West of England Partnership

West of England Suburban Rail

Business Case

REP/175/14

Rev A | 25 February 2015

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 234415-00

Ove Arup & Partners Ltd
63 St Thomas Street
Bristol BS1 6JZ
United Kingdom
www.arup.com

ARUP

Executive Summary

Background

Arup was appointed by Bristol City Council on behalf of the West of England Partnership to appraise the case for electrification of the MetroWest rail network.

The MetroWest project is designed to create a step change in local rail services and is planned for delivery in two phases. Phase 1 will provide half hourly train services for the Severn Beach line, between Bristol Temple Meads and Bath Spa, and on the reopened Portishead line. Phase 2 will provide half-hourly train services to Yate and Weston-super-Mare and provide hourly services on a reopened Henbury line.

The current proposals have MetroWest services operated by Diesel Multiple Units (DMU). With proposed electrification of the Great Western mainline these units will be operating "under wires" for a significant proportion of their route.

Deliverability and Cost

A review of the current and proposed local rail network has been undertaken to identify deliverability issues associated with electrification and to inform cost estimates. The review shows that there is no technical barrier to electrification but has identified a significant number of structures requiring modification including the Bath Road Bridge. Significant investment is also required in depot facilities and power distribution on the Weston-super-Mare line. In total, it is estimated that a capital investment of £175m would be required to electrify phases 1 and 2. This estimate takes account of works which would already be undertaken as part of Great Western electrification or reopening of the Portishead Line.

The estimated capital cost has been generated through application of available benchmark unit cost data for electrification schemes being progressed in other parts of the UK as well as an assessment of potential structural works required to provide sufficient clearances for overhead wires and initial costing of a new depot and electrical equipment upgrades.

Business Case

The economic case for electrification is justified on the basis of lower operating costs associated with electric rolling stock, and the benefits to passengers of faster journey times and improved quality. Electrification would also be expected to deliver an increase in revenue both because of improved journey times and a step change in passenger perceptions of the network. This is often referred to as the "sparks" effect. Electrification also delivers environmental benefits by reducing greenhouse gas emissions from rail services.

All things being equal, the case for electrification rests on two main factors: the size of the capital investment per kilometre of track electrified, and the intensity of the rail operation (the frequency of service and the level of passenger demand).

If the Metrowest network is considered in isolation, there is unlikely to be a strong economic case for electrification in the short term (Control Period 6, 2019-2024). The capital cost of electrification of this network is high relative to other schemes because of the higher concentration of structures with insufficient clearance and their associated constraints. Similarly, the frequency of service and the size of the

Metrowest rolling stock fleet is such that insufficient operating cost savings would be generated to justify the cost of electrification.

Phase 1 of Metrowest has a stronger business case than Phase 2. This is because part of the Phase 1 network will already be electrified as part of the Great Western mainline electrification, whilst in the base case Phase 2 bears the cost of the electrification of the main line between Bristol Temple Meads and Weston-super-Mare. The benefit-cost ratio for the electrification of Phase 1 is 0.61:1 in the 'base case'. For Phase 1 and 2 combined, the benefit cost ratio falls to 0.48:1.

Whilst the standalone case for Metrowest electrification is relatively modest, if a more comprehensive approach to electrification in the South West is considered the business case becomes more compelling. Electrifying a wider network of lines offers significant economies of scale by sharing the costs across a larger number of services (therefore minimising diesel mileage 'under the wires') and offering efficiencies in power supply, depot provision and potentially rolling stock costs.

As part of its refreshed electrification strategy, Network Rail will be considering further electrification of the Western route, including the main line between Bromsgrove and Bristol Temple Meads and the Bristol to Exeter line. If it is assumed that the cost of electrifying these lines is met by a main line scheme, the benefit cost ratio for Phases 1 and 2 rises to 1.06:1 in the base case.

Timing is also key to the business case for electrification. In the short term, Metrowest could be delivered using relatively inexpensive existing diesel rolling stock. When the existing fleet needs to be replaced, the cost of diesel operation could rise significantly relative to electric operation. If electrification is delivered during Control Period 7 (2024-2029) for commencement of operations in 2030, the scheme is more likely to deliver value for money with a benefit-cost ratio of 2.15:1 for Phase 1 or 0.95:1 for Phase 1 and 2. If it is further assumed that the main line routes are already electrified, then the benefit cost ratio of Phases 1 and 2 rises to 5.02:1, suggesting that the proposal offers very high value for money.

Conclusions and Strategy

In conclusion, there are practical and economic reasons for launching the Metro in diesel. The programme of electrification in the UK means that CP6 is the earliest that electrification could be delivered. Furthermore, the short and medium term availability of Electric Multiple Units (EMUs) is uncertain, with recent and planned investment in electrification creating significant competition for cascaded EMUs. Conversely the short to medium term availability of Diesel Multiple Units (DMUs) is good with a range of fleets due for cascade.

It is therefore recommended that the West of England Partnership and rail industry stakeholders continue to plan for the launch of MetroWest as a diesel network. This programme should focus on delivering the highest quality service possible to stimulate new demand and long term growth. The rolling stock needs to be the most efficient and highest quality on offer. A refurbished Class 165 type unit may be a more attractive option for the Metrowest than the older Class 150 trains and the potential for securing these fleets should be explored as part of the next refranchising process.

In the long term, the case for electrification is much stronger. Network Rail Control Period 7, looks like an obvious departure point because of the need to replace ageing diesel fleets by around 2030. Furthermore, by CP7 the rail industry may have more capacity to deliver electrification schemes as part of the next generation of electrification projects.

Finally, Metrowest electrification should be considered as part of a more comprehensive strategy for electrification in the South West of England. The case for Metrowest electrification cannot be separated from the case for electrifying the between Birmingham and Bristol and to the south west of Bristol to Weston-super-Mare, Exeter or beyond. A co-ordinated approach between authorities in the South West should therefore be taken when promoting the case for electrification in this part of the UK.

Contents

Appendices

1 Introduction

1.1 Appointment

Arup were appointed by Bristol City Council (BCC) on behalf of the West of England Partnership (WoEP) to prepare an outline business case for electrification of the West of England (WoE) suburban rail network. Delivery of the project has required extensive consultation with WoEP, Network Rail, First Great Western and other consultants preparing studies in support of MetroWest.

Arup also appointed IPEX Consulting to provide specialist advice relating to rolling stock and depot locations.

1.2 Scope

The WoEP, comprising of four local authorities – BCC, Bath & North East Somerset Council (B&NES), South Gloucestershire Council (SGC) and North Somerset Council (NSC) – have developed the MetroWest project as the next phase of transport improvements planned across the WoE area.

The MetroWest project is planned in two phases:

- MetroWest Phase 1 which will provide half hourly train services for the Severn Beach line, between Bristol Temple Meads and Bath Spa, and on the reopened Portishead line.
- MetroWest Phase 2 which will provide half hourly train services to Yate and Weston-super-Mare and hourly services on a reopened Henbury line (capacity for two new stations) with additional stations at Ashley Down and possibly Horfield.

A new stations package, comprising stations at Saltford, Ashton Gate and Corsham, may be implemented over the course of Phase 1 and 2 subject to business case and technical evaluations. All stations are subject to separate and individual business cases which are currently being prepared, and interim data for these stations has been included in this assessment.

The current proposals for MetroWest are based on Diesel Multiple Units (DMU). Arup were appointed to appraise the case for electrification of suburban rail lines and associated works to facilitate the introduction of Electric Multiple Units (EMU) which could potentially provide benefits to passengers and operators.

As agreed at the inception meeting, the purpose of the commission was to:

- Confirm if there is a case for electrification of the WoE suburban network and to identify how this might be achieved/phased;
- Identify potential cost savings to be made from electrification;
- Provide the partnership with a basis on which to respond to questions from local stakeholders regarding the potential for electrification of the metro area;
- Set-out deliverability issues and barriers, for example in relation to rolling stock and depots; and

- Provide guidance on the potential associated benefits which could result from electrification of the suburban network.

An outline business case for electrification has not been prepared at this stage because the evidence base gathered as part of this study does not support electrification at the current time or in the near future.

The report presents a clear strategy for moving forward with the MetroWest scheme with the possibility of extending electrification in the future and provides the WoEP with clear, evidence based recommendations for initial deployment of MetroWest services and implementation of EMU as part of a longer term strategy.

Our analysis and reporting has been undertaken in line with Department for Transport (DfT) and Network Rail GRIP requirements so that it may form the basis of any future business case or funding bid.

1.3 Report Structure

The report has been structured into the following sections:

- Section 2 – Presents the background and context of the study. The potential benefits and dis-benefits associated with electrification of the local rail network and services are discussed.
- Section 3 – Summarises the study methodology including the information supplied to Arup to inform our assessment.
- Section 4 – Provides a review of infrastructure along the Metrowest network. Using this information the capital investment required is estimated.
- Section 5 – Presents a review of likely rolling stock availability and depot locations.
- Section 6 – Summarises the timetabling of services and assumed operational patterns.
- Section 7 – Calculates passenger demand and user benefits
- Section 8 – Presents the economic assessment and tests different scenarios and sensitivities.
- Section 9 – Presents our conclusions and recommendations.

2 Background and Context

2.1 Introduction

This study has been commissioned to inform planning, assessment and future funding bids relating to the MetroWest project, which is summarised in section 2.2 below.

It also takes place against a background of committed electrification projects in the UK, most notably electrification of the Great Western Mainline from Paddington to Bristol Temple Meads and Cardiff (via Bristol Parkway), and electrification of Thames Valley services.

2.2 MetroWest

The MetroWest project is designed to facilitate a step change in public transport provision in the greater Bristol area through the introduction of new rail services and increased frequency along existing lines.

The MetroWest project is planned in two phases with a new stations package comprising of individual stations which will be implemented subject to business case and technical evaluations. A diagram locating stations and services is shown in Figure 1.

2.2.1 Phase 1

The MetroWest phase 1 proposals include:

- The reopening of the Portishead rail line and the introduction of half-hourly peak hour services to Bristol Temple Meads (hourly off-peak).
- A new half- hourly service is to be provided between Severn Beach and Bristol Temple Mead with one service continuing to Portishead and the other continuing to Bath Spa.
- New stations at Portway P&R, Ashton Gate and Saltford are proposed as part of a new stations package – separate to Phase 1.

Recent developments in timetabling and service patterns have recommended that the Portishead to Severn Beach service terminates at Avonmouth. Severn Beach will have an hourly service throughout the day, compared to the current two-hourly service.

Different options for these services have been tested and assumed service patterns are presented in Section 6.

Phase 1 rail services are assumed to start in May 2019 with diesel rolling stock. The indicative cost of works and rolling stock to implement Phase 1 is estimated at £58.1 million (2013 prices).

The Joint Transport Board have accepted the recommendation to proceed to the Outline Business Case for MetroWest Phase 1 based on the conclusions from the Preliminary Business Case.

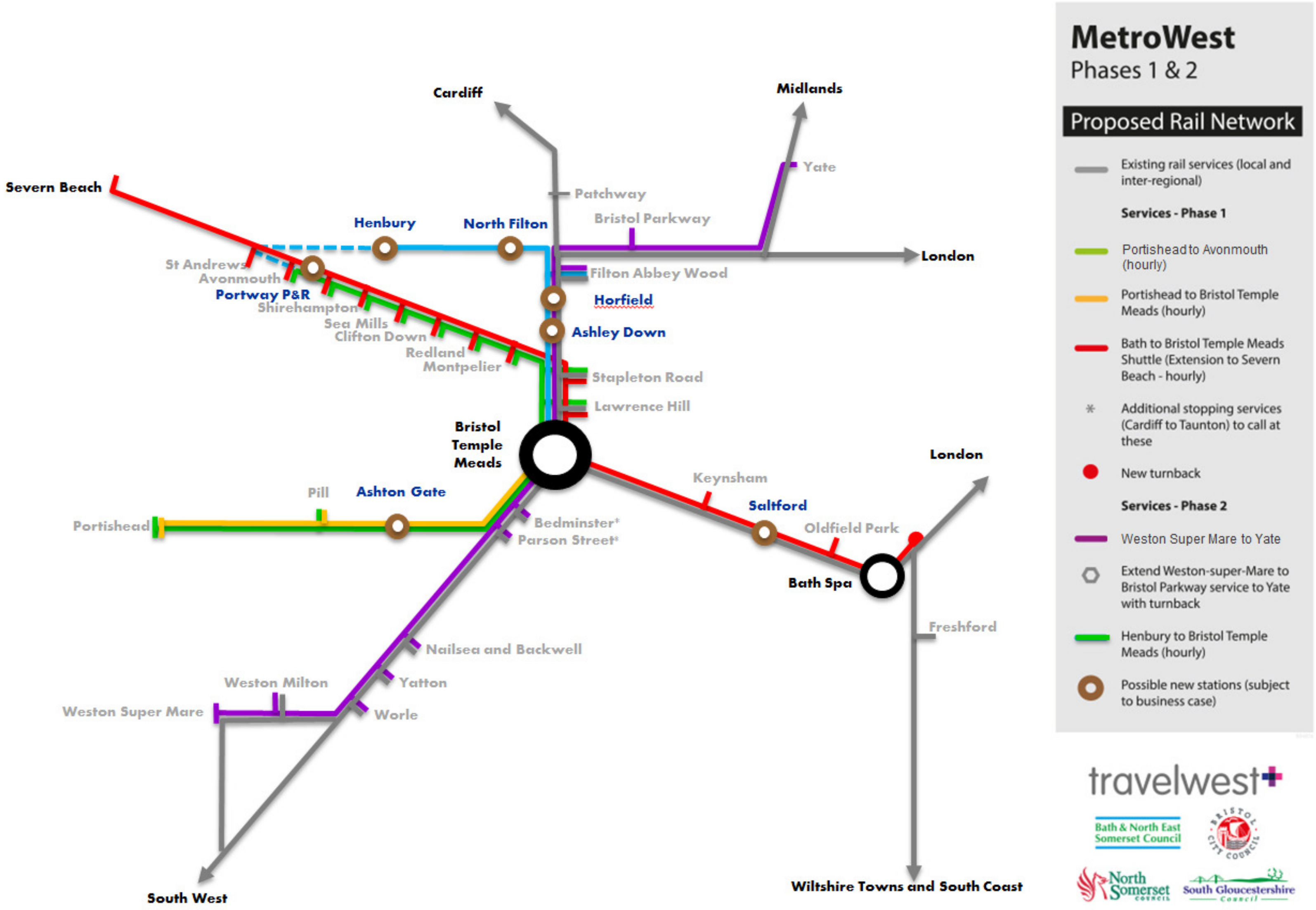


Figure 1: Proposed MetroWest Phases, Lines and Stations

2.2.2 Phase 2

Phase 2 will see the introduction of half hourly train services to Yate from Weston-super-Mare via Temple Meads. Sections of this route between Bristol Temple Meads and Bristol Parkway will be electrified as part of the Great Western electrification project.

Phase 2 will also establish hourly services on a reopened Henbury Line featuring new stations at Henbury and North Filton. In addition, the feasibility of creating two new stations (Ashley Down and Horfield) between Stapleton Road and Filton Abbey Wood are being examined – with this section of line being upgraded to four track as part of the separate Filton Bank project.

Phase 2 services are assumed to start in 2021. The indicative cost of works and rolling stock is currently being estimated by other consultants working on the Phase 2 business case.

2.2.3 New Stations

New stations at Saltford, Portway, Ashton Gate and Corsham are, subject to business cases, to be delivered over the course of Phase 1 and 2.

Business cases for each station are being prepared by Halcrow with initial forecasts (GRIP 2 stage) issued to Arup to inform passenger forecasting.

2.3 Electrification in the UK

There are a number of electrification schemes confirmed and/or likely within CP5 and CP6. The three schemes with most relevance to MetroWest electrification are:

- Great Western Mainline – which will electrify certain lines within the MetroWest area including Bath Spa to Temple Meads, Temple Meads to Parkway and Westerleigh Junction to the Severn Tunnel.
- Thames Valley – which will result in the potential cascade of existing diesel rolling stock into the MetroWest area and also offers a potential opportunity for extension of electrified services outside of the MetroWest area as well as shared stabling/depot facilities.
- South Wales Valley Lines – which provides opportunities for extension of electrified services outside of the MetroWest area as well as shared stabling/depot facilities.

In addition to offering opportunities the Thames Valley and South Wales Valley Line projects will produce additional demand for limited electrified rolling stock and OLE installation equipment. A number of other electrification improvement schemes in the UK have been identified for programme entry in Network Rail Control Period 5 (CP5), April 2014 – March 2019, and CP6 (April 2019- March 2024).

The Western Route Study (Draft for Consultation, published in October 2014) includes a 'south west' package of electrification for potential further consideration. This package includes electrification on the routes from Temple Meads to Weston-super-Mare, and from Weston-super-Mare to Plymouth and Paignton, with a possible extension to Penzance. However, the Route Study does not contain further details on the case for further electrification on these routes; this will be included in the Network RUS: Electrification Strategy Draft for Consultation due to be published later in 2015.

2.3.1 Great Western Mainline

The Great Western Mainline is being electrified as part of a £5 billion programme of works by Network Rail supported by the introduction of new electrified rolling stock. The programme, shown in Figure 2, will see electrification of the line between Paddington and Bristol by December 2016, electrification to Cardiff by December 2017 and electrification to Swansea by May 2018.

A new fleet of trains, delivered by the Intercity Express Programme (IEP), will provide faster, higher capacity services along the newly electrified railway. Three new depots, located at North Pole (Paddington), Stoke Gifford (Bristol) and Swansea are proposed to service IEP trains.

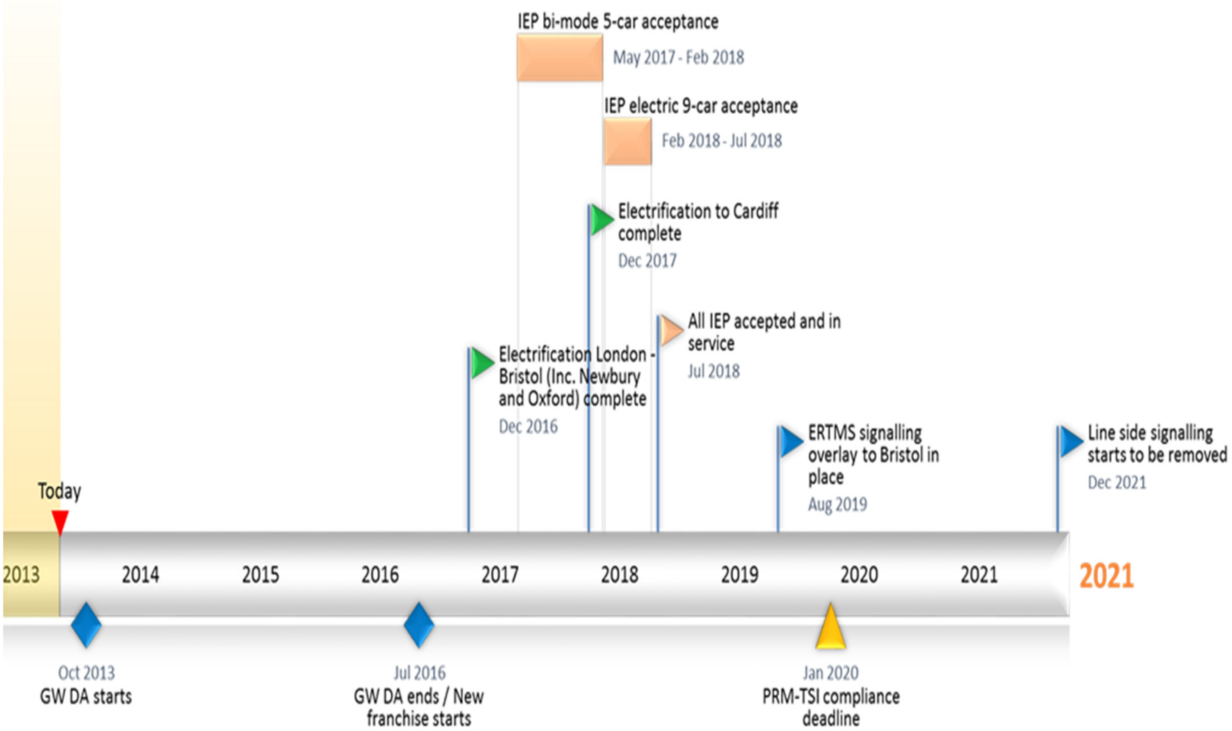


Figure 2: Great Western Electrification Programme and Key Service and Legislature Changes

2.3.2 Thames Valley

The High-Level Outline Specification (HLOS) for electrification of services on the Thames Valley Branch Lines; Acton - Willesden , Slough – Windsor , Maidenhead – Marlow, Twyford – Henley-on-Thames within CP5.

There is also the potential electrification of services between Reading and Basingstoke within CP6.

2.3.3 South Wales Valley Lines

Electrification of the Valley Lines network is programmed for delivery by 2020. This builds on the decision to extend the GWEP project to Swansea. Electrification of the network in South Wales opens up the prospect of operating electrified services between Swansea, Cardiff and Bristol in the future, although no decisions on future service patterns has been made. If this is the case, it is likely that such services would be operated by a fleet of EMUs based at Cardiff Canton depot.

2.4 Legislature Changes

Since 31 December 1998 the Rail Vehicle Accessibility Regulations (RVAR) have applied to all new rail vehicles entering service since. The RVAR standardised the requirements to meet the needs of disabled passengers.

On 1 July 2008, a new European standard came into force, the technical specification for interoperability for persons with reduced mobility (PRM TSI). The PRM TSI sets standards for accessible trains, stations and other facilities.

All rail vehicles must be compliant with PRM TSI by 1 January 2020. Compliance with PRM TSI must therefore be considered with regards to cascade of rolling stock and fleet replacement programmes.

2.5 Potential Benefits of Electrification

The potential benefits of electrification are multifaceted and include:

- Reduced operating costs to franchise operators as a result of lower fuel, leasing or line costs.
- Reduced journey times between stations as a result of the improved performance of EMU. This provides passenger journey time benefits and also additional timetable flexibility/reliability for operators.
- Improved perception of rail services potentially resulting in modal shift to rail from other modes – the “sparks” effect.

The potential benefits have been assessed and are discussed within the relevant sections of this report. Where appropriate direct and indirect financial benefits have been calculated to inform financial case appraisal.

2.6 Key Issues

Electrification of the Great Western mainline represents a significant opportunity to MetroWest as a significant proportion of the West of England rail network will be electrified.

The upgrade of MetroWest line and rolling stock to facilitate operation of EMU requires consideration of a number of issues within the local and national rail context:

- Costs associated with the installation of OLE on local lines – in particular modifications to bridges, tunnels and other structures as well as improvements to electrical distribution equipment.
- Assessing the potential timetable and operational impacts a switch to EMU services would facilitate and coordinating any timetable changes with the wider network including freight services to Avonmouth and Royal Portbury docks.

- Given the number of scheduled electrification improvement projects already programmed in CP5 it is assumed that electrification of MetroWest lines could not be undertaken until CP6 at the earliest. It is therefore assumed that electrified services could not operate along MetroWest lines until 2021 at the earliest.
- The backlog of electrification in the UK[1], and the programming and commitment to other CP5 schemes is such that electrification of the MetroWest network is unlikely to follow on from the Great Western scheme. In any case, the efficiencies of completing MetroWest immediately following Great Western are unlikely to be significant.
- Electrification of MetroWest rolling stock would introduce the possibility of new or extended services to Swansea, Cardiff or Thames Valley via the Great Western mainline.

These key issues, and associated considerations, have been identified and reviewed as part of the project with financial costs (capital and operational) calculated as appropriate to inform financial case appraisal.

[1] http://www.railtechnologymagazine.com/Inbox/electrification-hit-by-ballooning-costs-and-delays
http://www.walesonline.co.uk/news/wales-news/great-western-rail-electrification-threatened-7985981

3 Methodology

3.1 Introduction

In calculating the economic case for electrification of MetroWest Arup has been required to derive values for the capital investment required, the operational cost savings and the benefits of electrification – be they direct (revenues) or indirect (user benefits, decongestion benefits).

For a typical rail electrification value case the significant capital investment in OLE and associated infrastructure is funded by future savings in operational costs (OPEX) and benefits (user benefits, increase revenues, crowding reductions, highway decongestion benefits). Figure 3 shows a typical example of how Net Present Value (NPV) is derived in this manner.

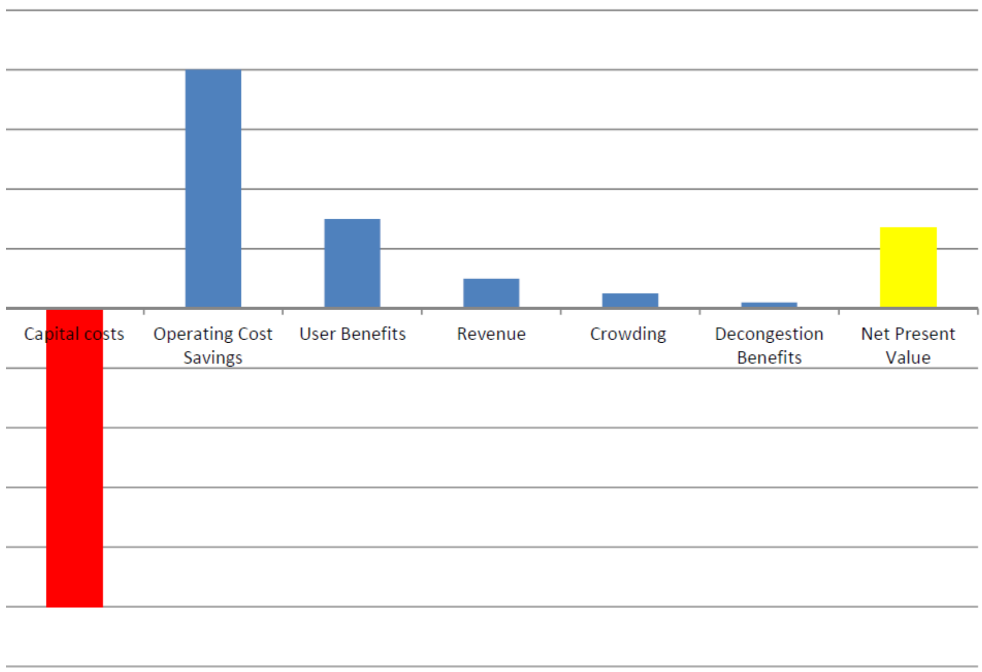


Figure 3: Typical Value Case for Electrification

This sections sets out the broad methodology adopted as a means of introducing the individual chapters dealing with key elements of the business case.

3.2 Methodology Adopted

The capital investment (CAPEX), operational costs (OPEX) and revenues/benefits were calculated through the concurrent assessment of various elements which are brought together to create the overall economic appraisal for electrification of MetroWest.

3.2.1 CAPEX

The capital investment in electrification has been assessed through an appraisal of infrastructure requirements including:

- New OLE including design and contractor fees.

- Structural works to provide the required clearance for OLE.
- Depot Investment.
- Power supply.

Section 4 provides a detailed breakdown of CAPEX assumptions and costing for each line in the MetroWest project.

3.2.2 OPEX

The operational benefits of a switch from DMU to EMU has been calculated through the production of operational costs for a “do-nothing” scenario which assumes DMU operation on MetroWest lines over the life of the economic appraisal.

A number of “do-something” scenarios have then been developed assuming electrification of MetroWest services in 2021 (the earliest year EMU services could operate) as well as later adoption at the end of DMU rolling-stock life.

In calculating the baseline and do-something scenarios it has been necessary to produce service diagrams for EMU and DMU services which reflect the lines and stations open in Phase 1 and Phase 2. This work is summarised in Section 6.

In calculating future operational costs it has been necessary to apply rolling stock cost assumptions. These have been based on an assessment of the most likely DMU and EMU rolling stock to be available for deployment on MetroWest (refer to Section 5).

3.2.3 Passenger Forecasting, Revenue and Associated Benefits

Section 7 summarises the passenger demand forecasting and forecasts for revenues and associated benefits.

An elasticity-based forecasting approach, based on guidance from the Passenger Demand Forecasting Handbook (PDFH) has been adopted to prepare rail forecasts. In this approach, rail passenger demand is expected to grow with the changes in exogenous (i.e. external growth factors such as GDP and population) as well as endogenous factors (i.e. factors resulting from MetroWest electrification).

Passenger demand forecasts have been produced for the do-minimum (DMU) option as well as the do-something (EMU) scenario. The same exogenous factors have been applied to both options.

Do-minimum demand and revenue for existing stations on the MetroWest network has been extracted from MOIRA[2] on a station to station basis. Do-minimum demand for all new stations on the MetroWest network has been taken from forecasts produced by other consultants working on Phase 1 and Phase 2.

To calculate do-something passenger demand forecasts, reference has been made to the Passenger Demand Forecasting Handbook (PDFH) which provides guidance on various drivers of rail demand and values of the elasticities of these drivers. The PDFH 5.1 forms the basis of the forecasting methodology adopted for this project.

[2] MOIRA provides ticketing data for the rail network. A copy of the latest model was obtained from First Great Western for use on this commission.

Using PDFH the effects of MetroWest electrification on a variety of demand factors has been calculated and applied to demand forecasts. These growth factors include timetable and service frequency improvements as well as non-timetable related service quality improvements – often referred to as the "sparks effect".

3.2.4 Economic Assessment

The economic assessment for electrification of MetroWest has been calculated by assessing the cumulative OPEX saving, increased revenues and associated benefits against the CAPEX required.

The economic assessment has assumed an assessment period of 60-years. The first year of electrification in the do-something scenario is year 2021[3].

Optimism bias has been applied as per Green Book guidelines for a rail project at GRIP 1 stage.

A discount rate of 3.5% has been applied as per Green Book guidelines.

The baseline assessment models a do-nothing, DMU option against a do-something, EMU option. A number of scenarios and sensitivity tests have been tested reflecting changes in key parameters such as the opening year of EMU services or reductions in CAPEX.

3.3 Sources of Information

3.3.1 Reports & Presentations

The following reports, notes and presentations were issued to Arup to inform our assessment:

- Bristol Area Rail Study Final Report, Halcrow.
- Analysis and Forecasting, MetroWest Interim Report, Network Rail.
- MetroWest Brief issued for GRIP 1 and 2, WoEP.
- MetroWest Train Service Optioneering Briefing and Recommendations, Rail Programme Board.
- Phase 1 Network Strategy & Planning: Capability Analysis, Network Rail.
- Phase 1 Demand Calculation Methodology Note, Halcrow.
- Phase 1, Options for Modelling & Appraisal for Economic Case, WoEP.
- Portishead Reopening, Option Selection Report, GRIP Stage 3, Network Rail.
- Phase 2 Value Management Workshop 1 Presentation & Notes, WoEP.
- Phase 2 Bristol North Fringe Stations, Technical Report, CH2MHill.
- Bristol New Stations, High Level Assessment Study – Filton Bank, CH2MHill.
- Demand Forecasts, North Fringe Stations Study, Technical Note, CH2MHill.
- Saltford Railway Station, Feasibility Investigation, Halcrow.

[3] This assumes that electrification of Phase 1 of MetroWest delays opening by approximately two years, as agreed at stakeholder workshop October 2014.

- West of England Strategic Economic Plan 2013-2030, WoEP.

The Western Route Study (Draft for Consultation) was published in October 2014 at the same time as the draft version of this report. The impact of the key recommendations of the study have been included as a sensitivity test.

3.3.2 Diagrams, Models and Modelling Information

The following information was obtained from First Great Western and Network Rail, taken from publically available sources or used previous Arup studies:

- General Arrangement and Layout Plans, Portishead Line, Network Rail.
- MetroWest Phase 1 Service Pattern Modelling.
- First Great Western MOIRA model.
- RailSys model.
- Network Rail's Five-Mile Diagrams.
- National Gauging Database (NGD).
- Passenger forecasts for Ashley Down and Ashton Gate.
- Station plans for Henbury East, Filton North and Henbury, CH2MHill
- Information regarding mileage, line speed, locations of structures and stations was taken from these publically available documents.
- Satellite imagery from Bing/Google.
- Previous Arup studies and information from Network Rail pertaining to the costs of depots and power supply.

3.3.3 Meetings

The following meetings were held with key stakeholders during the course of this project:

- Inception meeting with project sponsors and Network Rail, January 2014.
- Workshop 1 with project sponsors and Network Rail, February 2014.
- Discussions with FGW regarding rolling stock and depot facilities, March 2014.
- Workshop 2 with project sponsors and Network Rail, October 2014.

3.3.4 Report Feedback

A draft version of the report was issued to the WoEP on 27 October 2014. Comments received from the client have been incorporated into this issue version.

4 Infrastructure Cost Review

4.1 Introduction

Electrification of the MetroWest lines will require significant investment to upgrade existing and proposed lines to accommodate OLE.

Section 4 serves to outline the assumptions made in this cost estimation exercise and is based on data presented in Appendix A and Appendix B.

4.2 Cost Formulation & Assumptions

The processes and assumptions made in identifying and costing works to facilitate electrification of MetroWest lines are set-out within this section.

All cost estimation was carried out based on engineering judgement using the information available rather than detailed structural investigation. The level of cost accuracy is considered appropriate given the level of optimism bias applied to the business case (refer to later sections of this report).

4.2.1 Clearance Criteria

The vertical clearance limits assumed for different line sections are summarised in Table 1 .

Table 1: Adopted vertical clearance requirements

Condition	Clearance	Measurement
Open Route	5100mm	Rail to soffit
Station Structures	5800mm (Optimal 5400mm (Sub-optimal)	Rail to soffit
Level Crossings	5700mm	Rail to wire height

The wire height increase at crossings has the potential to create clearance issues at adjacent structures that would clear for normal wire heights. It is assumed that am allowable grading ratio of the contact wire is line speed multiplied by five. At a line speed of 40mph the maximum ratio = 1:200, meaning the wire height could reduce from 5.7m to 4.7m in 200m. At 125mph this would take 625m.

The costs and suggested methodology of achieving clearances at individual structures have been identified in Appendix B. The determination of cost is defined by the type of structure and the contributing constraints.

Points found within the top corners of the train envelope have also been considered as infringements, particularly when likely to encroach on pantograph positioning. Lenience has been granted at points that are further away. Figure 4 below shows an example of where a pantograph clash would be likely to occur.

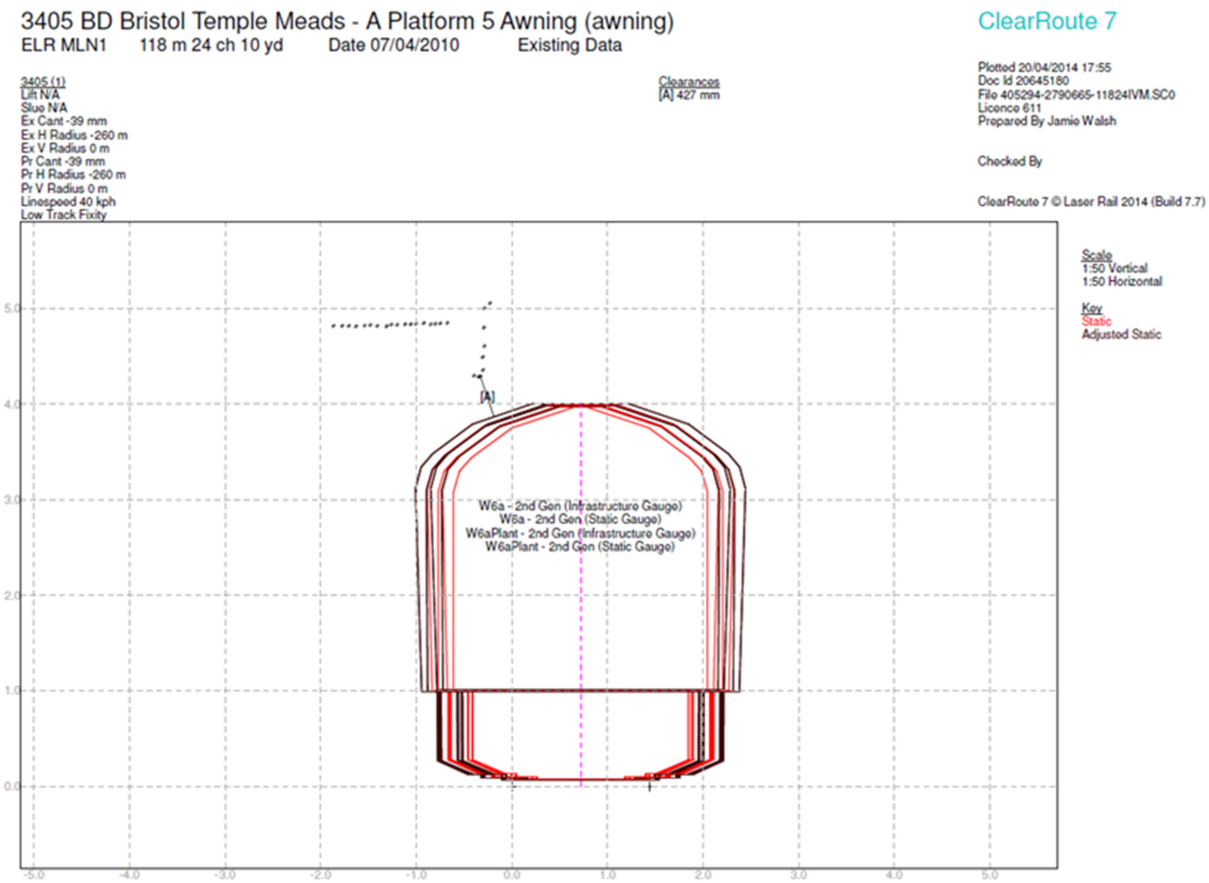


Figure 4: NGD Screenshot of Example Haunch Infringement

4.2.2 Overbridges

Each overbridge with less than the minimum clearance was looked at individually using Bing satellite imagery and Google Street View to gain a basic understanding of the local constraints. Table 2 summarises the number of structures along each line in Phase 1 and Phase 2.

Table 2: Summary of Overbridge Structures along each line

Line	No. of Highway Bridges	No. of Footbridges	No. of Highway Bridges to be Modified	No. of Footbridges to be Modified	No. of Track Lowers Rq'd for Bridges
Portishead to BTM	21	3	4	2	2
BTM to Severn Beach	11	4	7	3	4
BTM to Henbury	9	0	4	0	5
BTM to Yate	0	0	0	0	0
WSM to BTM	14	3	12	3	1
TOTAL	*60*	*10*	*27*	*8*	*12*

Main considerations included track alignment, proximity to junctions/switches and crossings (S&C), road/street level, alternative crossings, span of bridge, general topography and more. The likelihood of services being present in the bridge was also considered. The type of bridge (e.g. flat deck or brick arched) and the amount of infringement were also key factors assessed in calculating cost parameters.

The main solutions considered comprised reconstruction, deck jacking and track lowers. OLE solutions were suggested when none of these options seemed viable financially or practically. Combinations of these solutions were also recommended were appropriate.

NGD information was not provided for all bridges. In these instances the assumption was made that the minimum clearances were similar to adjacent bridges on the same line built in the same period. Assumptions regarding clearances have also been provided in Appendix B.

The costs associated with each set of works was estimated by permanent way and civil structural engineers experienced in electrification related bridge works. The values provided in Appendix B are all-in figures which already include indirect associated costs such as design, Network Rail project management, surveys and contractors' mobilisation.

An area for future feasibility assessment is the emergence of discontinuous electrification. Should it be prove financially viable, such a unit would have the capability to operate on sections of the route without overhead wires. This would offer the potential for sections of track running under restrictive structures to remain un-wired, reducing the clearances required to operate electric trains. A prototype battery powered train is currently being trialled by Network Rail and Bombardier as part of a feasibility study.

4.2.3 Tunnels

The costing of tunnels was advised by a previous study carried out by Arup on the Great Western Mainline (GWML). The worst case cross-section of each of the tunnels and perceived condition of the proposed lines were matched to the closest indicative tunnel on the earlier study. Overall costs were then prorated with respect to the length of the tunnels.

Table 3: Summary of Tunnel Lengths along each line

Line	Length of Tunnels (km)
Portishead to BTM	0.9
BTM to Severn Beach	1.9
BTM to Henbury	0.3
BTM to Yate	-
WSM to BTM	0.1
TOTAL	*3.2*

These costs include the component and installation costs of fixings, remedial works, support wires, tensioning equipment, etc. They exclude components such as possession charges.

Tunnel works require more specialised labour and resources which have been captured in the costs. Estimates for regular sections of OLE per kilometre do not apply, i.e.

gantries, foundations etc. are discounted. Integral unaffected components such as power supply and signalling would still apply.

NGD information was not provided for all tunnels. In these instances the assumption was made that the minimum clearances were similar to the other tunnels on the same line built in the same period.

4.2.4 Signals

Signal gantries interact with their surroundings less than bridges and tunnels. They are also structurally simpler. Signal gantries were noted to encroach on the required envelope to varying degrees, but as any infringement was assumed to result in reconstruction, each of these structures was estimated to cost £300,000.

4.2.5 Level crossings

The cost of level crossings were based on previous project experience where cost consultants calculated prices which were validated by Network Rail. This study assumed that all level crossings required renewal.

Table 4: Assumed level crossing costs

Type of Level Crossing	Cost per Crossing
CCTV/MCB	£2,000,000
PP/UWC	£100,000
FC/FPG/FPO/FPS/PED	£50,000

Table 5: Summary of level crossings along each line

Line	No. of Level Crossings	CCTV/MCB	PP/UWC	FC/FPG/FPO/FPS/PED
Portishead to BTM	2	1	1	0
BTM to Severn Beach	4	3	1	0
BTM to Henbury	1	0	0	1
BTM to Yate	0	0	0	0
WSM to BTM	8	2	1	5
TOTAL	*15*	*6*	*3*	*6*

4.2.6 Associated Electrification Projects

Due to the order and timing of the proposed works, overlap with external projects was considered. Network Rail's GWML programme has planned to electrify lines from London through to Swansea, including the Bath to Bristol Temple Meads line, Filton Bank (Bristol Temple Meads to Filton Junction) and along the MLN1. Phase 1 is to be constructed before Phase 2.

Lines which are scheduled for electrification through other projects have been excluded from our capital costing. These chainages have been recorded in Appendix A.

4.2.7 Price per Kilometre

Industry estimates for the inclusive cost of electrifying a Standard Track Kilometre (STK) are £1,310,000 without the application of any risk or optimism bias.

A previous study by Arup of urban line electrification identified costs to break down as shown in Table 6.

Table 6: Cost breakdown per kilometre

Cost Component	Description	% of cost	Breakdown cost when £1.31M/km
Bridges & Tunnels1	Gauge clearing works, bridge reconstruction and jacking	16.30%	£213,663
Parapets1	Increase in parapet height for compliance with electrical clearance	3.24%	£42,442
Platforms1	Work resulting from track lowers	0.24%	£3,198
Other1	Track lowers, level crossing changes, maintenance access	6.21%	£81,395
OLE1	Foundations, gantries, registration, wiring and bonding	22.68%	£297,238
Power Distribution1	Upgrades to the existing network to feed the OLE	6.02%	£78,866
Immunisation 1	Signalling, telecoms and line side power supplies	4.37%	£57,326
Control & Systems2	Signalling, crossings and system supervision	0.33%	£4,360
Contractors Indirects2	Contractor's preliminaries, supervision, management, overheads and profit	19.74%	£258,721
Survey & Design2	Contractors and designers.	7.54%	£98,837
NR Project Management2	Management of development and delivery programme of works	11.75%	£154,070
Possession Charges	Costs associated with applying possessions	1.57%	£20,640
1 = Direct costs **2 = Indirect costs**			

This study priced bridges and tunnels individually, so the "Bridges & Tunnels" estimate per kilometre was taken out and replaced by the assessments made specifically on structures within the MetroWest area. OLE solutions within tunnels has also been considered, and so "OLE" has also been discounted for the length of tunnels on the route.

Applicable direct costs (i.e. discounting Bridges & Tunnels) are to be multiplied by 2, 3 and 3.2 times for dual, triple and quadruple tracks respectively. Two single cantilever structures are used for dual tracks while triple and quadruple track OLE would be installed on gantry systems.

Table 7: Applied cost per kilometre (not including structures)

Track classification	Applied cost per kilometre without structural provision
Single	£480,000
Single Tunnelled	£180,000
Dual	£780,000
Dual Tunnelled	£240,000
Triple	£1,080,000
Quadruple	£1,130,000

The costs of structures for each scheme will be added to the total mileage multiplied by the relevant prices above.

Indirect costs accounted for 41% of the previous study which were then added on to the direct costs. This meant multiplying the direct costs by a factor of 1.695.

4.2.8 Power Supply to Weston-super-Mare

Initial power calculations for the operation of EMUs on MetroWest lines was provided to Network Rail for evaluation. It has been confirmed that the Weston-super-Mare line is likely to require additional electrical distribution supply equipment to ensure the security and reliability of supply. Arup estimates a total cost of around £10,000,000 for this equipment, based on recent design of equivalent infrastructure for Network Rail. This cost has been added the cost of the Phase 2 Weston-super-Mare to BTM total.

4.2.9 Depot Costs

Based on a high-level review of potential depot options a preferred option for a small, new local EMU depot at St Philips Marsh has been identified – refer to Section 5.

Arup has produced an initial estimate for the costs of constructing such a depot based on our experience in the design of IEP depots. A resulting depot cost of £14,000,000 with a range of £10,000,000 to £18,000,000 has been calculated with this cost added to the Phase 1 capital investment total.

A breakdown of depot costs has been provided in Appendix C.

4.2.10 Further Assumptions

The cost of re-commissioning stations has not been included in electrification estimates as the stations will be provided as part of works to facilitate DMU operation.

Arup have not reviewed structures' condition survey reports and have assumed that all structures are in fair condition.

There are gaps in the NGD information which have been highlighted in Appendix B. Clearances have been assumed for some structures. In particular no NGD information has been made available on ELR: POD.

Structural clearances for all structures on the Portishead line where NGD information was not provided were considered to have minimum of 4640mm as specified in the NR Track Design Handbook NR/L2/TRK/2049, section A.8.1a for "Secondary cross country links and inner suburban commuter routes”. The additional cost of electrifying this route with the relevant clearance modifications has been included with reasoning shown in Appendix B.

The connection of new OLE line into an existing network has not been priced.

The cost of cutting station awnings back is assumed to be covered by the “Platforms” allowance in Table 6.

Risk and optimism bias has not been applied to the costs presented in this section and are instead dealt with in Section 8 – Economic Appraisal.

4.3 Costs

4.3.1 MetroWest Phase 1

The total capital investment required to facilitate MetroWest Phase 1 is shown in Table 8 for each the three lines. Costs for the Portishead include major works to the Bath Road Bridge which are required to facilitate electrification (cost estimate £5,000,000).

The total cost for Phase 1 includes a depot construction estimate of £14,000,000 split equally between Portishead and Severn Beach to BTM.

Table 8: Costs of infrastructure for Phase 1 lines

From	To	Total length to electrify (STK)	Average cost per STK	Total distance-based cost	Costs due to structures	Cost of Depot	Total Cost
Portishead	BTM	20.4km	£1.1m	£22.1m	£13.7m	£7.0m	£42.9m
Severn Beach	BTM	18.6km	£1.3m	£24.1m	£14.4m	£7.0m	£45.6m
Bath	BTM	-	-		-		-
						Phase 1 Total =	£88.5m

4.3.2 MetroWest Phase 2

The total capital investment required to facilitate MetroWest Phase 1 is shown in Table 9 for each the three lines. The Weston-super-Mare route includes a cost of £10,000,000 associated with improvements to electricity supply and distribution equipment.

Table 9: Costs of infrastructure for Phase 2 lines

From	To	Total length to electrify (STK)	Average cost per STK	Total distance-based cost	Costs due to structures	Cost of power supply	Total Cost
Weston-super-Mare	BTM	51.7km	£0.8m	£40.5m	£8.4m	£10.0m	£59.0m
Yate	BTM	5.2km	£1.0m	£5.3m	£0.5m	-	£5.8m
Henbury	BTM	6.8km	£2.3m	£15.7m	£6.0m	-	£21.7m
						Phase 2 Total =	£86.5m

4.4 Conclusions

The total capital investment (CAPEX) required to facilitate operation of EMU on MetroWest Phase 1 and Phase 2 has been estimated to be £88,500,000 and £86,500,000 respectively. Given that this is a very early stage estimate, there is a significant degree of upside and downside risk to this estimate. Optimism bias and sensitivity testing has been employed in the economic appraisal to reflect these risks.

The prevalence of structures that require works to achieve the minimum clearance is a large contributor to the costs of these proposed lines. Included within the structural costs are modifications to the Bath Road Bridge which is estimated at £5m alone.

Considering the 103 STK distance and the total of £175,000,000 the average cost of is £1,700,000/km, which is 30% higher than Arup's previous study. A large portion of this increase in cost can be attributed to the higher concentration of structures with insufficient clearance and their associated constraints.

5 Rolling Stock and Depots

5.1 Introduction

A review of rolling stock options for operation on MetroWest services has been undertaken to identify potential DMU and EMU rolling stock which maybe cascaded as a result of planning investment in new rolling stock by other operators. This review has focussed on the size, composition and likely release date of rolling stock and the results have been carried forward into the rolling stock assumptions made in the business case.

A high level review of depot and stabling options has been undertaken based on current and planned facilities within the West of England and adjacent areas. This review has focussed on identifying the most likely option for the servicing of future EMU rolling stock and has informed capital investment and "empty mileage" operating assumptions in the business case.

5.2 Existing Rolling Stock

The West of England inter-urban and rural services are operated by a variety of two and three-car DMUs. The composition of this fleet, shown in Table 10, has developed out of necessity throughout the current franchise in order to provide additional capacity and relieve overcrowding. However the composition of the fleet has been significantly constrained by the limited availability of DMU rolling stock, such that efficiencies brought by synergy of fleet type have been second order considerations for the current franchise.

Table 10: Composition of Existing Fleet, West of England

Fleet	Formation	Total Number of Vehicles	Date Into service	Number of Seats per Unit
Class 143 Pacer	8 x two-car	16 vehicles	1986-87	104 seats
Class 150 Sprinter	34 x two-car; 2 x three-car (hybrid)	74 vehicles	1985-87	138 seats per two-car; 209 seats per three-car
Class 153 Super Sprinter	14 x 1-car	14 vehicles	1987-88	75 seats
Class 158 Express Sprinter	2 x two-car; 13 x three-car (12 hybrid)	43 vehicles	1989-92	140 seats per two-car; 210 seats per three-car
Total	73 units	147 vehicles	-	-

These DMUs are primarily maintained out of St Philips Marsh and Exeter depots with overnight servicing and repairs additionally carried out at Plymouth Laira, Penzance and Salisbury depots.

New DMU's were announced for a number of operators including Great Western as part of the 2008 High Level Output Specification (HLOS) Programme. Procurement of these units was to have been led by the DfT's Diesel Trains Limited, set up with the purpose of funding and managing the procurement of up to 200 DMU vehicles, with delivery of the first trains into service during 2011-2012. However during 2009, due to the difficulties in the financing markets obtaining funding for such projects, the procurement was put on hold, and ultimately scrapped for Great Western following the announcement of electrification.

5.3 Future Rolling Stock

5.3.1 Diesel Multiple Units

The planned introduction of EMU vehicles in the London Thames Valley area will result in the cascade of newer DMU units to the West to replace the older DMU vehicles currently in service.

London Thames Valley suburban services are primarily operated by the midlife Class 165 and 166 Turbo DMU fleet. Two three-car Class 150/0 units were transferred into the franchise from London Midland during 2012 to provide greater capacity. These units operate the Reading to Basingstoke Line on weekdays, allowing Turbo units previously deployed on the route to reinforce other services. All vehicles are leased from Angel Trains.

The Class 150/0 units are maintained at Reading depot alongside the Class 165 and 166. Key data on the London Thames Valley fleet is summarised in Table 11.

Table 11: Composition of London Thames Valley Fleet

Fleet	Formation	Total Number of Vehicles	Date Into service	Number of Seats per Unit
Class 165/1 Turbo	20 x two-car 16 x three-car	88 vehicles	1985-87	190 seats per two-car; 294 seats per three-car
Class 166 Turbo Express	21 x three-car	63 vehicles	1987-88	284 seats
Class 150/0 Sprinter	2 x three-car	6 vehicles	1985	209 seats
Total	59 units	157 vehicles	-	-

In order to operate the 16x fleet route in the West of England region, clearance modifications will be required. Angel Trains intends to conclude route clearance approvals during the current Direct Award period to support fleet cascade during 2017/2018.

It is expected that Class 16x will replace Class 158 on the Portsmouth – Cardiff services initially. Depending upon the EMU introduction this could be achieved as early as December 2016. These services are currently operated by Hybrid three-car Class 158. It is expected that this will enable these units to be reformed back into 20 x two-cars and these, together with Class 150 and further Class 16x from LTV, will displace all other DMU types from the Bristol area.

A surplus of Class 150 is also likely to be created depending upon the final number of Class 16x that can be cascaded from LTV and the number of Class 158 that can be introduced onto West of England services (a longer dwell time is required for the 158 due to the door design). This Class 150 surplus could be available to operate additional metro services from December 2016 or May 2017.

5.3.2 Electric Multiple Units

Electrification Schemes

Prior to the July 2012 HLOS announcement there were a number of committed 25kV AC electrification schemes in the UK:

- Great Western electrification is scheduled to be completed between London and Bristol including Newbury and Oxford. This scheme is expected to be a consumer of cascaded EMUs – widely assumed to be Class 319s from Thameslink, or possibly even Class 365s also from Thameslink.
- Edinburgh to Glasgow (via Falkirk) route is scheduled to be electrified by December 2016, along with diversionary routes and the route to the north from the Carmuirs area to Dunblane and Alloa. This scheme is expected to be a consumer of new EMUs.
- Lancashire Triangle – Liverpool to Manchester via Chat Moss, Preston to Blackpool South. Completion is scheduled for December 2016. This scheme will release Class 142 and Class 185 units. The Class 185 three-car units are planned to be redeployed onto other routes within their current franchise;
- Transpennine Electrification – Manchester to Leeds was scheduled for completion December 2013 but works are still ongoing. This will displace Class 158 and Class 185 DMUs and possibly some local services which will convert from Class 15x and Class 170 operation to EMU operation as well. This scheme is expected to be a consumer of cascaded EMUs – also widely assumed to be Class 319s from Thameslink, or potentially Class 317s.

Additional electrification schemes announced in the HLOS for CP5 include:

- Great Western extension from Cardiff to Swansea which will mainly be resourced by an altered mix of Super Express Sets. This will also facilitate operation of EMUs in place of a small number of Class 15x units on local services.
- Midland Main Line from Bedford to Derby / Leeds. This will release HSTs and cascade of the Class 222 Fleet.
- Basingstoke to Southampton, mainly providing an AC freight route to the port.
- Oxford – Birmingham, Coventry – Leamington Spa, Bromsgrove – Barnt Green. This allows for replacement of part of the Class 220 / 221 Cross Country fleet with electric rolling stock.
- Gospel Oak – Barking (pending agreement between TfL and DfT). This scheme would release a small number of Class 15x units.

Other schemes with a potential business case for progression in CP6 include:

- Basingstoke to Exeter and Salisbury to Bath (potentially 25kv AC requiring dual voltage EMUs, or 750v DC). This would facilitate release of Class 158/9 units.
- Bromsgrove – Bristol: This allows replacement of a further part of the Class 220 / 221 Cross Country fleet with electric rolling stock. There is currently no known business case for electrification of the cross country route south of Bristol.

The electrification programmes in CP5 and 6 provide little benefit in terms of EMU options for Bristol metro and indeed create a future drain on what is going to be an increasingly scarce resource while producing a surplus of DMU in the market.

Cascade Rolling Stock

As noted, the current West of England fleet is operated as a mix of two and three car DMU. There are no two car EMUs available in the UK other than the DC-only Class 456 and 466, both of which have long term commitments. Direct replacement of two car services is therefore not possible, with three car EMU services required to replace two car DMU services – presenting potential underutilisation issues on MetroWest routes.

With specific regards to potential options for the cascade of EMU rolling stock the following options have been identified and reviewed for suitability and availability for operation on MetroWest routes:

Cascade of Class 313 Units (built 1976-1977)

Up to 44 three-car Eversholt Class 313 units could potentially be displaced in whole or in part from the Thameslink, Southern and Great Northern (TSGN) franchise from mid to late 2016. However there is a good chance that some of the Class 313 could be fitted with ERTMS and continue to operate into the next decade on the Moorgate services.

A further 19 three-car Class 313 units, owned by Beacon Rail Leasing, are on lease with Southern until 2015. They are not part of the stock that will be displaced by Thameslink, however the franchise inherits a surplus of Electrostar rolling stock which they are required to retain, which may facilitate a cascade.

Cascade of Class 315 Units

Class 315 units will be displaced from Greater Anglia/C2C services from 2017 by new Crossrail unit. Some 44 four-car units are expected to be displaced in total.

It is expected that a portion of the Class 315 fleet will initially transfer to the C2C operator to allow Crossrail services to commence from May-2015. The remainder of the total fleet of 61 units are expected to the transferred to the new TfL operator as part of the West Anglia Devolution during 2015. It is anticipated that TfL will seek to rationalise its fleet on an Electrostar derivate such that it is conceivable that further 315 will become available from 2015.

Cascade of Class 317 Units (built 1981-1987)

Class 317 units are expected to be displaced in whole or in part from the TSGN franchise as new Electrostar Class 387 and Siemens Class 700 units are introduced between December 2014 and 2018 and / or potentially from Greater Anglia from 2018 as the train operating company seeks to rationalise smaller fleets.

Currently there are 12 four-car units on lease with First Capital Connect (to be replaced by TSGN) and 51 four-car units on Greater Anglia. First Capital Connect are expected to lease two further Class 317/7 units currently in storage to provide HM cover for their 365 fleet.

Greater Anglia are expected to lease a further two of the 317/7 units currently in storage to provide cover for the 379 being used for the NR funded traction battery trial. Greater Anglia are additionally being loaned the Angel “demonstrator” Class 317. There are also four Class 317/7 air-conditioned units expected to remain in storage.

Cascade of Class 319 Units (built 1987-1990)

Class 319 units are expected to be displaced in whole or in part from the TSGN franchise from 2014 to 2018 as new Electrostar Class 387 and Siemens Class 700 units are introduced. Currently there are 86 four-car units on FCC.

Three units look likely to be mandated to cascade to Northern from May 2014 to facilitate driver and maintainer training, with further units (anticipated to be up to a total of 15 four-car units) expected to follow in December 2014 as new Electrostar Class 387 units are introduced to First Capital Connect

The longer term deployment of Class 319 remains in flux pending the successful TSGN bidders rolling stock strategy, which will dictate the order in which existing First Capital Connect fleet will be cascaded.

Cascade of Class 365 Units (built 1994-1995)

Class 365 units (40 x four-car) could potentially be made available through a cascade from First Capital Connect. However availability remains unknown pending the successful TSGN bidder's rolling stock strategy.

The fleet size is also too large for Bristol Metro and insufficient to cover both London Thames Valley and Metro requirements.

Cascade of Class 360/2 Units (built 2002-2005)

Class 360/2 units (five five-car units) currently operate the Heathrow Connect stopping service between London Paddington and Heathrow Airport. It is understood that the Heathrow Connect service is to be replaced with Crossrail.

The fleet size is, on its own, too small for MetroWest and each unit provides excess capacity over that likely to be required.

Cascade of Class 387 Units (2014)

A total of 29 x four-car Dual Voltage units are the last of the options that could be called from the latest Southern Electrostar build. It is currently understood that these units will initially be introduced onto First Capital Connect to facilitate a cascade out of the older Class 3xx fleet to those franchises with electrification schemes concluding during late 2014 and 2015.

These units themselves are expected to be eventually cascaded out of the TSGN franchise following delivery of Class 700 units. Timescales for the cascade out of this fleet are dependent upon the successful TSGN bidder's rolling stock strategy.

Based on the analysis of the above fleets, it is considered that the most likely option would be to initially utilise a mid-life EMU such as class 36X or 31X rolling stock either operating as a sub-fleet or with an existing fleet broken up due to interest from smaller operators.

Joint Procurement of Rolling Stock

It would be feasible to extend some of the new EMU fast services to Bristol to feed a pool of units based in the Bristol area back to Reading for maintenance. However, it is envisaged that any new EMU for London Thames Valley would be a minimum of four-car, and more likely five-car, and may therefore provide too much capacity and at too great a cost for operation on MetroWest routes.

There is also the feasibility of operating MetroWest services as a sub-fleet of a South Wales EMU fleet procured for the valley lines. These would have similar operational requirements but there are potential issues in stabling and servicing as well as programme entry.

With regards to the business case for investment new EMUs are more costly and cascaded rolling stock always provides the most cost effective option particularly as refurbished units provide comparable performance and passenger experience. Where new rolling stock has been justified on other routes it has been on the basis of high yield routes and a lack of available cascaded rolling stock.

5.3.3 Rolling Stock Refurbishment

Rolling stock quality is important in delivering higher demand and revenue, particularly when a change in passenger perception of rail travel is required. The rolling stock needs to be the most efficient and highest quality on offer. Whatever the stock type, the rolling stock needs to be refurbished to a high standard.

Rolling stock providers have demonstrated that they can achieve a high quality ‘as new’ experience for passengers when refurbishing the interior and exterior of trains. Whilst this requires initial investment, it will deliver value in the long term through higher revenue.

MetroWest stakeholders should be engaged in decisions on rolling stock to ensure that the solution is tailored to the South West. The interior layout should be considered carefully. A metro service may require a metro-style layout arranged to aid rapid boarding and alighting of passengers. Furthermore, if allowance needs to be made for the higher proportion of users likely to be travelling to and from the station by bicycle, then sufficient standing room or bicycle storage should also be considered.

Delivering such improvements in the medium term will act to reinforce the actual and perceived step change in rail services being delivered in the West.

5.4 Depot Options Assessment

5.4.1 DMU Servicing

Under a diesel scenario, servicing of DMU operating on MetroWest will continue to be undertaken at the St Philips Marsh depot.

5.4.2 EMU Servicing

Options for the servicing of electrified rolling stock have been examined with four primary options identified:

- Servicing within a local depot, potentially at St Philips Marsh.
- Shared facility in Canton, Cardiff proposed for Valley Lines.
- Shared facility with IEP trains in Stoke Gifford.
- Shared facility with in Reading London Thames Valley.

There are no plans currently to electrify to or within St Philips Marsh depot. Servicing of EMU rolling-stock would require immunisation of the depot or construction of a smaller dedicated EMU depot facility on adjacent sidings – such a facility could also be provided elsewhere on the local Bristol network. This is the preferred option.

Canton is expected to be electrified as part of the Welsh Valleys electrification project and could potentially maintain a small fleet of EMUs for Bristol metro or possibly provide a sub-fleet from its own EMU fleet under a service agreement for operation on the Metro services. This is identified as the secondary option.

Agility Trains' Stoke Gifford depot is electrified and would have capacity to maintain and operate the 12 or so Metro units required. However Agility's performance regime for IEP is punitive and additional cleaning, stabling and light maintenance workload is likely to be seen as introducing significant risk to their IEP obligations for very limited reward. Furthermore there are a limited number of early morning departure slots which are all currently allocated to IEP trains – placing considerable scheduling issues on any local services operating from the depot. Following discussions with FGW and Network Rail this option was discounted.

It is also conceivable and would present cost benefits for the EMU solution for Metro units to be a common design to the London Thames Valley fleet and to create diagrams and services to work these units back to Reading for maintenance, with stabling and perhaps casualty repair at Canton. Given the distances involved issues with likely differences in rolling stock types this option is considered less feasible than a local depot or use of Canton.

5.5 Conclusions

There are a number of rail electrification schemes identified in the HLOS and additional schemes are being developed by promoters. With a large number of new electrified projects coming online during the next decade there will be considerable competition from other areas of the country for any EMU rolling stock cascaded by existing operators.

Leasing companies generally favour retaining fleet sizes and a number of potentially cascaded EMU fleets are too large MetroWest. There could be the option to jointly procure units with London Thames Valley or Wales and West, however both options present additional problems in terms of stabling and depot facilities, plus the suitability of rolling stock to cater for different franchise route requirements.

As noted, the most likely scenario is that any future EMU operation on MetroWest would initially utilise a mid-life EMU such as class 36X or 31X rolling stock either operating as a sub-fleet or with an existing fleet broken up due to interest from smaller operators. This rolling stock would be expected to provide service until 2030 before replacement by a more modern cascaded EMU.

Conversely while there is likely to be significant competition for EMU there will be a surplus of Class 150 diesel rolling stock as a result of electrification, with some class 16X rolling stock also likely to be available via cascade. This rolling stock would be expected to provide service until 2030 before replacement.

Replacement of DMU would be potentially problematic at this time due to a lack of new units entering the market resulting in a smaller UK fleet from which to cascade rolling stock. It would also be possible to electrify the MetroWest lines prior to 2030 so as to facilitate replacement by a modern cascaded or new EMU, from a sizeable UK fleet – see Figure 5.

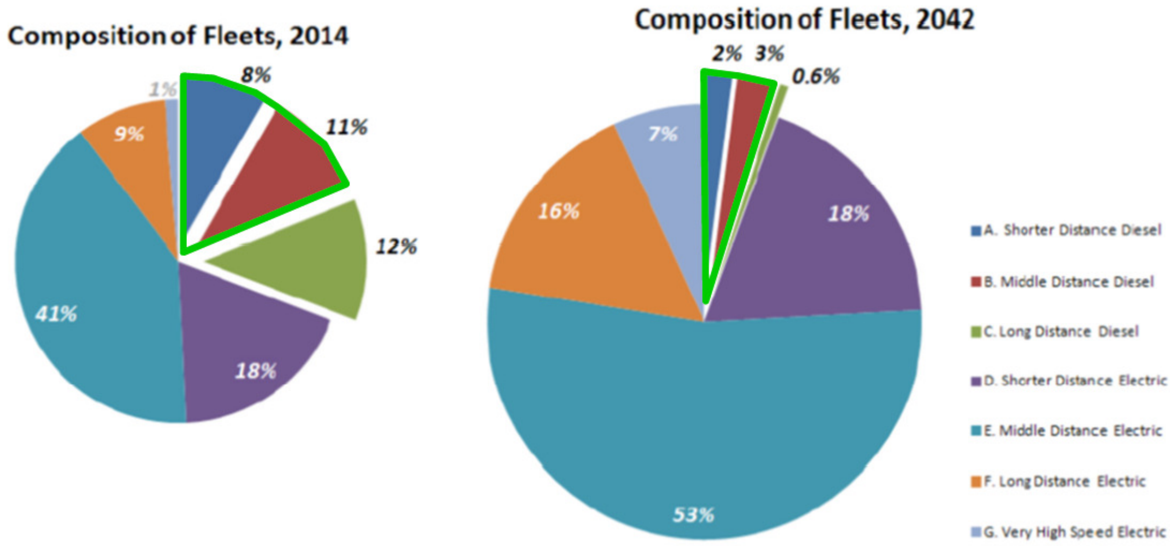


Figure 5: UK Passenger Rolling Stock Projections, ATOC

St Philips Marsh provides a major DMU depot facility within the MetroWest area and there are no proposals to immunise the depot to facilitate servicing of EMU. Should MetroWest electrification proceed the preferred option would be immunisation of the depot or construction of a new, small shed for the servicing of EMUs on adjacent sidings. If this is not achievable, an alternative location would need to be identified within the MetroWest network, or the feasibility of servicing EMU in Canton, as a sub-fleet of a larger South Wales fleet, would be feasible.

6 Timetabling and Operations

This chapter provides details of the Phase 1 and 2 timetables developed for the assessment of the scheme benefits.

6.1 Do-minimum Timetables

The service specification of Intercity Express Programme (IEP) services (Crossrail Iteration 5) was not received by the time this analysis was carried out and therefore has not been included in the timetable modelling. As instructed by WoEP[4], indicative “standard hour” timetables for Phase 1 and 2 have been produced using RailSys (provided by NR) Sectional Running Times (SRTs) to fit with the existing timetable.

6.1.1 Phase 1

Service specification for Phase 1 of the project is based on the option 5b service pattern developed as part of the MetroWest project and includes:

- Severn Beach to Bath Spa 1tph all day (forming 2tph between Bath Spa and Bristol Temple Meads with the existing timetable at the time of analysis).
- Avonmouth to Portishead 1tph all day.
- Portishead and Bristol Temple Meads 1tph all day.
- New station at Portway P&R on Severn Beach line.
- New stations at Portishead and Pill on Portishead line.

6.1.2 Phase 2

No service pattern for Phase 2 of the project was available as part of the MetroWest project at the time of this analysis.

Assumed service specification for Phase 2 of the project includes:

- Bristol Temple Meads to Henbury 1tph all day (assumed Henbury loop connecting at St Andrews & continues to form 1tph Avonmouth to Portishead services).
- Yate to Weston Super Mare 1tph all day (existing Weston Super Mare – Bristol Parkway Service extended to yate & retimed to form an hourly services to Yate and tops up existing Gloucester services at Yate forming 2tph at Yate with the existing timetable at the time of analysis).
- New stations at Henbury, North Filton, Horfield and Ashley Down on Henbury line.
- New station at Saltford on Bath Line.
- New station at Ashton Gate on Portishead line.
- New turn back facility at Yate.

The timetables developed have been reviewed using RailSys (a timetable planning and simulation tool developed by Network Rail) to check the running times with current infrastructure and rolling stock. Operational concerns in running the indicative

[4] Email 07/07/2014 from client Project Manager.

timetables were identified and adjustments were made to the final timetables. The proposed Do-minimum timetables for a standard hour are attached in Appendix D.

6.2 Future Timetables

Electrification of the Bristol suburban railway network will bring changes in timetables with faster journey times. The journey time savings resulting from deployment of the electric rolling stock compared to the diesel rolling stock is summarised in the Table 12.

Table 12: Journey Time Saving due to Electrification

	Diesel Timetable Journey Time	Electrification Timetable Journey Time	Journey Time Saving due to Electrification	% Difference
Bristol Temple Meads to Portishead	20:00	19:00	01:00	5%
Bristol Temple Meads to Severn Beach	37:00	37:00	00:00	0%
Bristol Temple Meads to Weston-super-Mare	31:00	28:00	03:00	10%
Bristol Temple Meads to Yate	28:00	27:00	01:00	4%
Bristol Temple Meads to Bath Spa	20:00	19:00	01:00	5%
Bristol Temple Meads to Henbury	25:00	25:00	00:00	0%
Portishead to Bristol Temple Meads	20:00	19:00	01:00	5%
Severn Beach to Bristol Temple Meads	38:00	38:00	00:00	0%
Weston-super-Mare to Bristol Temple Meads	30:00	27:00	03:00	10%
Yate to Bristol Temple Meads	26:00	25:00	01:00	4%
Bath Spa to Bristol Temple Meads	20:00	18:00	02:00	10%
Henbury to Bristol Temple Meads	24:00	24:00	00:00	0%

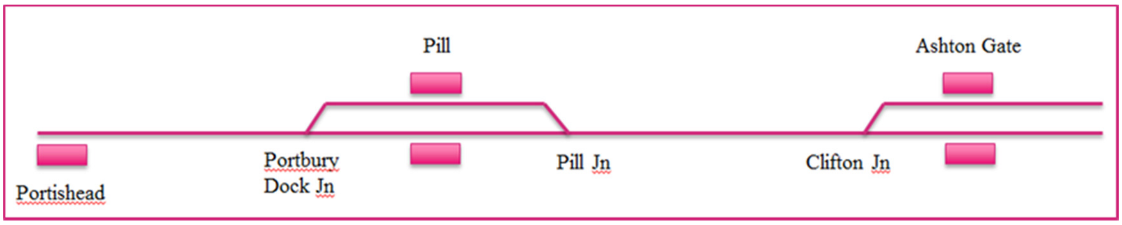
Overall, on average, around 4% journey time savings are expected due to electrification against the do-minimum timetable. Whilst journey time savings are small they are within the range that would be expected for an upgrade to rolling stock. There are a number of factors that limit journey time savings. There are timetabling or train pathing constraints to achievement of journey time savings. Furthermore, even trains are employed that have faster acceleration or deceleration, the improvements in running times are not always sufficient to trigger a change in the timetable and are ‘rounded down’. It is also the case that constraints on line speed mean that the performance of rolling stock is not always reflected in the timetable.

The above journey time savings have been used to develop the electrification (do-something) scenario timetables for Phase 1 and 2. The service patterns for the proposed EMU timetable is same as the do-minimum service patterns described in section 6.1 above. The proposed electrification timetables for a standard hour are attached in Appendix D.

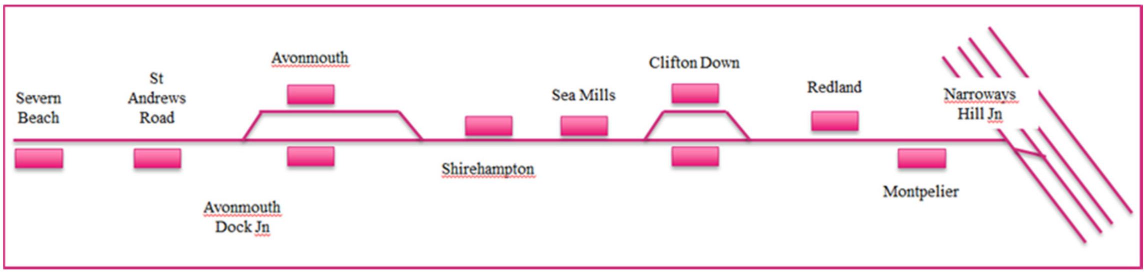
6.3 Conclusions

Exact half hour service pattern for the Severn Beach – Bath Spa and Avonmouth – Portishead services were not achieved due to the path availability on a single track section the Severn Beach and Portishead line.

For example, for exact half hour services at Portishead, Portishead – Bristol Temple Meads service will conflict with the Avonmouth – Portishead service, between Clifton Jnc and Pill Jnc. Therefore, the entire pattern of the Portishead – Bristol Temple Meads service should be re-timed at least three minutes before the Avonmouth – Portishead service passes at this location.



An extact half hourly service on Portishead – Avonmouth service and Severn Beach – Bath service will conflict on single line section between Clifton Down and Avonmouth Dock Jn. Similarly, Avonmouth – Portishead service and Bath – Severn Beach service will conflict between Clifton Down and Narrow Hill Jn. Therefore, the Up and the Down service should be re-timed to avoid potential performance risks.



Phase 2 service patterns with Henbury Loop were achieved with speed improvements on the Filton curve. As there are concerns regarding the turnaround time at Bristol Temple Meads which could have potential performance implications for the Henbury– Avonmouth – Portishead services. Reduction in additional stop on Henbury can provide some operational flexibility. Further performance modelling considering design speed of the new Henbury line should be undertaken for the next stage of the modelling. It could also be considered to run the Avonmouth – Portishead service as one set, and the Henbury – Bristol Temple Meads service as another set to avoid the conflict.

7 Demand and Revenue Forecasts

7.1 Approach

An elasticity-based forecasting approach, based on guidance from the Passenger Demand Forecasting Handbook (PDFH) has been adopted to prepare demand forecasts under diesel and electrification scenarios. The demand forecasting framework is based on two drivers:

- **Exogenous demand growth** - Exogenous factors are background changes which are assumed to be outside the direct control of the rail industry. These include factors such as GDP, employment, population, car ownership, car fuel costs, car journey times. The factors are constant under both diesel and electrification scenarios.
- **Endogenous demand growth** – Endogenous factors are scheme related initiatives which are assumed to be within the direct control of the rail industry. Endogenous factors for this scheme include timetable related Generalised Journey Time (GJT) and frequency improvements as well as non-timetable related service quality improvements.

This section sets out the result of demand and revenue forecasting with a more detailed explanation provided as a technical note in Appendix E.

7.1.1 Impact of Electrification

Electrification is expected to deliver higher demand for two reasons.

Journey Time Savings

As set out previously in this report, electric rolling stock offers marginal improvements in journey time. Lower journey times are expected to result in higher demand for MetroWest services.

The effects of timetable changes for existing stations/services have been modelled using MOIRA. MOIRA uses the mathematical framework based on established relationships between journey times and demand to estimate the change in demand due to timetable change. Both do-minimum and electrification scenarios have been modelled using the timetables described in Appendix D of this report.

Rolling Stock Quality Effects

Along with the timetable changes, the electrification of the Bristol suburban railway network is expected to offer improved service quality with the deployment of electric rolling stock.

Electric trains are quieter than diesel trains and is expected to offer a slightly improved ride quality. The impact of improvement in the ride quality is assumed to lead to an increase in demand across the study area.

This assumption is supported by evidence from various electrification studies which have shown that electrification leads to increase in demand by offering a better quality experience for passengers, often referred to as the “sparks effect”. It has been suggested that one of the reasons for the sparks effect is that people simply prefer electric trains (because they perceive them as more modern or because they value the environmental benefits of electrification). However, electrification is typically accompanied by other improvements such as frequency enhancements, faster journey times and rolling stock upgrades and therefore it may be that passengers have responded to more tangible improvements.

Notwithstanding this, in practice the investment electrification would provide the impetus for switching to more modern rolling stock or refurbishment of existing units to a high standard. Such a step change may not occur under a diesel scenario and therefore there are good reasons for applying rolling stock quality factors.

Three factors have been chosen to reflect the improvement in rolling stock brought about by electrification: the ride quality, the quality of the train interior/condition and the quality of passenger information provision. It is difficult to be specific about the improvements in rolling stock that would result and therefore these factors have been combined as a proxy for the overall improvement.

Table 13: Incremental Value of Time Multipliers

	Level From	Level To	Commuting	Business/Leisure
Environment	Train in poor condition – with damaged fixtures and seating	Train in good condition – with slightly damaged areas	0.018	0.020
Environment	Extremely bumpy ride	Very smooth ride	0.033	0.037
Information	Audible announcements easily heard	Flat screen display showing relevant information	0.001	0.001
Total			0.052	0.058

Source: PDFH 5.1

Rolling stock quality factors have been applied only to journeys that begin and end within the Bristol suburban network on MetroWest services so that uplift in demand outside the study area are not included in overall scheme benefit estimates. The benefits of improved ride quality due to electrification are assumed to deliver benefits throughout the appraisal period.

7.2 Demand & Revenue Forecasts

The overall net increase in passenger demand and revenue resulting due to electrification of the Bristol suburban railway network is shown in Figure 6 and Figure 7 respectively.

The net increase in demand resulting from the electrification of Phase 1 is estimated to be around 44,000 trips (based on levels of demand in 2019). The increase in demand is associated with revenue of approximately £134,000. The Phase 1 demand uplift is estimated to grow by 48 % to 62,000 by 2033 due to the exogenous factors noted above. Demand growth is capped from 2033 onwards in line with the WebTAG guidance.

The net increase in demand for Phase 1 and 2 is estimated to be around 110,000 in the year 2025, rising to 133,000 by 2033. Approximately, 35% of net increase in revenue is due to journey time savings and 65% is due to rolling stock quality improvements.

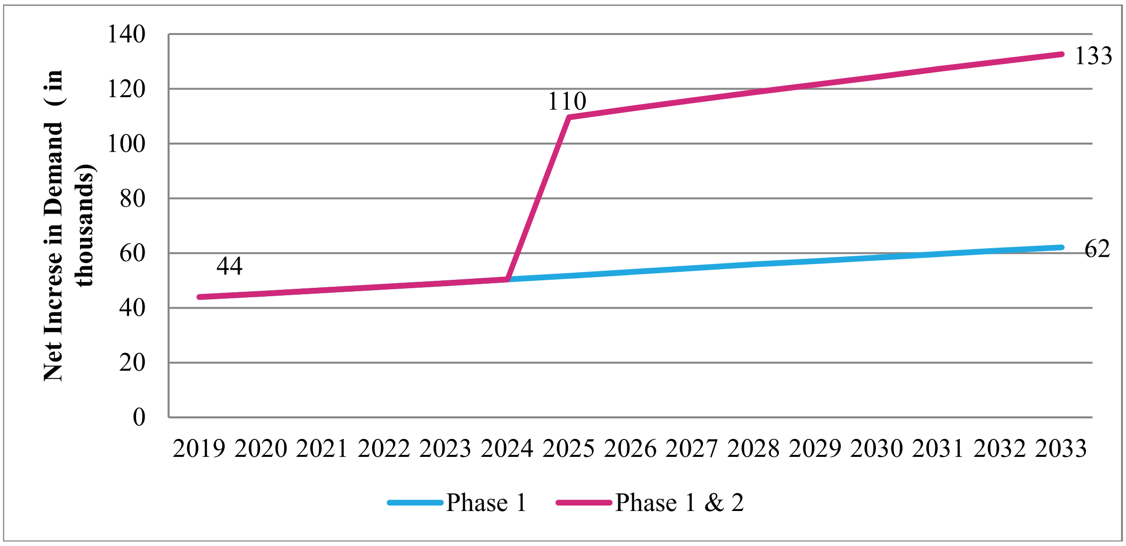


Figure 6: Net Increase in Demand (in thousands, 2013 levels)

The resultant revenue impacts of this increase in passenger numbers is as shown below in Figure 7.

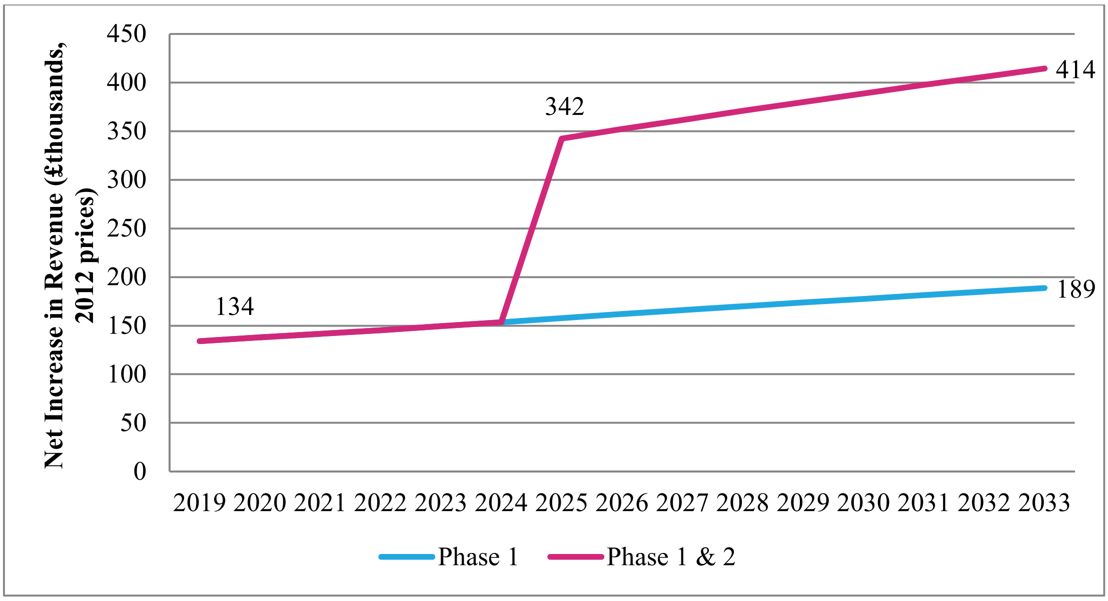


Figure 7: Net Increase in Revenue (£thousands, 2012 prices)

7.3 Capacity Assessment

An indicative assessment of the level of peak time demand that might be expected on each MetroWest train diagram has been undertaken in order to estimate the length of train that will be required on each diagram to inform the operating cost estimate. Whilst the base assumption in previous MetroWest reports has been two-car DMUs[5], future demand growth may require longer trains to be used.

In the context of MetroWest, future capacity requirements are difficult to predict. This is because it is difficult to accurately allocated annual demand forecasts to specific peak

5 Bristol Area Rail Study Final Report, Halcrow

time services in the context of an expanding network of stations and services. Therefore, the assessment is necessarily high level and has been undertaken for the purposes of the business case, not for operational planning purposes.

The MOIRA model has been used to extract morning peak (07:00-10:00) train loading on arrival at Bristol Temple Meads for existing services. For new services peak loading has been estimated using the MOIRA loading data on the existing suburban MetroWest services. These load profiles have not been calibrated against any passenger counts and therefore individual trains loads may vary from the observed count data.

Estimated maximum load factors – the proportion of used capacity – have been estimated for each diagram in the 'do-minimum' scenario. This is shown in Figure 8 below. It can be seen that, whilst the majority of trains can be operated with two-car units, a number of trains may be overcrowded, particularly in later years of the appraisal.

The rolling stock requirement based on this assessment is summarised in Table 10.

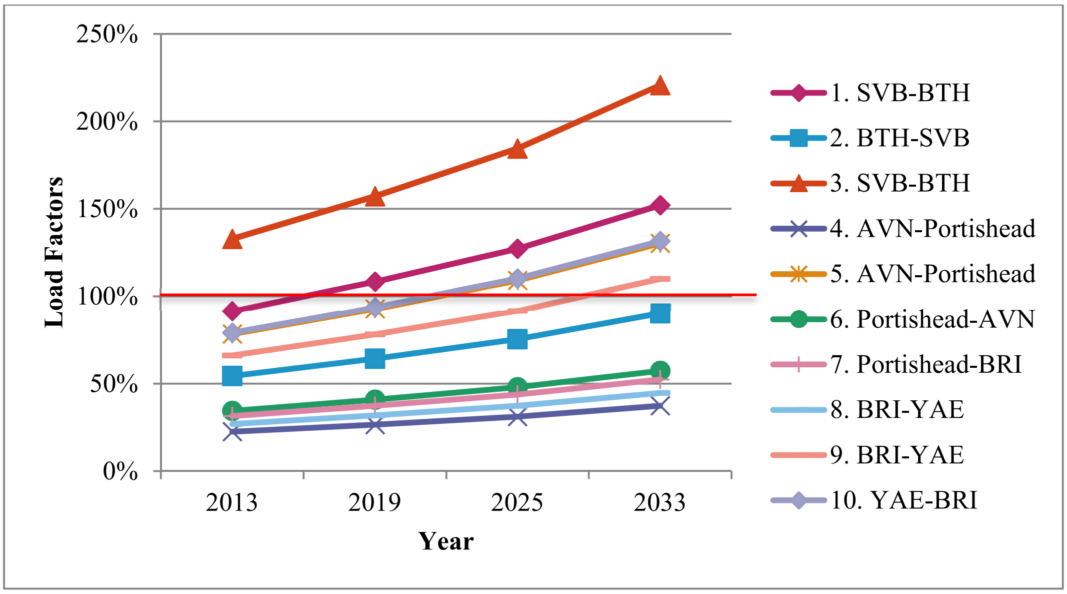


Figure 8: Max Load Factor based on Total Capacity by Diagram (Phase 1+2, DMU, Do-Min)

As noted, the demand analysis has been used to inform the train length and fleet size assumptions used in the operating cost assessment. Where a train reaches 100% of seated and standing capacity in the peak period, it is assumed that the capacity of the service is increased with an additional vehicle. By 2033, a mix of two, three and four-car trains are likely to be required.

Table 14: Rolling Stock requirement based on Total Capacity (Phase 1+2, DMU, Do-min)

Diagram	2013	2019	2025	2033
1 (Severn Beach-Bath Spa)	2-car	3-car	3-car	4-car
2 (Severn Beach-Bath Spa)	2-car	2-car	2-car	2-car
3 (Severn Beach-Bath Spa)	3-car	4-car	4-car	4-car
4 (Portishead-Bristol Temple Meads)	2-car	2-car	2-car	2-car
5 (Avonmouth-Portishead)	2-car	2-car	3-car	3-car
6 (Portishead-Avonmouth)	2-car	2-car	2-car	2-car
7 (Portishead-Avonmouth)	2-car	2-car	2-car	2-car
8 (Yate-Weston Super Mare)	2-car	2-car	2-car	2-car
9 (Yate-Weston Super Mare)	2-car	2-car	2-car	3-car
10 (Yate-Weston Super Mare)	2-car	2-car	3-car	3-car

7.4 High Growth Scenario

The demand forecasts developed for this study, using the PDFH approach, result in an overall growth rate of around 2.5% per annum. These forecasts are considered to be broadly in line with the Network Rail Western Route Study (which is in turn informed by the Market Studies) which suggests that demand growth on regional urban services into Bristol will be 2.4% per annum.

A review of historic growth rates at groups of MetroWest services based the Office of Rail Regulation (ORR) station usage data between 2008 and 2013 has been undertaken to understand recent trends in rail demand for the study area. The review shows that total rail demand on the MetroWest Lines has grown by 21% between 2008 and 2013, which is equivalent to an annual growth rate of 3.8 %. Taking out the major stations Bristol Temple Meads, Bristol Parkway and Bath Spa which use services other than Metrowest services, the patronage has grown by 41% between 2008 and 2013 (6.9% per annum).

In particular, total patronage on the Severn Beach line has experienced high growth of around 67% over the same period (10.8% per annum). A summary of recent trends is shown in Table 15.

Table 15: Rail Demand Trends

Station groupings	2008/09 to 2012/13 Total	2008/09 to 2012/13 Per annum	2011/12 to 2012/13 Per annum
MetroWest Lines	21%	3.8%	2.6%
Severn Beach Line	67%	10.8%	11.0%
Weston-super-Mare Line	26%	4.7%	2.4%
Bath Line	29%	5.2%	9.2%
MetroWest Lines (Ex Bristol Temple Meads, Bristol Parkway & Bath Spa)	**41%**	**6.9%**	**7.5%**

The comparison of predicted growth against the observed growth between 2008 and 2013 clearly shows that the MetroWest lines have been exceeding the predicted growth rates. Whilst it is far from certain that such rapid growth will be sustained, a sensitivity test has been applied to reflect the fact that rail demand in Bristol has grown strongly in recent years. This also acknowledges that there is a significant degree of uncertainty attached to the rolling stock quality effect which will influence the results of the economic benefits. For this test, a 5% increase in demand per annum (twice that of the baseline forecast) has been allowed from 2013 to 2023. Rail demand is assumed to grow in line with PDFH growth factors from 2023 to 2033.

8 Economic Appraisal

The economic appraisal considers whether electrification offers good value for money. The appraisal has been carried out in accordance with the WebTAG guidance. There are three main elements of the appraisal – capital costs, operating cost savings, and user benefits & revenue impacts. Each of these are dealt with in turn and the overall results provided.

8.1 Scenarios

The following scenarios have been evaluated within the economic appraisal:

- Electrification in CP6 (2019-2024) of Metrowest Phase 1 and Phase 2
- Electrification in CP7 (2024-2029) of Metrowest Phase 1 and Phase 2

Sensitivity testing has also been undertaken for the following:

- Higher passenger growth than forecast in the base cases.
- Lower capital costs for Phases 1 and 2.
- MetroWest electrification building on a wider electrification programme in the South West.

8.2 Capital Costs

The capital cost estimate is described in detail in Section 4. Costs for depot construction or modification of £14m are included based on an assumed small, new depot located at St Philips Marsh. For the purposes of the economic appraisal, optimism bias of 40% has been applied to reflect the systematic tendency for costs to be underestimated. This is the level of optimism bias required for GRIP 3 rail projects. Whilst the cost estimates for Metrowest electrification do not have a GRIP status, they are benchmarked against cost estimates for other electrification schemes which are GRIP stage 2 or 3.

Costs are discounted to a common year and price base – 2010 – to allow comparison with scheme benefits.

Table 16: Capital Costs

	Phase 1	Phase 1 and 2
Capital Costs (£m 2014 prices)	£74.4m	£150.8m
Depot Costs (£m 2014 prices)	£14m	£14m
Power Supply (£m 2014 prices)	NA	£10m
Total Capital Costs (£m 2014 prices)	£88.4m	£174.8m
Total Capital Costs Including Optimism Bias (£m 2014 prices)	£123.8m	£244.7m
Present Value Costs £m (2010 prices)	£92.7m	£183.2m

8.3 Operation Cost Assessment

8.3.1 Assumptions

Rolling Stock Scenarios

One of the major influences on the business case is the assumptions that are made on rolling stock deployment over the 60-year appraisal period. The availability of electric and diesel rolling stock is highly uncertain, particularly in later years of the appraisal. Therefore the business case needs to make sensible and comparable assumptions about rolling stock deployment under both the 'do-minimum' option and the intervention options. The assumed rolling stock scenarios are given in the Table 17.

Table 17: Rolling Stock Scenarios

	2019 – 2024	2025-2029	2030-2039	2040-2079
Do-minimum	Life Extended Class 150 (Sprinters)		Cascaded Modern diesel	New Diesel
Electrification	Cascaded Mid-Life EMU		Cascaded Modern EMU	New EMU

As noted, in Section 5, the most likely diesel train option for the commencement of MetroWest services would be a Class 150 Sprinter train. It is considered that these trains are likely to reach the end of their useful economic life at around 2030.

For the purposes of the economic appraisal, it is assumed that, from 2030, sufficient cascaded modern diesel trains can be secured from other UK franchises to replace the existing fleet in its entirety. When this second cascaded fleet itself is retired, it is assumed that a new diesel fleet would need to be procured.

Based on the assessment of rolling stock availability, it is assumed that a mid-life EMU would be used in the event of electrification. For consistency, under the cascaded EMU option it is also assumed that the fleet is eventually replaced by newer cascaded EMUs and then New EMUs. However, it should be noted that the pipeline of new EMU procurements in the UK suggest that the availability of cascaded EMU options in the future are likely to be much less constrained than under a diesel scenario.

Fleet Size

The size of fleet (the number of diesel or electric vehicles) is based on the number of train diagrams required to operate the service, the train formation (number of vehicles required for each train) – which is in turn a product of the demand analysis – and the number of maintenance spares required.

A sample of the fleet size assumptions is given in Table 18. Crucially, electric trains come in a minimum three-car formation. Therefore, where demand can be catered for with a two-car diesel train, the switch to electrification results in an additional vehicle. Therefore, electrification results in an increase in the overall fleet size.

The number of spare units required is estimated based on typical 'availability rates' in the industry. Electric rolling stock requires less maintenance than diesel rolling stock and therefore achieves a higher level of availability.

Table 18: Fleet Size Assumptions

Scenario		Train Diagrams	Vehicles (2025)	Total Vehicles Including Spares (2025)	Vehicles (2035)	Total Vehicles Including Spares (2035)
Phase 1	Do-minimum	6	16	20	17	21
	Electrification	6	19	22	20	23
Phase 1 and 2	Do-minimum	10	25	31	27	33
	Electrification	10	31	37	32	35

Rolling Stock Costs

Rolling stock costs include monthly capital and maintenance lease charges for each rolling stock type in 2013. Lease rates for each stock type are estimated based on industry knowledge. Capital lease charges are assumed to remain constant in nominal terms and non-capital lease charges are assumed to grow in line with RPI.

Maintenance and cleaning costs are included on a per vehicle mile basis. Train and vehicle mileages are estimated based on the proposed train diagrams and include travel to and from the depot.

Diesel and electricity consumption rates are included in the rolling stock assumptions table in litres per vehicle mile or kWh per vehicle mile respectively. The fuel consumption for each diagram is multiplied by the cost per unit, the rate of which is based on industry knowledge. The DECC diesel and electricity price forecasts are applied to diesel and electrify costs.

Network Rail charges

Variable usage charges – reflecting the costs of track wear caused by trains – are charged on a per vehicle mile basis. These costs have been estimated based on current rates charged by Network Rail for similar vehicle types.

8.3.2 Results

Figure 9 illustrates the cost savings delivered by electrification under the base case scenario. Cost savings are very modest (even negative in the case of Phase 1 and 2 combined) in the early years of the appraisal from 2022 to 2030. This is because of the relatively low cost of the likely diesel rolling stock and the requirement, under electrification, for three-car trains. Cost savings increase significantly over time, peaking at over £3m per annum by 2040. In part this is due to real terms growth in diesel fuel prices and increasing fleet size (to cater for growing demand), but is primarily the result of rolling stock type changes that occur in 2030 and 2040.

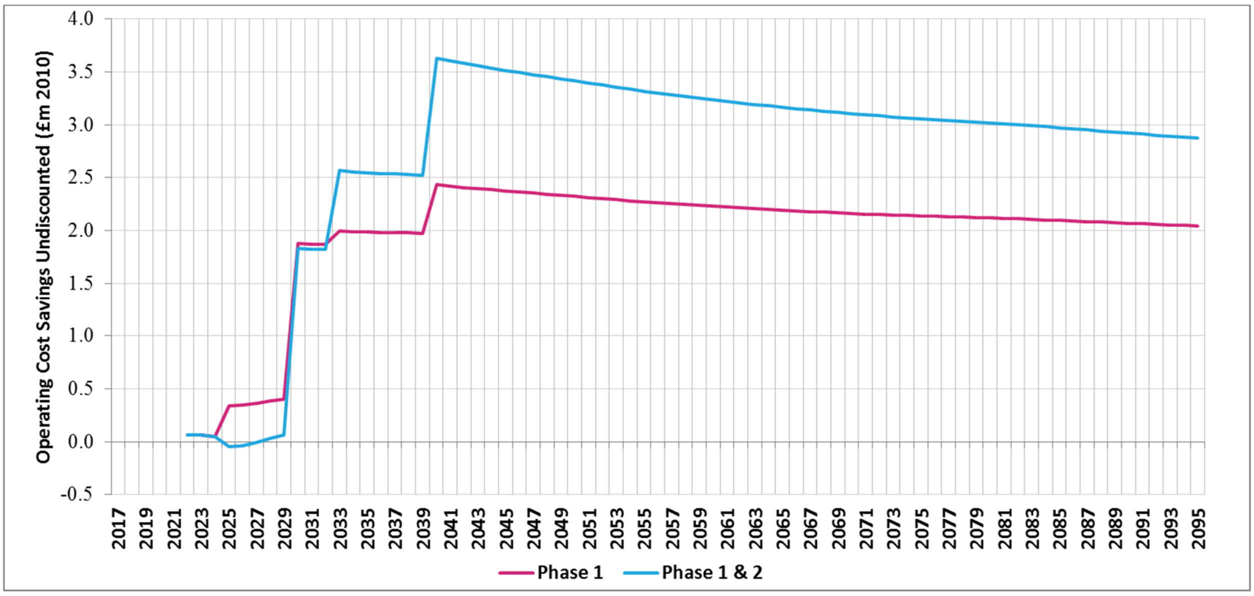


Figure 9: Operating Cost Savings

Over a 60-year period, operating cost savings – in present value (2010) terms – is £34.9m for the electrification of Phase 1 and £46.3m for the electrification of Phases 1 and 2 combined.

Table 19: Operating Cost Saving ('Base Case')

Scenario	Annual Cost Saving (£m, 2014 Prices)				60-Year Appraisal Period (£m, 2010 Prices Values)
	2025	**2030**	**2035**	**2040**	
Phase 1	-0.1	1.8	2.5	3.6	**£34.9m**
Phase 1 and 2	0.3	1.9	2.0	2.4	**£46.3m**

8.4 Overall Appraisal

8.4.1 Tests

The economic appraisal has been undertaken for a 'base case' and a range of sensitivity tests, reflecting the uncertainty surrounding some of the key assumptions:

- Timing;
- Demand Growth;
- Capital Costs; and
- Wider South West electrification programme.

8.4.2 Key Assumptions

Key economic assumptions are listed in Table 20.

Table 20: Key Assumptions

Input parameter	Values & data sources
Price Base	2010 (The DfT's current price base year)
Real prices and inflation	HMT's GDP deflator
Discount Rate	3.5% for first 30 years 3.0% for years 31 to 60
MetroWest Scheme Opening Year	Phase 1 2019 Phase 2 2021
Appraisal period	2022 – 2081 (2030 to 2089 for 'CP7 Tests')
Real terms fares growth	1% per annum from appraisal year 2013 to 2033, capped thereafter
Exogenous demand growth	Based on methodology in PDFHv5 .1, growth capped from 2033 onwards
Values of Time	As per WebTAG unit A1-3, Table A 1.3.1 and Table A 1.3.2
Marginal External costs of car use	As per WebTAG unit A5-4, Table A 5.4.2 for Urban roads and Rural Motorways. Estimate of km transferred from car from the National Transport Model

8.4.3 Results

Base Case

In the base case, assuming electrification in Control Period 6, the benefit-cost ratio for the electrification of MetroWest Phase 1 is 0.65:1 with a Net Present Value of -£18m. The case for the electrification of both Phases 1 and 2 is weaker with a benefit-cost ratio of 0.48 and a Net Present Value of -£64m.

If electrification takes place later, in Control Period 7 (completed by 2030), then the economic case improves considerably, with a benefit-cost ratio of 0.92:1 for Phase 1 and 0.66:1 for Phase 2.

The results of the base case are given in Table 21 below.

Table 21: Economic Appraisal: Base Case (£m 2010 prices/values)

	Electrification in Control Period 6		Electrification in Control Period 7	
	MetroWest Phase 1	MetroWest Phase 1 and 2	MetroWest Phase 1	MetroWest Phase 1 and 2
Costs and Revenue				
Capital expenditure	92.7	183.2	70.4	139.1
Operating expenditure	-34.9	-46.3	-30.4	-39.6
Revenue	-6.6	-13.3	-5.4	-11.5
Present value of costs (PVC)	**51.2**	**123.6**	**34.5**	**88.1**
Benefits				
Consumers travel time	25.2	47.6	23.9	46.4

	Electrification in Control Period 6		Electrification in Control Period 7	
	MetroWest Phase 1	MetroWest Phase 1 and 2	MetroWest Phase 1	MetroWest Phase 1 and 2
Decongestion	0.4	1.1	0.3	1.0
Infrastructure	0.0	0.0	0.0	0.0
Accident	0.3	0.8	0.2	0.7
Local Air Quality	0.0	0.0	0.0	0.0
Noise	0.0	0.1	0.0	0.0
Greenhouse Gases	13.6	19.7	11.9	17.6
Indirect Taxation	-6.4	-10.0	-4.5	-7.6
Present value of benefits (PVB)	**33.2**	**59.3**	**31.9**	**58.2**
Results				
Net Present Value NPV = B+R-C	**-18.0**	**-64.3**	**-2.7**	**-30.0**
Benefit Cost Ratio BCR = B/(C-R)	**0.65**	**0.48**	**0.92**	**0.66**

The primary reason that the business case for electrifying Phase 1 is more cost effective than the business case for electrifying both phases is that the inclusion of Phase 2 increases capital costs by a factor of 116% but delivers operating cost savings that are only 32% higher than for Phase 1. The reasons for this are:

- Phase 1 benefits from the fact that part of the network (between Bristol and Bath) would be electrified as part of the GWEP. Similarly, Phase 2 benefits from the electrification of the section of track from Bristol Temple Meads to Bristol Parkway. However, overall the track length required to be electrified for Phase 2 is 64 single track km compared with 39 single track km for Phase 1.
- With respect to operating costs, Phase 2 can be operated with the addition of just four train diagrams whereas Phase 1 requires six. Therefore the scope for savings is less.
- It is expected that Phase 2 could be operated mainly with two-car train sets in the 'do-minimum' case. Phase 1 requires a higher proportion of three or -car trains. Therefore, the lack of a two-car EMU option imposes higher costs on operation when Phase 2 is included.

The build-up of costs and benefits for Phase 1 and Phases 1 and 2 is illustrated in the Figure 10 and Figure 11.

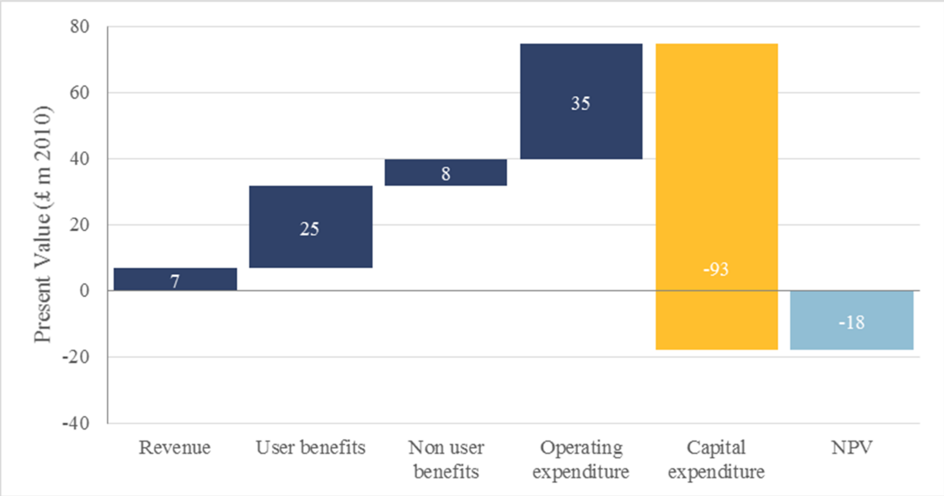


Figure 10: Appraisal Results - Metrowest Phase 1 (Base Case, CP6)

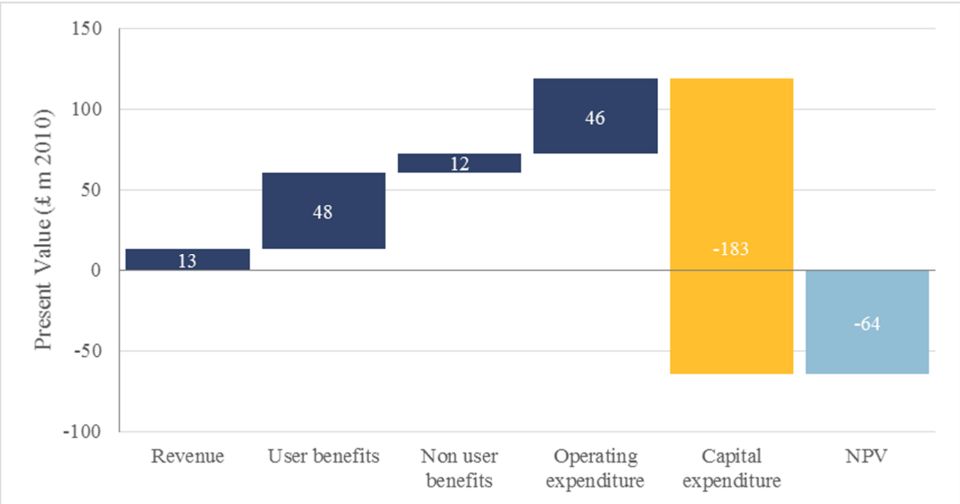


Figure 11: Appraisal Results - Metrowest Phase 1 and 2 (Base Case, CP6)

Within Phase 1, it is likely that electrification of the Severn Beach line would deliver higher benefits relative to the costs of electrifying the line in comparison to the Portishead Line. Similarly, in Phase 2, the cost of electrification between Yate and Bristol Temple Meads are dwarfed by the cost of electrifying between Bristol and Weston-super-Mare.

However, given the fixed costs of power supply and depots, and the inefficiencies of a smaller fleet of EMUs, it is unlikely to be attractive to ‘cherry pick’ routes for electrification. This approach would also limit the flexibility to operate train diagrams in an efficient manner – for example between Portishead and Portway, or between Yate and Weston-super-Mare. If through-running of services is compromised, there may also be capacity constraints to the achievement of the desired service frequencies.

The second key point from the appraisal is the fact that the appraisal result improves if electrification is delayed until Control Period 7 (CP7). Figure 12 and Figure 13 illustrate the build-up of the results with a CP7 electrification scheme.

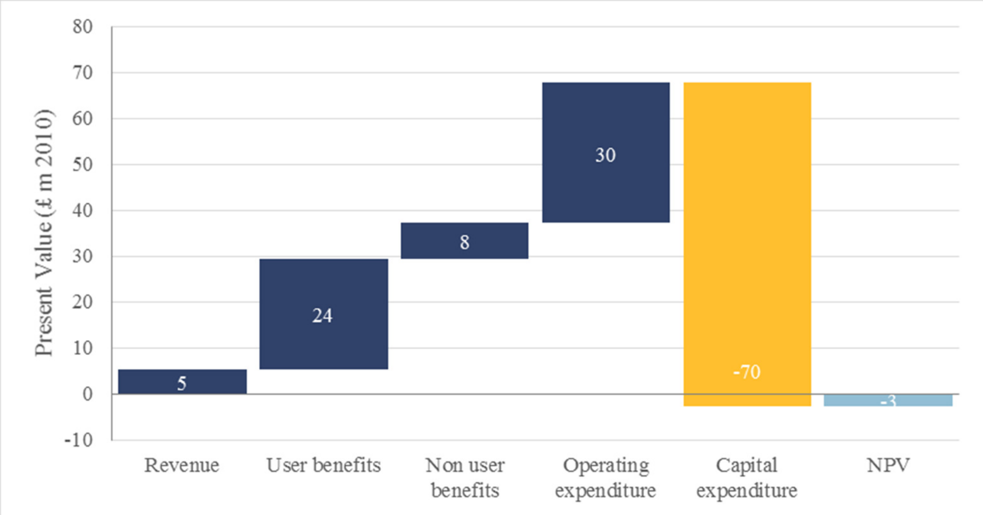


Figure 12 - Appraisal Results - Metrowest Phase 1 (Base Case, CP7)

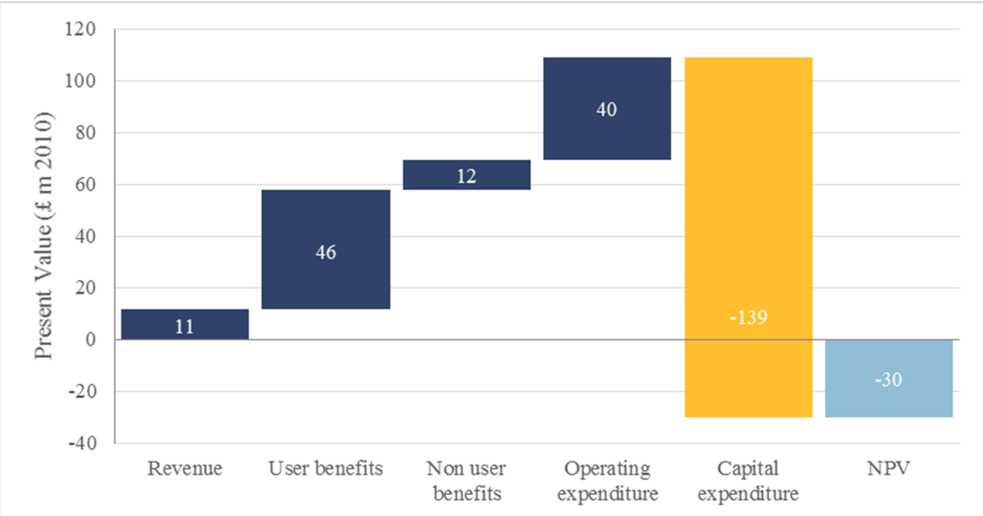


Figure 13 - Appraisal Results - Metrowest Phase 1 and 2 (Base Case, CP7)

There are two main reasons that explain why electrification in CP7 has a stronger case.

Firstly, by 2030 demand on the network is expected to be higher, resulting in higher user benefits and requiring higher capacity services (such that the overall fleet size will be larger).

Secondly, by 2030, the assumed 'do-minimum' fleet – Class 150 DMUs – would reach the end of their usable life and would need to be replaced with a more modern train type. From 2030 onwards, it is expected that the cost of diesel operation will increase relative to electric options. As set out in Section 5, increasingly commuter networks in the UK will be based on electric traction. This emphasis on electrification is having significant implications for the market for rolling stock in the UK. The market for new passenger rolling stock is increasingly moving away from diesel to electric trains. The electrification programme will greatly accelerate this trend and has signalled to suppliers that the market for new diesel trains will be eroded by electrification.

This trend has important implications for the case for electrification. Whilst there will be a number of diesel commuter fleets displaced as a result of electrification in the short and medium term, in the longer term the supply of cascaded commuter diesel rolling stock may be more constrained. This could result in higher lease costs for diesel trains. It may also dictate that at some point in the future a new fleet of diesel trains will need to be procured. As noted, we assume that this point comes in 2040. With manufacturers increasingly focussing solely on electric trains, the differential in cost between new diesel and new electric trains is expected to be greater than the difference in costs between cascaded diesel and electric fleets.

High Growth Scenario

It is important to consider how the economic case for electrification changes if demand growth is higher than forecast in the base case. Demand forecasting is inevitably uncertain and, importantly, the approach to forecasting future crowding levels and capacity requirements has been undertaken at a relatively high-level. As noted in Section 8 rail demand on services into Bristol has been growing strongly in recent years. Should this rapid growth continue, the level of user benefits would be higher than the base case would suggest. Equally, the operating cost savings would be higher due to a larger fleet size, reducing the penalty imposed due to the lack of a two-car EMU.

The effects of this high demand growth assumption on overall economic benefits is summarised in Table 22. Overall, the user benefits and revenue impacts of electrification are increased by around 25% compared to the base case. Operating cost savings increase by between 23% (Phase 1 and 2) and 39% (Phase 1 only).

Under this scenario, the case for electrification of Phase 1 is considerably stronger. If it is assumed that electrification takes place in CP7, the benefit-cost ratio for this option increases to 2.15:1 with a positive net present value of £21m. This would place the scheme in the 'high' value for money category according to DfT guidance.

The case for the electrification of Phases 1 and 2 is also considerably improved but remains marginal with a BCR of 0.95:1, suggesting broadly 'neutral' value for money.

Table 22: Economic Appraisal: High Demand Growth (£m 2010 prices/values)

	Electrification in Control Period 6		Electrification in Control Period 7	
	MetroWest Phase 1	**MetroWest Phase 1 and 2**	**MetroWest Phase 1**	**MetroWest Phase 1 and 2**
Present value of costs (PVC)	36.1	110.1	18.1	73.5
Present value of benefits (PVB)	40.5	71.4	39.0	70.0
Net Present Value NPV = B+R-C	**4.4**	**-38.7**	**20.8**	**-3.5**
Benefit Cost Ratio BCR = B/(C-R)	**1.12**	**0.65**	**2.15**	**0.95**

Low Cost Scenario

Further tests have been undertaken of the sensitivity of the analysis to the capital costs of electrification. As noted, the UK is embarking on a major programme of electrification. Cost estimates for electrification schemes have risen in recent years and therefore the cost estimate for this scheme has been benchmarked against recent cost estimates. However, delivering lots of electrification schemes may, in the long run, result in efficiency savings or through better understanding, greater certainty in cost forecasting.

To reflect this possibility, Optimism Bias has been removed entirely from the cost estimates. The results of this test should be treated with caution given that there is no empirical basis for excluding Optimism Bias.

Under the low cost scenario, assuming electrification in CP7, electrification of the entire MetroWest network shows a positive result with a BCR of 1.2:1.

Table 23: Economic Appraisal: Low Cost + Base Case Demand (£m 2010 prices/values)

	Electrification in Control Period 6		Electrification in Control Period 7	
	Metrowest Phase 1	**Metrowest Phase 1 and 2**	**Metrowest Phase 1**	**Metrowest Phase 1 and 2**
Present value of costs (PVC)	24.7	71.3	14.4	48.4
Present value of benefits (PVB)	33.2	59.3	31.9	58.2
Net Present Value NPV = B+R-C	**8.5**	**-12.0**	**17.4**	**9.8**
Benefit Cost Ratio BCR = B/(C-R)	**1.34**	**0.83**	**2.21**	**1.20**

If the low cost and high demand growth scenarios are combined, the case for electrification is more compelling. For Phase 1, the benefit-cost ratio rises to above 4, placing the scheme in the 'very high' value for money category. If the electrification of Phase 1 were to be delayed until CP7, the financial benefits of electrification would, over the 60 year appraisal period – outweigh the financial costs such that the scheme would offer 'no net cost' to Government. For Phases 1 and 2, the benefit-cost ratio rises to above 2, but electrification still provides value for money only if electrification occurs in CP7.

Table 24: Economic Appraisal: Low Cost + High Demand Growth (£m 2010 prices/values)

	Electrification in Control Period 6		Electrification in Control Period 7	
	Metrowest Phase 1	**Metrowest Phase 1 and 2**	**Metrowest Phase 1**	**Metrowest Phase 1 and 2**
Present value of costs (PVC)	9.7	57.7	-2.0	33.8
Present value of benefits (PVB)	40.5	71.4	39.0	70.0
Net Present Value NPV = B+R-C	**30.8**	**13.7**	**41.0**	**36.2**
NPV/Capital Cost = NPV/k	0.47	0.10	0.81	0.36
Benefit Cost Ratio BCR = B/(C-R)	**4.19**	**1.24**	**NO NET COST**	**2.07**

Wider South West Electrification Programme (Phase 1 and 2 Only)

Partial electrification of a network tends to offer relatively limited benefits because it often results in continued operation of diesel services 'under the wires'. By expanding electrification to a wide network, this can be avoided in order to maximise operating cost savings and benefits to passenger per km of track electrified.

This is illustrated in the analysis of the base case for MetroWest electrification. There is a stronger case for electrification of Phase 1 of MetroWest, in part, because the line between Bristol Temple Meads and Bath Spa will already be electrified as part of GWML electrification.

The standalone economic case for electrifying Phase 2 of MetroWest is less compelling. This is perhaps unsurprising given that the section of track between Bristol Temple Meads and Weston-super-Mare would continue to cater for mainly diesel rolling stock travelling between Bristol and the South West.

Network Rail's Western Route Study[6] identifies a range of potential electrification schemes that will be assessed by Network Rail as part of the Electrification Strategy. This includes Bromsgrove to Bristol Parkway (as part of a 'cross country' electrification package) and between Bristol and Weston-Super-Mare or beyond (as part of a 'South West' electrification package). Should these lines be programmed for electrification, this would significantly reduce the required scope and cost of Metrowest electrification. A more comprehensive approach to electrification offers a number of other important economies of scale. The costs of power supply and depot provision, for example, can be shared across a number of lines and services.

To illustrate this opportunity, a further test has been undertaken in which it is assumed that the costs of electrification between Yate and Bristol Temple Meads, and between Bristol Temple Meads and Weston-Super-Mare, are met by a main line electrification scheme. In effect, electrification of the Phase 2 network can be achieved at the cost of wiring the Henbury line only. The requirement for a £10m cost of power supply has been excluded and the costs of depot provision have also been removed to reflect the opportunity for such costs to be shared across a much larger fleet of EMUs serving the South West. As a result the benefit-cost ratio for the electrification of Phase 1 and 2 increases to 1.06:1 if the scheme is delivered in CP6, or 1.59:1 if the scheme is delivered in CP7. If higher demand growth or lower capital cost sensitivity tests are applied the BCR rises significantly above 2.0:1 in all cases. This suggests that, if the main line is electrified, there would be a good economic case for extending electrification to the Metrowest network in its entirety.

6 Western Route Study (Long Term Planning Process) – Draft for Consultation. October 2014.

Table 25: Economic Appraisal: Wider South West Electrification Programme + Base Case Demand Growth (£m 2010 prices/values)

	Electrification in Control Period 6		Electrification in Control Period 7	
	High Cost	Low Cost	High Cost	Low Cost
Present value of costs (PVC)	55.8	22.8	36.6	11.6
Present value of benefits (PVB)	59.3	59.3	58.2	58.2
Net Present Value NPV = B+R-C	**3.5**	**36.5**	**21.5**	**46.6**
NPV/Capital Cost = NPV/k	0.03	0.44	0.25	0.74
Benefit Cost Ratio BCR = B/(C-R)	**1.06**	**2.60**	**1.59**	**5.02**

Table 26: Economic Appraisal: Wider South West Electrification Programme + High Demand Growth (£m 2010 prices/values)

	Electrification in Control Period 6		Electrification in Control Period 7	
	High Cost	Low Cost	High Cost	Low Cost
Present value of costs (PVC)	42.2	9.3	22.0	-3.0
Present value of benefits (PVB)	71.4	71.4	70.0	70.0
Net Present Value NPV = B+R-C	**29.1**	**62.1**	**48.0**	**73.0**
NPV/Capital Cost = NPV/k	0.25	0.75	0.55	1.17
Benefit Cost Ratio BCR = B/(C-R)	**1.69**	**7.71**	**3.18**	**NO NET COST**

Alternative Scenarios – Increased Frequency

One possible avenue for sensitivity testing is to consider a higher service frequency of four trains per hour. Metrowest timetabling has assumed two trains per hour in the base case (diesel service operation). Two trains per hour have therefore been assumed for the baseline electrification assessment. A four train per hour timetable has therefore not been developed by Metrowest and it is likely that there would be timetabling issues at certain stations and junctions. Four trains per hour would therefore require further validation, however it is discussed here as a concept.

All things being equal, a more frequent timetable would result in greater operating cost savings because more trains would be required to operate services and because higher mileage also means higher fuel consumption, track wear and train maintenance savings.

However, in the case of a network like Metrowest the reverse is likely to be true. This is because a more frequent timetable would allow passenger loads to be spread across a greater number of services, making it more feasible to operate two-car diesel trains for a longer period of time in the 'do minimum' scenario. This makes more acute the problem of needing to replace two-car diesel trains with three-car electric trains which acts to offset the cost savings offered by electrification.

In view of this it is considered that the 'high demand growth' sensitivity test, under the proposed Metrowest service pattern, is more appropriate for this Network because a primarily four-car operation is likely to lend itself to electrification to a greater extent than a more frequent primarily two-car operation.

8.4.4 Summary

The results of the economic appraisal are summarised in the following graphs which show the lower and upper bound appraisal results.

For Phase 1, the base case benefit cost ratio is 0.65:1. Under a more optimistic set of demand and cost assumptions, assuming electrification in CP7, electrification could deliver an overall positive financial return (such that the scheme could be delivered at 'no net cost' to government in the long term).

For Phases 1 and 2 combined, the benefit cost ratio ranges from 0.48:1 in the base case to 2.0:1 under more optimistic assumptions. If it is assumed that a wider programme of electrification is delivered, then a positive financial return might also be expected for Phase 1 and 2.

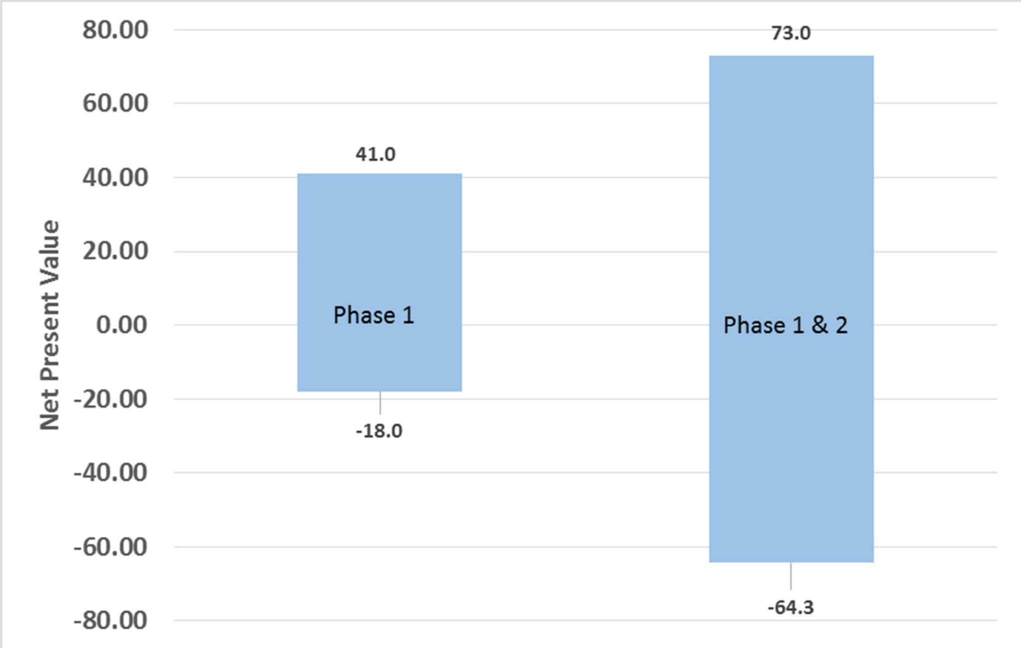


Figure 14: Overall Summary (Net Present Value)

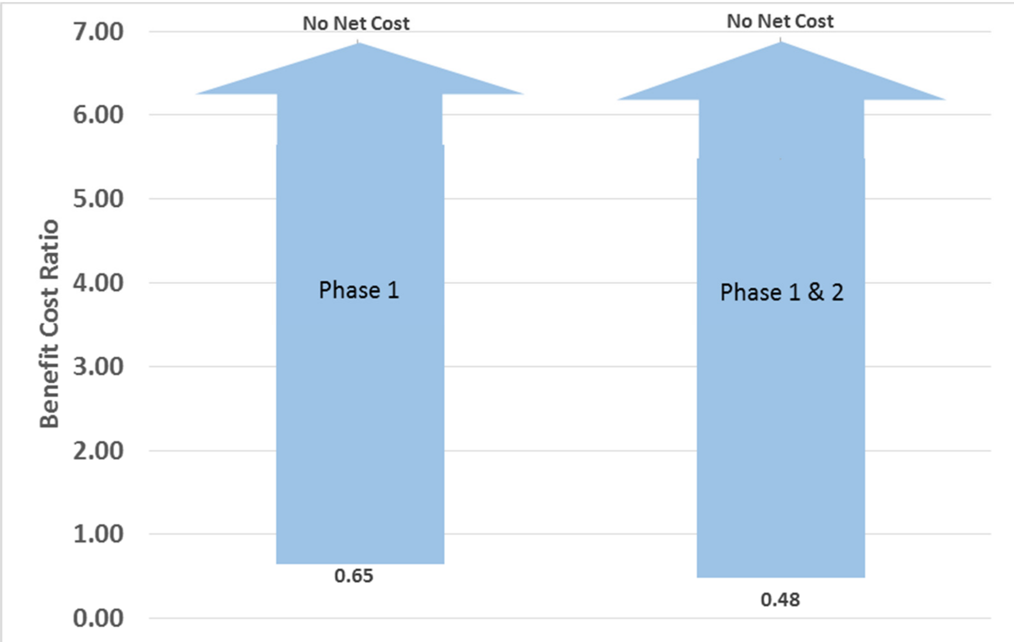


Figure 15: Overall Summary (Benefit-cost ratio)

8.5 Conclusions

In conclusion, if considered as a standalone scheme, electrification of the MetroWest network is unlikely to offer good value for money in the short term. It is therefore unlikely that operating cost savings and user benefits will outweigh the capital costs of electrification. Hence the benefit-cost ratio for electrification of Phase 1 is 0.65 and Phases 1 and 2 combined is 0.48

The intensity of the service on the MetroWest network – the frequency of services, the size of the fleet and the level of demand – is less than on other parts of the electrified network in the UK. Furthermore, the number of structures on the route and the requirements for power supply dictate that the capital costs are relatively high.

As a high-level means of comparison, the capital cost of electrifying the MetroWest network is considered to be some 30% higher than the current cost estimate for the electrification of the Valley Lines network in South Wales. Forecast demand per km of track requiring wires is approximately 13% lower on the MetroWest network compared to the Valley Lines, whilst predicted future fleet size and train mileage is also some 20% to 30% lower for MetroWest.

However, there is a good case for electrifying the network in the longer term. The relative availability and cost of diesel rolling stock, combined with rising demand, is likely to tip the balance in favour of electrification at the point in time that the existing diesel fleets become life expired. If considered as a CP7 scheme, the benefit cost ratio for electrification increases to between 0.66:1 and 2.07:1 for Phases 1 and 2 combined. Under high passenger demand scenarios – which reflect current rather than forecast annual passenger growth – the benefit cost ratio increases further.

Importantly, if considered as part of a wider programme of electrification in the South West, the case for Metrowest electrification becomes compelling. If it is assumed that the main line between Bromsgrove, Bristol and onward to Weston-Super-Mare is electrified, then the benefit cost ratio rises above 1.5:1 for all scenarios.

9 Conclusions and Recommendations

9.1 Conclusions

Arup were appointed by Bristol City Council on behalf of the West of England Partnership to appraise the case for electrification of MetroWest.

The MetroWest project is designed to create a step change in local rail services and is planned for delivery in two phases. Phase 1 will provide half hourly train services for the Severn Beach line, between Bristol Temple Meads and Bath Spa, and on the reopened Portishead line. Phase 2 will provide half-hourly train services to Yate and Weston-super-Mare and provide hourly services on a reopened Henbury line.

The current proposals have MetroWest services operated by Diesel Multiple Units (DMU). With proposed electrification of the Great Western mainline these units will be operating "under wires" for a significant proportion of their route, particularly Phase 1 routes, and Arup has been appointed to appraise the case for electrification of all MetroWest services.

Rail electrification requires significant investment in overhead lines, power distribution, rolling stock and depot/stabling facilities. The potential benefits of electrification, providing justification for this investment include:

- Reduced operating costs to franchise operators as a result of lower fuel, leasing or vehicle and line maintenance costs.
- Reduced journey times between stations as a result of the improved performance of EMU. This provides passenger journey time benefits and also additional timetable flexibility/reliability for operators.
- Improved perception of rail services potentially resulting in modal shift to rail from other modes – the "sparks" effect.

A review of the current and proposed rail network has been undertaken to inform cost estimates for electrification of MetroWest lines. We have also had discussions with Network Rail regarding power supply and distribution and considered the cost of new depot facilities. In total a capital investment of £88.5m is required for Phase 1 and £86.5m for Phase 2 resulting in a total capital investment of £175m.

There are practical and economic reasons for launching the Metro in diesel. The programme of electrification in the UK means that CP6 is the earliest that electrification could be delivered. Furthermore, the short and medium term availability of EMUs is uncertain, particularly given the relatively small fleet size required to operate MetroWest. Cascaded rolling stock provides the most cost effective means of procurement for MetroWest and with a large number of electrification projects currently being delivered competition for these units will be significant. Conversely the short to medium term availability of DMUs is good with a range of fleets due for cascade.

An appraisal of the economic case shows that if delivered in CP6, it is unlikely that electrification will offer good value for money. The economic appraisal indicates that the BCR may be below one for Phase 1. The business case for electrification of Phase 2 is weaker because of the additional costs associated with the electrification between Bristol and Weston-super-Mare to service a relatively small number of additional electric services.

The overriding reasons for low BCRs for electrification in the short term is the fact that operating cost savings and passenger benefits are not sufficient to outweigh the capital costs. The reasons for this are two-fold. Firstly, as noted, the number of structures on the route and the requirements for power supply dictate that the capital costs are relatively high. Secondly, the planned service frequency is too limited and, given levels of demand on the network, the likely fleet size is too small to generate sufficient cost savings to justify electrification.

However, there is a good case for electrifying the network in the longer term. The relative availability and cost of diesel rolling stock, combined with rising demand, is likely to tip the balance in favour of electrification at the point in time that the existing diesel fleets become life expired. If considered as a CP7 scheme, the benefit cost ratio for electrification increases to between 0.66:1 and 2.07:1 for Phases 1 and 2 combined.

Importantly, if considered as part of a wider programme of electrification in the South West, the case for Metrowest electrification becomes compelling. If it is assumed that the main line between Bromsgrove, Bristol and onward to Weston-Super-Mare is electrified, then the benefit cost ratio rises above 1.5:1 for all scenarios.

Therefore, in the short to medium term, operation of MetroWest services using diesel rolling stock would be the preferred option, with electrification reconsidered for CP7 when existing diesel rolling stock will need to be retired and electrified rolling stock will provide a more significant operational cost saving. Furthermore by CP7 the south-west would have one of the only sections of the UK intercity network without electrification. The political and financial case for electrifying of lines south of Bristol would be improved if considered as part of a more comprehensive programme of electrification in the south west.

9.2 Recommendations

It is recommended that the West of England Partnership and rail industry stakeholders continue to plan for the launch of MetroWest as a diesel network. The programme should focus on delivering the highest quality service possible to stimulate new demand and long term growth.

If launching in diesel, MetroWest still need a rolling stock strategy. Rolling stock solution and quality is important in delivering higher demand and revenue, particularly in the context of MetroWest, which needs to change the passenger perception of rail travel. The rolling stock needs to be the most efficient and highest quality on offer. At present the 165s may be a more attractive option for the Metrowest and the potential for securing these fleets should be explored as part of the next refranchising process.

Secondly, whatever the stock type, the rolling stock needs to be refurbished to a high standard. Whilst this requires initial investment, it will deliver value in the long term through higher revenue. The interior layout should be considered carefully, to include features such as sufficient bicycle storage or metro-style layouts to aid rapid boarding and alighting if required. Delivering such improvements in the medium term will act to reinforce the actual and perceived step change in rail services being delivered in the West.

In the long term, the case for electrification is much stronger. CP7 looks like an obvious departure point because of the need to replace ageing diesel fleets by around 2030. At this point, the economic case for electrification is likely to be considerably more positive. Furthermore, by CP7 the rail industry may have more capacity to deliver electrification schemes as part of the next generation of electrification schemes. There is also likely to be more clarity around the costs of electrification.

Finally, Metrowest electrification should be considered as part of a more comprehensive strategy for electrification in the South West of England. The case for Metrowest electrification cannot be separated from the case for electrifying the between Birmingham and Bristol and to the south west of Bristol to Weston-super-Mare, Exeter or beyond. A co-ordinated approach between authorities in the South West should therefore be taken when promoting the case for electrification in this part of the UK.

Appendix A

Chainages of MetroWest Lines

P1 Portishead to BTM	Distance from Origin (m)	No. of Platforms	Min. Platform Length (m)
Portishead (closed)	0	INA	INA
Pill (closed)	7262	INA	INA
Clifton Bridge Station (closed)	12734	INA	INA
Ashton Gate	13337	INA	INA
Parson Street	15249	2	92
Bedminster	16717	2	101
Bristol Temple Meads	**18206**	15	82

P1 Severn Beach to BTM	Distance from Origin (m)	No. of Platforms	Min. Platform Length (m)
Severn Beach	0	1	121
St Andrews Road	4305	1	155
Avonmouth	7363	2	82
Shirehampton	9616	1	128
Sea Mills	12231	1	118
Clifton Down	15611	2	108
Redland	16556	1	120
Montpelier	17300	1	132
Stapleton Road	19276	2	211
Lawrence Hill	20197	2	114
Bristol Temple Meads	**21887**	15	82

P1 Bath to BTM

Ignored as already to be electrified

INA = Information Not Available

P2 Henbury to BTM	Distance from Origin (m)	No. of Platforms	Min. Platform Length (m)
Holesmouth/Hallen Marsh JN	0	-	-
Chittening (closed)	845	INA	INA
Hallen Halt (closed)	3883	INA	INA
Henbury (closed)	5560	INA	INA
Charlton Halt (closed)	7229	INA	INA
North Filton (closed)	8860	-	-
Filton West JN No. 2	8932	-	-
Filton Abbey Wood	9656	3	108
Horfield (closed)	10762	INA	INA
Ashley Hill (closed)	12633	INA	INA
Narroways Hill JN	13418	-	-
Stapleton Road	14086	2	211
Lawrence Hill	15007	2	114
Dr Days JN	15591	-	-
Bristol East JN	16174	-	-
Bristol East JN	16174	-	-
Bristol Temple Meads	**16697**	15	82

P2 Weston-super-Mare to BTM	Distance from Origin (m)	No. of Platforms	Min. Platform Length (m)
Weston Super Mare	0	2	210
Weston Milton	2032	1	184
Worle (closed)	3279	-	-
Worle	4035	2	100
Puxton (closed)	4989	INA	INA
Yatton	10762	2	121
Nailsea & Backwell	17099	2	121
Flax Bourton (closed)	20559	INA	INA
Parson Street	27117	2	92
Bedminster	28586	2	101
Bristol Temple Meads	**30075**	15	82

P2 BTM to Yate	Distance from Origin (m)	No. of Platforms	Min. Platform Length (m)
Bristol Temple Meads	0		
Lawrence Hill	1690	2	114
Stapleton Road	2611	2	211
Ashley Hill (closed)	4064	INA	INA
Horfield (closed)	5934	INA	INA
Filton Abbey Wood	7041	3	108
Bristol Parkway	11004	4	255
Winterbourne (closed)	14102	INA	INA
Coalpit Heath (closed)	16315	INA	INA
Yate	**20982**	2	103

Phase I - Portishead to BTM notes

Station/Feature	Chainage			ELR	Cum.	Over Track		Tunnels	Under Track		Notes	Linespeed	# Tracks	Features
	Mi	Ch	Yd		Chainage (m)	Footbridges	Roads		Culverts	Roads		(mph)		
Portishead (closed)	**129**	**53**	**0**	MLN1			8			3	**Potential for loop?**		1	
Pill (closed)	125	12	0	MLN1	0		2	2		2	Pill Tunnel 30ch, Sandstone tunnel 4ch		1	
Clifton Bridge Station (closed)	121	60	0	MLN1	5471.7696	2	6	**2**		10	Clifton Bridge Tunnels 2 & 1 , 10.5ch & 3ch		1	Proposed turnaround at 122mi 23ch
Ashton Gate	121	30	0	MLN1	6075.2736		3			2			2	
Parson Street	120	15	0	MLN1	7986.3696	1	1			5		40, 90, 25	3	3rd track introduced after Parson Street to Bedminster
Bedminster	119	22	0	MLN1	9454.896		1			4	Bath Road A4	40, 90, 90, 25	4	
Bristol Temple Meads	118	28	0	MLN1	10943.5392						Numerous under track			
						Footbridges	Roads							
TOTAL					10943.5392	**3**	**21**	**4**	0	26				
								(47.5ch Total)						

Phase I - Severn Beach to BTM Notes

Station/Feature	Chainage Mi	Ch	Yd	ELR	Cum. Chainage (m)	Over Track Footbridges	Roads	Tunnels	Under Track Culverts	Roads	Notes	Linespeed mins (mph)	# Tracks	Features
Severn Beach	**11**	**64**	**0**	**AMB**	**0**	**1**	**2**		**11**	**10**		**30**	**1**	
St Andrews Road	14	38	0	AMB	4304.9952									
	16	3	0	AMB	6819.5952		1					15	1	
	9	29	0	CNX	6819.5952									
Avonmouth	9	2	0	CNX	7362.7488							30	2	Loop around Avonmouth Station
	9	2	0	CNX	7362.7488		1			1			1	Single track after loop, OTW to Shirehampton
Shirehampton	7	50	0	CNX	9615.8304		2		3	3		30	1	
Sea Mills	6	0	0	CNX	12231.0144		3	**1**			Clifton Down Tunnel 1mi	30	1	
Clifton Down	3	72	0	CNX	15610.6368	2	5					15	1	Loop around Clifton Down station
Redland	3	25	0	CNX	16556.1264		2					15	1	
Montpelier	2	68	0	CNX	17300.448	2	1	**1**		2	Montpelier tunnel 22ch	15	1	
Narroways Hill JN	2	3	1	BSW	18607.1256	1				4		60-75	2	
Stapleton Road	1	49	17	BSW	19276.4664		2			4		60-75	2	
Lawrence Hill	1	4	3	BSW	20194.524		3		2				4-2	From 4No. to 2No. tracks
Dr Days JN	0	55	4	BSW	20776.9968		2							Lines already electrified as part of the GWML Electrification Scheme
Bristol East JN	0	26	5	BSW	21359.4696							40, 25, 25, 25	4	
Bristol East JN	118	2	5	MLN1	21359.4696						Numerous under track			
Bristol Temple Meads	118	28	6	MLN1	21882.5064									
						Footbridges	Roads	Tunnels						
TOTALs					18607.1256	**5**	**17**	**2**	14	16				

(1mi 22ch Total)

Phase II - Henbury to BTM Notes

Station/Feature	Chainage			ELR	Cum. Chainage (m)	**Over Track**		**Tunnels**	**Under Track**		Notes	Linespeed (mph)	# Tracks	Features	
	Mi	Ch	Yd			Footbridges	Roads		Culverts	Roads					
Holesmouth/Hallen Marsh JN	118	42	0	AFR	0									Ties into Severn Beach Line	
Chittening (closed)	118	0	0	AFR	844.9056				13	8		60	2		
Hallen Halt (closed)	116	9	0	AFR	3882.5424		3					60	2		
Henbury (closed)	**115**	**0**	**0**	**AFR**	5559.639782		4		2			60	2		
Charlton Halt (closed)	114	0	0	AFR	7229.173248		2	1	2		Charlton Tunnel 302yds long	60	2		
North Filton (closed)	113	0	0	AFR	8859.760589		1						2		
Filton West JN No. 2	112	78	0	AFR	8931.8592								2		
Filton Abbey Wood	4	30	0	BSW	9656.064		2		1			75	2	3 Platforms at FAW	Lines already electrified as part of the GWML Electrification Scheme
Horfield (closed)	3	55	0	BSW	10762.488	1	1		2	2		60-75	2		
Ashley Hill (closed)	2	42	0	BSW	12633.3504	1			1	3		60-75	2		
Narroways Hill JN	2	3	0	BSW	13417.9056	1				4		60-75	2		
Stapleton Road	1	49	17	BSW	14086.332		2			4		60-75	2		
Lawrence Hill	1	4	0	BSW	15007.1328		3		2				4-2	From 4No. to 2No. tracks	Lines already electrified as part of Phase I
Dr Days JN	0	55	0	BSW	15590.52		2								
Bristol East JN	0	26	0	BSW	16173.9072										
Bristol East JN	118	2	0	BSW	16173.9072						Numerous under track			13No. Platforms	
Bristol Temple Meads	118	28	0	BSW	16696.944										
						Footbridges	Roads	Tunnels							
TOTALS					8931.8592	**0**	**10**	**1**	17	8					
								(14ch)							

Phase II - Weston-super-Mare to BTM Notes

Station/Feature	Chainage Mi	Ch	Yd	ELR	Cum. Chainage (m)	Over Track Footbridges	Over Track Roads	Tunnels	Under Track Culverts	Under Track Roads	Notes	Linespeed (mph)	# Tracks	Features	
Weston Super Mare	137	33	0	WSM		2	3		8			60	1		
Weston Milton	136	12	0	WSM	2031.7968		1		3			60	1		
Worle (closed)	135	30	0	WSM	3279.0384							40	1		
Worle JN	135	11	0	WSM	3661.2576		1								
Worle JN	135	0	0	MLN1	3882.5424				1			100	2		
Worle	134	42	9	MLN1	4638.7512	1	1		1	1		100	2		
Puxton (closed)	133	0	0	MLN1	7101.2304		2		8	4		100	2	25mph up and down loop close to Yatton	
Yatton	130	28	0	MLN1	11365.992	3	5		6	9		100	2		
Nailsea & Backwell	126	33	0	MLN1	17702.784	1	3		5	5		100	2		
Flax Bourton (closed)	124	0	0	MLN1	21585.3264	3	9	**1**	2	7	Flax Bourton Tunnel - 106 yds	100-90	2		
Parson Street	120	15	0	MLN1	27720.9504	1	1			5		40, 90, 25	3	3rd track after Parson Street to Bedminster	
Bedminster	119	22	0	MLN1	29189.4768		1			4	Bath Road A4	40, 90, 90, 25	4		Lines already electrified as part of
Bristol Temple Meads	118	28	0	MLN1	30678.12						Numerous under track				
						Footbridges	Roads	Tunnels	Culverts	Roads					
TOTALS					27720.9504	**10**	**25**	**1**	34	26					
								(5ch)							

Phase II - Yate to BTM Notes

Station/Feature	Chainage			ELR	Cum.	Over Track		Tunnels	Under Track		Notes	Linespeed	# Tracks	Features	
	Mi	Ch	Yd		Chainage (m)	Footbridges	Roads		Culverts	Roads		(mph)			
Bristol Temple Meads	118	28	0	MLN1	0						Numerous under track			15No. Platforms	
Bristol East JN	118	2	0	MLN1	523.0368										
Bristol East JN	0	26	0	BSW	523.0368		2					40, 25, 25, 25	4		
Dr Days JN		55	0	BSW	1106.424		3		2				4-2	From 4No. to 2No. tracks	
Lawrence Hill	1	4	0	BSW	1689.8112		2			4		60-75	2		Lines already electrified as part of Phase I
Stapleton Road	1	49	17	BSW	2610.612										
Narroways Hill JN	2	3	0	BSW	3279.0384	1			1	3		60-75	2		
Ashley Hill (closed)	2	42	0	BSW	4063.5936	1	1		2	2		60-75	2		
Horfield (closed)	3	55	0	BSW	5934.456		2		1			75	2	3 Platforms at FAW	
Filton Abbey Wood	4	30	0	BSW	7040.88	1	1		5	4		60	2	Filton Junction	
Patchway JN no. 2	5	61	0	BSW	9273.8448				4	1			2		
Patchway JN no. 2	112	68	0	SWB	9273.8448										
Stoke Gifford JN No. 2	112	5	0	SWB	10541.2032								2		
Stoke Gifford JN No. 1	111	79	0	SWB	10661.904					1			2		Lines already electrified as part of the GWML Electrification Scheme
Stoke Gifford West JN	111	73	0	SWB	10782.6048				1				2		
Bristol Parkway	111	62	0	SWB	11003.8896		3			4		100-125	2	Crosses Winterbourne Viaduct 139yds	
Winterbourne (closed)	109	68	0	SWB	14101.8768		1		1	5		100-125	2	Crosses Huckford Viaduct 269yds	
Coalpit Heath (closed)	108	38	0	SWB	16314.7248	1			1	4		100-125	2		
Westerly JN	107	14	0	SWB	18406.872				3	4		30	2		
Yate South JN	120	2	11	YAT	20529.1944							40-90	2		
Yate	**119**	**0**	**0**	**YAT**	22188.8304										
						Footbridges	Roads	Tunnels	Culverts	Roads					
TOTALS					3781.9584	**0**	**0**	**0**	3	4					

Appendix B

Structural Clearances by ELR

Structural Clearances Summary

Open Route	5100
Optimal Station Bridges	5800
Sub-Optimal Station Bridges	5400

https://mapsengine.google.com/map/edit?mid=zAeLkvWjUg3E.kOV_tE_YE93Q

Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
1	Portishead to BTM	POD	Portishead (Closed)	Station	129	53	0		N/A	N/A	Station	NGD information not provided for ELR: POD		-
1	Portishead to BTM	POD	Pill (Closed)	Station	126	12	0		N/A	N/A	Station	NGD information not provided for ELR: POD		-
1	Portishead to BTM	POD	Pill Station overbridge	Bridge	126	8	0	4800	Foul	1000	Station	NGD information not provided for ELR: POD - Flat deck, dual and signgle lanes, close to junctions and surrounded by residential properties. Close to viaduct so lowers not recommended. Clearance not mentioned so assumed to both be 4800mm. Likley that services are present in the road. Close to propose station.	Track lower / OLE	£2,500,000
1	Portishead to BTM	POD	Pill Overbridge	Bridge	126	7	0	4800	Foul	300	Open			
1	Portishead to BTM	POD	Pill Tunnel	Tunnel	125	63	5	4640	Foul	460	Tunnel	NGD information not provided for ELR: POD - nearly 700m long single bore tunnel. Assumed to have 4640mm. clearance, though from previous examination reports it looks less constrained. OLE solution would be the most feasible as cheapeast and least intrusive.	Track lower / OLE solution	£350,000
1	Portishead to BTM	POD	Pill Tunnel	Tunnel	125	33	0	4640	Foul	460	Tunnel			
1	Portishead to BTM	POD	Cages Overbridge	Bridge	124	77	0	6000	Clear	N/A	Open	NGD information not provided for ELR: POD. Pictures from examiation reports show large clerances, 6000mm assumed.	-	-
1	Portishead to BTM	POD	Pill Sandstone Tunnel No. 3	Tunnel	123	81	0	4640	Foul	460	Tunnel	NGD information not provided for ELR: POD. Nearly 90m long single bore tunnel. Assumed to have 4640mm clearance. OLE solution would bet he most feasible as cheapest and least	OLE solution	£50,000
1	Portishead to BTM	POD	Pill Sandstone Tunnel No. 3	Tunnel	123	77	0	4640	Foul	460	Tunnel			
1	Portishead to BTM	POD	Clifton Bridge Tunnel No. 2	Tunnel	122	62	12		N/A	N/A	Tunnel	NGD information not provided for ELR: POD. Approx. 230m long single line tunnel appears to be cut through rock with no linings at the portals. Assumed to have 4640mm clearance though headroom looks limited in previous work stream's inspections. The cost of getting clearance to 4640mm is assumed to be capture in the previous study.	OLE solution	£150,000
1	Portishead to BTM	POD	Clifton Bridge Tunnel No. 2	Tunnel	122	52	0		N/A	N/A	Tunnel			
1	Portishead to BTM	POD	Clifton Tunnel No.1	Tunnel	122	32	11	5000	Foul	100	Tunnel	NGD information not provided for ELR: POD. Nearly 300m long tunnel built for dual tracks only accomodates a single line now. Assumed to have a generous minimum clearance of	OLE solution	£180,000
1	Portishead to BTM	POD	Clifton Tunnel No.1	Tunnel	122	30	0	5000	Foul	100	Tunnel			
1	Portishead to BTM	POD	Clifton Bridge Overbridge	Bridge	121	68	0		N/A	N/A	Open	NGD information not provided for ELR: POD. Assumed to have a 4640mm clearance. A small road not open to the public.	Recon	£150,000
1	Portishead to BTM	POD	Clifton Bridge Station (Closed)	Station	121	60	0		N/A	N/A	Station		-	-
1	Portishead to BTM	POD	Footbridge	Footbridge	121	58	0		N/A	N/A	Open	NGD information not provided for ELR: POD. Assumed to have 4640mm clearance.	Jack	£75,000
1	Portishead to BTM	POD	Purells Overbridge	Bridge	121	33	0		N/A	N/A	Open	NGD information not provided for ELR: POD. Very difficult to modify the bridges themselves, particularly the A370. Assumed clearance to be 4640mm all all bridges but this is likely to be conservative.	Track Lower and OLE	£1,500,000
1	Portishead to BTM	POD	Ashton Gate	Station	121	30	0		N/A	N/A	Station			
1	Portishead to BTM	POD	A370 Overbridge	Bridge	121	27	0		N/A	N/A	Open			
1	Portishead to BTM	POD	Ashton Road Overbridge	Bridge	121	24	0		N/A	N/A	Open			
1	Portishead to BTM	POD	Ashton Junction CCTV Xing	Level Crossing	121	3	78		N/A	N/A	Open	Renewal of CCTV crossing assumed to cost £2,000,000. The extent of nearby track lowers will affect this price further.	Renewal	£2,000,000
1	Portishead to BTM	POD	Ashton Junction PP Xing	PP Crossing	121	1	10		N/A	N/A	Open	Renewal of PP Xing crossing assumed to cost £100,000. The extent of nearby track lowers will affect this price further.	Renewal	£100,000
1	Portishead to BTM	MLN1	Parson Street	Station	120	15	0		N/A	N/A	Station	NGD information not provided for ELR: POD	-	-
1	Portishead to BTM	MLN1	Down Parsons Street Bridge	Bridge	120	9	15	4354	Foul	746	Open	Very difficult to achieve clearance. Suggest a combination of recon, OLE solution and derogation. Track lower difficult due to S&C and adjacent station	Recon / OLE	£5,000,000
1	Portishead to BTM	MLN1	Up Parsons Street Bridge	Bridge	120	9	14	4288	Foul	812	Open			
1	Portishead to BTM	MLN1	Down Bartletts Footbridge	Footbridge	119	72	20	4346	Foul	754	Open	Jack existing bridge and reconstruct stairs	Jack	£150,000
1	Portishead to BTM	MLN1	Up Bartletts Footbridge	Footbridge	119	72	20	4456	Foul	644	Open			
1	Portishead to BTM	MLN1	Signal Gantry	Signal	119	56	21	4808	Foul	292	Open			£300,000
1	Portishead to BTM	MLN1	Signal	Signal	119	56	16	4871	Foul	229	Open			£300,000
1	Portishead to BTM	MLN1	Signal	Signal	119	30	10	4774	Foul	326	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	119	30	6	5132	Clear	N/A	Open			-
1	Portishead to BTM	MLN1	Bedminster	Station	119	22	0		N/A	N/A	Station			-
1	Portishead to BTM	MLN1	Signal Gantry	Signal	119	2	13	4936	Foul	164	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	119	2	7	4876	Foul	224	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	61	17	4978	Foul	122	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	61	14	4813	Foul	287	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	61	5	4719	Foul	381	Open			£300,000
1	Portishead to BTM	MLN1	Down Bath Road Bridge	Bridge	118	47	2	4182	Foul	918	Open	Very difficult to achieve clearance. Suggest a combination or recon, OLE solution and derogation. Track lower difficult due to S&C and Temple Meads. Recon a challenge due to busy highway	Jack / OLE	£5,000,000
1	Portishead to BTM	MLN1	Up Bath Road Bridge	Bridge	118	46	21	4177	Foul	923	Open			
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	42	10	4880	Foul	220	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	38	10	4819	Foul	281	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	37	17	4754	Foul	346	Open			£300,000
1	Portishead to BTM	MLN1	Platform 4 Awning	Station	118	32	11	4556	Foul	544	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 5 Awning	Station	118	32	10	4401	Foul	699	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 7/8 Awning	Station	118	32	1	4249	Foul	851	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 5 Awning	Station	118	32	0	4461	Foul	639	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 7/8 Awning	Station	118	31	12	4299	Foul	801	Station	BTM awnings assumed to be part of the GWML works		-

Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
1	Portishead to BTM	MLN1	Platform 9/10 Awning	Station	118	28	13	4282	Foul	818	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 9/10 Awning	Station	118	28	8	4299	Foul	801	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 11 Awning	Station	118	28	2	4387	Foul	713	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Bristol Temple Meads	Station	118	28	0		N/A	N/A	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 11 Awning	Station	118	24	18	4552	Foul	548	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 7/8 Awning	Station	118	24	18	4567	Foul	533	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Platform 5 Awning	Station	118	24	10	4427	Foul	673	Station	BTM awnings assumed to be part of the GWML works		-
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	22	6	4672	Foul	428	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	22	3	5020	Foul	80	Open			£300,000
1	Portishead to BTM	MLN1	Avon Street Bridge	Bridge	118	15	8	5245	Clear	N/A	Open			-
1	Portishead to BTM	MLN1	Viaduct No.11812q	Bridge	118	12	9	5245	Clear	N/A	Open			-
1	Portishead to BTM	MLN1	Kilbon Street Underbridge	Bridge	118	12	2	5245	Clear	N/A	Open			-
1	Portishead to BTM	MLN1	Gas Lane Bridge	Bridge	118	11	14	5245	Clear	N/A	Open			-
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	7	11	4834	Foul	266	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	7	6	4875	Foul	225	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	7	3	4746	Foul	354	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	6	20	4657	Foul	443	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	6	13	4792	Foul	308	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	6	12	4887	Foul	213	Open			£300,000
1	Portishead to BTM	MLN1	Signal Gantry	Signal	118	6	6	4745	Foul	355	Open			£300,000

Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
1	Severn Beach to BTM	AMB	Severn Beach	Station	11	64	0		N/A	N/A	Station			-
1	Severn Beach to BTM	AMB	St. Andrews Road	Station	14	38	0		N/A	N/A	Station			-
1	Severn Beach to BTM	AMB	Signal gantry	Signal	14	44	2	4572	Foul	528	Open			£300,000
1	Severn Beach to BTM	AMB	Dock Road Bridge	Bridge	14	48	18	4836	Foul	264	Open	Flat deck - bridge is in the wrong location on map (should be 1 mile north). Approach to bridge is on long viaduct	Jack	£1,500,000
1	Severn Beach to BTM	AMB	Signal gantry	Signal	14	49	7	4757	Foul	343	Open			£300,000
1	Severn Beach to BTM	AMB	Signal gantry	Signal	14	49	13	4850	Foul	250	Open			£300,000
1	Severn Beach to BTM	AMB	Signal gantry	Signal	15	4	0	5139	Clear	N/A	Open			-
1	Severn Beach to BTM	AMB	Signal gantry	Signal	15	67	17	4584	Foul	516	Open			£300,000
1	Severn Beach to BTM	AMB	ST Andrews Road MCB Xing	Level Crossing	16	0	0		N/A	N/A	Open	Renewal of MCB crossing assumed to cost £2,000,000	Renewal	£2,000,000
1	Severn Beach to BTM	CNX	Avonmouth Station CCTV Xing	Level Crossing	9	8	0		N/A	N/A	Open	Renewal of CCTV crossing assumed to cost £2,000,000	Renewal	£2,000,000
1	Severn Beach to BTM	CNX	Awning	Station	9	5	9	4362	Foul	738	Station			-
1	Severn Beach to BTM	CNX	Avonmouth	Station	9	2	0		N/A	N/A	Station			-
1	Severn Beach to BTM	CNX	Avonmouth Station Awning	Station	9	5	15	3600	Foul	1500	Station	Haunch clearance issue - corner sticking in 2ch long		
1	Severn Beach to BTM	CNX	Avonmouth Dock CCTV Xing	Level Crossing					N/A	N/A	Open	Renewal of CCTV crossing assumed to cost £2,000,000	Renewal	£2,000,000
1	Severn Beach to BTM	CNX	Shirehampton	Station	7	50	0		N/A	N/A	Station			-
1	Severn Beach to BTM	CNX	Hung Lane Bridge	Bridge	7	41	0	4442	Foul	658	Open	Flat Deck - Difficult to see bridge type. Road already has a hump, increasing by 736mm will be difficult to achieve and will have major impact on adjacent connecting roads	Recon	£2,500,000
1	Severn Beach to BTM	CNX	Hung Lane Bridge	Bridge	7	40	17	4416	Foul	684	Open			
1	Severn Beach to BTM	CNX	Hung Lane Bridge	Bridge	7	40	11	4389	Foul	711	Open			
1	Severn Beach to BTM	CNX	Hung Lane Bridge	Bridge	7	40	6	4364	Foul	736	Open			
1	Severn Beach to BTM	CNX	Woodwell Ln/ Powder House Bridge	Bridge	7	15	9	4527	Foul	573	Open	Flat deck - bridge carries a minor road, but is adjacent to residential properties, on a large skew and on a junction. Increasing height by 618mm will be very challenging.	Recon	£1,800,000
1	Severn Beach to BTM	CNX	Woodwell Ln/ Powder House Bridge	Bridge	7	15	4	4482	Foul	618	Open			
1	Severn Beach to BTM	CNX	Sea Mills UWC Xing	Level Crossing	6	4	0		N/A	N/A	Open	Renewal of UWC crossing assumed to cost £100,000. May be further affected by neaerby track lowers.	Renewal	£100,000
1	Severn Beach to BTM	CNX	Sea Mills	Station	6	0	0		N/A	N/A	Station			-
1	Severn Beach to BTM	CNX	Portway Bridge	Bridge	5	67	1	4565	Foul	535	Open	Flat deck - steel deck, high skew, carries portway, major structure. Increasing height by 557mm will likely require a recon which will be extremely disruptive.	Recon	£3,500,000
1	Severn Beach to BTM	CNX	Portway Bridge	Bridge	5	66	17	4551	Foul	549	Open			
1	Severn Beach to BTM	CNX	Portway Bridge	Bridge	5	66	6	4543	Foul	557	Open			
1	Severn Beach to BTM	CNX	Sneyd Park Bridge	Bridge	5	50	1	4523	Foul	577	Open	Arched - Haunch issues too. Demolish and replace with standard steel footbridge to achieve 648mm	Recon	£400,000
1	Severn Beach to BTM	CNX	Sneyd Park Bridge	Bridge	5	49	18	4452	Foul	648	Open			
1	Severn Beach to BTM	CNX	Clifton Down Tunnel	Tunnel	5	5	7	4897	Foul	203	Tunnel	Severe Haunch clearance issue throughout. Track lower with OLE solution	Track lower/ OLE solution	£700,000
1	Severn Beach to BTM	CNX	Clifton Down Tunnel	Tunnel	4	7	0	4897	Foul	203	Tunnel			
1	Severn Beach to BTM	CNX	St. Johns Road Bridge	Bridge	4	0	6	4731	Foul	369	Open	Arched - Jacking not an option. Potential to recon with a conarch. Track lower probably a more suitable option, but may not achieve full clearance, therefore may need combination	Track Lower / Recon	£1,000,000
1	Severn Beach to BTM	CNX	St. Johns Road Bridge	Bridge	4	0	1	4744	Foul	356	Open			
1	Severn Beach to BTM	CNX	Clfiton Down	Station	3	72	0		N/A	N/A	Station			-
1	Severn Beach to BTM	CNX	Down Station Footbridge	Footbridge	3	71	2	4765	Foul	1035	Station	Flat deck - Jacking bridge possible, but entire ramp will need modifying and extending to achieve 1094mm optimal (694 sub-optimal). Track lower will probably be required under Whiteladies Road, so can also track lower under footbridge	Jack	£250,000
1	Severn Beach to BTM	CNX	Up Station Footbridge	Footbridge	3	70	13	4706	Foul	1094	Station		Track Lower	£3,500,000
1	Severn Beach to BTM	CNX	Whiteladies Road Bridge	Bridge	3	69	2	4326	Foul	774	Open	Arched - Track lower - reconstruction not an option, due to buildings located on bridge	Track Lower	
1	Severn Beach to BTM	CNX	Whiteladies Road Bridge	Bridge	3	68	2	4393	Foul	707	Open			
1	Severn Beach to BTM	CNX	Down Park Road Bridge	Bridge	3	60	9	4593	Foul	507	Open	Arched - Recon could be an option to reduce structural depth and achieve clearance, but due to nature of area, the aesthetics of the arch may need to remain. Suggest track lower.	Track Lower	
1	Severn Beach to BTM	CNX	Up Park Road Bridge	Bridge	3	59	20	4589	Foul	511	Open			
1	Severn Beach to BTM	CNX	Down Hampton Road Bridge	Bridge	3	56	15	4508	Foul	592	Open	Arched - Recon could be an option to reduce structural depth and achieve clearance, but due to nature of area, the aesthetics of the arch may need to remain. Suggest track lower.	Track Lower	
1	Severn Beach to BTM	CNX	Up Hampton Road Bridge	Bridge	3	56	4	4488	Foul	612	Open			
1	Severn Beach to BTM	CNX	Redland Green Bridge	Bridge	3	29	8	4841	Foul	259	Open	Reconstruct with a conarch to achieve 259mm. Track lower not proposed as bridge is located adjacent to a station	Recon	£750,000
1	Severn Beach to BTM	CNX	Footbridge No.328	Footbridge	3	28	2	4390	Foul	710	Open	Flat deck - reconstruct footbridge to achieve 710mm. Footbridge may be listed, so complications likely.	Recon	£500,000
1	Severn Beach to BTM	CNX	Redland Station Awning	Station	3	26	8	4806	Foul	294	Station			-
1	Severn Beach to BTM	CNX	Redland	Station	3	25	0		N/A	N/A	Station	Lines already electrified as part of the GWML Electrification Scheme		-
1	Severn Beach to BTM	CNX	Montpelier	Station	2	68	0		N/A	N/A	Station			-

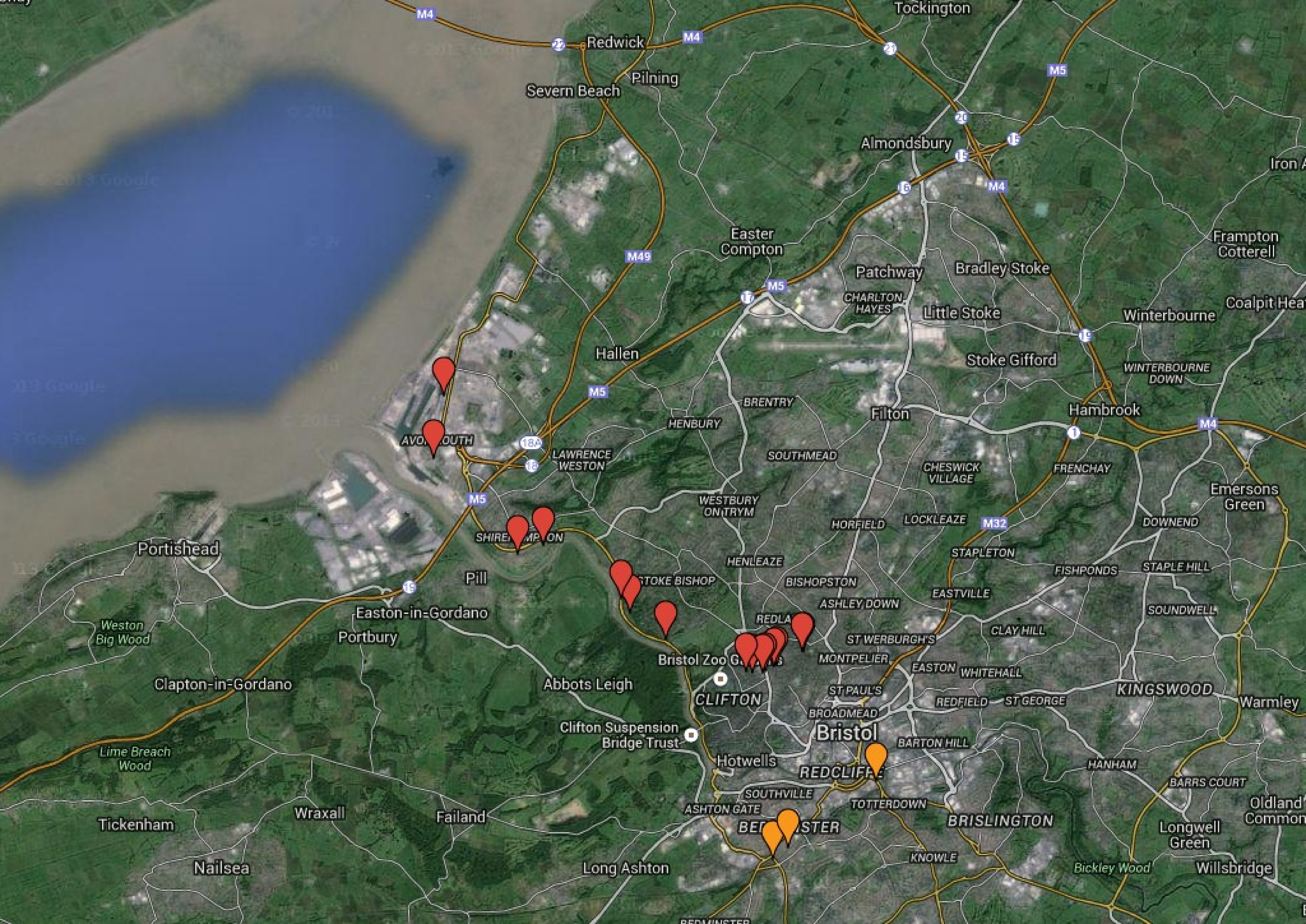
Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
1	Severn Beach to BTM	CNX	Montpelier Station Footbridge	Footbridge	2	66	0	4700	Foul	1100	Station	NGD information not provided - Assume clearance similar to Clifton Down Station: Jacking could be straightforward, ramps would only be needed on the station side. Track lowers would also be in place as part of the tunnel works	Track lower/ OLE solution	£600,000
1	Severn Beach to BTM	CNX	Montpelier Tunnel	Tunnel	2	59	4	4850	Foul	250	Tunnel	NGD information not provided - Assumed clearance similar to Clifton Down Tunnel: Severe Haunch clearance issue throughout. Track lower with OLE solution	Track lower/ OLE solution	
1	Severn Beach to BTM	CNX	Montpelier Tunnel	Tunnel	2	47	0	4850	Foul	250	Tunnel			
1	Severn Beach to BTM	CNX	Ashley Hill Overbridge	Bridge	2	36	0		Clear	N/A	Open	Structures made clear as part of Filton Bank electrification scheme		-
1	Severn Beach to BTM	CNX	Narroways Hill Footbridge	Footbridge	2	12	0		Clear	N/A	Open	Structures made clear as part of Filton Bank electrification scheme		-
1	Severn Beach to BTM	BSW	Narroways Hill JN	Junction	2	0	66		N/A	N/A	Open			-
1	Severn Beach to BTM	BSW	Stapleton Road	Station	1	0	1095		N/A	N/A	Station			-
1	Severn Beach to BTM	BSW	Lawrence Hill	Station	1	0	88		N/A	N/A	Station			-
1	Severn Beach to BTM	BSW	Dr Days JN	Junction	0	0	1210		N/A	N/A	Open			-
1	Severn Beach to BTM	BSW	Bristol East JN	Junction	0	0	572		N/A	N/A	Open			-
1	Severn Beach to BTM	MLN1	Bristol East JN	Junction	118	0	44		N/A	N/A	Open			-
1	Severn Beach to BTM	MLN1	Bristol Temple Meads	Station	118	0	616		N/A	N/A	Station			-

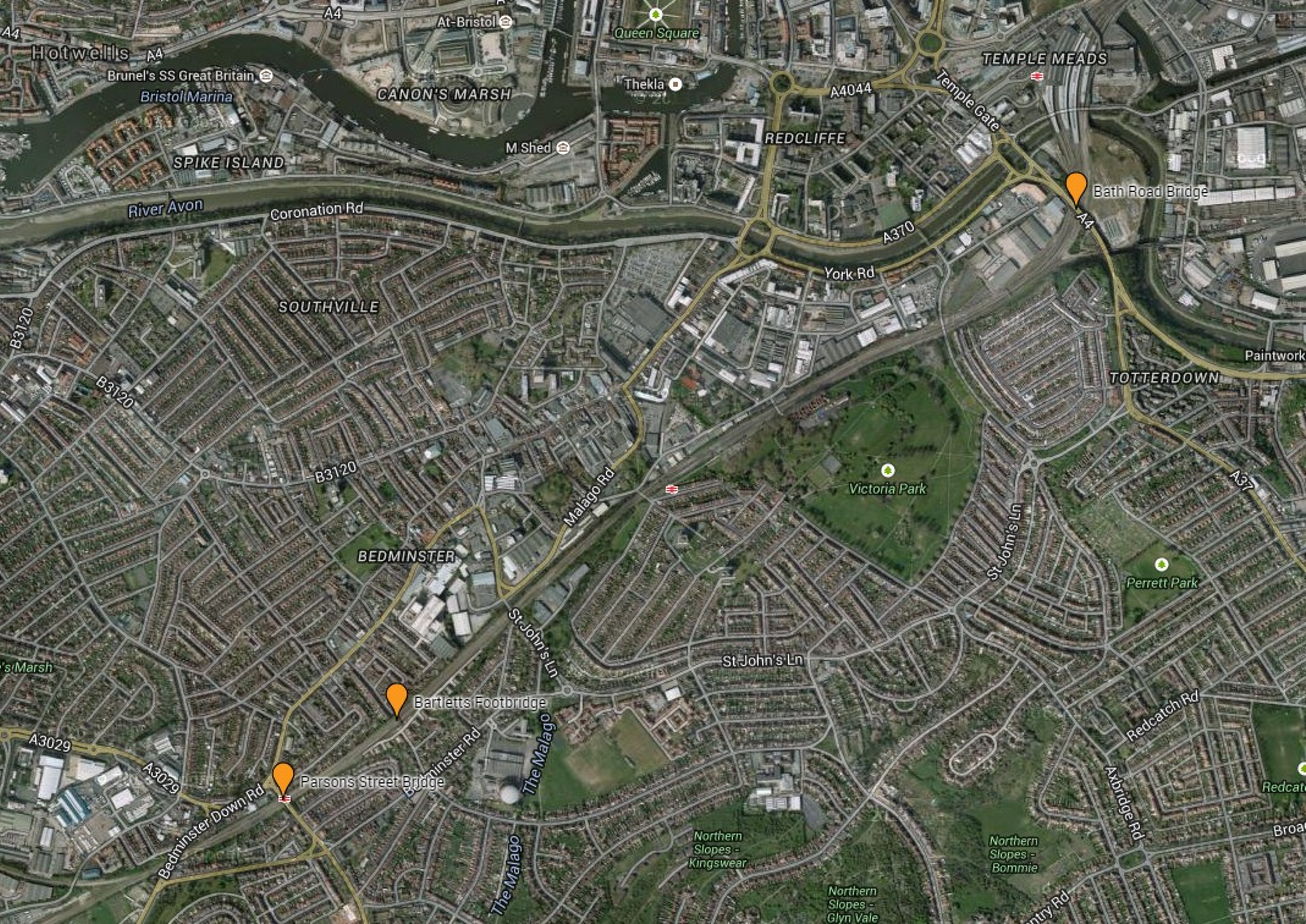
Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
2	Weston-super-Mare to BTM	WSM	Weston-super-Mare	Station	137	33	0		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	WSM	WSM Station Awning	Station	137	32	17	4579	Foul	521	Station	Throughout length of station (single line)		-
2	Weston-super-Mare to BTM	WSM	Overbridge 13729	Bridge	137	28	17	4950	Foul	150	Open	Flat Deck - Unable to track lower due to station and OLE solution not desirable due to proximity to platform. Jack bridge	Jack	£350,000
2	Weston-super-Mare to BTM	WSM	Overbridge 13729	Bridge	137	27	12	5049	Foul	51	Open			
2	Weston-super-Mare to BTM	WSM	Drove Road Ashcombe Bridge	Bridge	137	18	6	4262	Foul	838	Open	Flat Deck - S&C so no track lower. Jacking 838mm not likely to be feasible. Reconstruct, possibly in combination with an OLE solution	Recon	£2,500,000
2	Weston-super-Mare to BTM	WSM	Pottery Street Bridge	Bridge	136	78	20	4258	Foul	842	Open	Flat Deck Footbridge - move span east on new abutments and add new ramp section.	Jack	£120,000
2	Weston-super-Mare to BTM	WSM	Locking Road FPO Xing	Level Crossing	136	56	0		N/A	N/A	Open	Renewal of FPO crossing assumed to cost £50,000.	Renewal	£50,000
2	Weston-super-Mare to BTM	WSM	Hutton Moor Road Bridge	Bridge	136	31	9	4327	Foul	773	Open	Arched - track lower unlikely to be achievable with station platform to the north. Reconstruct with a conarch	Recon	£750,000
2	Weston-super-Mare to BTM	WSM	Weston Milton	Station	136	12	0		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	WSM	Locking Moor Road Bridge	Bridge	136	5	20	4244	Foul	856	Open	Arched - track lower unlikely to be achievable with station platform to the north. Reconstruct with a conarch	Recon	£900,000
2	Weston-super-Mare to BTM	WSM	WSM FP FPG Xing	Level Crossing	135	64	0		N/A	N/A	Open	Renewal of FPG crossing assumed to cost £50,000.	Renewal	£50,000
2	Weston-super-Mare to BTM	WSM	Wells BC17 FPS Xing	Level Crossing	135	45	0		N/A	N/A	Open	Renewal of FPS crossing assumed to cost £50,000.	Renewal	£50,000
2	Weston-super-Mare to BTM	WSM	Worle (Closed)	Station	135	30	0		N/A	N/A	Station	NGD information not provided for given chainage		-
2	Weston-super-Mare to BTM	WSM	Worle JN	Station	135	11	0		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Worle JN	Station	135	0	0		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Worle	Station	134	0	933		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Puxton & Worle MCB Xing	Level Crossing	133	79	0		N/A	N/A	Open	Renewal of MCB crossing assumed to cost £2,000,000	Renewal	£2,000,000
2	Weston-super-Mare to BTM	MLN1	Puxton (Closed)	Station	133	75	0		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Down Puxton M5 Bridge	Bridge	133	50	3	4908	Foul	192	Open	Track Lower	Track Lower	£200,000
2	Weston-super-Mare to BTM	MLN1	Up Puxton M5 Bridge	Bridge	133	45	18	4899	Foul	201	Open			
2	Weston-super-Mare to BTM	MLN1	Down Hardwicks Bridge	Bridge	132	69	18	4262	Foul	838	Open	Reconstruct bridge and approaches to achieve additional 838mm	Recon	£1,300,000
2	Weston-super-Mare to BTM	MLN1	Up Hardwicks Bridge	Bridge	132	69	13	4581	Foul	519	Open			
2	Weston-super-Mare to BTM	MLN1	Oldbridge FPS Xing	Level Crossing	132	42	0		N/A	N/A	Open	Renewal of FPS crossing assumed to cost £50,000	Renewal	£50,000
2	Weston-super-Mare to BTM	MLN1	Huish CCTV Xing	Level Crossing	132	11	0		N/A	N/A	Open	Renewal of CCTV crossing assumed to cost £2,000,000	Renewal	£2,000,000
2	Weston-super-Mare to BTM	MLN1	Gas House Lane PED Xing	Level Crossing	130	49	0		N/A	N/A	Open	Renewal of PED crossing assumed to cost £50,000	Renewal	£50,000
2	Weston-super-Mare to BTM	MLN1	Down Yatton Footbridge	Footbridge	130	25	7	4831	Foul	269	Open	Jack Footbridge	Jack	£75,000
2	Weston-super-Mare to BTM	MLN1	Up Yatton Footbridge	Footbridge	130	25	7	4991	Foul	109	Open			
2	Weston-super-Mare to BTM	MLN1	Up Fishers Overbridge	Bridge	130	19	2	4739	Foul	361	Open	Jack Bridge	Jack	£350,000
2	Weston-super-Mare to BTM	MLN1	Down Fishers Overbridge	Bridge	130	18	18	4718	Foul	382	Open			
2	Weston-super-Mare to BTM	MLN1	Yatton	Station	130	0	616		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Mud Lane UWC Xing	Level Crossing	129	23	0		N/A	N/A	Open	Renewal of UWC crossing assumed to cost £100,000	Renewal	£100,000
2	Weston-super-Mare to BTM	MLN1	Down Burgess Overbridge	Bridge	128	76	19	4233	Foul	867	Open	Reconstruction	Recon	£350,000
2	Weston-super-Mare to BTM	MLN1	Up Burgess Overbridge	Bridge	128	76	13	4250	Foul	850	Open			
2	Weston-super-Mare to BTM	MLN1	Down Claverham Bridge	Bridge	128	57	15	4252	Foul	848	Open	Reconstruction	Recon	£450,000
2	Weston-super-Mare to BTM	MLN1	Up Claverham Bridge	Bridge	128	57	9	4283	Foul	817	Open			
2	Weston-super-Mare to BTM	MLN1	Down Chelvey Bridge	Bridge	127	44	4	4304	Foul	796	Open	Reconstruction	Recon	£600,000
2	Weston-super-Mare to BTM	MLN1	Up Chelvey Bridge	Bridge	127	43	19	4281	Foul	819	Open			
2	Weston-super-Mare to BTM	MLN1	Nailsea & Blackwell	Station	126	0	726		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Down Nailsea Station Footbridge	Footbridge	126	33	1	4267	Foul	1533	Station	Reconstruction. Jacking may be possible, but the bridge level needs to increase nearly 1600mm for optimum, 1200mm for sub-optimal, so reconstruction is a safer option	Recon	£450,000
2	Weston-super-Mare to BTM	MLN1	Up Nailsea Station Footbridge	Footbridge	126	32	16	4231	Foul	1569	Station			
2	Weston-super-Mare to BTM	MLN1	Down Park Lane Bridge	Bridge	125	4	13	4191	Foul	909	Open	Reconstruction possibly with a conarch. Severing access over the bridge should also be considered as there are other bridges nearby and it is a minor road	Recon	£500,000
2	Weston-super-Mare to BTM	MLN1	Up Park Lane Bridge	Bridge	125	4	1	4207	Foul	893	Open			
2	Weston-super-Mare to BTM	MLN1	Down Flax Bourton Lane Bridge	Bridge	124	38	7	4721	Foul	379	Open	Reconstruction possibly with a conarch.	Recon	£600,000
2	Weston-super-Mare to BTM	MLN1	Up Flax Bourton Lane Bridge	Bridge	124	37	21	4584	Foul	516	Open			
2	Weston-super-Mare to BTM	MLN1	Flax Bourton (Closed)	Station	124	21	0		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Flax Bourton Tunnel	Tunnel	123	66	0		Clear	N/A	Tunnel	OLE solution	OLE solution	£100,000
2	Weston-super-Mare to BTM	MLN1	Flax Bourton Tunnel	Tunnel	123	61	6		Clear	N/A	Tunnel			
2	Weston-super-Mare to BTM	MLN1	Aqueduct Bridge	Bridge	123	40	9	5175	Clear	N/A	Open			-
2	Weston-super-Mare to BTM	MLN1	Down South Liberty Footbridge	Footbridge	121	1	1	4184	Foul	916	Open	Reconstruction		£200,000
2	Weston-super-Mare to BTM	MLN1	Up South Liberty Footbridge	Footbridge	121	0	18	4316	Foul	784	Open			
2	Weston-super-Mare to BTM	MLN1	Parson Street	Station	120	0	130		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Bedminster	Station	119	0	484		N/A	N/A	Station			-
2	Weston-super-Mare to BTM	MLN1	Bristol Temple Meads	Station	118	0	616		N/A	N/A	Station			-

Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
2	BTM to Yate	MLN1	Bristol Temple Meads	Station	118	0	616		N/A	N/A	Station	Lines already electrified as part of Phase I		-
2	BTM to Yate	MLN1	Bristol East JN	Junction	118	0	44		N/A	N/A	Open			-
2	BTM to Yate	BSW	Bristol East JN	Junction	0	0	572		N/A	N/A	Open			-
2	BTM to Yate	BSW	Dr Days JN	Junction	0	0	1210		N/A	N/A	Open			-
2	BTM to Yate	BSW	Lawrence Hill	Station	1	0	88		N/A	N/A	Station			-
2	BTM to Yate	BSW	Stapleton Road	Station	1	0	1095		N/A	N/A	Station			-
2	BTM to Yate	BSW	Narroways Hill JN	Junction	2	0	66		N/A	N/A	Open			-
2	BTM to Yate	BSW	Ashley Hill (closed)	Station	2	0	924		N/A	N/A	Station			-
2	BTM to Yate	BSW	Horfield (Closed)	Station	3	0	1210		N/A	N/A	Station			-
2	BTM to Yate	BSW	Filton Abbey Wood	Station	4	0	660		N/A	N/A	Station	Lines already electrified as part of the GWML Electrification Scheme		-
2	BTM to Yate	BSW	Patchway JN no. 2	Junction	5	61	0		N/A	N/A	Open			-
2	BTM to Yate	SWB	Patchway JN no. 2	Junction	112	68	0		N/A	N/A	Open			-
2	BTM to Yate	SWB	Stoke Gifford JN no. 2	Junction	112	5	0		N/A	N/A	Open			-
2	BTM to Yate	SWB	Stoke Gifford JN no. 1	Junction	111	79	0		N/A	N/A	Open			-
2	BTM to Yate	SWB	Stoke Gifford West JN	Junction	111	73	0		N/A	N/A	Open			-
2	BTM to Yate	SWB	Bristol Parkway	Station	111	62	0		N/A	N/A	Station			-
2	BTM to Yate	SWB	Winterbourne (Closed)	Station	109	0	1496		N/A	N/A	Station			-
2	BTM to Yate	SWB	Coalpit Heath (Closed)	Station	108	0	836		N/A	N/A	Station			-
2	BTM to Yate	SWB	Westerly JN	Junction	107	14	0		N/A	N/A	Open			-
2	BTM to Yate	YAT	Westerly JN	Junction	121	28	0		N/A	N/A	Open			-
2	BTM to Yate	YAT	Signal Gantry	Signal	121	5	13	4973	Foul	127	Open			£300,000
2	BTM to Yate	YAT	Signal Gantry	Signal	120	35	7	5058	Foul	42	Open			£300,000
2	BTM to Yate	YAT	Signal Gantry	Signal	120	35	1	4988	Foul	112	Open			£300,000
2	BTM to Yate	YAT	Yate South JN	Junction	120	2.5	0		N/A	N/A	Open			-
2	BTM to Yate	YAT	Yate	Station	119	60	0		N/A	N/A	Station			-

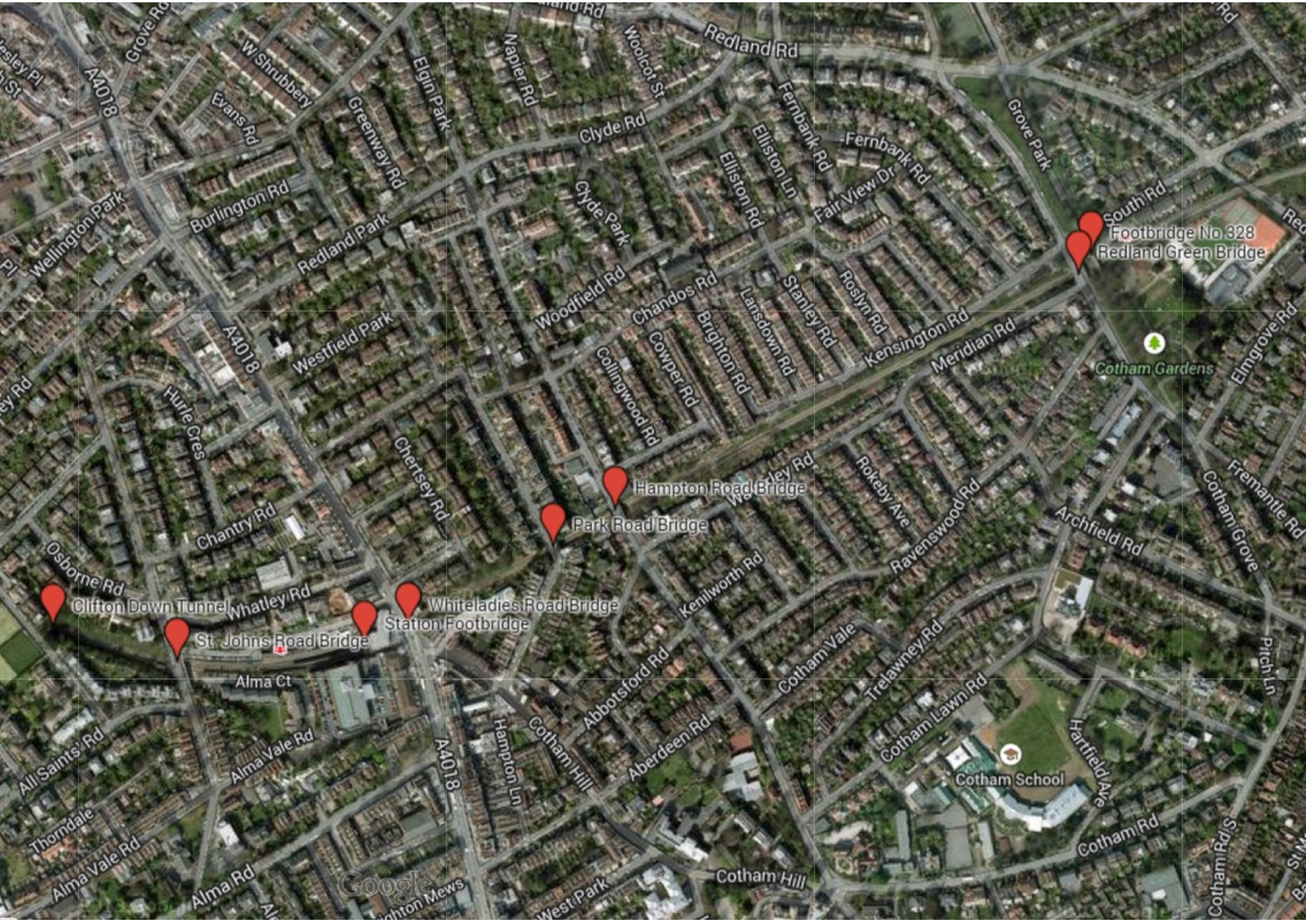
Phase	Route	ELR	Structure Name	Structure Type	Chainage			Clearance	Status	Distance to be Raised	Route Status	Notes / Commentry	Proposal	Estimated Cost
2	Henbury to BTM	AFR	Rockingham Road A403 (Smoke Lane)	Bridge	118	23	6	4650	Foul	450	Open	NGD information not provided. Assume clearance of 4650mm. Flat deck. Track lower would have been recommended, but S&C at junction. Jack and regrade road.	Jack	£500,000
2	Henbury to BTM	AFR	Blaise (Hallen Road)	Bridge	116	5	6	4650	Foul	450	Open	NGD information not provided. Assume clearance of 4650mm. Already considerable gradient on road surface, avoid jacking.	Track Lower	£4,000,000
2	Henbury to BTM	AFR	Overbridge	Bridge	115	55	0	4650	Foul	450	Open	NGD information not provided. Assume clearance of 4650mm. Currently only used as footbridge. If necessary recon as smaller structure for pedestrians		
2	Henbury to BTM	AFR	Station Road B4055	Bridge	115	35	9	4650	Foul	450	Open	NGD information not provided. Assume clearance of 4650mm. If Henbury station is to be rebuilt here clearance requirements would increase by 700mm. In this event consider recon/jack, but this outcome has not been costed.		
2	Henbury to BTM	AFR	Wyck Beck Road A4018	Bridge	115	18		4650	Foul	450	Open	NGD information not provided. Assume clearance of 4650mm. Bust dual carriageway with nearby junctions. Avoid jacking.		
2	Henbury to BTM	AFR	Henbury (Henbury)	Station	115	0	0		N/A	N/A	Station			
2	Henbury to BTM	AFR	Up Fish Pool Overbridge	Bridge	114	65	11	4283	Foul	817	Open	Track lower. Reconstruction possible, but only access to housing estate north of railway line, so temporary access may also need to be constructed		
2	Henbury to BTM	AFR	Down Fish Pool Overbridge	Bridge	114	65	10	4213	Foul	887	Open			
2	Henbury to BTM	AFR	Up Charlton/Henbury Bridge	Tunnel	114	12	4	5126	Clear	N/A	Tunnel	OLE solution	OLE solution	£150,000
2	Henbury to BTM	AFR	Down Charlton/Henbury Tunnel	Tunnel	113	78	10	5107	Clear	N/A	Tunnel			
2	Henbury to BTM	AFR	Signal Gantry	Signal	113	78	3	4572	Foul	528	Open			£300,000
2	Henbury to BTM	AFR	Charlton Halt (Closed)	Station	114	0	0		N/A	N/A	Station			-
2	Henbury to BTM	AFR	Down Overbridge 11366a	Bridge	113	66	3	4414	Foul	686	Open	OLE solution	OLE solution	£150,000
2	Henbury to BTM	AFR	Up Overbridge 11366a	Bridge	113	66	0	4414	Foul	686	Open	Jack or reconstruct bridge	Jack	
2	Henbury to BTM	AFR	Up North Filton Bridge	Bridge	113	9	1	4921	Foul	179	Open	Ideally track lower under this bridge and Gloucester Road bridge, but junction is only 100m north of Gloucester Road. Consider jacking, combined with an OLE solution	Jack and OLE	£1,000,000
2	Henbury to BTM	AFR	Down North Filton Bridge	Bridge	113	8	21	4799	Foul	301	Open			
2	Henbury to BTM	AFR	Up Gloucester Road Bridge	Bridge	113	3	7	4248	Foul	852	Open	Ideally track lower under this bridge and Gloucester Road bridge, but junction is 100m north of Gloucester Road. Consider reconstructing in sections to reduce structural depth (jacking would push road to high), combined with an OLE solution and possible derogation.	Reconstruct and OLE	£4,000,000
2	Henbury to BTM	AFR	Down Gloucester Road Bridge	Bridge	113	3	4	4236	Foul	864	Open			
2	Henbury to BTM	AFR	North Filton (Closed)	Station	113	0	0		N/A	N/A	Station	NGD information not provided for given chainage		-
2	Henbury to BTM	AFR	Filton West JN No.2	Junction	112	78	0		N/A	N/A	Open			
2	Henbury to BTM	FWC	Cotham Park FC Xing	Level Crossing	5	20	0		N/A	N/A	Open	Renewal of FC crossing assumed to cost £50,000.	Renewal	£50,000
2	Henbury to BTM	FWC			4	66	0		N/A	N/A	Open			-
2	Henbury to BTM	BSW			4	0	1452		N/A	N/A	Open			-
2	Henbury to BTM	BSW	Filton Abbey Wood	Station	4	0	660		N/A	N/A	Station	Lines already electrified as part of the GWML Electrification Scheme		-
2	Henbury to BTM	BSW	Horfield (Closed)	Station	3	0	1210		N/A	N/A	Station			-
2	Henbury to BTM	BSW	Ashley Hill (Closed)	Station	2	0	924		N/A	N/A	Station			-
2	Henbury to BTM	BSW	Narroways Hill JN	Junction	2	0	66		N/A	N/A	Open	Lines already electrified as part of Phase I		-
2	Henbury to BTM	BSW	Stapleton Road	Station	1	0	1095		N/A	N/A	Station			-
2	Henbury to BTM	BSW	Lawrence Hill	Station	1	0	88		N/A	N/A	Station			-
2	Henbury to BTM	BSW	Dr Days JN	Junction	0	0	1210		N/A	N/A	Open			-
2	Henbury to BTM	BSW	Bristol East JN	Junction	0	0	572		N/A	N/A	Open			-
2	Henbury to BTM	MLN1	Bristol East JN	Junction	118	0	44		N/A	N/A	Open			-
2	Henbury to BTM	MLN1	Bristol Temple Meads	Station	118	0	616		N/A	N/A	Station			-


Legend
P1 Portishead to BTM
P1 Severn Beach to BTM
P2 Henbury to BTM
P2 Weston-super-Mare to BTM
Newport
Rogerstone
Bassaleg
Duffryn
COEDKERNEW
Marshfield
St Bride's Wentlooge
Magor
Rogiet
Caldicot
Aust
Alveston
Olveston
Rudgeway
Severn Beach
Almondsbury
Iron Acton
Easter Compton
Patchway
Frampton Cotterell
Nibley
Winterbourne
Stoke Gifford
Filton
Hambrook
HENBURY
AVONMOUTH
WESTBURY ON TRYM
HORFIELD
CHESWICK VILLAGE
FRENCHAY
Emersons Green
Pill
Portishead
Portbury
Abbots Leigh
FISHPONDS
SOUNDWELL
MONTPELIER
ST PAUL'S
WHITEHALL
KINGSWOOD
HANHAM
BRISLINGTON
KNOWLE
Longwell Green
Bitton
Keynsham
Saltford
Clevedon
Tickenham
Failand
Long Ashton
Flax Bourton
Backwell
Kenn
BISHOPSWORTH
WHITCHURCH
Dundry
Yatton
Cleeve
Felton
Winford
Hewish
Congresbury
Wrington
Redhill
Chew Magna
Pensford
Kewstoke
St Georges
WEST WICK
Weston-super-Mare
Langford
Chew Stoke
Farmborough
Priston
Bishop Sutton
Clutton
Timsbury
Temple Cloud
UPHILL
Hutton
Banwell
Blagdon
Corston
M4
M48
M49
M5
M32
A403
A4
A4174
A38
A371


M4
Redwick
Tockington
Pilning
Severn Beach
M5
Almondsbury
Easter
Compton
Frampton
Cotterell
M49
Patchway
Bradley Stoke
CHARLTON
HAYES
Little Stoke
Winterbourne
Hallen
Stoke Gifford
WINTERBOURNE
DOWN
BRENTRY
Filton
Hambrook
HENBURY
LAWRENCE
WESTON
SOUTHMEAD
CHESWICK
VILLAGE
FRENCHAY
Emersons
Green
WESTBURY
ON TRYM
HORFIELD
LOCKLEAZE
M32
DOWNEND
Portishead
STAPLETON
HENLEAZE
FISHPONDS
STAPLE HILL
Pill
BISHOPSTON
EASTVILLE
ASHLEY DOWN
SOUNDWELL
Easton-in-Gordano
Weston
Big Wood
Portbury
ST WERBURGH'S
CLAY HILL
MONTPELIER
EASTON
WHITEHALL
Abbots Leigh
Clapton-in-Gordano
ST PAUL'S
KINGSWOOD
Warmley
CLIFTON
REDFIELD
ST GEORGE
BROADMEAD
Clifton Suspension
Bridge Trust
Bristol
BARTON HILL
Lime Breach
Wood
Hotwells
HANHAM
SOUTHVILLE
BARRS COURT
ASHTON GATE
TOTTERDOWN
Oldland
Common
Wraxall
Failand
Tickenham
BRISLINGTON
Longwell
Green
KNOWLE
Nailsea
Long Ashton
Bickley Wood
Willsbridge

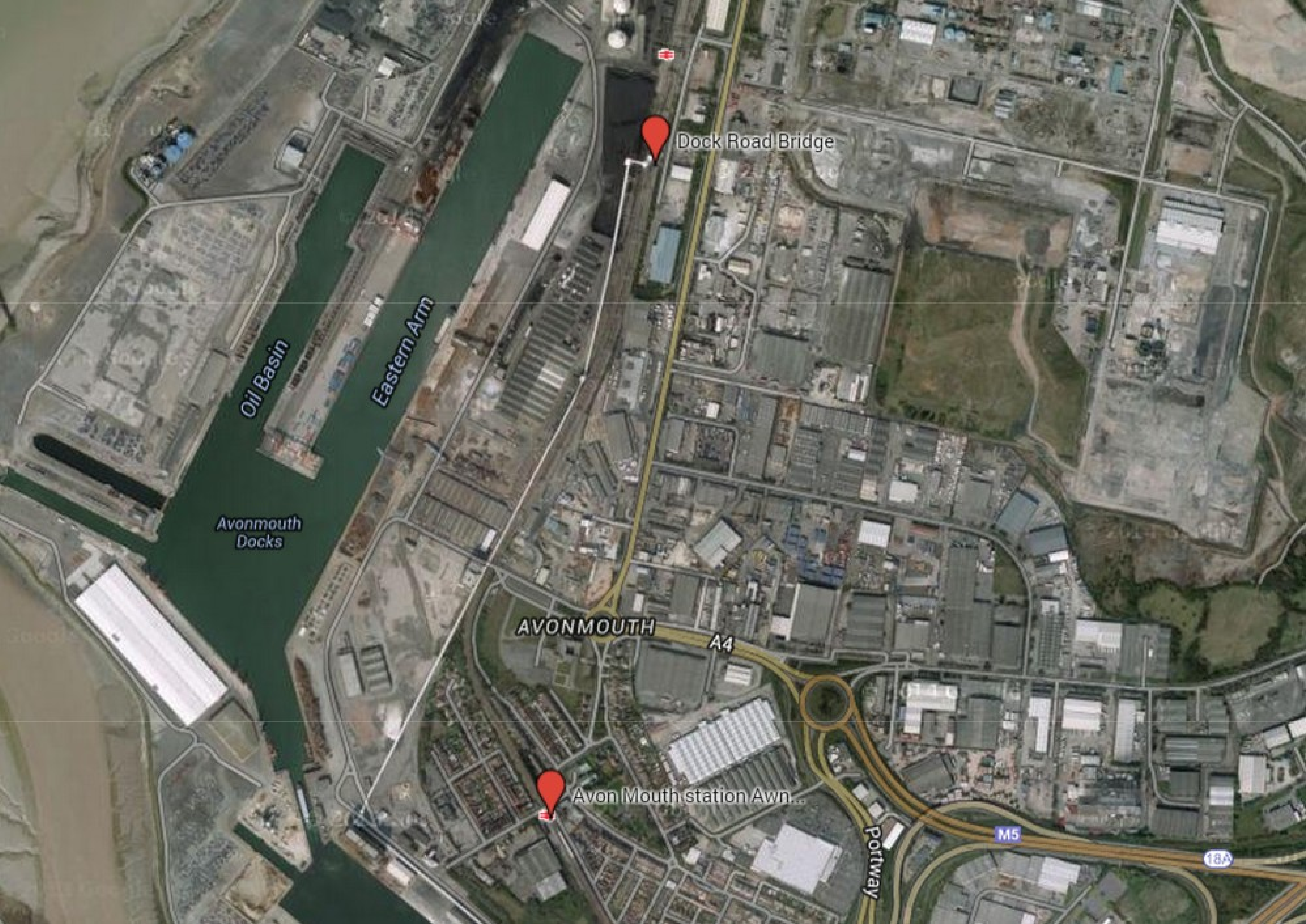


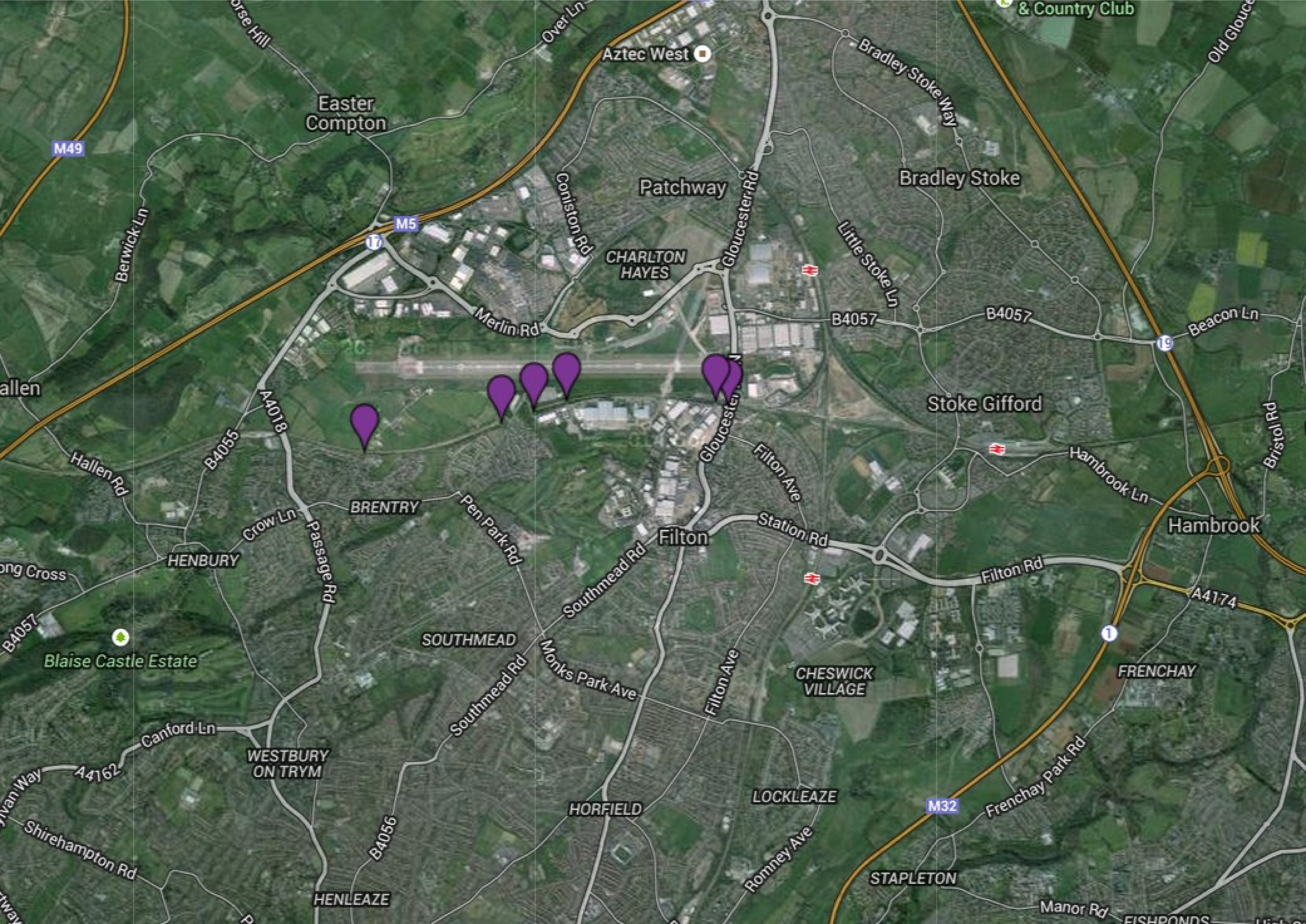
Hotwells
A4
At-Bristol
Queen Square
Brunel's SS Great Britain
Bristol Marina
CANON'S MARSH
Thekla
TEMPLE MEADS
A4044
Temple Gate
REDCLIFFE
M Shed
SPIKE ISLAND
River Avon
Coronation Rd
Bath Road Bridge
A370
York Rd
SOUTHVILLE
B3120
TOTTERDOWN
Paintwork
Victoria Park
Malago Rd
BEDMINSTER
A37
St John's Ln
Perrett Park
Bartletts Footbridge
Redcatch Rd
A3029
Parsons Street Bridge
Bedminster Rd
The Malago
Bedminster Down Rd
Axbridge Rd
Northern Slopes - Kingswear
Northern Slopes - Bommie
Northern Slopes - Glyn Vale


Redland Rd
Grove Rd
W Shrubbery
Elgin Park
Napier Rd
Woolcot St
A4018
Evans Rd
Greenway Rd
Clyde Rd
Fernbank Rd
Elliston Ln
Grove Park
Fair View Dr
Elliston Rd
Burlington Rd
Wellington Park
Redland Park
Clyde Park
South Rd
Footbridge No 328
Redland Green Bridge
Woodfield Rd
Chandos Rd
Stanley Rd
Roslyn Rd
Lansdown Rd
Kensington Rd
Westfield Park
Brighton Rd
Cowper Rd
Meridian Rd
Collingwood Rd
Cotham Gardens
Elmgrove Rd
Hurle Cres
Chertsey Rd
Hampton Road Bridge
Rokeby Ave
Ravenswood Rd
Park Road Bridge
Archfield Rd
Chantry Rd
Fremantle Rd
Cotham Grove
Osborne Rd
Kenilworth Rd
Clifton Down Tunnel
Whatley Rd
Whiteladies Road Bridge
Station Footbridge
St. Johns Road Bridge
Abbotsford Rd
Cotham Vale
Trelawney Rd
Pitch Ln
Alma Ct
Cotham Lawn Rd
All Saints' Rd
Alma Vale Rd
Hampton Ln
Cotham Hill
Aberdeen Rd
Hartfield Ave
Cotham School
Thorndale
Cotham Rd
Alma Rd
West Park
Google
Cotham Rd S


Seamills Wood
STOKE BISHOP
Portway Bridge
University of Bristol
Botanic Garden
Stoke Hill
Sneyd Park Bridge
Portway
River Avon
SNEYD PARK
Portway
Oak Wood
Clifton Down Tunnel
A4

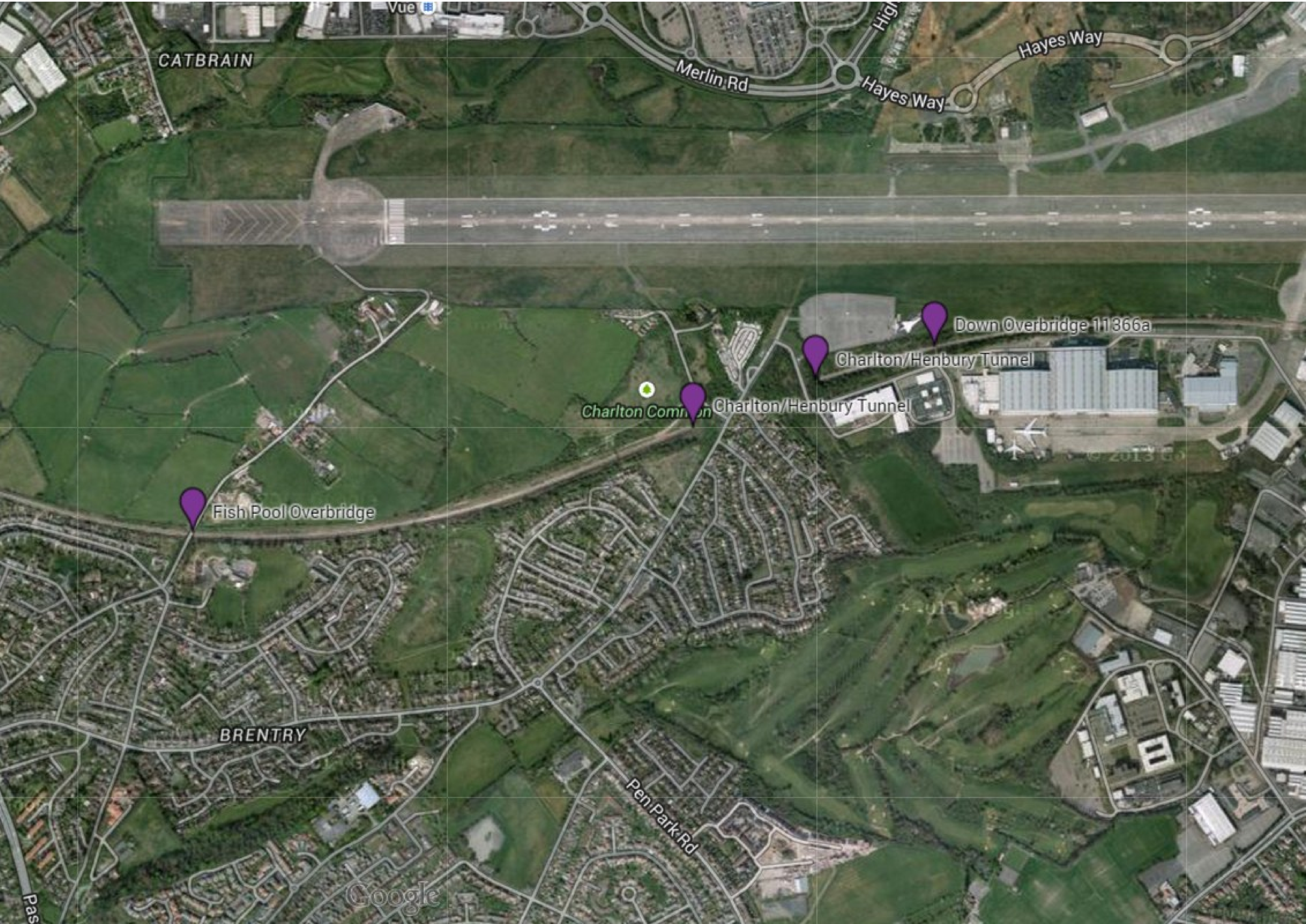
M5
Portway
High St
B4054
Shirehampton Rd
Shirehampton Park Golf Club
SHIREHAMPTON
Portway
Portway
A4
Crabtree Slip Wood
Woodwell Ln/ Powder Ho...
The Daisy Field
Hung Lane Bridge
River Avon
River Avon
River Avon
Pill
HAM GREEN


Dock Road Bridge
Oil Basin
Eastern Arm
Avonmouth
Docks
AVONMOUTH
A4
Avon Mouth station Awn...
Portway
M5
A18



& Country Club
Aztec West
Over Ln
Easter Compton
M49
M5
Patchway
Bradley Stoke
Bradley Stoke Way
Coniston Rd
Gloucester Rd
CHARLTON HAYES
Little Stoke Ln
Berwick Ln
Merlin Rd
B4057
Beacon Ln
Old Gloucester
A4018
B4055
Hallen Rd
Stoke Gifford
Bristol Rd
Filton Ave
Hambrook Ln
BRENTRY
Pen Park Rd
Crow Ln
Passage Rd
HENBURY
Hambrook
Filton
Station Rd
Southmead Rd
Filton Rd
A4174
Blaise Castle Estate
SOUTHMEAD
Monks Park Ave
CHESWICK VILLAGE
FRENCHAY
Canford Ln
A4162
WESTBURY ON TRYM
LOCKLEAZE
Frenchay Park Rd
M32
Shirehampton Rd
B4056
HORFIELD
Romney Ave
STAPLETON
HENLEAZE
Manor Rd

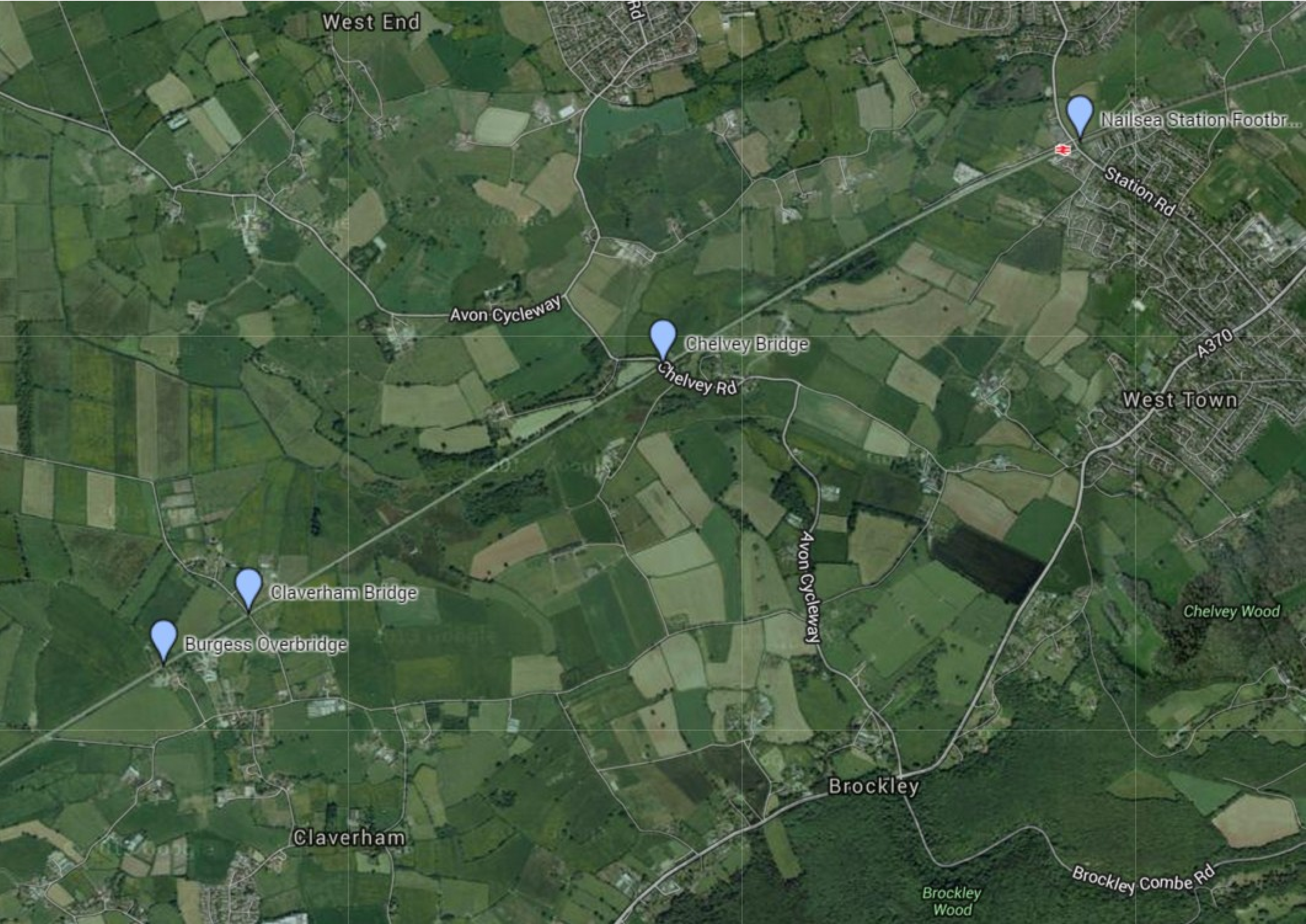

A38
North Filton Bridge
Gloucester Road Bridge
North Bristol Park
North Way
North Way
New Rd
Gloucester Rd N
College Way
College Way
Blenheim Dr
Lower House Cres
Conygre Rd
Bude Rd
Rodney Cres
Boverton Rd
Meadowsweet Ave
Google

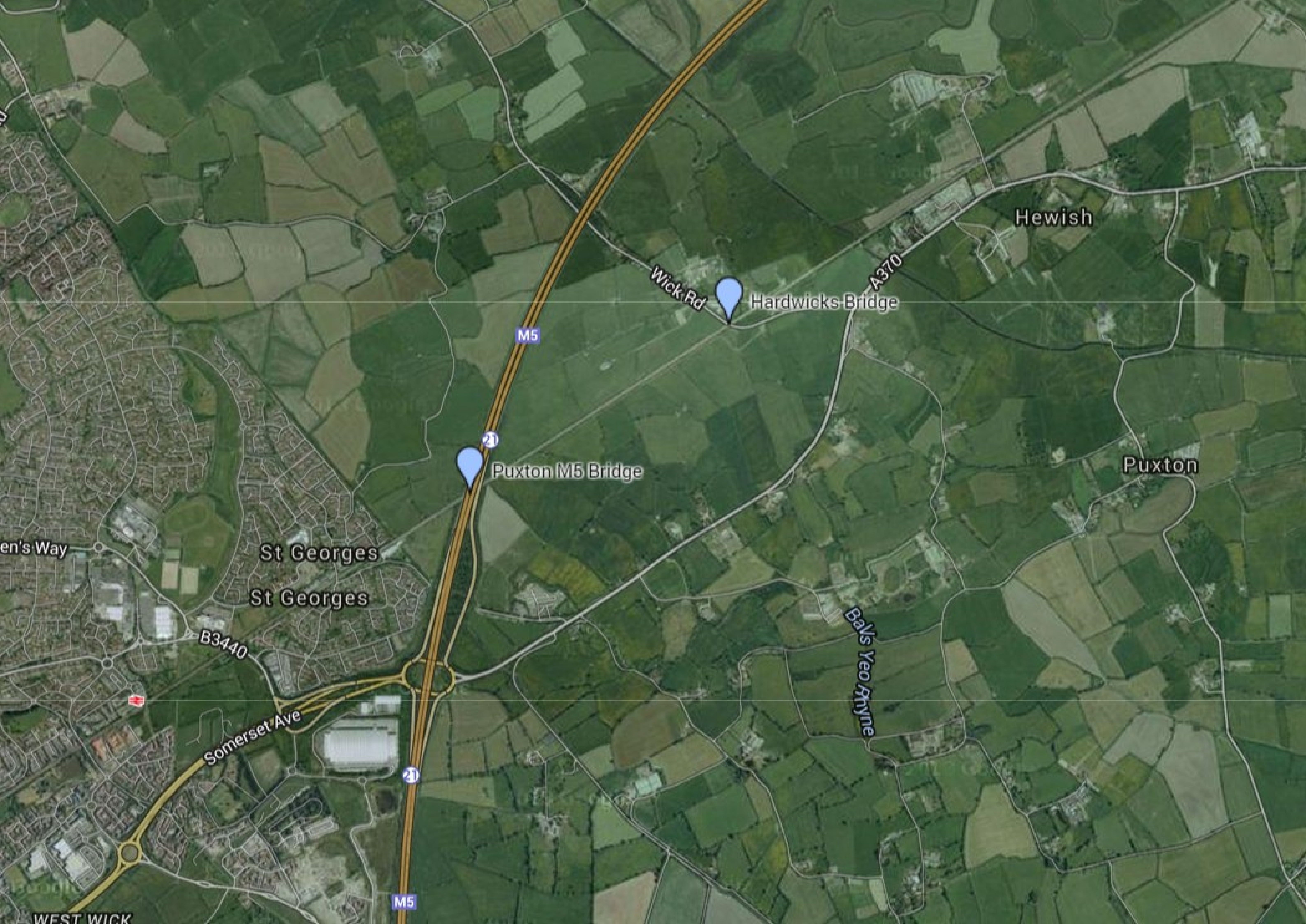


Vue
CATBRAIN
Merlin Rd
Hayes Way
Hayes Way
Down Overbridge 11366a
Charlton/Henbury Tunnel
Charlton/Henbury Tunnel
Charlton Common
Fish Pool Overbridge
BRENTRY
Pen Park Rd
Google

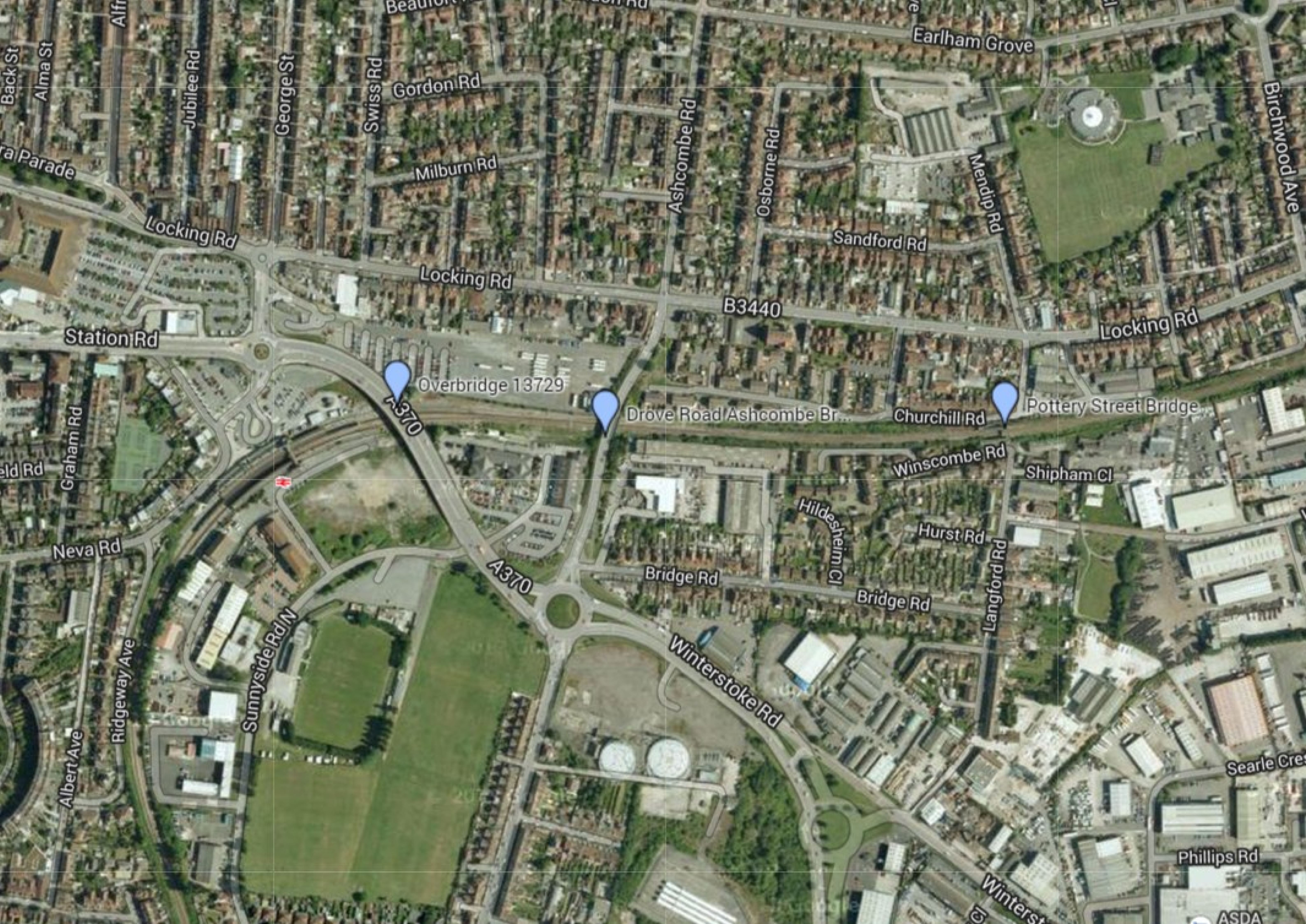

© 2013 Google
Hambrook
Filton
HENBURY
AVONMOUTH
CHESWICK VILLAGE
FRENCHAY
WESTBURY ON TRYM
HORFIELD
M32
SHIREHAMPTON
Portishead
Pill
FISHPONDS
BISHOPSTON
A4
REDLAND
SOUNDWELL
Portbury
MONTPELIER
WHITEHALL
Abbots Leigh
ST PAUL'S
KINGSWOOD
M5
Bristol
REDCLIFFE
HANHAM
Clevedon
Tickenham
Failand
BEDMINSTER
BRISLINGTON
Longwell Green
Long Ashton
KNOWLE
A4
Flax Bourton
A4174
Kenn
BISHOPSWORTH
Keynsham
Backwell
WHITCHURCH
A38
Dundry
Yatton
Cleeve
Felton
Winford
Hewish
Congresbury
Pensford
Kewstoke
St Georges
Wrington
Redhill
Chew Magna
WEST WICK
Chew Stoke
Langford
A371
Bishop Sutton
Clutton
UPHILL
Hutton
Banwell
Blagdon
A38
Temple Cloud
Shipham
West Harptree
Bleadon
Paulton
Winscombe
East Harptree
Brean
Mendip Hills AONB
Lympsham
Axbridge
Cheddar
Chewton Mendip
A38
A37
Chilcompton
Berrow
East Brent
Draycott


B3130
Nailsea Park
Bristol Rd
Nailsea
B3129
Station Rd
ueens Rd
Flax Bourton Lane Brid...
Station Rd
Nailsea Station Footbr...
A370
Flax Bourton
Station Rd
A370
West Town
Backwell
Google


West End
Rd
Nailsea Station Footbr...
Station Rd
Avon Cycleway
Chelvey Bridge
Chelvey Rd
A370
West Town
Avon Cycleway
Claverham Bridge
Chelvey Wood
Burgess Overbridge
Brockley
Claverham
Brockley Combe Rd
Brockley Wood


Hewish
Wick Rd
Hardwicks Bridge
A370
M5
21
Puxton M5 Bridge
Puxton
St Georges
St Georges
B3440
Somerset Ave
21
M5
WEST WICK


Capell Cl
St Austell Rd
Chesham Rd S
Charter Rd
Locking Rd
Locking Rd
Rutland Cl
Warwick Cl
B3440
Martindale Rd
Teesdale Cl
Corondale Rd
Newbourne Rd
Fernlea Rd
Saville Rd
Locking Moor Road Brid...
Maltlands
Hutton Moor Road Bridge
Clover Ct
Pennycress
Pennycress
Charlock Rd
Hornets
Rugby Club
Aisecome Way


Earlham Grove
Back St
Alma St
Jubilee Rd
George St
Swiss Rd
Gordon Rd
Milburn Rd
Ashcombe Rd
Osborne Rd
Mendip Rd
Birchwood Ave
Sandford Rd
Locking Rd
Locking Rd
B3440
Locking Rd
Station Rd
Overbridge 13729
A370
Drove Road Ashcombe Br...
Churchill Rd
Pottery Street Bridge
Winscombe Rd
Shipham Cl
Graham Rd
Hildesheim Cl
Hurst Rd
Neva Rd
Bridge Rd
Bridge Rd
A370
Langford Rd
Winterstoke Rd
Sunnyside Rd N
Ridgeway Ave
Albert Ave
Phillips Rd
ASDA

Appendix C

Depot Costs

St Philips Marsh **New AC Depot at St Philips Marsh**

Equipment	Assumed Size		Cost Assumption			Total cost (2003 SPONS prices)	Total cost adjusted for inflation to 2014	Total cost adjusted for - 30%	Total cost adjusted for + 30%
							42%	30%	30%
	120	15	Substructure	£279.42	£502,956.00				
	120	15	Frame	£246.55	£443,790.00				
	120	15	Roof	£197.25	£355,050.00				
	120	15	External walls	£98.63	£177,534.00				
	120	15	Windows and doors	£65.75	£118,350.00				
Maintenance facility	120	15	Internal walls	£32.87	£59,166.00				
	120	15	Finishes	£65.76	£118,368.00				
	120	15	Sanitary finishes	£32.87	£59,166.00				
	120	15	Mechanical	£230.11	£414,198.00				
	120	15	Electrical	£115.06	£207,108.00				
	120	15	Drainage and external work	£279.42	£502,956.00	£2,958,642.00	£4,201,271.64	£2,940,890.15	£5,461,653.13
	7	10	Substructure	£532.06	£37,244.20				
	7	10	Frame	£608.07	£42,564.90				
	7	10	Roof	£380.04	£26,602.80				
	7	10	External walls	£152.03	£10,642.10				
	7	10	Windows and doors	£114.01	£7,980.70				
Bogie/Equipment Drop	7	10	Internal walls	£38.00	£2,660.00				
	7	10	Finishes	£114.00	£7,980.00				
	7	10	Sanitary finishes	£76.00	£5,320.00				
	7	10	Mechanical	£722.08	£50,545.60				
	7	10	Electrical	£380.04	£26,602.80				
	7	10	Drainage and external work	£684.08	£47,885.60	£266,028.70	£377,760.75	£264,432.53	£491,088.98
OLE within facility & CET Road	450		OHLE	£250.00	£112,500.00	£112,500.00	£159,750.00	£111,825.00	£207,675.00
	2000		Track Foundations	£92.62	£185,232.00				
Track	300		Rails, sleepers and fixings	£300.00	£90,000.00				
	3		Switches & crossings	£25,000.00	£75,000.00	£350,232.00	£497,329.44	£348,130.61	£646,528.27
	15	60	Substructure	£279.42	£251,478.00				
	15	60	Frame	£246.55	£221,895.00				
	15	60	Roof	£197.25	£177,525.00				
	15	60	External walls	£98.63	£88,767.00				
	15	60	Windows and doors	£65.75	£59,175.00				
Stores and Offices	15	60	Internal walls	£32.87	£29,583.00				
	15	60	Finishes	£65.76	£59,184.00				
	15	60	Sanitary finishes	£32.87	£29,583.00				
	15	60	Mechanical	£230.11	£207,099.00				
	15	60	Electrical	£115.06	£103,554.00				
	15	60	Drainage and external work	£279.42	£251,478.00	£1,479,321.00	£2,100,635.82	£1,470,445.07	£2,730,826.57
CET Installation	1		CET	£500,000.00	£500,000.00	£500,000.00	£710,000.00	£497,000.00	£923,000.00
Signalling/DPS				£500,000.00	£500,000.00	£500,000.00	£710,000.00	£497,000.00	£923,000.00
Staff Car park	20	10	At Grade Car Park	£1,200.00	£240,000.00	£240,000.00	£340,800.00	£238,560.00	£443,040.00
OLE upgrades to St Philips Marsh Yard		2500		£1,400.00	£3,500,000.00	£3,500,000.00	£4,970,000.00	£3,479,000.00	£6,461,000.00
							£14,067,547.65	£9,847,283.36	£18,287,811.95

Assumptions

The building can be built on existing stabling roads with no operational issues/further work due to loss of capacity

The shed will be 2 roads with and four cars long. (120m long 15m wide)

Offices and stores of 15m x 60m

No new stabling is required

Modifications/demolitions to existing infrastructure is excluded from the figures

The existing train wash and wheel lathe can be re-used

Signalling requirements are unknown, a figure has been estimated

OLE can be fed of the Mainline installation works

New OLE for wiring of the St Philips Marsh loop is based on £1.4m per Km

Appendix D

Technical Note: Demand and Revenue Forecasting

Introduction

ARUP has been commissioned by the Bristol City Council (BCC) to prepare an outline Business Case for the MetroWest project to support potential electrification of the Bristol suburban railway network.

Passenger demand and revenue forecasts have been developed for the Bristol suburban railway network as an input to outline Business Case. This technical note provides details of forecasting approach used to develop passenger demand and revenue forecasts. It also provided summary of the economic benefit estimates.

Approach

An elasticity-based forecasting approach, based on guidance from the Passenger Demand Forecasting Handbook (PDFH) has been adopted to prepare rail forecasts. In this approach, rail passenger demand is expected to grow with the changes in exogenous and endogenous factors.

Exogenous factors are background changes which are assumed to be outside the direct control of the rail industry. These include factors such as GDP, employment, population, car ownership, car fuel costs, car journey times.

Endogenous factors are scheme related initiatives which are assumed to be within the direct control of the rail industry. Endogenous factors for this scheme include timetable related Generalised Journey Time (GJT) and frequency improvements as well as non-timetable related service quality improvements.

Do minimum demand forecasts are linked to the changes in exogenous factors, while Do something demand forecasts are linked to the changes in both exogenous and endogenous factors. Do something forecasts have the same exogenous growth characteristics as Do minimum.

Details of the data sources and methodology adopted to prepare passenger demand and revenue forecasts are provided in this section. It also provides details of the capacity assessment that has been used to inform the rolling stock requirement and operating costs.

Data Sources

A number of data sources as listed below have been used for the preparation of the demand and revenue forecasts.

MOIRA

MOIRA is a standard forecasting tool that models the impact of the timetable changes on passenger demand and revenue. It is well-establish and widely used tool within the rail industry. First Great Western has provided the MOIRA model to Arup for the purpose of the MetroWest project. This MOIRA model included demand and revenue data for the year 2013. This model has been used to model the effect of the timetable changes to the existing station/services.

Any information reported from the MOIRA model in this note is commercially confidential and **must not be disclosed to third party.**

PDFH

The Passenger Demand Forecasting Handbook (PDFH) provides guidance on the preparation of rail passenger demand forecasts in the UK. It provides information on various drivers of rail demand and values of the elasticities of these drivers. The PDFH 5.1 forms the basis of the forecasting methodology adopted for this project.

Any information reported from the PDFH in this note is also **commercially confidential.**

TEMPro

The TEMPro (Trip End Model Presentation Program) software provides forecasts for population, employment and car ownership based on data from the National Transport Model (NTM). Growth factors for future year planning data (i.e. population, employment and car ownership) were derived from TEMPro 6.2.

WebTAG

Growth factors for GDP per person have been taken from the WebTAG Unit A 1.3.Growth factors for the value of time per person used to convert journey time savings in to monetary values have been taken from the WebTAG unit A1-3, Table A1.3.1 and Table A1.3.2. Growth factors for the fuel cost and proportion of vehicles by fuel type have been taken from Table A1.3.7 and Table A1.3.9.

Do Minimum Demand

Do minimum demand and revenue for existing stations have been extracted from the MOIRA model on a station to station basis. Do minimum demand for all the proposed new stations within the study area has been provided by the Bristol City Council. Total annual demand provided at each station is summarised in the Table 1 below. The annual demand numbers are with full build out of the Temple Quarter Enterprise Zone (TQEZ).

Table 1: Annual Demand at New Stations

Station	Source	Part of Phase	Data Year	Total Demand
Pill	Greater Bristol Metro Bristol Area Rail Study – Final Report, February 2013	Phase 1	2011	144,699
Portishead		Phase 1	2011	289,979
Portway P&R		Phase 1	2011	54,940
Ashley Down	Bristol New Stations High Level Assessment Study – locations on Filton Bank, May 2014	Phase 2	2022	178,000
Horfield		Phase 2	2022	98,000
Ashton Gate		Phase 2	2022	72,000

Station	Source	Part of Phase	Data Year	Total Demand
Henbury	Bristol North Fringe Stations, January 2014	Phase 2	2022	187,000*
Filton North		Phase 2	2022	149,000*
Saltford	Saltford Railway Station - Feasibility Investigation, May 2012	Phase 2	2010	123,410*

Note: * data source unclear regarding inclusion of TQEZ demand

Annual demand at all new stations were converted to 2013 levels and split in four sectors using a comparator existing station:

- Sector 1: Demand travelling to/from new station and any suburban station within the study area
- Sector 2: Demand travelling to/from new station and Bristol Temple Meads
- Sector 3: Demand travelling to/from new station and Bath Spa
- Sector 4: Demand travelling to/from new station and any station outside the study area

Comparator station for each station was selected on the basis of similarity to the new station. Journey times for each individual OD pairs travelling to/from these new stations were estimated manually from the proposed Do minimum timetable.

Forecasting Methodology

The forecasting methodology adopted takes account of changes in both exogenous and endogenous factors.

Exogenous Growth

Growth in rail demand due to the changes in exogenous factors for individual station to station pairs were estimated by applying the PDFH mathematical framework set out below:

$$I_E = \left(\frac{GDPPercapita_{ds}}{GDPPercapita_{dm}}\right)^g X \left(\frac{EMP_{ds}}{EMP_{dm}}\right)^e X \left(\frac{POP_{ds}}{POP_{dm}}\right)^p X$$

$$EXP(n\,X(NC_{ds} - NC_{dm}))X \left(\frac{RAILFARE_{ds}}{RAILFARE_{dm}}\right)^r X \left(\frac{FUELCOST_{ds}}{FUELCOST_{dm}}\right)^f X$$

$$\left(\frac{CARTIME_{ds}}{CARTIME_{dm}}\right)^c X \left(\frac{BUSCOST_{ds}}{BUSCOST_{dm}}\right)^b X \left(\frac{BUSTIME_{ds}}{BUSTIME_{dm}}\right)^t$$

Where:

I_E is the exogenous factors index for the change in demand between the Do minimum and Do something

The parameters are all elasticities, with the exception of n that determines the non car-ownership elasticity

A spreadsheet model has been developed for three ticket types (full, reduced & season) to implement the PDFH approach. Station to station and station to sector pairs affected by the scheme has been imported to the spreadsheet model. Trip origins and destinations have been assigned to a zone system based on local authority areas within the study area. Any station outside the study area was grouped in two coarse zones London and Rest of the UK. Each of the above exogenous factors has been forecast and applied within this zoning system.

Table 2 below lists the exogenous factors included and the source for growth assumptions for these. The elasticities shown in Table 3 has been taken directly from PDFH version 5.1 and applied to relevant exogenous factor in the model to estimate the change in demand resulting from changes in each factor. Resulting average growth rates from 2013 to 2033 is around 2.5% per annum.

Table 2: Exogenous Factors – Data Sources/ Assumptions

Exogenous Factor	Data Source/Assumption
GDP per capita	WebTAG Unit A 1.3
Employment	TEMPRO 6.2
Population	TEMPRO 6.2
Car Ownership	TEMPRO 6.2 car ownership projections
Rail Fares	Rail fares assumed to growth at RPI + 1%
Car Travel Times	Google Maps
Motoring Costs	WebTAG Unit A 1.3 Table A1.3.7 & Table A1.3.9
Bus Costs	assumed to grow at the same rate as rail fares
Bus Travel Times	assumed to change at the same rate as car travel times

Table 3: PDFH5.1 Elasticities

Exogenous Factor	Elasticity
GDP per capita	0.85 to 1.4
Employment	1.0 to 1.7
Population	1.0
Car Ownership	0.00 to 0.94
Rail Fares	-0.4 to -1.3
Car Travel Times	0.25 to 0.70
Motoring Costs	0.50
Bus fares and travel times	0.00 to 0.22

Endogenous Growth

Effects of the scheme related factors on demand forecasts include timetable related GJT and frequency improvements as well as non-timetable related service quality improvements. Treatment of both aspects in producing demand forecasts is described below.

Timetable Related Changes

The effect of timetable changes on demand for individual station to station pair is estimated using the PDFH mathematical framework set out below:

$$I_j = \left(\frac{GJT_{ds}}{GJT_{dm}}\right)^g$$

where: I_j is the index for the change in demand due to journey time related factors

g is the generalised journey time elasticity

GJT_{dm} are the Do minimum generalised journey time

GJT_{ds} are the Do something generalised journey time

GJT represents journey time, frequency of service and interchange and is defined as follows:

$$GJT = J + S + I$$

where: J is the total station-to-station journey time (including interchange time)

S is the service interval penalty

I is the sum of the interchange penalties for any interchanges required

The effects of timetable changes for existing stations/services have been modelled using MOIRA. Do minimum and Do something runs have been modelled using the timetables described in Appendix A of this report. MOIRA uses the mathematical framework described in section E.2.2.2.1 above and PDFH 4.1 elasticity values to estimate the change in demand.

In order to update the change in demand with the latest PDFH 5.1 elasticity values, all station to station pairs that experience a change in GJT has been identified and exported to the spreadsheet model. Do minimum demand, GJT_{dm} and GJT_{ds} for these pairs were also extracted from MOIRA runs. Do something demand was then estimated using the same PDFH mathematical framework and the PDFH 5.1 elasticity values.

It has been assumed that proportion of trips transferring from existing stations to new station will not change in electrification scenario compared to the without electrification scenario and therefore not considered for this analysis.

Do minimum and Do something journey times for station to sector pairs has been estimated manually from the proposed Do minimum and Do something timetables and converted to GJT using the standard PDFH interval and service penalties.

The effects of timetable changes on demand for new stations/services were then has been estimated using the same PDFH mathematical framework, the Do minimum demand and GJTs derived as above. Timetable related changes to existing services/stations and new stations/services have been combined together at the end.

Non-Timetable Related Changes

Along with the timetable changes, the electrification of the Bristol suburban railway network is expected to offer improved service quality and increased seating capacity with the deployment of electric rolling stock.

Electric trains are quieter than diesel trains and is expected to offer a slightly improved ride quality. The impact of improvement in the ride quality is assumed to lead to an increase in demand across the study area.

This assumption is supported by evidence from various electrification studies which have shown that electrification leads to increase in demand by offering a better quality experience for passengers, often referred to as the “sparks effect”.

However, the primary reason for applying rolling stock quality factors is that the investment electrification would provide the impetus for switching to more modern rolling stock or refurbishment of existing units to a high standard.

Three factors have been chosen to reflect the improvement in rolling stock brought about by electrification: the ride quality, the quality of the train interior/condition and the quality of passenger information provision. It is difficult to be specific about the improvements in rolling stock that would result and therefore these factors have been combined as a proxy for the overall improvement.

The rolling stock quality factors used to estimate the impact of rolling stock quality on demand is summarised in Table 4. These factors are applied to the ‘in-vehicle’ element of GJT to calculate an adjusted journey time through application of the formula below:

$$Adjusted\ GJT = IVT * (1 - VoT) + SFP$$

where: the $Adjusted\ GJT$ is the GJT adjusted for rolling stock quality

IVT is the amount of ‘in-vehicle’ time in minutes

VoT is the value of time multiplier

SFP is the service frequency penalty

Table 4: Incremental Value of Time Multipliers

	Level From	Level To	Commuting	Business/Leisure
Environment	Train in poor condition – with damaged fixtures and seating	Train in good condition – with slightly damaged areas	0.018	0.020
Environment	Extremely bumpy ride	Very smooth ride	0.033	0.037
Information	Audible announcements easily heard	Flat screen display showing relevant information	0.001	0.001
Total			0.052	0.058

Source: PDFH 5.1

The uplift in demand due to rolling stock improvements is calculated by applying the PDFH GJT elasicities to the adjusted generalised journey time through application of the formula below:

$$Uplift\ in\ Demand\ (\%) = \left(\frac{Adjusted\ GJT}{Unadjusted\ GJT}\right)^{E} - 1$$

where: E is the GJT elasticity parameter

Rolling stock quality factors have been applied only to journeys that begin and end within the Bristol suburban network on MetroWest services so that uplift in demand outside the study area are not included in overall scheme benefit estimates. The benefits of improved ride quality due to electrification are assumed to deliver benefits throughout the appraisal period.

Capacity Assessment

An indicative assessment of the level of crowding that might be expected on the MetroWest services has been undertaken to inform the rolling stock requirements & operational costing. Estimating benefits from crowding relief is complex process. Particularly for the new services and stations, crowding is difficult to model accurately because of the need to establish loads on individual trains. Therefore, crowding relief benefits have not been modelled at this stage.

The MOIRA model has been used to extract morning peak (07:00-10:00) train loading on arrival at Bristol Temple Meads for existing services. For new services peak loading has been estimated using the MOIRA loading data on the existing suburban MetroWest services. These load profiles have not been calibrated against any passenger counts and therefore individual trains loads may vary from the observed count data.

A maximum load factor for each diagram, for the Do minimum scenario has been estimated as a percentage of total capacity of 2-car Class 150. The total capacity of 2-car Class 150 is assumed as 204[1] (139 seating + 65 Standing) passengers.

The estimated maximum load factors for each diagram and selected forecast years are shown in the Figure 1 below. The rolling stock requirement based on this assessment is summarised in Table 5.

Figure 1: Maximum Load Factor Based on Total Capacity by Diagram (Phase 1+2 Diesel Do Minimum)

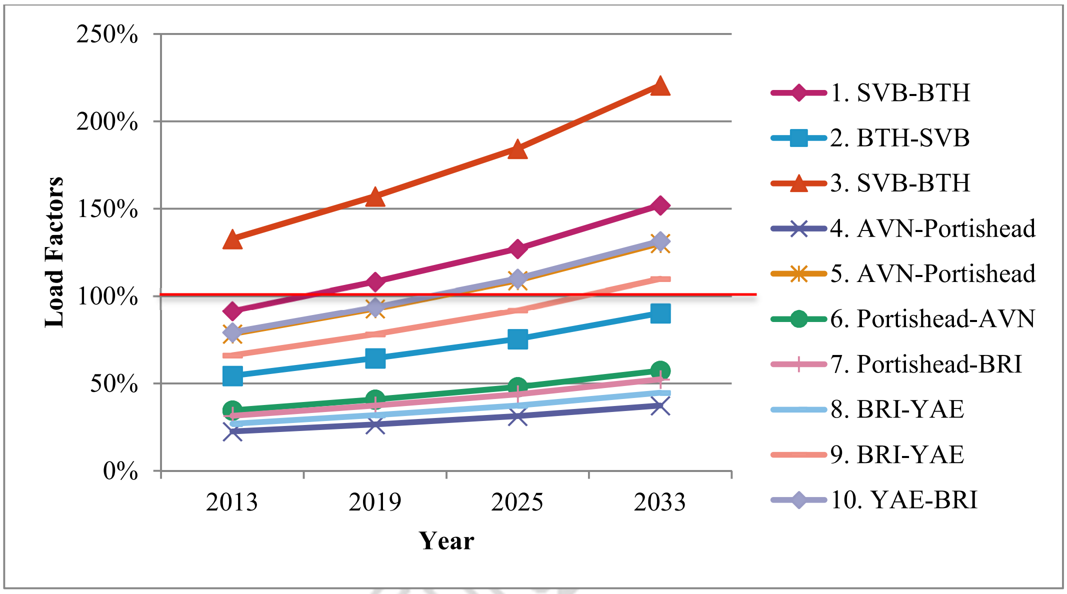


Table 5: Rolling Stock requirement Based on Total Capacity (Phase 1+2 Diesel Do minimum)

Diagram	2013	2019	2025	2033
1	2 Car	3 Car	3 Car	4 Car
2	2 Car	2 Car	2 Car	2 Car
3	3 Car	4 Car	4 Car	4 Car
4	2 Car	2 Car	2 Car	2 Car
5	2 Car	2 Car	3 Car	3 Car
6	2 Car	2 Car	2 Car	2 Car
7	2 Car	2 Car	2 Car	2 Car
8	2 Car	2 Car	2 Car	2 Car
9	2 Car	2 Car	2 Car	3 Car
10	2 Car	2 Car	3 Car	3 Car

[1] (PDFH v5.1 Table 6.6)

Demand & Revenue Forecasts

Net increase in demand and revenue resulting due to electrification of the Bristol suburban railway network is shown in Figure 2 and 3 below. The net increase in demand for Phase 1 is estimated to be around 44,000 in the year 2019. The increase in demand is associated with approximate revenue of £134,000. Phase 1 demand is estimated to grow by 48 % to 62,000 in the year 2033. Demand onwards 2033 is capped at 2013 levels in line with the WebTAG guidance.

The net increase in demand for Phase 1+2 is estimated to be around 110,000 in the year 2025. The increase in demand is associated with approximate revenue of £342,000. Phase 1+2 demand is estimated to grow by 21 % to 133,000 in the year 2033. Approximately, 35% of net increase in revenue is due to journey time savings and 65% is due to rolling stock quality improvements.

Figure 2 Net Increase in Demand (in thousands, 2013 levels)

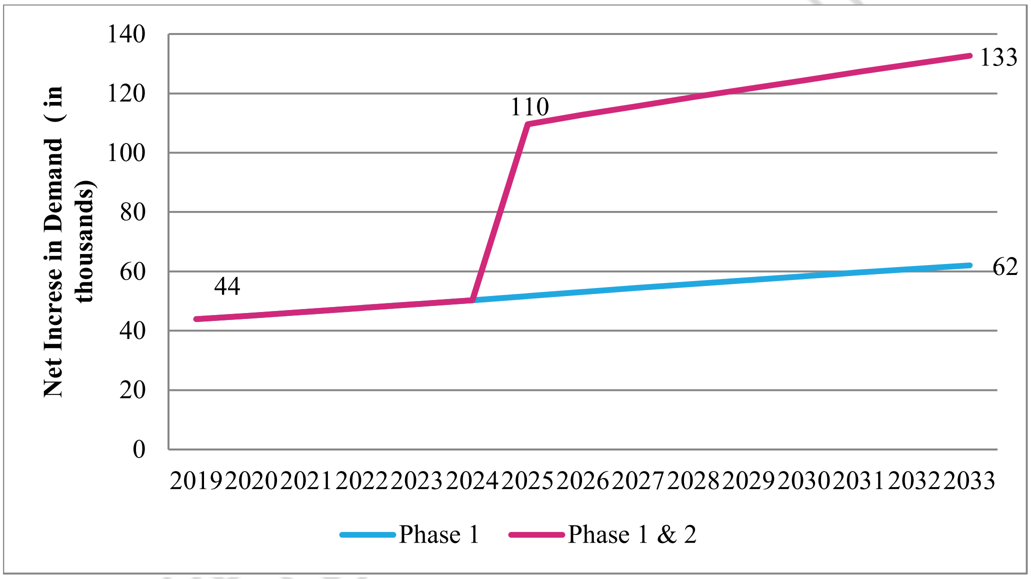
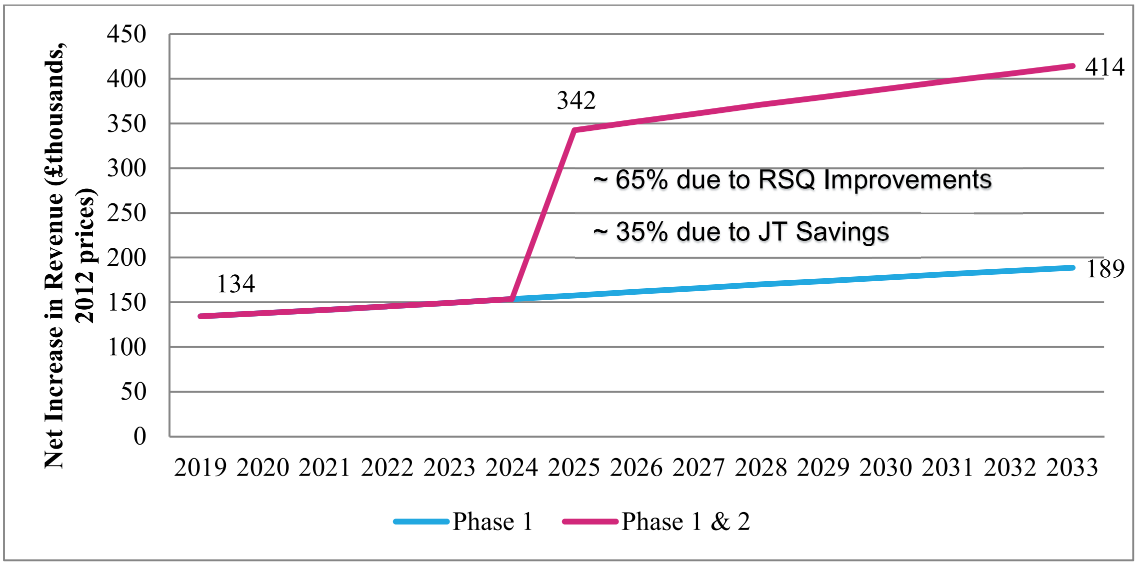


Figure 3 Net Increase in Revenue (£thousands, 2012 prices)



Economic Benefits

Economic benefits estimated relating to improved passenger services comprises:

- User benefits,
- Revenue benefits, and;
- Benefits of reduced car use.

Economic benefits are calculated by comparing the future year situation with the scheme (Do-Something scenario) against that without the scheme (Do-Minimum). Benefits of the scheme accrued over a 60 year period are estimated in monetary terms for the economic appraisal. In order to ensure consistency, all monetary values are discounted to a common price base to give 'present values'. The current price base year for economic assessments stipulated by the guidance is 2010.

Revenue and User Benefits

User benefits resulting from journey time savings and service frequency enhancements are made up of the following:

- Consumer user time savings,
- Business user time savings,
- Other user time savings, and;
- Rolling Stock Quality benefits.

A summary of the approach taken to quantifying Revenue and User Benefits is given in Table 6.

Table 6 - User Benefits Appraisal Parameters

Parameter	Approach	Source Data / Guidance
Demand forecast	Growth scenario – 2.5% per annum, growth capped at 2033	PDFH, TEMPRO
Journey Time Savings (existing passengers)	Application of MOIRA software, WebTAG values of time and value of time growth;	WebTAG unit A1-3
Journey Time Savings (new passengers)	As above employing the 'rule of half'	WebTAG unit A1-3
Rolling Stock Improvements	PDFH approach applied only to journeys that begin and end within the study area	PDFH

Benefits of Reduced Car Use

Mode switch from car to rail as a result of the electrification of the Bristol suburban railway network is likely to result in benefits from reduced congestion for existing road users and reductions in the externalities relating to car use such as accidents and emissions.

Benefits of reduced car use have been estimated using the Marginal External Cost (MEC) method provided in TAG Unit A5.4. The change in car kilometres due to mode switch is estimated using the diversion factor of -26% based on the National Transport Model (NTM). The characteristics of the car journeys removed is assumed to be urban or rural motorway journeys as the scheme covers urban and rural motorway roads of south west region of England. The proportions of traffic in each congestion level for these road type for the South West region has been taken from the TAG Data Book Table A5.4.1. Proportions of traffic are given for 2010 and five year intervals to 2035. Proportions for intermediate years have been estimated by linear interpolation.