Crossrail 2: Summary of Option Development

May 2013

Introduction

Transport for London (TfL) working with Network Rail are undertaking a public consultation on proposals for a new rail line to cross London, known as Crossrail 2. This new line, previously known as the Chelsea-Hackney line, would run on a south west to north east alignment. The response to the public consultation will help shape future work on the development of Crossrail 2. The purpose of this document is to provide stakeholders and the general public with information on the need for and background to the proposed new line and the development of possible future options.

Background to Crossrail 2

The concept of cross-London tunnelled rail services connecting mainline services first emerged in the 1944 Greater London Plan[1] with a focus on east-west services. It was six decades later, however, before a hybrid bill for an east-west Crossrail was placed before Parliament in 2005. Crossrail gained Royal Assent in 2008, construction commenced in 2009 and trains are due to begin operating in 2018.

In 1991 the route of the Chelsea-Hackney line (**Figure 1**), envisaged at that time as an Underground line, was safeguarded by directions issued by the Secretary of State for transport to protect the route from development. However, with the emphasis on east-west Crossrail, the Chelsea-Hackney route was not progressed until more recently. In 2008 the safeguarding for the Chelsea-Hackney line was refreshed. In 2009 the Department for Transport asked the Mayor of London to review the case with a view to re-examining the thinking behind the scheme, identifying new options and reviewing the safeguarding of the existing route.

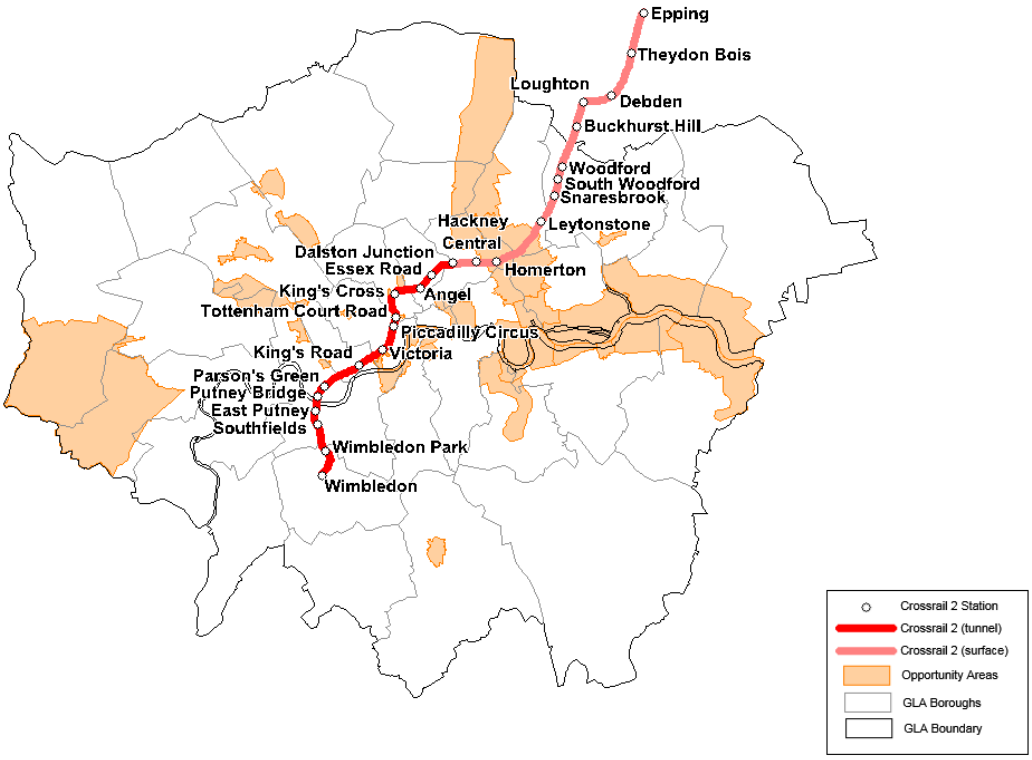

Figure 1: The safeguarded route

[1] Ministry of Works (1944) *The Greater London Plan*

A number of alternative alignments have been proposed for Crossrail 2 since the scheme was first safeguarded in 1991, notably in London Underground's 1995 consultation on the Chelsea-Hackney line and in the shadow Strategic Rail Authority's (sSRA's) 2000 East-West Study.

London's Growth and the Impact on the Rail Network

London's population continues to rise and, based on the forecasts used in the work undertaken to date, was expected to have grown by 14% from the 7.8 million forecast for 2011 to 8.9 million by 2031. That increase in population was expected to be accompanied by an increase of 14% in employment. In combination this was expected to lead to some 16% additional trips per day.

With the release of figures from the 2011 census, it became apparent that London's population had already reached 8.2 million in 2011 and is now expected to grow to between 9.7 and 10 million by 2031, a 9% to 12% increase on the forecasts used to date. TfL proposes to re-base and update the population and employment forecasts once the appropriate level of detail is available from the census. Those new forecasts will then be used as the case for Crossrail 2 is taken forward. For the purposes of this consultation the existing forecasts have been used, implying an underestimate of future levels of crowding and an understatement of the benefits attributable to Crossrail 2.

Overcrowding on the Underground network is evident today. This overcrowding will be significantly relieved by the rail and Underground upgrades, including Crossrail, which are already committed to be constructed by 2021. This is shown in **Table 1**. Despite this investment, the forecast growth in demand by 2031 (without Crossrail 2) is such that significant overcrowding will be evident once again, as illustrated in **Figure 2**.

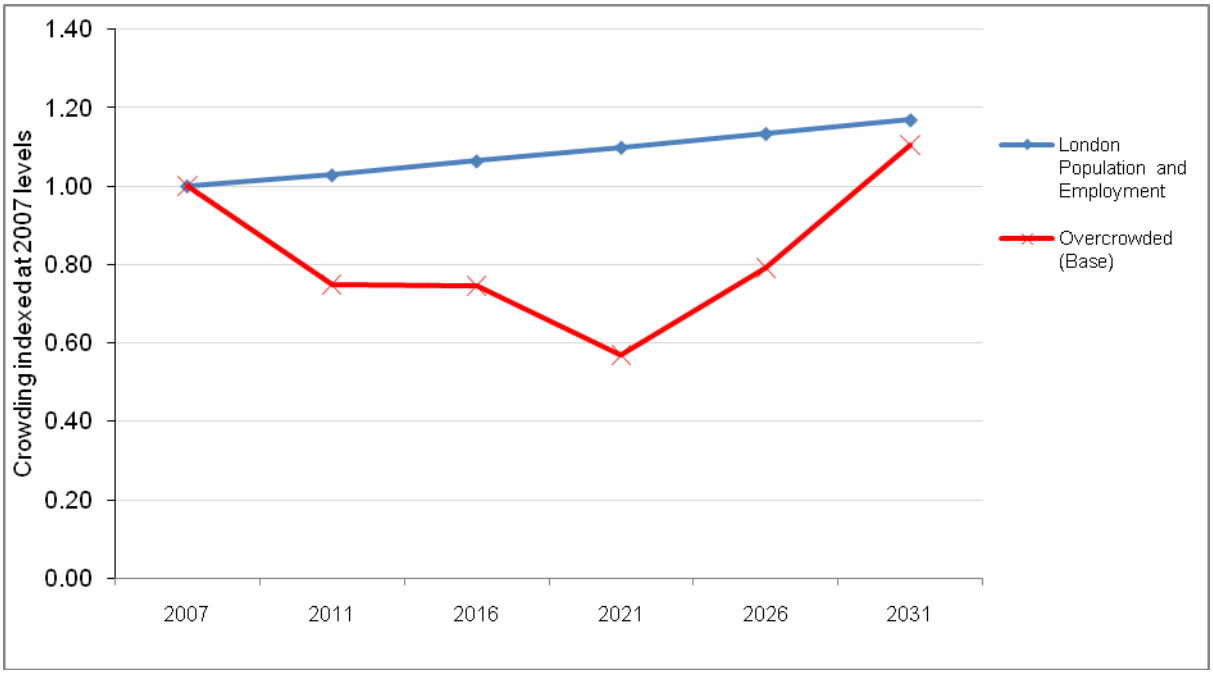

Figure 2: Crowding levels 2007 – 2031, indexed to 2007. (Proportion of passenger kilometres on rail based public transport in London in very crowded conditions between 7am and 10am)

This overcrowding is particularly evident on the Victoria, Northern and Piccadilly lines but also will be significant on suburban rail services, adding to congestion at London rail termini. Furthermore, by 2026, the first phase of the new high speed line (HS2) is expected to be in operation to the West Midlands, delivering significant numbers of additional passengers to

Euston station, where the Underground station is already at capacity. The second phase of HS2, due to complete in 2033, would add further demand for dispersal at Euston.

If London is to continue to grow and avoid its rail and underground networks becoming seriously congested, there is a need for further investment beyond that already committed. It is believed that the additional capacity offered by Crossrail 2 could contribute to the relief of all of the above overcrowding issues.

Table 1: Committed improvements to the Underground network

Line	Improvements	Completion Dates
Victoria	New trains and signalling – 33 trains per hour (tph) service – 21% capacity increase World Class Capacity - 36tph service	2013 2017/18
Metropolitan	New trains and signalling – 27% capacity increase	2018
Circle / H&C	New trains and signalling – 65% capacity increase	2018
District	New trains and signalling – 24% capacity increase	2018
Northern	NLU1: Signalling upgrade with increased frequency – 24tph service – 20% capacity increase NLU2: Partial separation of the Charing Cross and Bank branches – up to 33tph service – additional 30% capacity increase	2014 2021/22
Jubilee	World Class Capacity 36tph service	2018/19
Post 2022		
Piccadilly	New trains and signalling	2030s
Bakerloo	New trains and signalling	2030s
Central	New trains and signalling	2030s

TfL has produced forecasts of trips for 2021 and 2031 that indicate the levels of growth from 2007 levels. These are shown in **Table 2**.

Table 2: Growth forecasts

Growth from 2007 Base	to 2021	to 2031
Daily trips (with one end at home) within London	10%	17%
Daily public transport trips within London	17%	30%
Rail passenger kilometres	14%	32%
Underground passenger kilometres	18%	22%

[i] the percentage of motorised trips undertaken by public transport

Despite the growth in trips, crowding levels on both rail and Underground services are forecast to reduce from the 2007 base to 2021 and then to increase to 2031, as was shown in **Figure 2**. This reflects the impact of the additional committed schemes in the rail and Underground networks through to 2021 and the lower level of commitments beyond 2021.

Key Aims and Objectives for Crossrail 2

For any scheme that has been developed over a number of decades, it would be expected that there would have been shifts in policy direction. National and regional policy has, however, remained consistently supportive of rail improvements as a means of delivering sustainable transport. In particular, the Mayor's Transport Strategy[2] (MTS) supports new rail

[2] Greater London Authority (2010) *Mayor's Transport Strategy*

capacity in a broad southwest to northeast corridor for example, new lines or services using the Chelsea Hackney Line (Crossrail 2) safeguarded alignment. Network Rail[3] has also stressed the important role that Crossrail 2 could play in relieving congestion on suburban rail services into Waterloo and Liverpool Street.

The MTS sets out six thematic goals, which link to the six themes of the London Plan[4], that is:

- supporting economic development and population growth;
- enhancing the quality of life for all Londoners;
- improving the safety and security of all Londoners;
- improving transport opportunities for all Londoners;
- reducing transport's contribution to climate change, and improving its resilience; and
- supporting delivery of the London 2012 Olympic and Paralympic Games and its legacy.

Whilst the level of crowding on the network is a fundamental issue for London's development and economy and tackling this is therefore a key objective for Crossrail 2, the other MTS goals provide wider objectives for the scheme. For example, providing the connectivity to underserved locations, such as in the Lea Valley, Chelsea or Hackney, improves transport opportunities for all Londoners and enables regeneration. Relieving crowded lines, such as the Victoria line or the South West Main Line, enhances the quality of life and safety of passengers as well as providing a more reliable service. The current set of objectives for the appraisal of Crossrail 2 has therefore been mapped from the objectives and challenges of the MTS, and is as follows:

- ***"Alleviate crowding****: Crossrail 2 should alleviate crowding on the London transport network, especially on the London Underground Victoria, Piccadilly and Northern lines, and national rail, thereby improving transport capacity and supporting London's growth and economic prosperity.*
- ***Improve termini dispersal****: Crossrail 2 should assist in the effective dispersal of passengers arriving at the main national rail termini in central London.*
- ***Improve connectivity****: Crossrail 2 is needed to improve connectivity in particular parts of London where access to the Underground and rail network is limited.*
- ***Support economic growth and regeneration****: Crossrail 2 must support local Opportunity Areas and Intensification Areas, as well as helping to improve access to employment for communities in London which suffer high levels of deprivation.*
- ***Ensure value for money****: any investment in a new line across London must demonstrate that it represents maximum value for money and that it also supports London's economy through wider impacts.*
- ***Improve transport quality:*** *Crossrail 2 would be expected to improve transport quality, through providing new direct less crowded journeys, with consequential reductions in overall journey times (especially where changes of trains or modes are no longer required).*
- ***Reduce CO_2 emissions****: Crossrail 2 would need to reduce CO_2 emissions through encouraging mode shift to more sustainable modes for some journeys."*

Development and Assessment of Possible Route Options

In 2008, the safeguarding for the Chelsea Hackney Line was refreshed. This work, overseen by the Department for Transport, did not review alternative alignment options, but did include a statutory consultation on the safeguarding with local planning authorities. The resulting changes to the safeguarding were very minor in nature.

[3] Network Rail (July 2011) *London and South East Route Utilisation Strategy*
[4] Greater London Authority (2011) *The London Plan*

In 2009, the Secretary of State for Transport requested that the Mayor of London review the Chelsea Hackney Line safeguarded alignment, in order to see if changes needed to be made and TfL has subsequently undertaken this review.

As part of the development of the Mayor's Transport Strategy in 2009, TfL considered the need for a Crossrail 2 scheme and its broad alignment. Initial tests showed that a new rail line was still needed in a broad north east to south west corridor across London, in order to relieve congestion and promote connectivity to support development and regeneration. The need to serve Euston also became important, in order to help address additional demand for onward travel that any HS2 line terminating at Euston would create.

A long list of route options were assessed, including shorter metro options in central London, longer metro options reaching inner London and Crossrail-type options serving centres such as Croydon, Sutton and Kingston in the south and Stratford, Wood Green, Barking and Enfield in the north and east. Alternative central London alignments were also included such as a route via the City of London. This led to development of a shorter list that was assessed in more detail, including the existing safeguarded alignment from Wimbledon to Epping. These options were assessed against the Crossrail 2 specific objectives, as set out above. This led to a further short listing, which involved optimisation of the best performing elements of previous route options, resulting in the two options now being considered.

The assessment process highlighted that for Crossrail 2 to be fully effective, it needs to serve Clapham Junction to help resolve capacity challenges on the National Rail network, as well as on London Underground lines. Some of the previous options discounted included route alignments serving the City of London, as they were unable to also serve HS2 at Euston, routes to the east as they were less able to provide relief to the Victoria and Piccadilly lines, and routes to Croydon, rejected as the benefits appear greatest in serving South West London and Surrey.

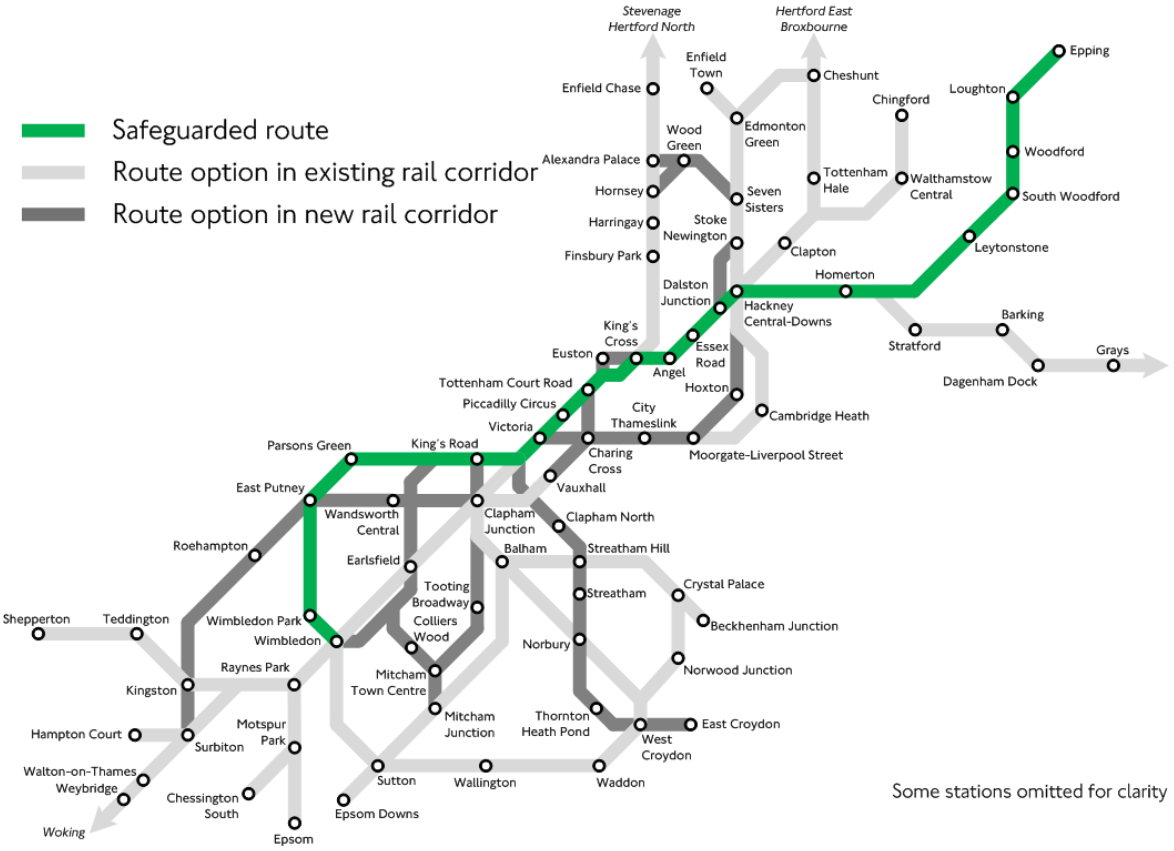

Figure 3 – longer list of route options

In 2010 and 2011, forecasts were produced in more detail for around 10 best-performing options, including analysis of the crowding reductions that could be expected from each option and a high-level estimate of the benefit-cost ratios (BCRs). In order to reduce the options list further, the best performing elements (assessed against the aims and objectives discussed earlier) of each option were optimised and combined to develop a shortlist of two or three options. These options are described below:

- **Metro Option** connecting south-west London to north and/or east London via the central core using the 'West-End' alignment;
- **Regional Option** potentially connecting the South West Main Line (SWML) inner suburban network and the West Anglia Main Line (WAML) inner suburban network; and
- **the safeguarded route**.

The Three Identified Options

The **safeguarded route** that was protected in 1991 and 2008 had proposed to take over part of the Central line. This would have entailed converting the Epping branch north of Leyton to Crossrail 2 operation, with all trains south-west of Leyton taking a different alignment and no longer offering a direct service to the City of London. The Central line would still have served the route to Leyton and the Hainault Loop via Newbury Park, where Crossrail 2 would have branched off the existing Central line, and would thereby have doubled the capacity between Leyton and central London. It was also proposed that the route safeguarded in 1991 and 2008 would take over the District line from Parsons Green to Wimbledon. This does relieve some crowding on this stretch of the line but does not address the more significant crowding challenges on National Rail lines from Wimbledon or the Northern line from Tooting.

In north-east London, the Victoria and Piccadilly line corridor has since emerged as the greatest capacity gap in London's rail network, worsened by long term growth in the Upper Lea Valley, which without a solution like Crossrail 2, would lead to far worse crowding levels than experienced today on these two lines. The safeguarded route does not serve this highly congested corridor or the new High Speed 2 terminal at Euston.

The removal of the safeguarded route would mean that the direct link between the Epping branch of the Central line and the City will no longer be lost. The Central line operates a high frequency 30tph peak period service, with 33tph services from the east during the peak hour. The Central line has long suffered from crowding. The opening of Crossrail should provide some relief to the line although crowding is forecast to continue. To help address this, there are future plans to upgrade the Central line before the completion of Crossrail 2 (forecast for around 2030), which will help to relieve the crowding. Those plans are in development as part of the work on a New Tube for London.

The safeguarded route would have required all trains on the District line Wimbledon branch to run into the Crossrail 2 tunnel at Parsons Green, which would have severed the direct link between the Wimbledon branch and the City, as well as to Edgware Road via Kensington High Street and Paddington. The removal of the safeguarded route allows those connections to be retained. Furthermore, residents of Wimbledon and other nearby stations a short journey away will benefit from a new range of direct destinations served and improvements to National Rail services.

The safeguarded route has therefore been retained as a comparator, but, as it did not meet the objectives for Crossrail 2 to the same extent as the other options, due to its inability to adequately relieve the Victoria, Piccadilly and Northern lines and National Rail, it has not been the subject of further detailed analysis and assessment.

Metro Option

The **Metro Option**, a stand-alone Underground line, could deliver valuable crowding and congestion relief to the Victoria line, whilst helping relieve Waterloo, Victoria and to a lesser extent, Liverpool Street National Rail termini.

This London-focused metro scheme, from Wimbledon to Alexandra Palace, would provide a high capacity Underground railway with a frequency of up to 40 trains per hour and a peak capacity of up to 38,500 passengers per hour per direction. The station platforms only need to be 120 m long as the trains are shorter than for the Regional Option, with a tunnel diameter of 5.5 m, the same as for the DLR. However, this means that any subsequent extension would require its own right of way rather than joining the National Rail network.

The Metro Option (**Figure 4**) shares most of its core route with the 2008 safeguarded alignment, but is extended at its northern and southern ends, serving Alexandra Palace and Seven Sisters in the north and Clapham Junction and Wimbledon in the south to provide interchange with national rail services. Such changes to the safeguarding deliver valuable crowding and congestion relief to the Victoria line, whilst helping relieve Waterloo, Victoria and to a lesser extent, Liverpool Street. There are also some differences in intermediate stations served, notably with Euston added to help dispersal of passengers from HS2 and interchange with the Northern and Victoria lines.

The route was initially developed between Clapham Junction and Alexandra Palace, but the additional benefits of serving Tooting Broadway and Wimbledon were recognised and the route was extended southwards. In particular this provides crowding relief to the Northern line in south London.

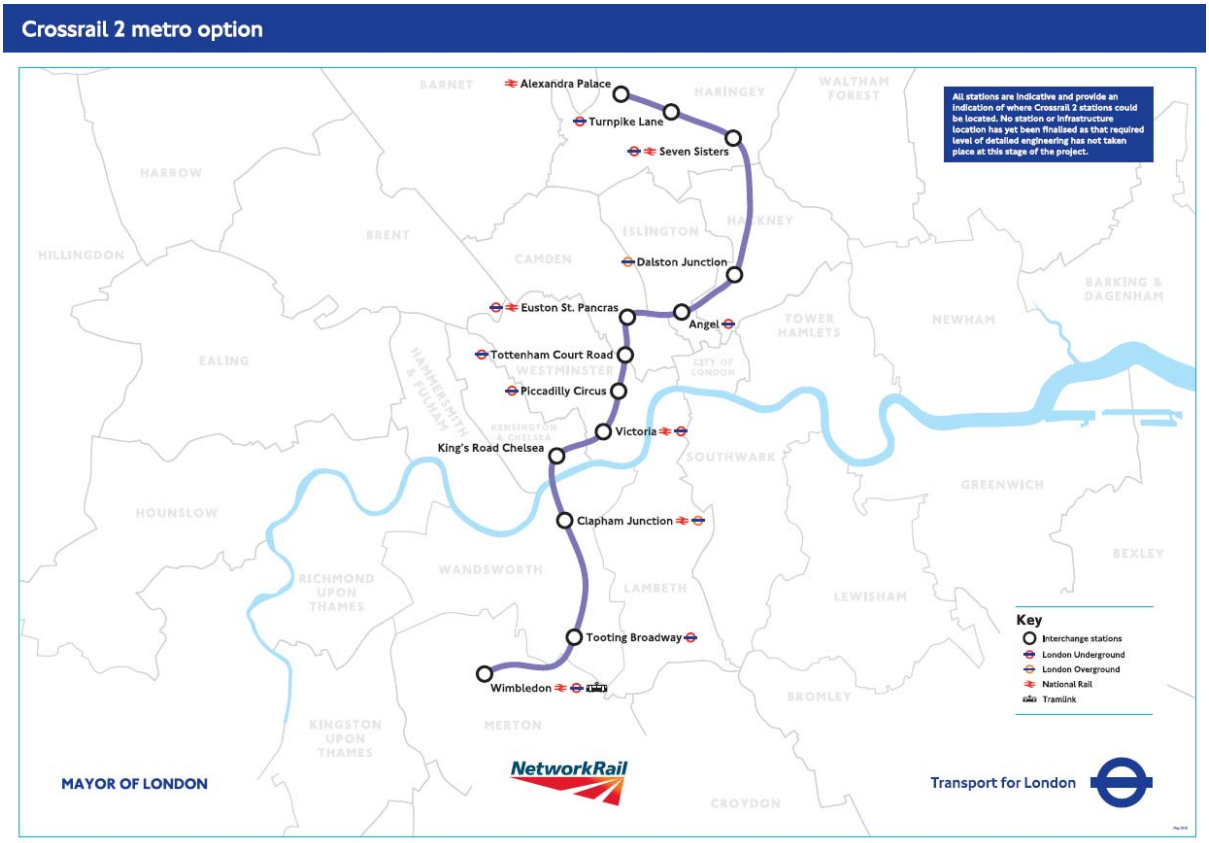

Figure 4: The Metro Option route

Regional Option

The **Regional Option** could provide a greater choice of central London destinations for suburban passengers in the South West and North East and remove some inner suburban trains from Waterloo and Liverpool Street by running them through a Crossrail 2 tunnel beneath central London. This could in turn, depending on a number of factors and allied with other works, release some capacity for additional services to be provided on National Rail routes into these termini.

The Regional Option would be similar in operation to Crossrail. The system is more extensive geographically than the Metro Option and in the length and capacity of the trains that would be used. The alignment of the central section would be similar, but would be extended at both the northern and southern ends of the route onto the suburban rail lines. The route could be built in stages and eventually serve the area shown in **Figure 5**.

The number of trains on the central section in the peak hours would be up to 30 trains per hour. As the trains would be 10 cars initially, this would give the system the capacity to move up to 45,000 passengers an hour in each direction in the peak hours. There is the possibility of moving to 12 car trains later if required to meet the demand , and to accommodate these train lengths the station platforms would be 250 m long (as opposed to the 200 m identified for the original shortlisted option).

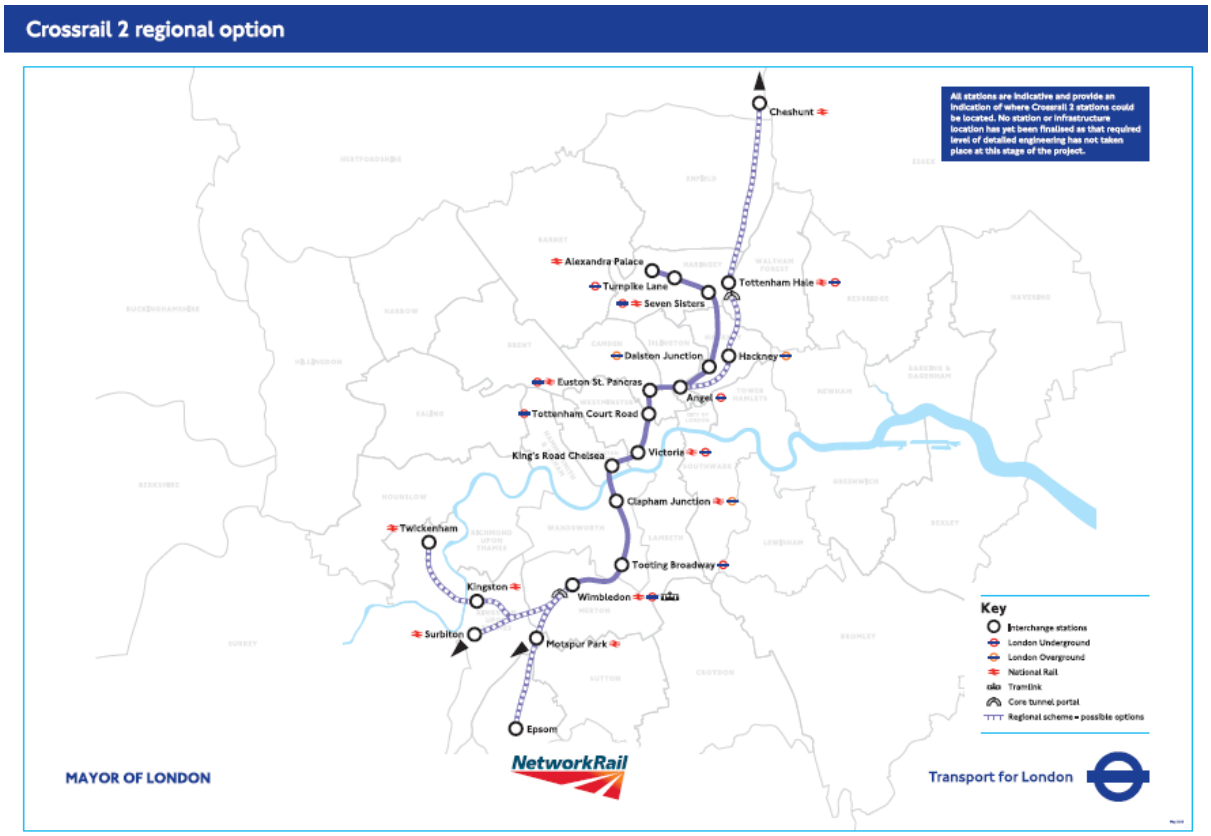

Figure 5: Regional Option route

The southern end of the route could potentially connect the existing SWML slow lines to a new underground station at Wimbledon. The twin bore tunnels would then proceed on a new alignment through stations at Tooting Broadway, Clapham Junction, Kings Road Chelsea, Victoria, and Tottenham Court Road. At Tottenham Court Road there would be a passenger interchange with the Crossrail line.

Instead of two stations at Euston and Kings Cross there would be one station in the area of Euston Road serving Euston, St Pancras and Kings Cross. The tunnel route would then continue to a station at Angel before splitting to two branch lines.

The eastern branch would continue in tunnels to a station at Hackney Central and then surface to the south of Tottenham Hale close to Coppermill Junction. The branch could then join the WAML at a grade separated junction. The WAML may have been partially 4 tracked before Crossrail 2 is completed and the Crossrail 2 lines on leaving the portals would join the slow (suburban) lines to enable the trains to potentially serve destinations such as Angel Road, Cheshunt, Broxbourne and Hertford East. Serving this branch would boost the case for regeneration in the Upper Lea Valley and raise the levels of potential development. The Regional Option would improve links to Stansted by providing additional capacity at Tottenham Hale, but it could also be reconfigured to serve Stansted airport if additional aviation capacity were provided there. This may be in the form of a stopping service or by providing more capacity at Liverpool Street for faster services enabled by the additional tracks on the WAML.

The western branch would continue in tunnels from the junction north of Angel and then on through Dalston Junction to Seven Sisters and Turnpike Lane before terminating at Alexandra Palace. A high-frequency on this branch with its interchanges with Victoria and Piccadilly lines would relieve congestion into the King's Cross and Euston areas.

In the South West trains would continue beyond Wimbledon on existing routes (although additional infrastructure will be needed at some locations) to destinations such as Epsom, Surbiton, Kingston, and Twickenham and further options may be considered.

The removal of some of the inner suburban services that currently run from these locations into Waterloo to run directly under central London instead, would, depending on a number of factors and allied with other works, release some capacity into Waterloo for other National Rail services. Network Rail has already identified the SWML as likely to be one of the most congested routes in the South East of England. The benefits to the Northern and Victoria lines identified for the Metro Option for Euston and the HS2 terminal are also applicable to the Regional Option.

There would be a reduction in passengers who would otherwise interchange between the National Rail network and the Underground network at Waterloo, Victoria and London Bridge (since they would now be able to access central London directly from the Crossrail 2 routes.

The Regional Option would use two single bore tunnels, similar to Crossrail, and would be built to accommodate national rail standards with a tunnel diameter of 6.4 m (as opposed to the 6.2 m tunnels proposed for the original shortlisted option).

Summary of Benefits and Costs for the Metro and Regional Options

High-level engineering solutions were developed for the Metro and Regional options. Cost estimates were based on data held by the engineering consultants with rates and prices derived from similar large infrastructure projects, including Crossrail. The costings reflect the level of design information available at the time of the estimate. Cost estimates relating to the National Rail network are at a very early stage of development.

The cost estimates are shown in **Table 3** (£bn with a first quarter 2012 price base). The DfT requires that an element of optimism bias is added to the costs in the appraisal of all transport schemes, reflecting the likelihood that cost estimates will increase during the development of projects. At this stage of design, an additional 66% is recommended.

In all cases it should be noted these costs represent very early stage estimates and are liable to change.

Table 3: Cost Estimates (£bn)

	Metro Option	Regional Option
Cost estimate	9.4	12.0
Cost estimate with Optimism Bias	15.7	19.7

Both the Metro and Regional options would provide significant travel time savings and reductions in crowding for passengers, with consequent improvements in accessibility to jobs, particularly from northeast and southwest London. The wider area served by the Regional Option results in some 60% additional journey time savings over the Metro Option.

Transport benefits for both options have been estimated following computer modelling and forecasting. These benefits come from shorter journey times, new trips and journeys being less crowded. Standard appraisal techniques were then applied to compare the costs and benefits. This is expressed as the ratio of the total social benefits to the net financial effect, known as the benefit to cost ratio (BCR). The BCR for the Metro Option is 1.2:1 and 1.8:1 for the Regional Option.

In addition to these ‘standard’ benefits, transport schemes also generate wider benefits by stimulating the economy to be more productive. There is a range of these wider benefits but

they can be very substantial, particularly when a scheme serves central London. Including these wider benefits could raise the BCRs to 3.5:1 for the Metro Option and 4.1:1 for the Regional scheme, depending on the assumptions that are used.

Figure 2 showed that significant overcrowding is forecast on rail based public transport by 2031. **Figure 6** shows that both the Metro and Regional options will have a noticeable impact on reducing severe crowding, with the regional option performing better than the Metro Option.

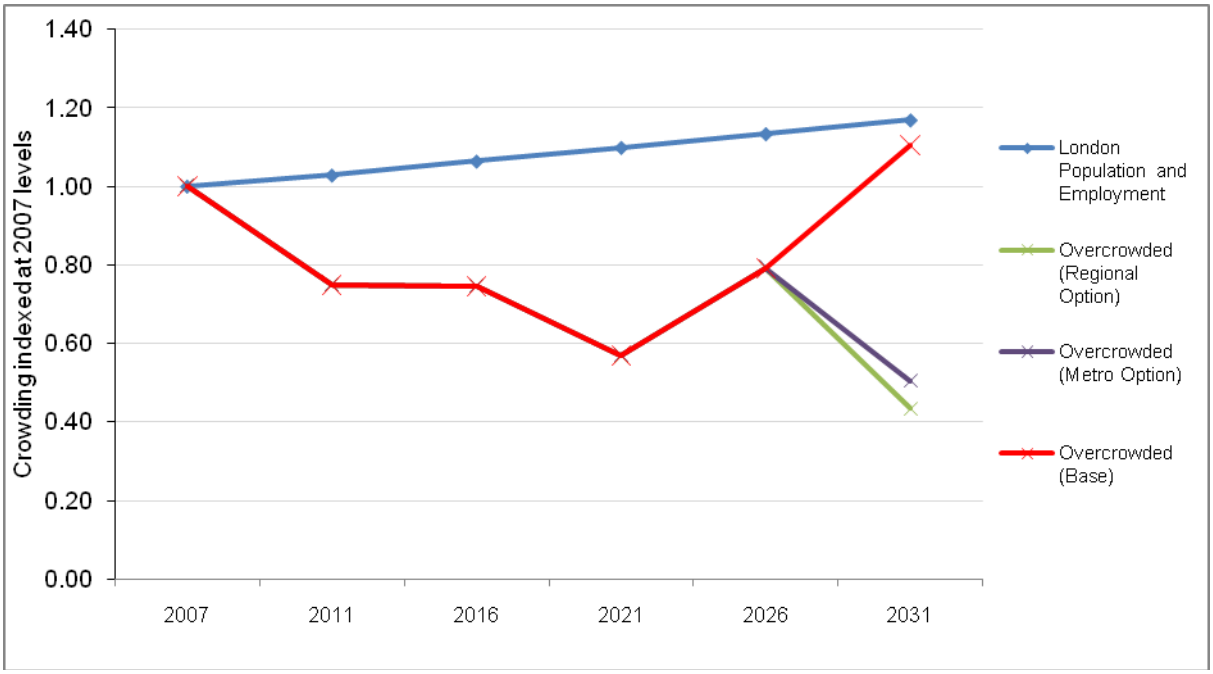

Figure 6: Crowding levels 2007 – 2031, indexed to 2007. (Proportion of passenger kilometres on rail based public transport in London in very crowded conditions between 7am and 10am)

In addition to the direct impacts of the Options on crowding relief, the increased accessibility would give rise to wider impacts such as increased productivity benefits for London's economy, through the efficiencies of firms being located in proximity to each other. The economy would also gain from the increased ease of movement to more productive jobs that would arise from reduced travel times. Again, the more widespread effects of the Regional Option would result in higher levels of these wider impacts than for the Metro Option.

Table 4 summarises the operational characteristics of the options taken forward for costing. These assumptions may change as the scheme is developed.

Table 4: Operating characteristics assumed for Metro and Regional Options

Criterion	Metro Option	Regional Option
peak passenger capacity (per direction)	Up to 38,500	Up to 45,000
cars per train	4	10
station length (m)	120	250
tunnel diameter (internal) (m)	5.5	6.4
minimum curvature (m)	50	300
maximum gradient (%)	6	3
train type	DLR type	Crossrail Class 345

Glossary

Crossrail	the east west rail line across London currently under construction
Crossrail 2	formerly known as the Chelsea-Hackney line
DfT	Department for Transport
DLR	Docklands Light Railway
GLA	Greater London Authority
MTS	Mayor's Transport Strategy
SWML	South West Main Line
TfL	Transport for London
tph	trains per hour
WAML	West Anglia Main Line