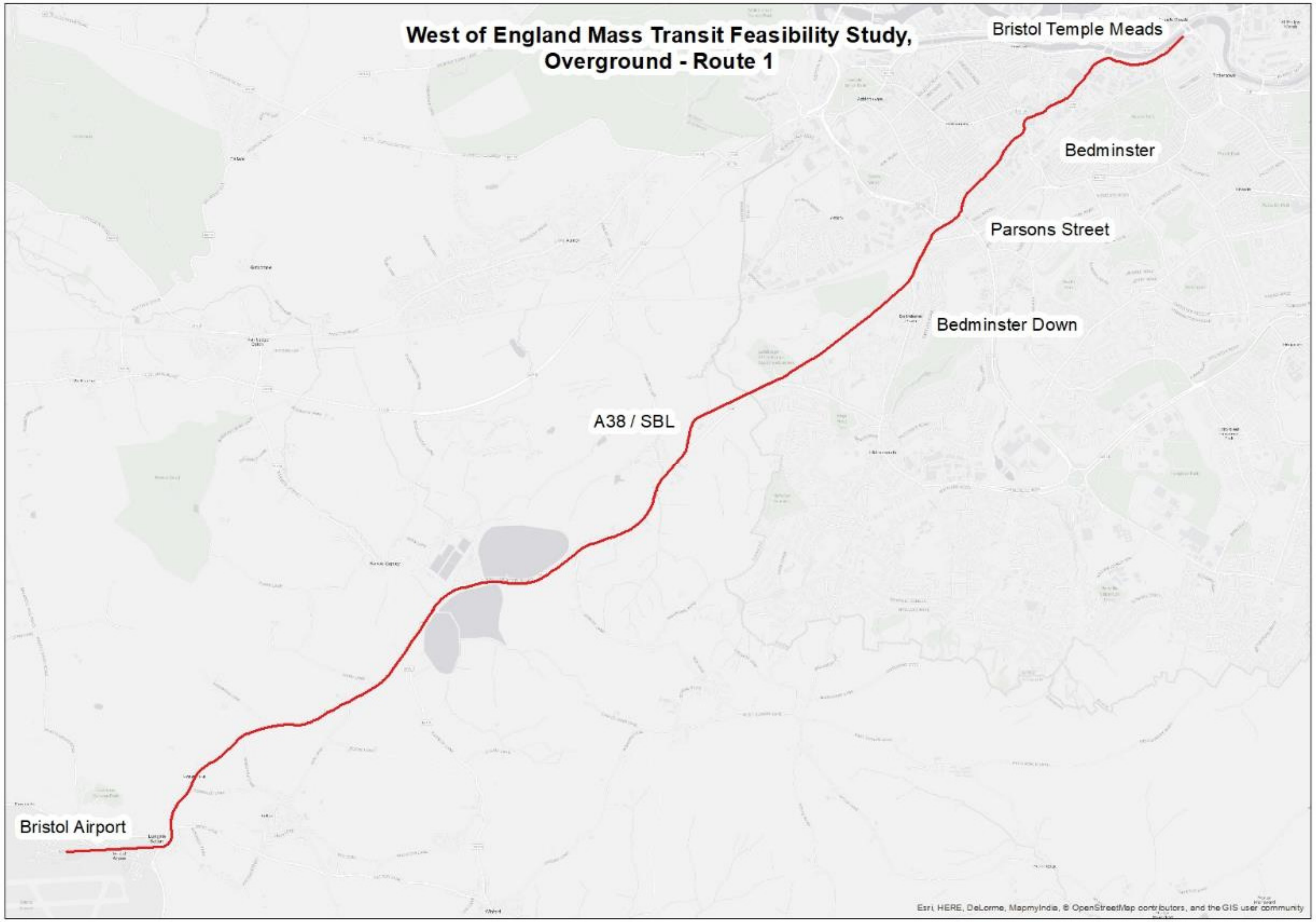

Figure 6.13: Corridor 1 (overground) – South Bristol and Airport

Key considerations and risks

Key considerations and risks for each of these routes have been identified through an initial high-level, Designers Risk Assessment which has been carried out to highlight initial design/construction/ maintenance/operational risks. These risks have been evaluated and appropriate mitigation placed against them with further assessment necessary during the forthcoming development stages of the study.

The key risks are listed below:

- Crossing the A4174 South Bristol Link, either at grade junction, or via over bridge,
- Potential water courses to divert/ culvert with adequate construction protection to avoid accidental pollution adjacent to A38 Bridgwater Road,
- Bristol Water covered reservoir with assumed below ground infrastructure beneath Bridgewater Road,
- Existing bridge spanning the mainline railway to and from Bristol Temple Meads, which may require replacing due to width constraints,
- Depending upon the position of the mass transit vehicle, its own vehicle weight may pose a significant loading risk to the Avon (New Cut) River wall adjacent;
- Existing Grade I & Grade II Listed structures, along with Locally Listed structures causing width restrictions.
- Construction of the underground mass transit terminal at the Airport, with linkages to the existing arrivals/departures building;
- Construction of the tunnel and portal entrance to enable to mass transit system to re-join the above ground network;
- Potential water courses to divert/ culvert with adequate construction protection to avoid accidental pollution adjacent to A38 Bridgewater Road;
- Construction of potential elevated section adjacent to the water reservoirs due to restricted width;
- Third party land required; and
- Relocation of existing utilities, where required.

Capital costs

Capital engineering costs have been identified for the corridor of **£0.37bn** which include assumptions for land, client costs and contingency. The costings do not substantially differ between online and offline alignments; therefore the no recommendation has been made at this stage as to which is preferred.

FINAL DRAFT

6.4.2.2 Route 2 – North Bristol and North Fringe

Corridor Description

This corridor commences at Bristol Temple Meads railway station and continues north, for approximately 12.6km, along Temple Gate, Temple Way, Bond Street, St. James Barton Roundabout (The Bear Pit), North Street, Stokes Croft, Cheltenham Road, Gloucester Road, Filton Road, Gloucester Road North, and Gloucester Road where it terminates in the local area north of the M5 J16 grade separated interchange at an assumed 4,000 space Park & Ride/interchange facility.

The route is predominately made up of two corridor sections. The first section reference is BW-A1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-010), which is predominately between North Street to Filton Roundabout. This 17.95m wide section diagram has been configured to allow for on-street dual mass transit vehicles with intermittent loading/ on street parking areas within the corridor (general through traffic has been removed with restricted local access only), 3m wide segregated cycleway and adjacent footways with varying width.

The second section reference is BW-C1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-012) and predominately extends between Filton Roundabout and M5/J16, with a couple of minor amendments to allow for geographical constraints. This capitalises on the increased carriageway space to allow for general traffic to also use the A38 in this area. It is 29.10m in width and has been configured to allow for two general traffic lanes in each direction with the central area for bi-directional mass transit corridor which widens to allow for a central platform loading area where required. There is also a 3m wide segregated cycleway and adjacent footways with varying width.

The effect of applying these sections along the proposed corridor has a significant impact on third-party land, a number of residential/ commercial buildings would also be affected by these measures.

To shorten and improve the overall journey time of the mass transit vehicles, it is proposed to restrict the general traffic movements onto the mass transit corridor, which will require appropriate infrastructure, enforcement measures and technology. This will allow the mass transit vehicles unobstructed movement along the corridor due to the removal of queuing traffic and other obstructions. For the current proposal there will be approximately:

- 46 permanent road closures onto the corridor;
- 12 partial road closures allowing local access to the 21 cul-de-sacs and residential/commercial properties; and
- 12 new signal junctions to allow for cross movements[30].

Potential mass transit stops are currently proposed at the commencement of the alignment near Bristol Temple Meads railway station, with further stops at approximately 500m intervals. The location of these stops has not yet been determined at this stage. It is anticipated that the key destinations will include: Temple Way; Old Market Roundabout; Cabot Circus; Stokes Croft (access to bus/coach station); Cheltenham Road (near Montpelier railway station); Gloucester Road (access to Southmead Hospital); Filton Roundabout; Filton College; Gipsy Patch Lane; Patchway; Aztec West Roundabout and the terminal point at the assumed Park & Ride near M5 J16. Intermediate stops will be located where there is little or no impact on third parties, wherever possible.

Figure 6.14 illustrates the indicative alignment described above and identified for this study.

[30] No assumptions have been included for the upgrade of existing signal junction infrastructure along the corridor, including life-expired infrastructure.

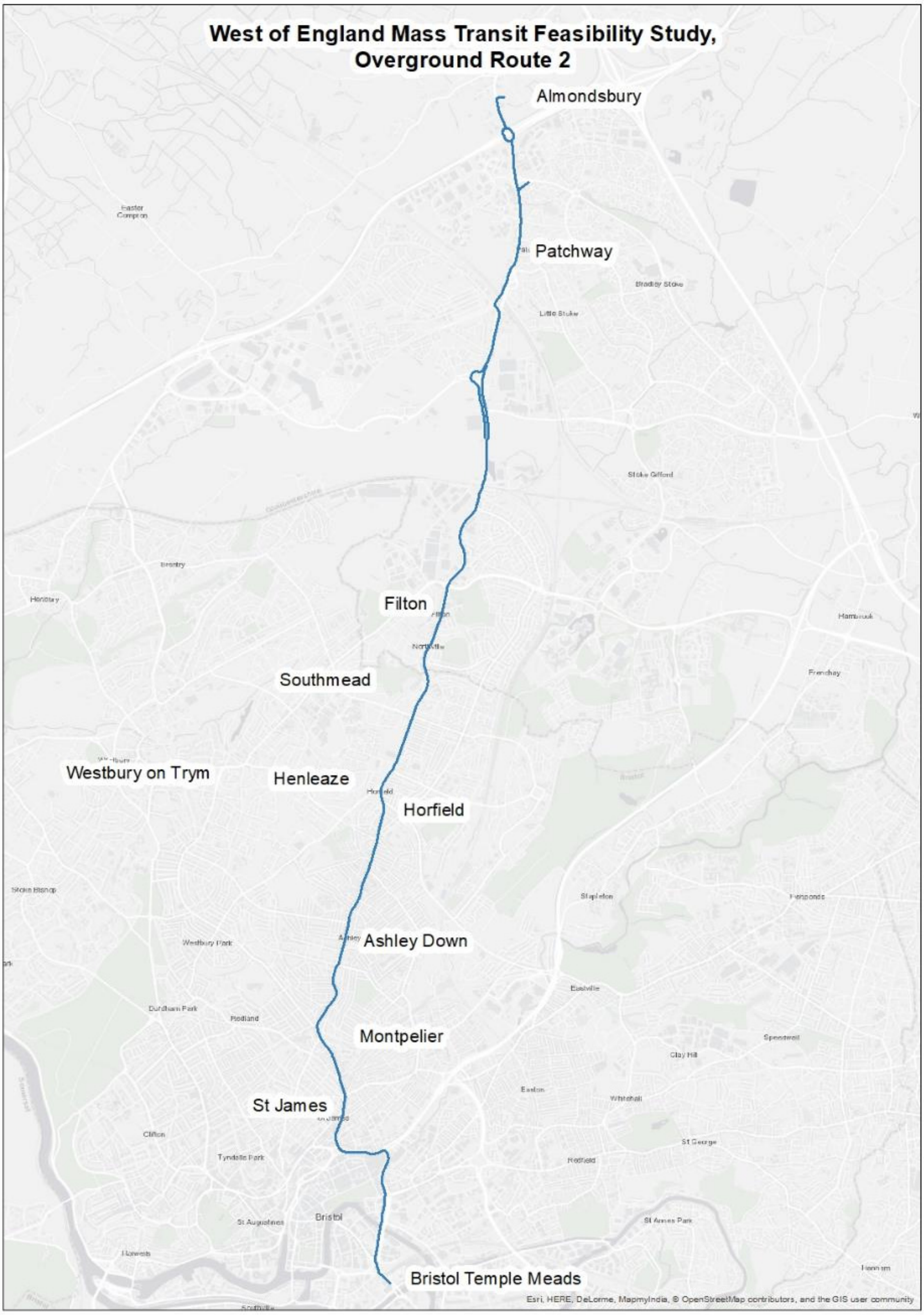

Figure 6.14: Corridor 2 (overground) – North Bristol and North Fringe

Key considerations and risks

Key considerations and risks for this route have been identified through an initial high-level, Designers Risk Assessment which has been carried out to highlight initial design/ construction/ maintenance/ operational risks. These risks have been evaluated and appropriate mitigation placed against them with further assessment necessary during the forthcoming development stages of the study.

The key risks are listed below:

- Bridge spanning the Inner Harbour;
- Old Market roundabout and its associated structure, along with maintaining general traffic to and from Castle Street to Old Market Street;
- Height restriction due to a building spanning the A38 adjacent to St. James' Barton Roundabout;
- It is assumed that many properties along Stokes Croft; Cheltenham Road; and Gloucester Road have underground cellars that extend beyond the highway boundary. This may affect the construction of the mass transit corridor;
- Height and width restriction due to the Network Rail (archway);
- Existing bridge spanning over Network Rail mainline;
- Existing water course to divert/ culvert with adequate construction protection to avoid accidental pollution;
- Existing bridge with restricted width spanning over Network Rail mainline, with new bridge proposed adjacent;
- Existing M5 overbridge spanning A38 – height and width restriction; and
- Existing Grade I & Grade II Listed structures, along with Locally Listed structures causing width restrictions.

Capital costs

- Capital engineering costs have been identified for the corridor of **£0.22bn**, which include assumptions for for land, client costs and contingency.

FINAL DRAFT

6.4.2.3 Route 4 – Hicks Gate/Keynsham

Corridor Description

Two options for corridor 4 have been shortlisted for further development and consideration, these are:

- Option 4a - Bristol Temple Meads to Hicks Gate (Keynsham) via A4; and
- Option 4bi – Bristol Temple Meads to Hicks Gate (Keynsham) via Callington Road Link.

Figure 6.15 illustrates the indicative alignment described above and identified for this study.

Option 4a – Bristol Temple Meads to Hicks Gate/Keynsham via A4

The Bristol Temple Meads to Hicks Gate/Keynsham corridor commences at Bristol Temple Meads railway station and continues west, for approximately 7.55km, along Temple Gate, Bath Bridges Roundabout, Bath Road, Eagle Road (inbound only), Grove Park (outbound only), Bristol Hill, Bath Road, and terminating in the vicinity of Hicks Gate roundabout (Keynsham). The route is predominately made up of two corridor sections.

Initial feasibility considerations for a further extension to Keynsham were included in the work undertaken for the long-list sifting for this option. However on further development of the concept design, engineering constraints limited the availability of segregated access between Hicks Gate and Keynsham (railway station or town centre). Significant impacts result from the limited availability of land and securing the alignment between Keynsham bypass and the railway, to facilitate access to the existing station without severe impact on properties. Therefore it has been assumed that Keynsham proper will be served by a feeder service, with an interchange at the Hicks Gate terminus.

The first section reference is BW-C1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-012). It is 23.10m in width and has been configured to allow for one general traffic lane in each direction with the central area for bi-directional mass transit corridor which widens to allow for a central platform loading area where required. There is also a 3m wide segregated cycleway and adjacent footways with varying width. This section extends from the south of Bath Bridges to Three Lamps Junction and from Callington Road/A4 junction to the proposed Park & Ride site at Hicks Gate. This section is proposed to maximise the opportunity to provide for general traffic along the A4 corridor.

The second section reference is BW-A1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-010). This 17.95m wide section diagram has been configured to allow for on-street dual mass transit vehicles with intermittent loading/ on street parking areas within the corridor (general through traffic has been removed with restricted local access only), 3m wide segregated cycleway and adjacent footways with varying width. This section extends from Three Lamps junction to the Callington Road/A4 junction.

The effect of applying these sections along the proposed corridor has major consequences from Bath Bridges to Three Lamps due to width constraints from the bridge which passes over Network Rail mainline railway into Bristol Temple Meads and the level difference between the A4 and the potential development within the Enterprise Zone. There are also specific areas where there will be a requirement for third party land.

To shorten and improve the overall journey time of the mass transit vehicles, it is proposed to restrict the general traffic movements onto the mass transit corridor (where section reference TW-A1 is proposed), which will require appropriate infrastructure, enforcement measures and technology. This will allow the mass transit vehicles unobstructed movement along the corridor due to the removal of queuing traffic and other obstructions. For the current proposal there will be approximately:

- ten permanent road closures onto the corridor;
- six partial road closures allowing local access to the 7 cul-de-sacs and residential/ commercial properties; and

- 12 new signal junctions to allow for cross movements[31].

Potential mass transit stops are currently proposed at the commencement of the alignment near Temple Meads railway station, with further stops at approximately 500-750m intervals. The precise location of other stops has not yet been determined at this stage. It is anticipated that there will be stops in the vicinity of: Three Lamps; Arnos Vale; Brislington; Brislington Retail Park; current Brislington Park & Ride site (identified for development) and terminating at an assumed 4,000 space Park & Ride/interchange site at Hicks Gate (assumed to be expansion of the proposed Hicks Gate Park & Ride). Intermediate stops will be located at points with little or no impact on third parties, wherever possible.

Key considerations and risks

An initial high-level Designers Risk Assessment has been carried out where initial design/ construction/ maintenance/operational risks have been identified. These risks have been evaluated and appropriate mitigation placed against them with further assessment required during the next stage of development. The key risks associated with this corridor are listed in the corridor descriptions below:

- Potential width constraint from the existing bridge spanning the Avon River (New Cut) – Bath Bridges;
- Potential width constraint from the existing bridge spanning Network Rail mainline railway into Bristol Temple Meads;
- Width constraint due to the level difference from the A4 to the potential development area;
- Width constraint due to the level difference between the A4 and the Paintworks Development;
- Access to Arnos Vale Cemetery;
- Potential width constraint from the existing bridge spanning the Callington Link;
- Third party land required;
- Relocation of existing utilities whether above or below ground; and
- Existing Grade I & Grade II Listed structures, along with Locally Listed structures causing width restrictions.

FINAL DRAFT

[31] No assumptions have been included for the upgrade of existing signal junction infrastructure along the corridor, including life-expired infrastructure.

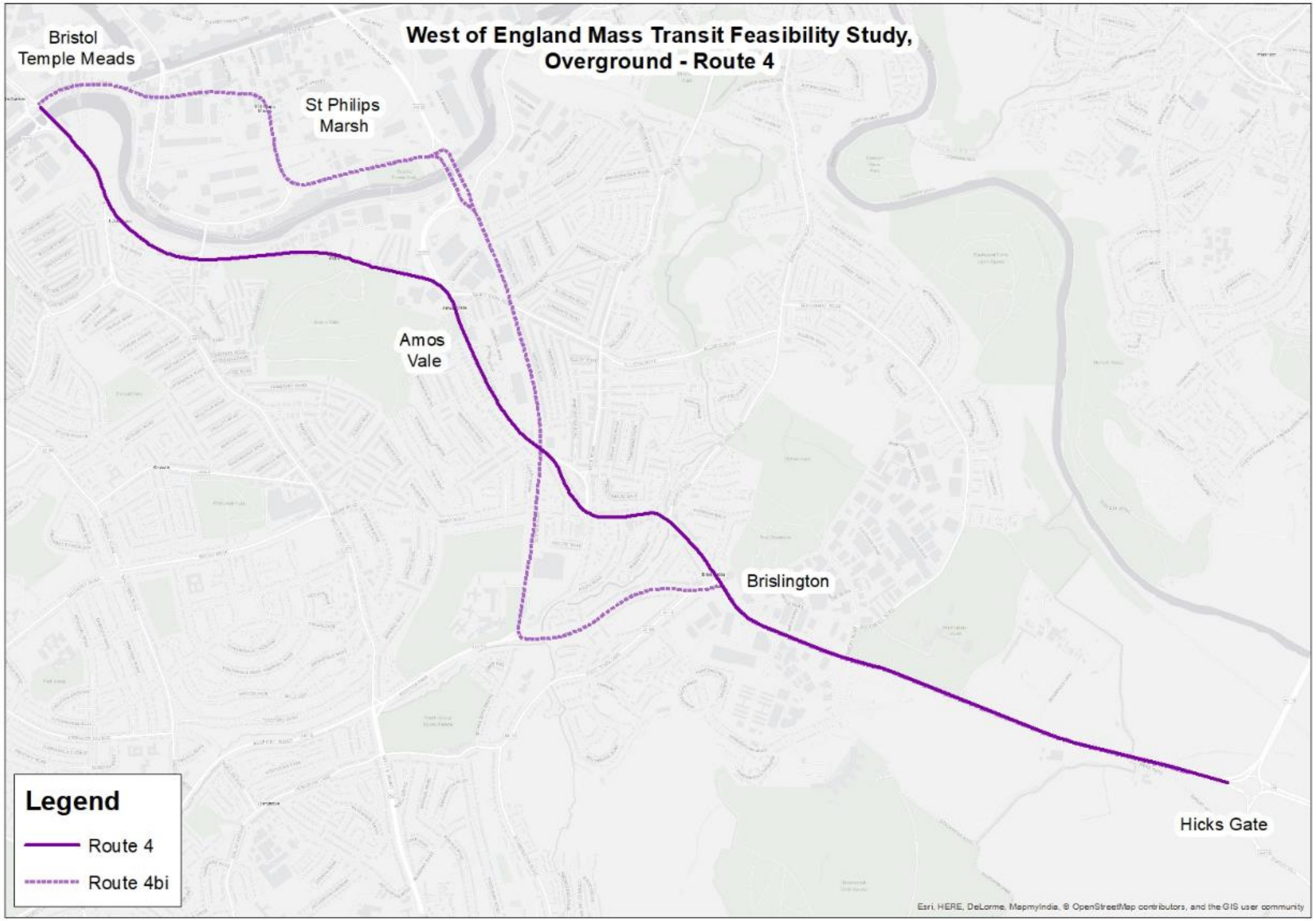

Figure 6.15: Corridor 4 (overground) – Hicks Gate (Keynsham)

Option 4bi – Bristol Temple Meads to Hicks Gate via Callington Road Link

The Bristol Temple Meads to Hicks Gate corridor commences at Bristol Temple Meads railway station and continues west for approximately 8.35km along: Temple Gate; Cattle Market Road; Chapel Street; Albert Crescent; Albert Road; St Philips Causeway; Broomfield Road Link; Callington Link (former rail alignment); A4174 Callington Road; Bath Road; and terminating in the vicinity of an assumed 4,000 space Park & Ride/interchange at Hicks Gate. The route is predominately made up of three corridor sections.

The first section reference is BW-A1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-010). This 17.95m wide section diagram has been configured to allow for on-street dual mass transit vehicles with intermittent loading/ on street parking areas within the corridor (general through traffic has been removed with restricted local access only), 3m wide segregated cycleway and adjacent footways with varying width. The effect of applying this section along the proposed corridor has significant consequences through St Philips Marsh Estate due to current third party ownership. It is understood that the area is subject to a Master planning exercise, as part of the Enterprise Zone, which could utilise the proposed alignment to facilitate access to the area. This section extends from Cattle Market Road to St Philips Causeway/Albert Road junction.

The second section reference is BW-E1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-014). This 13.95m wide section diagram has been configured to allow for a bidirectional mass transit corridor with a 4m wide shared foot/ cycleway adjacent along what is known as Callington Road Link.

The third section reference is BW-B1 which is shown in Appendix C (drawing reference 673846.EA.03.01-05-011). It is 23.10m in width and has been configured to allow for one general traffic lane in each direction with the central area for a bi-directional mass transit vehicle which widens to allow for a central platform loading area where required. There is also a 3m wide segregated cycleway and adjacent footways with varying width. This section extends from St Philips Causeway to the proposed Park & Ride site at Hicks Gate. This section is proposed to maximise the opportunity to provide for general traffic along the A4 corridor.

There are also specific sections of the corridor requiring third party land to facilitate construction.

To shorten and improve the overall journey time of the mass transit vehicles, it is proposed to restrict the general traffic movements onto the mass transit corridor (where section reference BW-E1 is proposed), which will require appropriate infrastructure, enforcement measures and technology. This will allow the mass transit vehicles unobstructed movement along the corridor due to the removal of queuing traffic and other obstructions. For the current proposal there will be approximately:

- 19 new signal junctions to allow for cross movements[32].

Potential mass transit stops are currently proposed at the commencement of the alignment near Temple Meads railway station, with further stops at approximately 500-750m intervals. The precise location of other stops has yet been determined at this stage. It is anticipated that there will be stops in the vicinity of: Bristol University Campus adjacent to Bristol Temple Meads Station (Cattle Market Road); St Philips Marsh; Arnos Vale (Sainsbury's); Tramway Road (Trading Estate); Callington Road (Tesco); Brislington Retail Park; current Brislington Park & Ride (identified for development); and terminating at an assumed 4,000 space Park & Ride/Interchange facility at Hicks Gate (assumed to be expansion of the proposed Hicks Gate Park & Ride). Intermediate stops will be located where there is little or no impact on third parties, wherever possible.

[32] No assumptions have been included for the upgrade of existing signal junction infrastructure along the corridor, including life-expired infrastructure.

FINAL DRAFT

Key considerations and risks

An initial high-level Designers Risk Assessment has been carried out where initial design/ construction/ maintenance/ operational risks have been identified. These risks have been evaluated and appropriate mitigation placed against them with further assessment required during the next stage of development. The key risks associated with each corridor are listed in the descriptions below:

- Potential width and height constraint from the existing Network Rail structure with Bristol Temple Meads station above;
- Embankment from Cattle Market Road down to Avon River (New Cut);
- Deep foul sewers and transatlantic fibre optic cables;
- Shallow structure spanning river dock;
- Extensive land required through St Philips Marsh Trading Estate, with access restrictions for the mass transit corridor;
- Height and width restriction to due over bridge linking First Great Western Train Depot to the mainline rail network;
- Potential width restriction due to St Philips Causeway bridges spanning Avon River (New Cut);
- Height and width restriction due to overbridges spanning the mass transit corridor;
- Existing water course to divert/ culvert with adequate construction protection to avoid accidental pollution;
- Considerable amount of third-party land required;
- Relocation of existing utilities whether above or below ground; and
- Existing Grade I & Grade II Listed structures, along with Locally Listed structures causing width restrictions.

Capital costs

Capital engineering costs have been identified for corridor 4bi of **£0.17bn**, which include assumptions for land, client costs and contingency. This has been used to inform the economic assessment.

Capital engineering costs have been identified for corridor 4a (to Hicks Gate) of £0.13bn, which includes assumptions for land, client costs and contingency.

Comparative capital engineering costs have been identified for corridors 4a and 4bi for tram infrastructure, £0.59bn and £0.65bn respectively, with costs including for assumptions for land, client costs and contingency.

6.4.3 Summary of capital costs

Table 6.13 outlines the summary of capital costs (in 2018 prices) for engineering and rolling stock requirements for each of the network options investigated in the economic assessment.

Table 6.13: Summary of capital costs

<table>
<tr><th>Option</th><th>Engineering CAPEX</th><th>Rolling Stock CAPEX</th><th>Total</th></tr>
<tr><td>Underground – 4 corridors (DLR-style technology)</td><td rowspan="3">£4.58bn</td><td>£0.168bn</td><td>£4.749bn</td></tr>
<tr><td>Underground – 4 corridors (Tram-style technology)</td><td>£0.168bn</td><td>£4.749bn</td></tr>
<tr><td>Underground (4 corridors) (BRT-style technology)</td><td>£0.042bn</td><td>£4.623bn</td></tr>
<tr><td>Underground (3 corridors) (DLR-style technology)</td><td>£3.71bn</td><td>£0.138bn</td><td>£3.849bn</td></tr>
<tr><td>Overground (3 corridors) (BRT/bus-style technology)</td><td>£0.75bn</td><td>£0.034bn</td><td>£0.784bn</td></tr>
</table>

FINAL DRAFT

6.5 Option assessment – benefits and revenue

This section presents the approach and results for the revenue and benefits forecasts for the feasibility study. It builds upon demand estimates presented in the previous section.

6.5.1 Revenue

The mass transit system would generate revenue from its passenger farebox. It has been assumed that the initial fare would be £2.00[33], as a flat rate for all trips across the network and across the day. This fare is expressed in 2018 prices.

In addition, a premium fare at £4.00 per trip has been considered for all additional trips generated from/to Bristol airport, to reflect similar fares elsewhere in the country.

Based on those assumptions, Table 6.14 shows the generated revenue for the three layers of demand previously presented:

Table 6.14: Annual Revenue (£m, 2018 prices)

Option	Metric	500 m	750 m	Rest of Sector	Ind. Rail	Core Dev.	P&R	Airport	Total
Underground	Demand	14.0m	5.5m	4.1m	1.0m	3.5m	8.2m	6.0m	42.3m
	Revenue	£27.9m	£11.1m	£8.1m	£2.0m	£7.0m	£16.5m	£24.0m	£96.6m
Overground	Demand	6.3m	2.9m	2.2m	0.3m	0.8m	3.8m	4.5m	20.7m
	Revenue	£12.6m	£5.8m	£4.4m	£0.5m	£1.6m	£7.6m	£18.0m	£50.6m

A total annual revenue of over £96m would be generated for the central scenario for the underground and £50m for the overground, expressed in 2018 prices. The total annual revenue generated for the sensitivity test scenarios combined would be over £122m in 2018 prices for the underground system and £59m for the overground system.

6.5.2 Benefits

Benefits have been estimated in accordance with guidance from the Department for Transport for rail appraisal, as set out in the latest WebTAG databook (November 2018) and in the HM Treasury Green Book.

Benefits calculated for the mass transit system mainly include three sources:

- User benefits for demand transferred from public transport
- User benefits for demand transferred from car
- Non-user benefits or highway externality benefits

User benefits are driven by variations in the GJT incurred at introducing a new mode. In accordance with economic appraisal guidance, existing users benefit from the full variation in GJT whereas the new users benefit from half of the variation in GJT (known as 'rule of a half').

In this context, it has been assumed that demand transferring from other public transport modes can be considered as existing demand to 'public transport' and therefore benefits from the full improvement in GJT. However, it has been assumed that demand transferring from car is new to 'public transport' and therefore benefits from half of the GJT improvement.

[33] Currently, a single ticket flat rate in Bristol costs £2.07 when bought when boarding a bus. The model proxied this as £2.00 Fare information is provided on page 13: https://www.firstgroup.com/uploads/node_images/Fares%20Guide%2011%20Nov%202018_1.pdf

FINAL DRAFT

Non-user benefits or highway externality benefits[34] reflect the impact of the reduction of car journeys on the highway network. WebTAG provides a value for the benefit realised per car kilometre removed from the highway network. The non-user benefits have been estimated using the mode transfer from car to mass transit, obtaining an annual benefit linked to this

User benefits are then monetised with the Value of Time from the latest WebTAG databook (November 2018). This is typically expressed in 2010 values for consistency.

Table 6.15 and Table 6.16 below show the annual benefits for the three different layers of demand analysed in this report, expressed in millions of pounds, in 2010 values.

Table 6.15: Underground Annual Benefits (£m, 2010 values)

Benefits	500m	750m	Rest of Sector	Induced Rail	Core Dev	P&R	Airport	Total
User benefits (public transport)	£20.1m	£7.9m	£5.8m	£1.4m	£5.1m	-	£8.6m	£49.0m
User benefits (car)	£17.5m	£6.9m	£5.1m	£1.3m	£4.4m	£28.8m	£7.5m	£71.4m
Non-user benefits (externalities)	£7.2m	£2.8m	£2.1m	£0.5m	£1.8m	£7.1m	£3.1m	£24.6m
Total	**£44.7m**	**£17.7m**	**£13.0m**	**£3.2m**	**£11.3m**	**£35.9m**	**£19.2m**	**£145m**

Table 6.16: Overground Annual Benefits (£m, 2010 values)

Benefits	500m	750m	Rest of Sector	Induced Rail	Core Dev	P&R	Airport	Total
User benefits (public transport)	£12.8m	£6.0m	£4.5m	£0.5m	£1.6m	-	£9.2m	£34.6m
User benefits (car)	£1.9m	£0.9m	£0.6m	£0.1m	£0.2m	£13.4m	£1.3m	£18.4m
Non-user benefits (externalities)	Calculated in Table 6.20 as Present Value over 60 years							
Total	**£14.8m**	**£6.9m**	**£5.1m**	**£0.6m**	**£1.9m**	**£13.4m**	**£10.6m**	**£53.0m**

For underground, user benefits represent a total of 83% of the total benefits, split by 34% realised by demand abstracted from public transport and 49% by demand abstracted from cars. The remaining 17% corresponds to highway externalities.

For the overground, the majority of the benefits are generated through abstraction from public transport (65%), with 34% being car abstraction and the remaining 1% externality benefits.

Given that the overground option requires the reallocation of existing road space from the existing highway network, it has been assumed that no marginal external decongestion benefits can be claimed. In fact, it is more likely that an overground option would generate additional congestion on users who would remain to use their car and the wider network,

A high-level assessment has been undertaken using GBATS to understand indicatively the likely scale of these disbenefits. It looks at the impacts of closing the three corridors, in terms of change in vehicle kilometres across the network, these have been monetised and interpolated to provide a conservative estimate of (£700-900m)[35] over 60 years, expressed as Present Values in 2010 prices. This indicatively represents, at a high-level, the impacts of construction and operation on highway network of overground proposals.

[34] Decongestion, infrastructure maintenance, air quality, noise, accidents, greenhouse gases, and indirect taxation

[35] For calculation purposes, £800m over 60 years expressed as Present Values in 2010 prices has been used to understand the scale of the disbenefit.

A high-level estimate of the benefits has been produced that would be incurred over a 60-year appraisal period. For this, high-level assumptions on demand growth and system opening year have been assumed, as follows:

- Opening year: 2030
- Forecast year: 2036 (demand forecasts year)
- End of appraisal: 2089 (60 years from the opening year)
- Demand growth between 2030 and 2036: annual 3.0%, which represents a total 23% growth.
- Demand growth beyond the demand cap (2049): 0.4%, in line with population TEMPRO growth for Bristol between 2036 and 2051.

It has been considered that demand grows at a 3.0% rate between 2027 and 2049, after which it grows at 0.4%. In addition to demand growth, we have considered the Value of Time real growth in accordance to WebTAG's latest databook (November 2018).

Finally, the benefits values have been discounted to 2010 to derive the Present Value of Benefits consistent with WebTAG. These calculations have resulted in a conversion factor of 22 from a single-year benefits figure in 2036 to a 60-year WebTAG-compliant Present Value of Benefits.

The high-level estimates for a 60-year appraisal period benefits are shown below:

Table 6.17: Underground 60-year Appraisal Benefits (£m, 2010 values)

Benefits	500m	750m	Rest of Sector	Induced Rail	Core Development	P&R	Airport	Total
User benefits (public transport)	£450m	£178m	£130m	£32m	£113m	-	£193m	£1,097m
User benefits (car)	£391m	£155m	£113m	£28m	£98m	£646m	£168m	£1,600m
Non-user benefits (externalities)	£161m	£64m	£47m	£12m	£40m	£158m	£69m	£550m
Total	**£1,002m**	**£396m**	**£290m**	**£72m**	**£252m**	**£804m**	**£430m**	**£3,247m**

Table 6.18: Overground 60-year Appraisal Benefits (£m, 2010 values)

Benefits	500m	750m	Rest of Sector	Induced Rail	Core Development	P&R	Airport	Total
User benefits (public transport)	£287m	£133m	£100m	£12m	£36m	-	£206m	£775m
User benefits (car)	£42m	£19m	£14m	£2m	£5m	£300m	£30m	£412m
Non-user benefits (externalities)	Calculated in Table 6.20							
Total[36]	**£329m**	**£153m**	**£114m**	**£14m**	**£42m**	**£300m**	**£236m**	**£980m**

The annual benefits realised have been assessed for the sensitivity tests described in the previous section. With all scenarios combined, the total annual benefits that would be realised further to the introduction of the mass transit system would be of around £188m annually for Underground and £65m for Overground, in 2010 values.

[36] The total values do not include the non-user benefits (externalities) which are calculated to include the (£700-900m adjustment)

Table 6.19: Annual Benefits – Sensitivity Tests (£m, 2010 values)

Scenario	Underground Demand	Underground Benefits (£m, 2010 values)	Overground Demand	Overground Benefits (£m, 2010 values)
All sensitivity tests	**55.1m**	**£188.6m**	**25.4m**	**£65.6m**

6.6 Economic appraisal

A high-level economic appraisal has been undertaken to assess the Value for Money (VfM) provided by the construction of the mass transit system. Data produced in the previous sections along with assumptions on the remaining aspects has been gathered to inform this analysis.

Appraisal Period

The following assumptions around the appraisal period have been considered to undertake the analysis. These assumptions are the same for underground and overground:

- Opening year: 2030
- Demand cap year: 2049
- End of appraisal: 2089

6.6.1 Present Value of Benefits

The Present Value of Benefits (PVB) has been derived from the Annual Benefits estimates for 2036 as presented in the previous section of this report. Annual benefits have been profiled using demand growth, Value of Time growth and discounted to 2010 values for consistency with general appraisal guidance. A summary of the PVB for underground and overground are shown below:

Table 6.20: Present Value of Benefits

Benefit Category	Underground Annual Benefits – 2036 (£m, 2010 values)	Underground 60-year Present Value (£m, 2010 values)	Overground Annual Benefits – 2036 (£m, 2010 values)	Overground 60-year Present Value (£m, 2010 values)
User Benefits – transfer from Public Transport	£49m	£1,097m	£36m	£775m
User Benefits – transfer from Car	£71m	£1,600m	£18m	£412m
Non-user Benefits – Highway externalities	£25m	£550m	-	(£700-900m)[37]
Total Benefits	**£145m**	**£3,247m**	**£53m**[38]	**£387m**

The PVB is over £3.2bn and £0.4bn for underground and overground respectively, expressed in 2010 values.

6.6.2 Present Value of Costs

The Present Value of Costs (PVC) is comprised of three components: net revenue, operating costs and capital costs.

[37] For calculation purposes, £800m over 60 years expressed as Present Values in 2010 prices has been used to understand the scale of the disbenefit.

[38] The Non-user Benefits – Highway externalities is £0.6m. This is not included in the calculation of total benefits, as the negligible figure would be lost in rounding.

FINAL DRAFT

Net Revenue

Annual revenue estimates generated by the metro for 2036 are taken from Table 6.14. In addition, we have considered the revenue lost by other public transport demand which transfers to the metro. We have assumed an average fare of £2.00[39] as a proxy for bus services, with the total lost revenue equalling this fare for the public transport demand transferred to the metro system.

This value, expressed in 2018 prices, was firstly expressed in 2010 prices by deflating it by GDP deflator growth between 2010 and 2018. This value was then profiled throughout the appraisal period by applying demand growth and a real fare growth of 1.0%[40] and finally discounting the cash flow to 2010 values for consistency with the treatment of benefits.

Table 6.21 and Table 6.22 below summarise the revenue calculations for the economic appraisal for underground and overground respectively.

Table 6.21: Underground Appraisal Net Revenue

Revenue Category	Annual Revenue (2018 prices)	Annual Revenue (2010 prices)	60-year Present Revenue (£m, 2010 values)
Mass transit Revenue Generated	£97m	£85m	£1,876m
Public Transport Revenue Lost	(£25m)	(£22m)	(£482m)
Total Net Revenue	**£72m**	**£63m**	**£1,395m**

Table 6.22: Overground Appraisal Net Revenue

Revenue Category	Annual Revenue (2018 prices)	Annual Revenue (2010 prices)	60-year Present Revenue (£m, 2010 values)
Mass transit Revenue Generated	£51m	£44m	£983m
Public Transport Revenue Lost	(£17m)	(£15m)	(£328m)
Total Net Revenue	**£34m**	**£30m**	**£655m**

Despite having a revenue estimate derived through a bottom-up approach, in the light of the likely scale of operating costs, it has been considered that the revenue-generated should be limited to the operating cost of each option plus 20%, which would still represent an operating surplus. Based on experience, this would be typical with other mass transit systems and any revenue generation above that threshold would seem unrealistic.

Operating Cost

The operating cost estimates have been used to inform the economic appraisal of each option under consideration. The approach to calculating these operating costs is based on benchmarked rates (e.g. £ per vehicle km) for each of the systems being appraised, and a distance-based calculation of annual kilometres in operation, using the assumed speeds consistent with the rest of the economic appraisal and allowances for layover/turnaround. Table 6.23 presents the assumed rates.

Table 6.23: Assumed operating cost rates (£ per vehicle kilometres, 2018 prices)

Assumed system	£ per vehicle km (2018 prices)
BRT	£3.0
Tram	£7.2
Light Rail	£7.3

[39] A bus fare of £2.07 corresponds to a single ticket fare when purchased in advance of boarding the bus, which we believe is the best proxy for the current fare levels.
https://www.firstgroup.com/uploads/node_images/Fares%20Guide%2011%20Nov%202018_1.pdf

[40] Assumption based on professional judgement.

FINAL DRAFT

The cost rates have been expressed in 2030 prices using CPI growth both from outturn values and ONS projections. Over the 60-year appraisal period, operating cost has been assumed to grow at a real annual rate of 1.0%. It should be noted that the operating cost provided represents 18 daily hours of operation.

Table 6.24 presents the summary of annual operating costs by line and system type for the opening year, 2030, expressed in 2030 prices:

Table 6.24: Annual operating costs by line and system type (£m, 2030, in 2030 prices)

Assumed system	South	North	North East	South East	All lines
Underground – Light Rail	£19.5m	£17.3m	£12.7m	£9.2m	**£58.8m**
Underground – Tram	£19.1m	£17.0m	£12.4m	£9.1m	**£57.5m**
Underground – BRT	£8.0m	£7.1m	£5.2m	£3.8m	**£24.0m**
Overground – BRT	£6.1m	£6.4m	-	£3.9m	**£16.4m**

Capital Cost

Capital cost for (engineering) construction of the mass transit system has been estimated to amount to £4.58bn for the underground option (4 corridors) and £0.75bn for overground option (3 corridors), in 2018 prices, including contingency. It is assumed that the cost is incurred at 25% per year during four years prior to the mass transit opening year, this is from 2026 to 2029.

Rolling stock capital costs have been calculated to amount to between £0.042bn and £0.168bn for the underground option (technology dependent), in 2018 prices, including contingency. Overground rolling stock capital costs (bus/BRT technology) amount to £0.034bn, in 2018 prices.

Construction and rolling stock cost

In line with the development stage of this scheme – pre-feasibility study stage – an optimism bias factor of 66% is added to the above capital costs.

Capital cost, in order to include it in the economic appraisal, was firstly expressed in 2018 prices in a similar way to revenue. It was then discounted to 2010 prices for consistency. Table 6.25 below summarises how capital cost has been treated in the appraisal for both underground and overground.

Table 6.25: Appraisal Capital Cost

Capital Cost	Underground light rail/tram (£m)	Underground BRT (£m)	Overground BRT (£m)
Capital Cost Value (2018 prices)	£4,750m	£4,630m	£784m
Capital Cost Value (2010 prices)	£4,186m	£4,063m	£688m
Capital Cost with Optimism Bias (66%)	£6,919m	£6,774m	£1,141m

The capital cost requirements for each of the individual lines for each of the systems are shown in Table 6.26.

FINAL DRAFT

Table 6.26: Capital Cost by Line and System, £m 2018 prices

Line	Underground light rail/tram (£m)	Underground BRT (£m)	Overground BRT (£m)
South	£1,170m	£1,130m	£380m
North	£1,590m	£1,156m	£230m
North East	£1090m	£1,060m	-
South East	£900m	£880m	£170m
Ave. Cost/km (range)	£74m - £120m / km	£71m - £117m / km	£18m - £31m / km

The range for the average capital cost per kilometre for the overground BRT option might be low, considering the significant proportion of land uptake that might be required, so this would merit from further investigation and benchmarking against other systems.

Renewals

For the purposes of the economic appraisal, it has been assumed that over the 60-year appraisal period, both the infrastructure and the rolling stock would need to be renewed and/or refurbished.

Infrastructure renewals have been assumed to take place in 2060, after 30 years of the opening of the system, and would cost 2% of construction cost. For the rolling stock, different assumptions for renewals and maintenance profile depending on the system have been considered. These assumptions are presented in Table 6.27.

Table 6.27: Assumed schedule of rolling stock renewals

Assumed system	Fleet Value (£m, 2018 prices)	Full Fleet Replacement	Fleet refurbishment	
Underground – Light Rail	£168m	2060	30% fleet value	2045, 2075
Underground – Tram	£168m	2060	30% fleet value	2040, 2050, 2070, 2080
Underground – BRT	£42m	2045, 2060, 2075	30% fleet value	2037, 2052, 2067, 2082
Overground – BRT	£33m	2045, 2060, 2075	30% fleet value	2037, 2052, 2067, 2082

6.6.3 Net Present Value and Benefit Cost Ratio

Once the PVB and PVC were calculated, the metrics for assessing the Value for Money (VfM) of the scheme were calculated:

- Net Present Value (NPV), which is the difference between PVB and PVC
- Benefit Cost Ratio (BCR), which is the ratio between PVB and PVC

Table 6.28 summarises the costs and benefits of the scheme for the four different system options and provides a high-level VfM assessment to inform the investment decision-making process.

FINAL DRAFT

Table 6.28: Appraisal Summary for all systems (£m, 2010 values and prices)

Appraisal Category	Underground Light Rail	Underground Tram	Underground BRT	Overground BRT
User Benefits – transfer from Public Transport	£1,097m	£1,097m	£1,097m	£775m
User Benefits – transfer from Car	£1,600m	£1,600m	£1,600m	£412m
Non-user Benefits – Highway externalities	£550m	£550m	£550m	(£700-900m)
Present Value of Benefits (PVB)	**£3,247m**	**£3,247m**	**£3,247m**	**£387m**
Capital Costs	£3,955m	£3,924m	£3,784m	£628m
Operating Costs	£813m	£796m	£499m	£295m
Revenue	(£1,395m)	(£1,395m)	(£1,395m)	(£654m)
Present Value of Costs (PVC)	**£3,373m**	**£3,326m**	**£2,888m**	**£269m**
Net Present Value (NPV)	**(£126m)**	**(£78m)**	**£359m**	**£118m**
VfM Category	**Poor**	**Poor**	**Low**	**Low**

All of the base underground and overground options have a poor-low VfM, but this currently excludes wider economic impacts.

Further detailed modelling is required to understand the impacts of construction and operation of both under- and overground options, along with associated economic appraisal at a later stage. It is likely this could vary the scale of benefits depending on the selected system. At this time it has not been considered fully, however it could decrease the economic performance of some options, such as the overground BRT further.

An illustrative sensitivity has been carried out looking at scenarios to capture the impact of three years of construction on overground corridors (ground floor businesses only and not including Bristol city centre). Table 6.29 summarises the low, medium and high scenarios investigated, assuming different levels of disruption to businesses. This assessment does not account for the impact of construction on these overground corridors, with regards to the high streets and the local identities and a sense of place within communities they provide.

Currently there are circa. 700 ground floor businesses providing over 1,000 jobs on the three short-listed corridors. Annual turnover of businesses is likely to be some £135 million (2016 prices) with annual GVA contributions of the businesses likely to be circa £40 million (2016 prices).

Table 6.29: Indicative impact of construction

Scenarios[41]	Indicative GVA lost over three years (2016 prices)	Indicative turnover lost over three years (2016 prices)
Low	£55 million	£200 million
Medium	£75 million	£270 million
High	£94 million	£340 million

The impact of closures and three years of disruption to businesses directly impacted on the overground corridors can only be illustrative until businesses are consulted. However more investigations can be undertaken to inform the business case as the study progresses.

Table 6.30 below presents a summary of the performance of individual lines for underground (three technology solutions) and overground options.

[41] Disruption to business: low = yr 1 - 50%, yr 2 - 50%, yr 3 - 50%; medium = yr 1 - 50%, yr 2 - 75%, yr 3 - 75%; and high = yr 1 - 50%, yr 2 - 100%, yr 3 - 100%.

FINAL DRAFT

Table 6.30: Mass transit appraisal summary by line

System	Value (£m PV)	1: South	2: North	3: North East	4: South East
Underground Light Rail	PVB	£1,059m	£694m	£773m	£720m
	PVC	£766m	£1,221m	£723m	£543
	VfM Category	Low	Poor	Low	Low
Underground Tram	PVB	£1,059m	£694m	£773m	£720m
	PVC	£757m	£1,214m	£717m	£539
	VfM Category	Low	Poor	Low	Low
Underground BRT	PVB	£1,059m	£694m	£773m	£720m
	PVC	£622m	£1,100m	£627m	£475m
	VfM Category	Medium	Poor	Low	Medium
Overground BRT	PVB	£156m	£128m	-	£103m
	PVC	£150m	£87m	-	£32m
	VfM Category	Low	Low		High

6.6.4 Wider Economic Benefits

Wider Economic Benefits occur where changes in transport costs deliver additional productivity benefits over and above those captured within the 'conventional' transport user benefits. These benefits may include:

- Static clustering (agglomeration);
- Labour supply impacts; and
- Output change in imperfectly competitive markets.

Static Clustering (Agglomeration)

Agglomeration benefits quantify productivity changes that result from increased clustering of business activity, and better matching between business needs and skills availability. Agglomeration-based productivity benefits are likely to be experienced in a transport scheme which brings economic centres closer together. The mass transit system is likely to improve the connectivity between, and across, key corridors and Bristol City Centre, significantly increasing the overall level of 'effective density' – the measure of agglomeration.

Labour Supply Impacts

Based upon the scheme options developed, and the potential for improved public transport along the scheme corridor, there is potential for the scheme to reduce the journey costs associated with travelling to work, improve the financial return to individuals from employment, and hence increase the overall supply of labour within the local economies along the corridor.

Imperfectly Competitive Markets

Imperfect competition benefits quantify the increase/decrease in output by firms resulting from changes in transport costs. They represent the welfare gain achieved as consumers' willingness to pay for the increased output will exceed that of producing it. Imperfect competition benefits are estimated as a fraction of the total business users time savings and therefore are likely to be significant where a scheme demonstrates significant time savings to users.

FINAL DRAFT

Mass Transit Wider Economic Benefits Estimates

Based on previous experience in similar schemes, it has been considered that the total of the three Wider Economic Impacts presented above would deliver an additional 40% of the 'conventional' benefits.

For the 'base' case, the Present Value of Benefits was £3.2bn and £0.4bn in 2010 values for underground and overground respectively. The Present Value of Benefits including the Wider Economic Benefits would amount to £4.5bn for underground and £0.8bn for overground.

Table 6.31: Appraisal Summary including Wider Economic Impacts (WEI) for all systems (£m, 2010 values and prices)

Appraisal Category	Underground Light Rail	Underground Tram	Underground BRT	Overground BRT
Present Value of Benefits (PVB)	£3,247m	£3,247m	£3,247m	£387m
Present Value of Benefits (PVB) including WEI	£4,546m	£4,546m	£4,546m	£542m
Present Value of Costs (PVC)	£3,373m	£3,326m	£2,888m	£268m
Net Present Value (NPV) incl. WEI	£1,173m	£1,220m	£1,658m	£274m
VfM category	**Low**	**Low**	**Medium**	**High**

When wider economic impacts are considered, the 'base' case underground (light rail and tram) options increase from poor VfM to low VfM, and underground (BRT) increases from low VfM to medium VfM. The overground option continues to be slightly better Value for Money, this is mainly driven by lower capital costs. However, it is recommended that more modelling and investigation of the differential benefits/disbenefits is undertaken as these proposals progress. Depending on the system selected, there are likely to be further impacts to the VfM of a less transformational option with more impacts during construction and operation.

Table 6.32 below presents a summary of the performance of individual lines for underground (three technology solutions) and overground options.

Table 6.32: Mass transit appraisal summary by line (including WEI)

System	Value (£m PV)	1: South	2: North	3: North East	4: South East
Underground Light Rail	PVB (inc. WEI)	£1,483m	£972m	£1,082m	£1,009m
	PVC	£766m	£1,221m	£723m	£543m
	VfM Category (inc. WEI)	Medium	Poor	Medium	Medium
Underground Tram	PVB (inc. WEI)	£1,483m	£972m	£1,082m	£1,009m
	PVC	£757m	£1,214m	£717m	£539m
	VfM Category (inc. WEI)	Medium	Poor	Medium	Medium
Underground BRT	PVB (inc. WEI)	£1,483m	£972m	£1,082m	£1,009m
	PVC	£622m	£1,100m	£627m	£475m
	VfM Category (inc. WEI)	High	Poor	Medium	High
Overground BRT	PVB (inc. WEI)	£219m	£179m	-	£144m
	PVC	£150m	£86m	-	£32m
	VfM Category (inc. WEI)	Medium	High		V High

FINAL DRAFT

6.6.5 Central, high and low scenarios

In order to account for the sensitivity tests undertaken as part of the generated over and above the 'base' case, these have been used to inform scenarios in order to show the potential range of the economic appraisal.

Previous sensitivity tests show that underground demand can range between 36 and 55 million annual passengers around the 'base' case, for which underground has 42.3 million passengers. For overground, it has been considered that demand can range between 19 and 26 million passengers around the 'base' case, which is 20.7 million passengers. Table 6.33 below outlines this comparison.

Table 6.33: Mass transit appraisal – low and high scenarios

System	Value (£m PV)	'Base' Scenario	Low Scenario	High Scenario
Underground Light Rail	Demand (m)	42.3m	36.4m	55.1m
	PVB incl. WEI	£4,546m	£3,904m	£5,917m
	PVC	£3,373m	£3,570m	£2,953m
	VfM category (incl. WEI)	Low	Low	High
Underground Tram	Demand (m)	42.3m	36.4m	55.1m
	PVB incl. WEI	£4,546m	£3,904m	£5,917m
	PVC	£3,326m	£3,523m	£2,905m
	VfM category (incl. WEI)	Low	Low	High
Underground BRT	Demand (m)	42.3m	36.4m	55.1m
	PVB incl. WEI	£4,546m	£3,904m	£5,917m
	PVC	£2,888m	£3,085m	£2,468m
	VfM category (incl. WEI)	Medium	Low	High
Overground BRT	Demand (m)	20.7m	19.1m	25.4m
	PVB incl. WEI	£542m	£499m	£664m
	PVC	£269m	£320m	£121m
	VfM category (incl. WEI)	High	Medium	V High

For underground scenarios, the VfM range between low and high, showing that the cases are comparatively robust and can provide even better Value for Money under an aspirational scenario. Equally, the overground scenario are also moderately robust and provide resilient VfM.

It should be noted that these results are preliminary and based on a number of assumptions, where slight variations to these assumptions could impact the VfM categorisation. Further, more detailed work would be required to develop the economic case to a greater level of detail to provide a more robust VfM assessment.

FINAL DRAFT

6.6.6 Additionality Benefits

In addition to the standard benefits and wider economic impacts, the mass transit scheme would be transformational to the Greater Bristol region. Amongst other economic impacts, this would mean an increase in the number of jobs located in the region, which could be reflected as a move to more productive jobs.

The 'move to more productive jobs' measures the productivity benefits of existing workers being able to move into more productive forms of employment as a result of a transport investment. Measuring this would involve analysing where workers are located and how productive they would be with and without the transport investment. This would represent the net increase in productivity for the whole of the UK.

The Department for Transport advise that the base case should assume that there are no net improvements in jobs productivity in the UK, but sensitivity scenarios may be undertaken on this.

An initial estimate has been calculated for the increase in productivity generated by the additional jobs induced in Bristol. The average[42] Gross Value Added (GVA) per worker in the region is £50,750 (nominal, 2016, 'smoothed').

Based on the approach presented earlier in this chapter, it has been estimated that around 26,200 jobs would materialise in the region (but not necessarily being a net increase in jobs). The GVA per worker figure has then been applied to this number of jobs, expressed in 2010 prices over 60 years, and discounted to calculate the increase in productivity linked to this increase in jobs in the Greater Bristol area.

The economic principles behind the move to more productive jobs states that it needs to be proven that the increase in jobs is both dependent on the transport intervention ('dependency') and that the uplift in GVA in net additional to the UK economy ('additionality').

Since no specific modelling has been carried out at this stage of the study to quantify this, a number of sensitivity scenarios have been tested on both dimensions to understand the likely scale of these benefits and expressed the results as a proportion of standard benefits.

Figure 6.16 presents the proportion that productivity benefits represent for three dependency scenarios and three additionality scenarios.

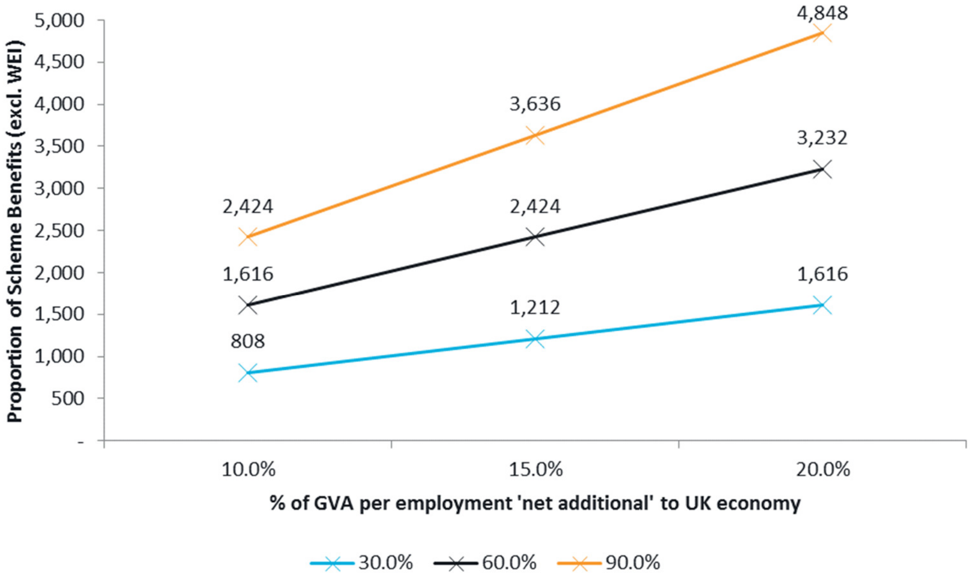

Figure 6.16: Productivity benefits relative to scheme standard benefits

[42] This average is considered appropriate for the purposes of providing the likely increase in productivity linked to the scheme, given the level of detail presented in the analysis.

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This proportion ranges from around 28% to 165% of standard benefits. It is likely that the mass transit system will have the potential to unlock a significant number of dwellings and jobs, which could result in the expectation of a high dependency proportion. However, it is difficult to prove that this scheme, as many others, will create a significant number of net additional GVA to the UK economy.

In a scenario where there is a high dependency and a medium additionality, the VfM would increase to represent a High Value for Money category for the underground options; however, these results would merit from further scrutiny at a later stage of the project.

6.6.7 Summary

The following table summarises the key comparators for the short-listed options outlined in this chapter, with regards to demand, development unlocked, impacts and value for money.

FINAL DRAFT

Indicator			Underground (light-rail)	Underground (tram)	Underground (BRT)	Overground (BRT)
Demand	Annual 'initial' (no development)		38.8m			19.9m
	Annual 'base'		42.3m			20.7m
	Annual 'base' with sensitivities		54.7m			25.2m
	Annual 'base' with high optimism scenario		63.0m			25.2m[43]
Development and jobs unlocked	Housing	'base'	31,000			15,500
		aspirational	43,000			21,500
		high optimism (inc. indirect)	c.61,000			21,500
	Land value uplift[44]	'base'	£480m			£240m
		aspirational	£668m			£334m
		high optimism	£868m			£334m
	Jobs	'base'	26,000			13,000
		aspirational	52,500			26,000
		high optimism (inc. indirect)	c.65,000			26,000
	GVA[45]	'base'	£5bn			£2.5bn
		aspirational	£10bn			£5bn
		high optimism	£11bn			£5bn
Impacts of construction	Third party land impacted		Stations and portals to be located in places to avoid impact on dwellings, where reasonably practicable			Indicative Medium - high (200-350 properties)
	Indicative impact to businesses (loss of GVA/turnover) directly affected on corridors		Limited adverse impact on corridors, predominantly in vicinity of stations, vent shafts and portals.			Significant adverse impact on corridors, indicative three-year impact: GVA – c. £55-94 million, Turnover – c. £200-340 million
	Impact to existing transport network		Limited adverse impact on highways during construction, predominately impacts due to construction traffic (HGVs) and removal of excavated materials Bus network management likely required Induced rail demand			Reallocation/partial closure of three key arterial routes into Bristol c. 80 permanent and 20 partial local road closures Bus network management likely required Segregated pedestrian and cycle provision along alignments
	Public Realm/sense of place		Limited impact on high streets and local community during construction. Potential for redevelopment around station locations, including public realm enhancements			Significant impact on high streets and local community during construction, including removal of on-street parking Potential for redevelopment on corridors, public realm enhancements etc.
	Deliverability		Impacts of construction need to be developed further – local impacts			Impacts of construction need to be developed further - local impacts
	Public acceptability		Cost is likely to be a factor in public acceptance of the system, particularly if local taxation is identified to part-fund. However construction and operational impacts are not likely to unacceptable to the wider public.			Although a lower capital cost option than underground, the construction and operational impacts on the existing highway network, along with demolitions required to implement the system are likely to be unacceptable to those directly impacted as well as the wider public.
Capital Cost			£4.75bn	£4.75bn	£4.62bn	£0.78bn
VfM 'base'			**Poor**	**Poor**	**Low**	**Low**
VfM with WEI			**Low**	**Low**	**Medium**	**High**

Table 6.34: Summary of comparators for short-listed options

43 Overground is unlikely to have the level of transformational impact as an underground system, due to the constraints of an above ground network predominantly utilising existing alignments. Therefore the 'high optimism' scenario has not been included for the overground option, with the sensitivities scenario reported.

44 Land value uplifts reflect the number of dwellings enabled by mass transit – given the need for wider investment in other infrastructure to unlock the housing, it would be wrong to attribute all the dwellings to the mass transit system. However, it is clear that without the mass transit investment it will not be possible to unlock this development, therefore it has been considered as gross value uplift for mass transit enabled development, but we recognise that further infrastructure would be needed,

45 GVA impacts reflect the number of jobs enabled by mass transit – given the need for wider investment in other infrastructure to unlock the jobs, it would be wrong to attribute all the jobs to the mass transit system. However, it is clear that without the mass transit investment it will not be possible to unlock these jobs.

FINAL DRAFT

6.7 Conclusions and next steps

This chapter outlines the development of the short-listed options, including demand forecasting, concept design and costings, as well as their assessment, in terms of likely revenue, benefits and the economic appraisal of mass transit system options.

Due to the high-level nature of this feasibility study, sensitivities have been undertaken in terms of demand and economic appraisal to appreciate the range of scenarios and associated assumptions, to demonstrate the potential for a mass transit system in Greater Bristol and provide comparison between overground and underground options.

All of the base case underground and overground options have a poor-low VfM, however this increases to low-medium VfM for underground with wider economic benefit considerations and could further increase to high VfM with consideration of additionality benefits resulting from such a transformative change in public transport provision.

The overground option has a better VfM than underground currently, which is mainly driven by lower capital costs, high-level consideration has been given to the wider impacts of construction and operation on the highway network. However consideration of construction impacts, in terms of loss of GVA to the local economy, has not been included, which could be considerable.

Next steps include further modelling to inform demand forecasting and benefits assessment, along with more detailed consideration of wider economic impacts, particularly of construction and enhanced development opportunities.

FINAL DRAFT

7 Funding/Financial Case

7.1 Introduction

Unlike the Economic Case, which focuses on welfare benefits to society, the Financial Case focuses on the costs and revenues associated with the project and their impact on government accounts. However, like the Economic Case, the Financial Case is cognisant of the Strategic Case objectives - the financial impact of a mass transit system should be considered in the context of the benefits and value it realises for the region.

An important question in developing and implementing a large-scale transport infrastructure scheme is identifying how it can be funded. This is particularly important given the wider economic and political environment of a reduced public-sector funding leading to the end of an era where UK central government grant funding would be made available provided the proposed scheme had a strong case and was technically feasible. There is now a clear expectation that a large proportion of funding for major transport investment should be secured from local sources, whereby the funding strategy seeks to capture part of the value from the investment that accrues to a range of beneficiaries.

In addition, a robust funding strategy for large-scale transport infrastructure schemes should consider finding ways of capturing the uplift in benefits enabled by the scheme as this can reduce reliance on public sector funding. For instance, a mass transit network in Bristol will help increase land values, a proportion of which could, through the use of an appropriate funding mechanism, be retained by the public sector to help pay for the initial infrastructure costs (e.g. by providing a revenue stream that supports borrowing). This approach to funding is particularly pertinent in the West of England region given the ambitious growth aspirations of the area.

Capturing these benefits to generate funding for transport infrastructure can be achieved by developing an appropriate funding package that utilises the powers available to local authorities and combined authorities. For instance, land value or benefit uplifts could be captured through introducing tax supplements on businesses or residents and ring-fencing direct development taxes.

This chapter therefore focuses on the range of alternative funding options that are available to the Combined Authority and local authorities to support the capital costs of mass transit should they be implemented. An outline of additional funding sources to be examined as part of future work to generate further funding is also provided. Appendix F provides further information on funding and financing options.

Funding vs. Financing

It is important to distinguish the difference between funding and financing. Funding refers to what capital ultimately pays for the up-front costs of the scheme i.e. it does not need to be directly repaid. Financing refers to how the capital requirements of the scheme are met through sources that are repaid over time. Financing is generally required for a project if funding is insufficient to cover a project full costs during construction. For instance, a loan (financing) may be used to meet the upfront capital costs of the project which is then repaid over time through surplus passenger revenue (funding). Financing costs (e.g. interest payments) will be payable on financing sources which increases the costs to deliver the project and therefore the funding requirement of the project.

Policy context

Public investment in the UK is more dependent than ever on finding sufficient additional funding and increasingly the ability to raise income locally is determining whether a scheme is taken forward or not. As central government funding has become increasingly constrained, it has become rarer for infrastructure projects to be publicly funded based on the economic, social or environmental benefits it generates. In addition, devolution has focused decision making on seeking to find local beneficiaries of investment.

FINAL DRAFT

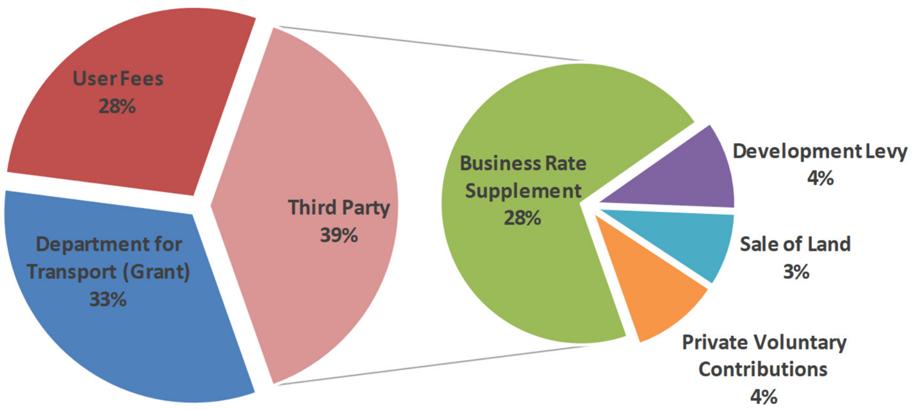
Crossrail 1 is seen as setting the benchmark for establishing the case for public investment in transformative transport infrastructure and, in particular, identifying and securing an alternative funding package. These include the following broad principles:

- At least 50% of funding required to deliver a transport infrastructure project is from local sources;
- That the project should be able to cover its longer run operating, maintenance and ideally renewal costs;
- That a mix of local funding can be secured, supported by local businesses, developers and users; and
- That the wider economic benefits of the project are significant and that increased taxes can help recover any central government outlay (particularly through increased productivity, generating additional and higher paying jobs).

Crossrail

Crossrail is Europe's largest transport project, delivering a new 21km underground urban railway and connections to the existing UK national rail network, increasing capacity of London's transport network by 10% along with transforming the city-region's connectivity.

One of the biggest challenges was developing a robust funding strategy for the £15bn project and securing its approval. Crossrail is being funded by a range of income streams, many of which have never been used before, including a business rate supplement and development levies across London. Analysis was undertaken to make the case for investment in Crossrail and the value generated, for example by assessing how local businesses will see increased activity resulting from Crossrail's opening. This was critical in securing support from stakeholders to introduce the new income streams representing over 2/3 of total funding.



The Challenge

The focus of this Financial Case is to identify a selection of potential funding sources that could be utilised to meet the capital cost of the mass transit system. The capital cost (including rolling stock) has been estimated at £780m for an overground Bus/BRT solution along three corridors, and between £3.85bn - £4.75bn for an underground solution along three or four corridors where the range is based on the choice of technology of bus/BRT, DLR or tram. All values are in (2018/19, real prices) and further details on capital cost elements are set out in Chapter 6.

The total capex (engineering plus rolling stock) are listed below:

- Bus/BRT (3 corridors) - £0.78bn
- Underground (3 corridors – DLR/Tram) - £3.85bn
- Underground (4 corridors – Bus/BRT) –£4.62bn
- Underground (4 corridors – DLR/Tram) –£4.75bn

7.2 Funding

As noted in the introduction, a robust funding strategy for large-scale transport infrastructure schemes should look to reduce reliance on the public funding and seek local sources of funding.

7.2.1 Beneficiary pays

A key concept in our assessment of local alternative funding sources is the concept of 'beneficiary pays'. This concept is based on the principle that those who benefit from the improvement in transport should contribute to its cost. Beneficiaries include direct users of the development, such as passengers and economic beneficiaries. These are people or organisations who obtain increased economic benefit either in capital or revenue terms from the improved transport provision.

This approach creates an invest cycle where transport infrastructure generates benefits to a series of beneficiaries and funding mechanisms then capture a proportion of these benefits to invest into transport. Figure 7.1 outlines this process.

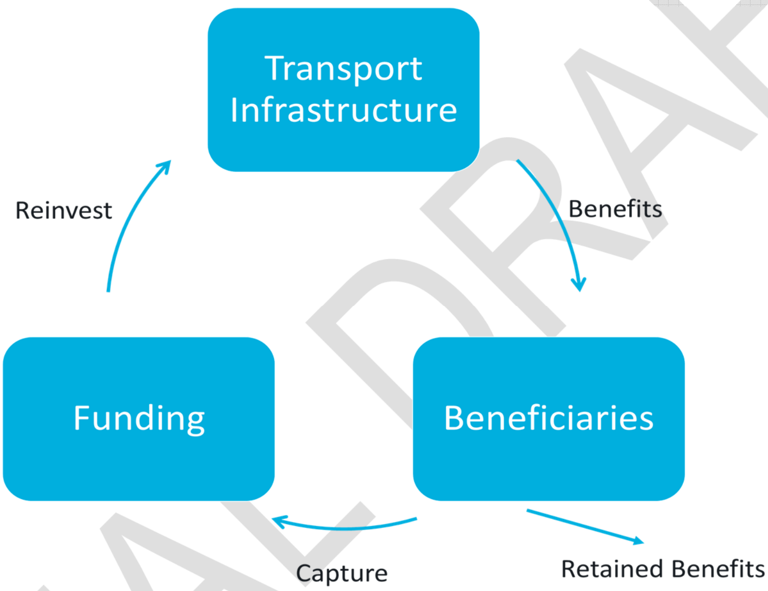


Figure 7.1: Beneficiary pays cycle

A step-change improvement in transport accessibility, connectivity and capacity can result in a range of beneficiaries, whether it is passengers who benefit from the improvement in service or developers who benefit from increased land values near the stations. An overview of the potential beneficiaries of the mass transit options in Bristol is set out below, including how they may benefit from the project. Appendix D contains more information on recent funding cases.

FINAL DRAFT

Table 7.1: Benefactors of transport infrastructure

Benefactor	How they benefit from transport
Businesses/ Workers	They benefit from the improved mobility through agglomeration as greater productivity and lower costs arise from the concentration of economic activity. The increased concentration has a productivity 'bonus' that is shared between businesses and workers that can lead to increased revenues and/or reduced costs. In addition, businesses can benefit from being able to draw from a wider pool of prospective employees who can more easily access their business.
Residents	They benefit from the improved mobility through better connectivity and increased mobility and (if they own their property) through the uplift in land values.
Developers and land owners	They benefit from the improved mobility through an increase in land value as more businesses and/or residents look to relocate to the area. This benefit translates into a financial benefit as higher land values can result in higher density developments and/or an increase to rental values and/or sale incomes.
Transport Users	They benefit from the improved mobility through reduced journey times, improved reliability and/or increased frequency. These benefits allow users to access a wider pool of jobs and can lead to productively gains where both may result in financial benefits to the user.
The Road Maintainer	benefits from the improved mobility through reduced road usage as people increasingly travel by public transport, walking or cycling as opposed to by private car. In this instance, it may reduce the need to expand the road network around Cambridge to meet growing demand.

7.2.2 Alternative funding sources

An assessment of the funding potential from alternative funding sources to support a mass transit system has been undertaken and is presented below, where the focus on alternative sources is based on the growing expectation that large infrastructure projects will be partially funded locally. This assessment is to aid the Combined Authority and local authorities in prioritising which mechanisms to pursue as part of future work. As such, this analysis does not present a complete funding plan for the mass transit system but rather a selection of partial funding options to be considered.

Furthermore, this assessment focuses on locally generated funding sources that are primarily achievable with the powers the local authorities have in place. These funding sources could be combined with other funding options such as local or central grant funding or other innovative mechanisms that would likely require new powers to be devolved to the local authorities. These other sources are discussed later in the chapter.

It is important to note that the assessment presents a range of different potential funding sources and does not consider at this stage the economic, environmental and most importantly, political challenges in developing and agreeing a robust funding package. It is also important to note that further investigation of any of the funding sources will be required to better understand the benefits, implications and practicality of securing any funding proposal.

Given the challenges with implementation and likely requirement for political and public support for many of the funding mechanisms below, it is likely that the implementation of these mechanisms would require a transformational change in connectivity to justify the use. As such, the funding mechanisms below are more applicable to an underground solution that leads to more transformational improvement in connectivity. While some of the options outlined in section 7.4 are more applicable to an overground option.

FINAL DRAFT

7.2.3 Approach overview

This section summarises the general approach undertaken to identify a short list of funding options and general assumptions.

Long-list/short-list of funding options

A long list of 20 funding options has been identified for the mass transit options in Bristol and assessed based on: potential contribution, legal deliverability, political deliverability and alignment with beneficiaries. From this assessment, a short list of seven possible funding options has been identified, quantified and combined into several different funding scenarios. The short-listed funding options are shown below.

Table 7.2: Short listed funding options

Funding Mechanism	Beneficiary	Precedent	Description
Business Rate Supplement (BRS)	Businesses	Crossrail	A 2% levy on the rateable value of commercial properties across the geography in scope.
Workplace Parking Levy (WPL)	Businesses and/or Workers	Nottingham	A charge on businesses at key Bristol employment centres based on the number of workplace parking places they provide, at daily rate between £1.50 and £5.00 depending on area and ambition. Note, this is assumed to only be charged once the mass transit system is operational.
Council Tax Precept	Residents	London Olympics	A 2% levy on council tax on dwellings across the geography in scope.
Community Infrastructure Levy	Developers	Across UK	A development levy on residential and commercial developments based on a £ per m^2 basis, introducing rates from Charging Schedules.
New Homes Bonus	Government	Across UK	Grant paid by central government to local councils if they exceed the national baseline for the housing growth (0.4%). Although it is unclear whether NHB will continue after the 2019 Spending Review it is likely some housing growth incentive will be in place. In light of no better information we have assumed NHB continues into the future.
Shadow toll	Road maintainer	Unused	A reallocation (50% of cost savings) of funding for road enhancements in the surrounding area to support an improvement in public transport.
Local tax retention	Businesses	Northern Line Extension	New developments enabled by the mass transit system will be a subject to local taxes, such as the Business Rates paid by the businesses, or council tax paid by the households. A proportion of those charges, collected by the local authority could be allocated to fund the mass transit on the rationale that these developments would not come forward without such a funding mechanism.

Focus has predominately been given to those funding mechanisms that the local authorities or Combined Authority have the power to implement[46] (i.e. they do not require primary legislation but may need approval from central government). A council tax precept has been included as, although a precept on council tax did not feature in the Devolution Deal, it could be included in a future local agreement or alternatively the growth in council tax could be ring-fenced under current legislation.

A Shadow toll mechanism has been included for the ambitious scenarios. Improving the supply and quality of public transport systems in Bristol will support a modal shift from road to public transport. If fewer A-road and/or motorway upgrades are required, the introduction of a mass transit system in the

[46] Note, this may be subject to approval with other parties e.g. a Business Rate Supplement and the Local Enterprise Partnership.

FINAL DRAFT

West of England effectively enables future road enhancements and maintenance cost saving for Highways England. Highways England or local authorities could potentially reallocate funding for road enhancements in the surrounding area to support an improvement in public transport.

Local tax retention has also been included. Under this model, this mechanism would not result in additional charges to land owners/developers in the area but would instead ring-fence tax receipts. Since these developments rely on the improvements to the transport network, and as such would not come-forward (nor would the tax receipts) without them, the contribution towards the mass transit scheme would be justifiable. The analysis of this source focuses on business rates with a top slice of council tax of 10% from new developments enabled by mass transit. An agreement of this funding source would be dependent on central government approval and potentially with local businesses and as such consultation to ascertain whether there is appetite for such a mechanism is recommended in future work.

Note, some of the funding options above target the same beneficiary (e.g. a WPL and a BRS) and, as such, are therefore unlikely to be introduced together to prevent overcharging a single beneficiary group. The selection of the short-listed funding options above are arranged into several funding scenarios as presented later in this chapter.

Geographic Assumptions

The analysis assumes the funding mechanisms are introduced in each of the local authorities of the West of England Combined Authority (consisting of Bristol, Bath and North-East Somerset and South Gloucestershire) and North Somerset authority as these authorities primarily benefit from the mass transit options.

- The analysis also assumes that certain funding mechanisms could be targeted to developments that are enabled by a mass transit system, for example, retaining the full proportion of development levies raised within a specific boundary.

Development Assumptions

A key driver of the funding potential is the forecast residential and commercial development within Bristol and the surrounding area. We have split this into ‘underlying growth’ which accounts for growth in the area which is not directly dependant on the mass transit system and ‘mass transit enabled growth’ which accounts for development directly enabled by the mass transit system.

Commercial and Residential Developments – Underlying Growth

The basis for the residential development estimates is the Joint Spatial Plan 2017, where we have used the forecasted housing growth over the period of 2016-2036 and calculated the average growth per year and extrapolated to cover a 30-year period. For commercial developments, we have used the West of England Economic Development Needs Assessment 2015, with the minimum between demand and supply forecasted per annum for each local authority used.

Commercial and residential developments – mass transit enabled

The improved connectivity due to the delivery of the mass transit system could support greater density developments in the area surrounding Bristol and could enable certain large greenfield/brownfield developments to come forward. The development enabled by the mass transit system are based on two development scenarios for residential and commercial growth at the transport-enabled sites based on analysis undertaken as part of the demand forecasting. These development scenarios presented assume an underground solution is introduced based on the rationale that the implementation of the alternative funding sources would be contingent on a transformational connectivity improvement.

FINAL DRAFT

A core and an aspirational development scenario have been modelled, based on the same methodology used for demand forecasting[47]. The potential for development, the uplift percentages for employment and houses are detailed in the table below. It should be noted that the growth in dwellings include 23 000 dwellings which are estimated from four brownfield/greenfield sites, which have been identified to have significant potential for new or further densified developments.

Table 7.3 Uplifts percentages in the two scenarios for employment and houses

Employment/Homes	Core	Aspirational
High	25%	40%
Medium	10%	20%
Low	-	-

The commercial floorspace has been calculated assuming 11m^2 per employee, as in the development scenarios for West of England.

Table 7.4: Sites development scenarios

	Growth in residential dwellings (over ten years)	Growth in number of jobs (over ten years)	Growth in Commercial floor space (m2)
'Base'	31 000	26 000	286 000
Aspirational	43 000	52 000	572 000

In these developments scenarios, it has been assumed that developments are completed over a period of ten years, between year 2028 and 2038 assuming a 2030 opening of the mass transit system. Currently working assumptions are that the number of houses built and the number of jobs created will be equal each year. It is expected that this assumption will be further refined in future analysis.

Funding estimates are all provided in real 2018/19 terms and over a 30-year period. The annual growth rates used in the funding calculations have been assumed to grow in line with inflation.

FINAL DRAFT

[47] See section 6 of this report for detailed methodology

Manchester Metrolink

The Metrolink 'Big Bang' expansion includes a £1.5bn Metrolink investment programme which will triple the size of the network. The extent of the project will help reduce congestion levels, with an estimated five million fewer cars on the road network, increasing public transport trips per day from 55 000 to more than 90 000.

The project's successful delivery is highly attributable to Greater Manchester Combined Authority (GMCA) and their ability to resource innovative funding sources following the rejection of a new road pricing scheme by public referendum.

The ten councils worked together to generate funding through a series of authority-wide mechanisms and agreed a prioritisation of schemes to fund based on the GVA and employment growth potential and overall cost across the authority.

The Metrolink extension is part of the transformational growth project which is seeing major investment, including bus priority measures, six new and better cycle routes into the city centre and major rail improvements, all of these align with the GMCA vision of become a self-reliant city-region.

FINAL DRAFT

7.2.4 Funding Scenarios

An effective funding strategy for the mass transit options in West of England should look to target the beneficiaries of the scheme where the funding contribution by beneficiary should aim to be proportional to the benefits received. With this context, the short-listed funding options have been arranged into a series of funding scenarios that aim to target each beneficiaries of the scheme without overcharging an individual beneficiary. The funding scenarios are summarised below:

Table 7.5: Summary of funding scenarios

Scenario	Period of Funding	Development Scenario- Sites	WPL Charging Scenario	Funding Source Included?						
				BRS	WPL [48]	CTP	CIL	NHB	SHT	LTR
Local funding	30 years	'Base	Central	×	✓	✓	✓	✓	×	×
Local funding - alternative	30 years	'Base'	n/a	✓	×	✓	✓	✓	×	×
Local funding – ambitious	30 years	Aspirational	Optimistic	×	✓	✓	✓	✓	✓	×
Local Funding - ambitious alternative	30 years	Aspirational	Optimistic	✓	×	✓	✓	✓	✓	×
Local Funding – ambitious +	30 years	Aspirational	n/a	×	×	✓	✓	✓	✓	✓

- **Local funding.** This scenario assumes: a 30-year period; Central development scenario for the transport enabled sites; the central charging structure for WPL; CIL receipts; a council tax precept; and New Homes Bonus funding.
- **Local funding - alternative.** This scenario is an alternative central scenario where a Business Rate Supplement is implemented as opposed to a Workplace Parking Levy. Both of these funding options target businesses and as such are unlikely to be implemented alongside each other to prevent a single beneficiary being charged twice.
- **Local funding – ambitious.** This scenario includes all the mechanisms from the Local funding scenario including a shadow toll. It also assumes the High development scenario for the mass transit system enabled development and an 'Optimistic' option for the WPL charge.
- **Local Funding - ambitious alternative.** This scenario is an alternative ambitious scenario where a Business Rate Supplement is implemented as opposed to a Workplace Parking Levy. A very high development forecast for the mass transit system enabled developments is used.
- **Local Funding - ambitious +.** This scenario is the optimistic scenario which includes the local tax retention as well as all the other funding sources except Business Rate Supplement and Workplace Parking Levy.

7.2.5 Funding results

The five funding scenarios presented below result in a funding potential between £1000m and £2100m (real 2018/19) over a 30-year period starting in year 2019. The total funding pots available for each scenario are shown in Table 7.6. Note, inflation has not been applied to these figures.

Table 7.6: Funding potential of different scenarios

Scenario	Funding potential (£m 2018/19, real)
Local funding	1,057
Local funding - alternative	1,259
Local funding – ambitious	1,737
Local funding - ambitious alternative	1,703
Local funding – ambitious +	2,102

[48] Note, WPL is assumed to be introduced aligned with the opening of West of England mass transit.

FINAL DRAFT

The contribution of each funding mechanisms towards the total funding available in each scenario is shown in Table 7.7 and Figure 7.2.

Table 7.7: Funding contribution by source and funding scenario rounded to nearest £5m)

Potential Funding; £m; Real 2018/19	Local funding	Local funding - alternative	Local funding - ambitious	Local funding – ambitious alternative	Local funding – ambitious +
Workplace Parking Levy	290	-	540	-	-
Business Rate Supplement	-	490	-	505	-
Council Tax Precept	390	390	395	395	395
Community Infrastructure Levy	160	160	205	205	205
New Homes Bonus	210	210	280	280	280
Shadow toll	-	-	320	320	320
Local tax retention	-	-	-	-	900
Total	**1,060**	**1,260**	**1,740**	**1,705**	**2,100**

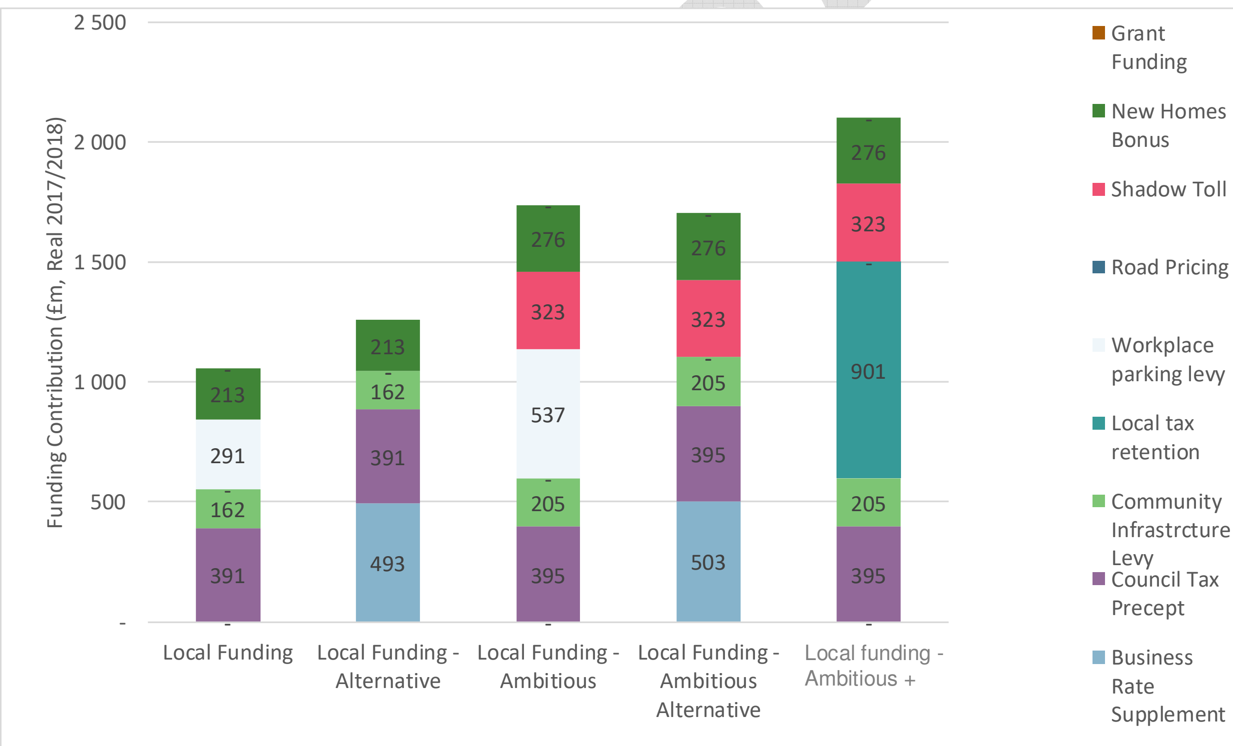


Figure 7.2: Funding contribution by source and funding scenario; £m; Real 18/19

Note, figures are in Real 2018/19 prices (i.e. undiscounted and current) and due to financing costs, they cannot be directly compared to scheme costs.

These figures show that local funding could generate up to £2.1bn for a mass transit system against which financing could be secured. This is a significant amount of funding; however it highlights that additional funding would likely be needed for at least 50% of the mass transit capital costs for the underground (3 and 4 corridors) options, particularly once financing is considered. Furthermore, it should be noted that implementing any of these funding mechanisms would be challenging and require support (and often approval) from local stakeholders.

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7.3 Financing

7.3.1 The need for financing

The first ten years of the mass transit project may require between £0.78bn to £4.75bn of capital investment dependent on the chosen scheme while many of the funding options outlined above will generate funding over a longer period e.g. 30 years. This disparity between the capital cost and the funding during the initial years of the project can be met by financing where for instance, debt is secured against future funding receipts in the same way that a mortgage is secured to finance the purchase of a home. An illustration of this is provided in Figure 7.3 which highlights a negative cashflow in the initial years.

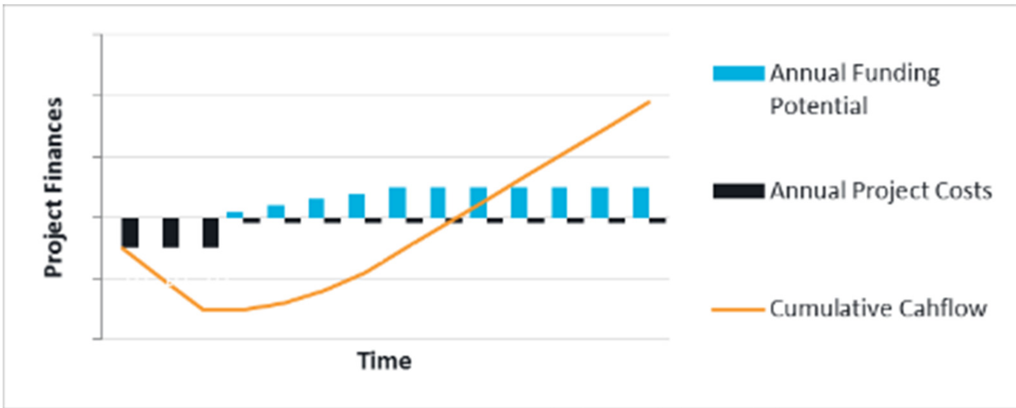
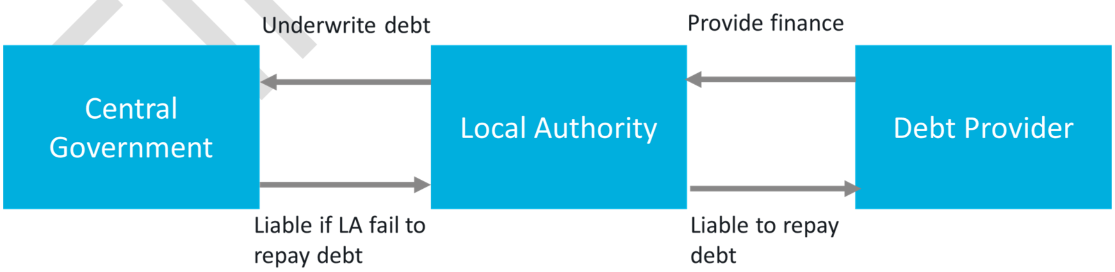


Figure 7.3: Illustrative Example of Project Finances

Interest payments would be payable on finance where the interest rate for debt that the Combined Authority could achieve depends on the arrangement and source.

Servicing finance through interest ultimately reduces the capital costs that a funding option could support. Based on a loan term of 30 years and PWLB rates, circa one third of the funding potential from sources over time would be needed to meet debt service charges. If private finance was to be used to cover the funding gap as opposed to the PWLB, the interest rate would be significantly higher and the extra interest payments would have to be accounted for.

Irrespective of the source it is important to note that any financing secured by a local authority (e.g. the Combined Authority), including commercial debt, is effectively underwritten by central government and so will impact the central public balance sheet.



FINAL DRAFT

7.3.2 Financing assumptions

Interest rate and loan assumptions

The interest rate for debt that the local or combined authority could achieve depends on the arrangement and source of the loan.

In the analysis, it has been assumed that finance from the Public Works Loan Board (PWLB), which provides debt financing options to public bodies from the central government National Loans Fund. The interest rate for an annual repayment loan over 30 years from the PWLB, which stands at 2.80% (published in October 2018) has been used.

Note it has been assumed that variable interest and principal repayments in line with funding receipts and therefore, each scenario will result in a different borrowing capacity. This is a simplifying assumption as the repayment profile of the debt is more likely to be set at the start of the loan however for a WECA SOBC this is seen to be a reasonable assumption.

The inflation rate applied to the capital cost is based on the Faithful & Gould construction forecast and has been set at 3.40%. The funding income is expected to grow in line with RPI which has been set at 2.90% (RPIX UK forecast, Office of Budget Responsibility). The combination of these factors suggests a real increase in costs over time at a rate of 0.5% per annum.

Financing results

It has been assumed that each year the loan repayments (principal and interest) will be equal to the amount of funding collected via the chosen funding mechanisms. Figure 7.4 shows the total loan possible under each scenario and the breakdown of the loan into the principal and interest where the principal is the amount of finance available in each scenario to cover capital costs. The increase in the principal loan compared to the Local Funding scenario, is 20%, 65%, 63% and 98% for the Local Funding – alternative, Local Funding – ambitious, Local Funding – ambitious alternative and Local Funding – ambitious + scenario, respectively

Note, the total figures differ from Figure 7.2 as these values are in nominal prices (i.e. include inflation). The Underground DLR/Tram (4 corridors) option has been used to illustrate the capital costs.

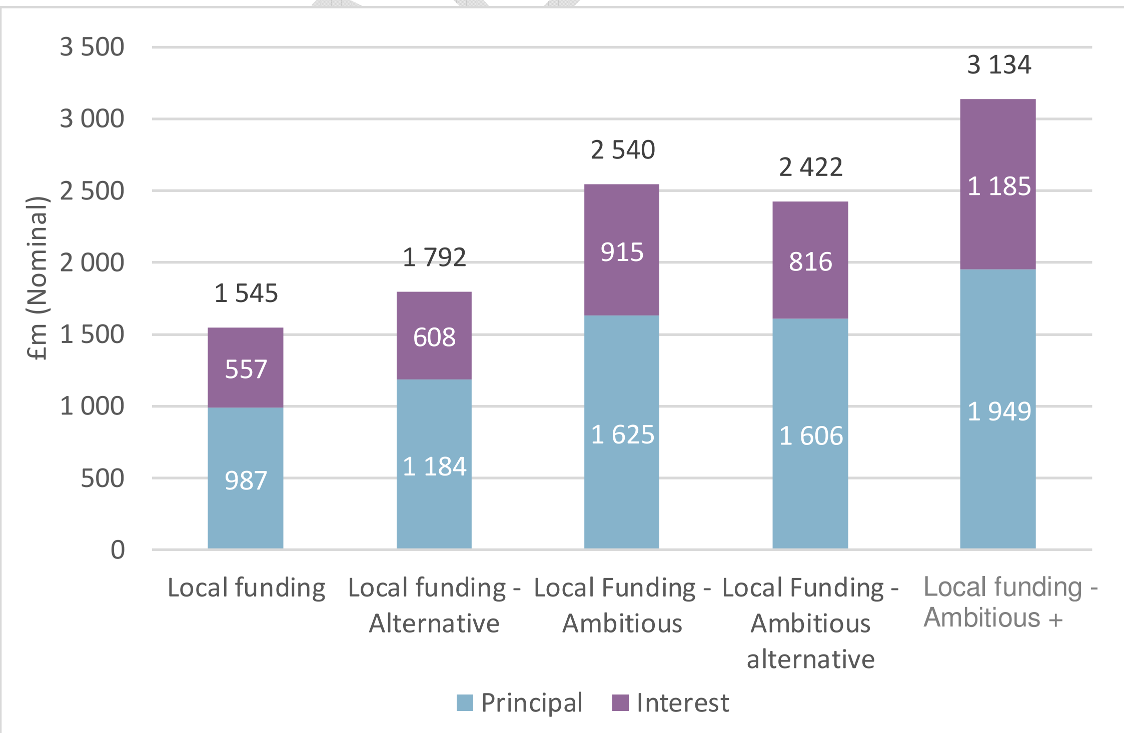


Figure 7.4: Loan cost breakdown for each Scenario; £m; Nominal

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The above shows the interest payments are circa one third of the total debt repayments and as such circa two thirds of the funding potential in each scenario can be used to cover capital costs of the mass transit system.

The Local Funding – ambitious + scenario allows for the largest loan as it generates the greatest amount of funding. However, it also leads to the highest interest payments due to the higher initial value of the loan. The higher interest costs, effectively increase the total costs to deliver the mass transit project as these costs are in addition to the capital costs. For instance, under the 'Local Funding – ambitious +' scenario and based on the interest payments of £1,185 outlined above, the cost to deliver the project would increase by 18%.[49] While the overall value of the cost is higher, the total funding gap (costs less local generated funding) will decrease with the increasing funding potential of the local generated funding.

7.3.3 Scenario cashflows and the funding 'gap'

The analysis specifies the funding 'gap' as the difference between the total capital cost (incl. financing) and the amount of local generated funding. The funding gap for the scenarios is shown in Figure 7.5. The underground DLR/Tram (4 corridors) option has been used to illustrate the capital costs where this would vary under the other scheme options.

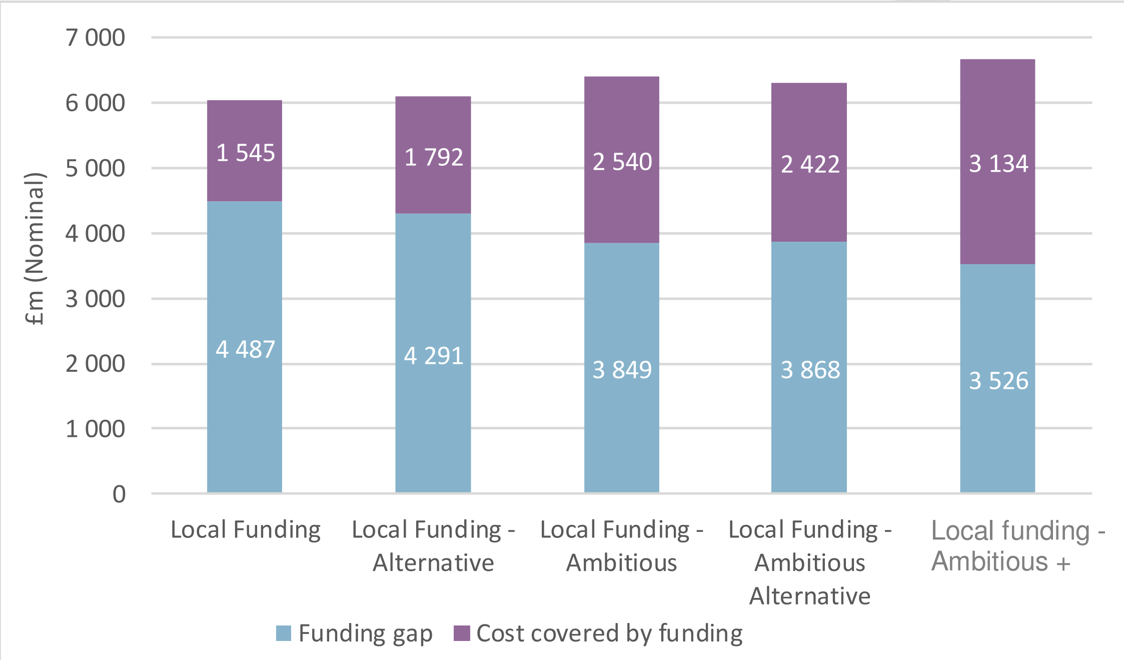

Figure 7.5: Funding amount and funding gap for each Scenario; £m; Nominal

As discussed earlier in this section, a larger proportion of local generated funding leads to a higher interest expenses, which can in turn increase the overall cost of the project. However, as it can be seen in Figure 7.5, while the overall cost increases with a greater proportion of local generated funding, the funding gap decreases. Effectively, the proportion of the project cost covered by the funding mechanism increases, as shown in Table 7.8.

[49] If private finance was to be used to cover the funding gap as opposed to the PWLB, the interest rate would be significantly higher and the extra interest payments would have to be accounted for.

Table 7.8: Funding gap in different scenarios

Scenario	Proportion of the total cost covered by funding mechanisms	Funding gap value (£m, Nominal)	Decrease in funding gap value compared to the Local Funding scenario
Local funding	26 %	4,487	-
Local funding - alternative	29%	4,291	3%
Local funding – ambitious	40%	3,849	14 %
Local funding – ambitious alternative	39 %	3,868	13%
Local funding - ambitious +	47%	3,526	21%

7.4 Closing the Funding Gap

As illustrated above, in every local generated funding scenario the funding potential is not large enough to cover the capital and financing costs of the project. As such, additional funding sources will need be sought out in order to close the funding gap.

There are several options to consider, such as funding from the central government or contributions from organisations which will directly benefit from mass transit enabled development, such as, large developments which will benefit from improved connectivity.

The sources outlined below are would be applicable to either an overground or underground option however the scale of funding possible under each option would vary depending on the chosen option.

As part of the financial analysis consideration has been given to the possible options that may be available to secure additional funding to deliver the mass transit system. It is recommended that further work is necessary to test their feasibility, both economically and politically.

Grant funding

In addition to local funding sources, the mass transit project could apply and receive grant funding from UK central government, such as the Housing Infrastructure Fund (HIF). HIF is a £2.3bn infrastructure fund which the combined authorities are eligible to bid for, provided that the infrastructure development they are proposing is going to unlock housing potential. The first investment round of HIF (2017/18) allocated a total of £866 million to help deliver a total of 200,000 homes which represents an average funding amount of £4,330 per home though there is significant variation across successful bids.

Since mass transit is expected to generate significant amount of new homes and jobs, it would have a high chance of qualifying for such schemes. While the bid period for the HIF has now been closed, a similar scheme would be expected to appear in the near future.

Aside from HIF, there may be other opportunities for grant funding, such as, through future 'deals'.

Direct contributions

There are several examples where major benefactors of a transport improvement have contributed directly to the implementation costs. For instance, the Crossrail funding package included direct contributions from several private companies; Canary Wharf Group contributed £150m to develop the Isle of Dogs station as Crossrail will increase the transport capacity to Canary Wharf supporting expansion of the area. Similarly, another developer, Berkeley Homes, has agreed to support the

FINAL DRAFT

construction of the Crossrail station in Woolwich, which will increase the land value around the station and effectively improving property sales in the area nearby.

Manchester Airport & Trafford Park Shopping Centre have contributed towards the Trafford Park extension of Manchester mass transit link. The extension will grant their customers an easier access to their businesses which should increase their business.

Private companies within Bristol and the wider West of England would see an improved connectivity across the West of England area. Increased accessibility can lead to a wider pool of skilled labour and increase in the quality of life of the employees. Also, customers who are currently discouraged by the lack of accessibility might start visiting customer-orientated business, which in return might see an increase in their market share. Similarly, Bristol Airport and its owners, Ontario Teachers' Pension Plan, would likely see an increase in passenger numbers as accessibility to the airport is improved through the introduction of the mass transit system.

Direct contributions could also be expected from the landowners and / or developers of specific sites that would be more attractive and valuable due to the accessibility provided by mass transit system.

Mayoral CIL/Strategic Infrastructure Tariff

The developer levy, Mayoral CIL was introduced across Greater London to support Crossrail and generated above its £300m target over the first four years of implementation. This is estimated to only be a fraction of the uplift in land values driven by Crossrail which real estate research suggesting the residential and commercial property values around Crossrail stations grew by more than £5.5bn compared to the wider London property market.

The Strategic Infrastructure Tariff proposed by government for Combined Authorities, which would be like a Mayoral CIL, could be introduced across the Combined Authority where the charge could be introduced on only residential developments, commercial developments or both. This would be payable by new developments only (i.e. existing properties are not charged) where this would seek to capture a proportion of the land uplift driven by the mass transit system with the remainder being retained by local developers. If the levy were introduced at a rate of £20 per square metre on only residential developments initial estimates suggest this could raise close to £220m towards the mass transit system development over a 30-year period. There is currently no CIL charges in place across the Combined Authority area.

Premium fares

Another possibility for generating an additional funding is an increase in the user fare. The increase could be applied across all services, or across peak time services only, or to specific trips (e.g. premium at park & ride sites). This has been used to part fund Crossrail and Manchester Tram link extensions. However, striking the right balance between creating funding potential and ensuring the mass transit system is affordable to users would be a key consideration.

Consultation

Many of the shortlisted funding options are subject to support/agreement from public or private bodies. For instance:

- Direct contributions from beneficiaries would need to be negotiated and agreed with each contributor on a case-by-case basis.
- Local tax retention within a defined area would need to be agreed and approved by various levels of government
- For West of England Combined Authority to introduce a council tax levy, powers need to be granted through a government deal with support from the local authorities within the Combined Authority and government; and
- For West of England to introduce a BRS, approval from local businesses would be required.

It is important to consult with the various local public and private bodies to gauge views on funding options in order to help filter the funding options/scenarios presented in the results section and identify the most feasible funding strategy. Preparing and presenting evidence that illustrates the benefits from the mass transit options during this consultation will increase the chance of support for the scheme. For instance, when introducing a BRS in London, a wider economic benefits assessment of Crossrail was undertaken to demonstrate that the benefits received by businesses in each borough was greater than the support being they would provide.

Undertaking an initial consultation exercise with the relevant stakeholders in West of England is recommended.

7.5 Summary

The West of England mass transit is a large-scale transport infrastructure project which requires a high level of investment, but it can help transform the region. It will enable a number of benefits, including congestion relief, journey time savings, affordability improvements, productivity gains and sustainability benefits, supporting the achievement of the Mayor and Combined Authority. The benefits enabled by mass transit will be felt by numerous beneficiaries across the region including business, developers, residents, land owners and transport users.

The new transport network will lead to an increase in the land value, which can be captured via specific mechanisms. Since central government funding is becoming increasingly limited, the local funding instruments become increasingly important in bridging the funding gap and allowing the developments to proceed.

The analysis of potential local funding solutions applicable to mass transit include seven funding schemes arranged into five separate scenarios. The results are based on the forecast for residential and commercial development within the areas which will benefit from the new transport link. The mechanisms analysed include; Business Rate Supplement, Workplace Parking Levy, Council Tax Precept, Community Infrastructure Levy, New Homes Bonus, Shadow Toll and Local Tax Retention.

The results suggest that the local funding mechanisms could make a significant contribution towards the project, with the funding pots ranging between £1000m (Real 2018/19) and £2100m (Real 2018/19) across the tested scenarios. This translates to 21-45% of the total project cost (excl. financing) for the underground DLR/Tram & Bus/BRT (4 corridors) option but would be 26%-55% of the underground (3 corridor) project cost. The total amount of funding collected over a 30-year period was then used to determine the magnitude of the PWBL principal loan that could be secured against the future funding receipts.

An increased financing requirement generates an increase in the interest cost, which results in a higher overall cost of the project. Since the scenarios assume that the amount of financing will be determined by the local funding potential, the total cost of mass transit increases with an increasing funding pot. Underground DLR/Tram (4 corridors) has been used for illustrative purposes and the most optimistic scenario has been calculated to increase the costs of delivery by 18% but ultimately reduces the funding requirement by 47%. The total cost of the project (including financing) ranges between £6,032 m (Nominal) and £6,660 m (Nominal) for the underground 4 corridor option. The total cost (including financing) ranges would decrease to between £4,994 m (Nominal) and £5,622m (Nominal) for the underground (3 corridors).

Since the local funding potential is not large enough to cover the whole cost of the project, alternative funding options will need to be considered to close the funding gap. These could include grant funding (e.g. HIF) from central government and direct contributions from major benefactors of transport improvement. Additional mechanisms could also be introduced, such as Combined Authority wide developer charges to further generate funding for a mass transit scheme.

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Next steps which should be considered include:

- Consulting with local stakeholders, local business groups and developers on the feasibility of the options outlined in this funding assessment;
- Continuing an ongoing dialogue with UK Government to set out the additionality benefits of the mass transit at the UK-level and discuss the potential for securing the ability and powers to leverage local funding sources and / or the ability to secure funding from Government.
- Further analysis of the practicality of introducing the funding options identified and the scale of funding that could be raised;
- Consider in more detail how to bridge any remaining funding gap, including further assessment of alternative funding options; and
- Assess financing issued, outline options and discuss with financing experts on requirements to establish a robust financing package (for example to mitigate risk).

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8 Next Steps

8.1 Further option development and assessment

This report finds that there remains a good case for continuing to investigate and develop the mass transit scheme. The study concludes that the system will likely result in significant opportunities for unlocking further growth in housing and employment in the wider Bristol urban area post-2036, as well as providing enhanced public transport connectivity and interchange, transforming the way people travel around Bristol.

The proposals for the mass transit system are identified for post-Joint Spatial Plan timescales, which is outside the scope of current and proposed regional policies. There is a need to be mindful of planning horizons for delivery and begin development of strategic planning policy for post 2036. Therefore, in order to build on the strategic case for mass transit, one of the key elements to be developed includes regional strategic economic and planning policies. There is potential for a mass transit system to assist in bringing forward some of the JSP growth, however this is very dependent on delivery timescales of both mass transit and the JSP developments, this requires further investigation as the scheme is progressed.

The key findings of the report identify main differences between the over- and under-ground schemes include: levels of development unlocked; deliverability (in terms of construction and operation); and cost.

Whilst the underground proposal would require substantial capital expenditure, the development (housing and employment) opportunities enabled by the scheme are also considerable. Underground proposals also have a generally positive impact with the adverse impact on communities and existing transport infrastructure, being limited to movement of excavated and construction materials and the construction of stations, vent shafts and tunnel portals.

Whereas the overground proposal would require less capital expenditure to construct than underground proposals, however the development opportunities enabled by the scheme are also reduced. Overground proposals would have significant adverse impacts on communities and existing transport infrastructure, with three out of seven main roads into Bristol impacted directly by the mass transit implementation, not only during construction but also during operation, with further impacts on other arterial roads and more local roads as traffic reassigns. Local access for communities will also be disrupted along the mass transit corridors.

In all cases, more detailed multi-modal modelling and demand forecasting refinement is required. Further shortlisting of options and/or investigation of hybrid options to appreciate the optimum case for more detailed demand forecasting and iterative process of operations.

Further work to investigate the impacts of construction and operation is also required. Development of initial construction programmes to assist in informing the modelling of impacts, along with land requirements and costings to be developed.

Funding of the scheme remains a challenge, as a large-scale infrastructure project, it requires a high-level of investment. However the new transport network will lead to an increase in the land value, which can be captured by specific mechanisms. Local funding potential is not large enough to cover the whole cost of the project, therefore alternative funding options will need to be considered to close the funding gap. Further investigation of additional mechanisms should be tested, particularly the appetite for local taxation for fund/finance the capital expenditure.

Traditionally in transport economic cases, journey time savings are one of the key benefits for transport infrastructure schemes, whether improving connectivity or reducing congestion. Although important, this is not the main aim of the proposed mass transit system, as it would benefit transport choice, connectivity and congestion levels. One of the main aims of this proposed scheme is to unlock further development opportunities, as such the value for money (VfM) should not only be taken on transport benefits alone, but on the potential opportunities for further development.

FINAL DRAFT

Impacts on the local economy, fundamentally transforming the way people travel, potential to unlock housing growth, employment growth and overall vibrancy of the city region are paramount to capturing what only mass transit can bring to the region. This creates the need for different VfM indicators such as cost/house, cost/job, regional GVA, for example. This needs to be further developed to ensure the case for mass transit is sufficiently reflecting what it can bring to the region.

Another key next step is to begin targeted stakeholder engagement. Due to the stage this study and scheme are at, there has been limited stakeholder engagement. Key stakeholders including relevant senior local authority officers and local councillors, Mayors, and potentially the Airport would be initial stakeholders to engage with. As local elections are programmed for spring 2019 in Bath and North East Somerset, North Somerset and South Gloucestershire, timing of stakeholder engagement needs to be carefully considered. It has been discussed as part of the client group, that a positive statement be provided more widely in early 2019, then further technical work undertaken to enable more engagement throughout 2019.

8.2 Delivery

8.2.1 Timeline

Whilst upon a simple inspection the overground could be delivered in a shorter timescale than that of the underground, this will still require a substantial amount of time. Delivery of further development stages of the proposal, whether over- or underground, are expected to take a similar amount of time to deliver. As whilst the powers needed are different, both options are likely to require a public inquiry and planning powers, again the specific mode could alter the powers required.

Figure 8.1 below shows indicative timescales. Within this, it has been assumed that the separate routes are all prepared as a programme of works and delivered as separate contracts, although contracts could be concurrent and in the case of the underground option.

For the overground option, the routes have been assumed to be delivered in a sequential rather than concurrent manner. This reflects the need to manage the substantive traffic impacts, and not stifle movement within the WECA urban area. Clearly if some overlaps were possible this would reduce the programme, however confirmation as to the utility companies ability to deliver substantial works in these timescales would be needed for the reduced programme.

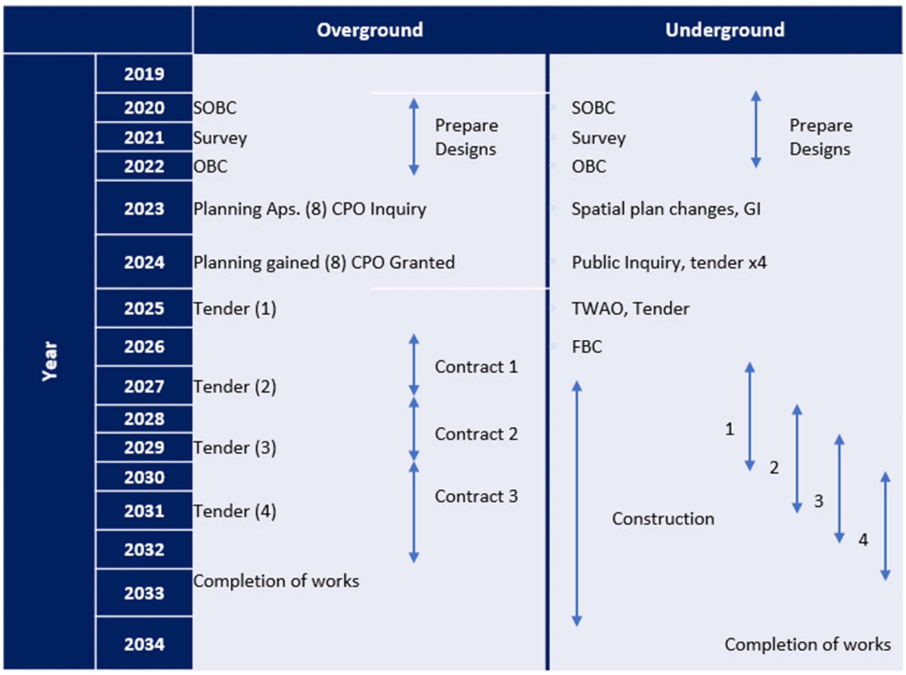

Figure 8.1: Indicative delivery programmes

8.2.2 Powers and planning

It is likely that the overground, if bus-based, would be delivered using the Town and County planning powers, using CPO powers for land acquisition where required. Should the preferred mode be tram (on corridor 4 only), it is likely that a Transport and Work Act (TWA) would be the preferred delivery approach. Given the routes cover three lines and four planning authorities, it may prove to be desirable to seek a DCO for the combined schemes, as this could limit the public inquiries. When CPO powers are required, again it would be desirable to combine these to the greatest extent possible.

For underground options, a TWA is the likely approach, although there would be merits in considering DCO as an alternative approach depending on the specific mode chosen. Both of these would provide comprehensive powers for the scheme being developed.

In general, the timeline for the schemes is relatively similar as all approaches require wide ranging powers and formal examinations in public to secure.

8.2.3 Approach to delivery

It is reasonable to suppose that the overground option, split into packages similar to the deliver approach of MetroBus, as the works are typical of large general engineering contracts let by public authorities.

The underground would however require a more formal structure and possibly a joint venture vehicle to deliver. Examples of this is the Crossrail delivery vehicle. This would enable a consortia approach possibly including development partners that could help to capitalise on the commercial opportunities the route would offer.

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Appendix A. - Previous mass transit proposals

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Appendix B. – Long-list sifting table and note

FINAL DRAFT

Appendix C. – Concept designs and cross-sections

FINAL DRAFT

Appendix D. – Funding/financing options

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