Trans-Pennine Tunnel Study

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1 Executive summary

1.1 Context

1.1.1 In December 2014 the Department for Transport (DfT) published its *Road Investment Strategy: Investment Plan*,[1] which confirmed that it would be exploring the feasibility of a major new road link under the Pennines between Sheffield and Manchester.

"Following the Trans-Pennine Routes Feasibility Study there is a need for further examination of the case for Manchester and Sheffield to be connected by a high-performance link. We are keen to explore the costs and feasibility of this potentially transformational improvement.

"Such a connection could have a dramatic impact on the economy of the North, particularly in combination with plans for high speed rail links. It would be capable of fundamentally changing the nature of the journey between two of the most important cities of the North. But the invaluable landscapes and ecological significance of the Peak District National Park (PDNP) rule out a surface link. The only credible solution may be to construct a tunnel under the central part of the Pennines. This carries with it the potential to bring important environmental improvements to the PDNP.

Such a project would be the most ambitious road scheme since the construction of the first motorways fifty years ago. The engineering and delivery of such a tunnel would be a national first. The proposal therefore needs to be studied in detail to confirm its viability, and we want to begin a national debate.

Working in conjunction with Transport for the North, this study will examine the strategic options for the tunnel, to understand the viability, costs and deliverability of such a connection, and determine its role and priority within the emerging transport strategy for the North."

1.1.2 In July 2015, the DfT and Transport for the North (TfN) jointly commissioned Highways England to assess the feasibility of a new strategic highway route connecting Manchester and Sheffield across the Pennines.

1.1.3 The Government and TfN[2] believe that an improved transport corridor between Manchester and Sheffield could improve the economic prosperity of both cities and the wider Northern Powerhouse region.

1.1.4 In March 2016 TfN, alongside DfT, published its *Northern Transport Strategy Spring 2016 Report*[3] which reaffirmed the Government's commitment to improving transport links between major cities in the North, putting this at the heart of its plans to build a Northern Powerhouse. It identified the priorities for future investment in the North's strategic road network and indicated the Trans-Pennine Tunnel as one of the key strategic link/priorities.

1.1.5 Also in March 2016 the recently formed National Infrastructure Commission published its report outlining strategic advice on regional connectivity challenges in the North.[4] In this report they presented the 'Pennine challenge' highlighting the lack of capacity for east-west connections, particularly between some major cities, and indicated that the vast majority of potential travel is not happening. They also reported that in addition to improving connectivity to these two city regions the proposed strategic link

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[1] DfT. *Road investment strategy: Investment plan and statement of funds available,* December 2014

[2] TfN. *The Northern Powerhouse: One agenda, One economy, One North – A report on the Northern Transport Strategy*, March 2015

[3] *TfN and DfT, Northern Transport Strategy Spring Report, March 2016*

[4] *National Infrastructure Commission, High Speed North, March 2016*

will also provide an additional strategic route across the Pennines, including a new route for freight traffic.

1.1.6 In the budget announcement on 16 March 2016 the Chancellor announced that, from the £300m identified in the Transport Development Fund, £75m will go towards accelerating the three northern strategic studies. It is anticipated that the added £75m will secure the path towards construction, should the studies outcomes determine these are viable schemes.

1.1.7 In this strategic study (the *Trans-Pennine Tunnel Study),* we are investigating the viability of constructing and operating a new link between Manchester and Sheffield and exploring the strategic and economic case for the scheme.

1.1.8 We continue to consider a strategic highways link with above-ground connections to the existing Strategic Road Network (SRN) between Manchester and Sheffield, and a significant length of road tunnel where the route passes through the PDNP.

1.2 Updated Interim Report

1.2.1 This strategic study will present its findings in the autumn of 2016. This revised version of the November 2015 Interim Report provides an updated response to DfT and TfN on the following issues:

- The strategic case for a scheme, involving an assessment of scheme objectives against national, regional and local policies and the wider case for change in the North of England
- The economic case for a scheme, using the principles described in the Government's *Transport Analysis Guidance* (TAG)
- The environmental impact of the scheme

This report also presents the DfT and TfN with new work and analysis. This includes developing a long list of route corridors and a short list of route options, between Manchester and Sheffield, which can be taken forward into the next stage of the study.

The following issues, considered in the first Interim report, will be explored again in more detail in the final stage of the study:

- The feasibility of designing and constructing a new strategic route between Manchester and Sheffield, recognising the particular issues associated with the construction of very long sections of tunnel
- The feasibility of operating and maintaining this new strategic route, focusing on the particular challenges (including driver behaviour and incident management) associated with long lengths of tunnel
- The potential synergies that could result from combining a road corridor with a heavy-rail or light-rail service following a similar route

1.2.2 Some initial analysis, using a high level strategic model, has provided an indication that there could be significant benefits associated with travel time savings. The analysis presented in this updated report is purely to determine whether there is a case to do more intensive work on investigating and shortlisting route options. Based on the work carried out so far there is a good case for further work but more modelling will need to be done before we are in a position to reach a conclusion about the full case for investment in a tunnel.

1.2.3 Given the large study area an incremental approach to identifying, assessing and sifting corridors and route options was proposed, as this was deemed the most efficient approach to developing a shortlist. Undertaking a sifting exercise on a large number of options within a large geographical area is a resource intensive exercise, therefore, it was agreed that a proportionate approach would be undertaken. Using the study area boundary agreed in the first stage of the study, we, in collaboration with stakeholders, adopted a corridor approach identifying five corridors with the aim of reducing this down to one or two. From this analysis the aim then, was to develop three to four options within the better performing corridors.

1.3 Preliminary findings

1.3.1 In the Interim Report published in November 2015 we explored the feasibility of a new strategic highway route connecting Manchester and Sheffield and found that:

- Against the background of the Government's ambition to establish the Northern Powerhouse economy there is a clear strategic case for the scheme, which is aligned with central and sub-national Government policy and which reflects the transportation, socio-economic and environmental objectives of the scheme.
- The economic benefits of the scheme could include direct user benefits resulting from time savings and the improved resilience of the route compared to existing roads across the Pennines together with wider and more significant benefits in productivity, labour markets, land use and investment in the region.
- The scale of the wider economic benefits has yet to be established but initial analysis shows that these could be significant and complementary to other elements of the developing Northern Powerhouse strategy. As we identify potential route options the scale of economic benefits will be quantified and compared with the costs which will also be very large.
- The construction of a new strategic route between Manchester and Sheffield is technically feasible, recognising that the extensive tunneling required through the National Park and the provision of suitable connections to the SRN presents some significant technical challenges.
- The operation and maintenance of this new road link – which includes extensive tunnel sections – would also be feasible.
- The development of a combined road and rail corridor through the tunnelled section could offer some additional benefits, although road and rail would need to occupy separate tunnel bores and we have not yet established the operational case for this type of solution.

In this update we find that:

- There remains a clear strategic case for the scheme because it is aligned with central and sub-national Government policy, and because it provides additional capacity, brings two major centres closer together and contributes to the aspirations of the northern regions to maximise economic benefits through the creation of a single economic centre.
- A trans-Pennine link, as expected, will have greatest impact on connectivity for Greater Manchester and South Yorkshire but other areas could experience significant improvements (for example, Merseyside and East Midlands).
- Further analysis of transport user benefits and wider user benefits indicates that potentially these could be significant given the transformative nature of this scheme although we will need to carry out further modelling of the scheme to fully determine magnitude.

- The analysis that has been undertaken indicates route corridors in the north of the study area, especially those closest to the existing trans-Pennine trunk road, perform best.
- Five route options are worthy of prioritisation for further analysis within the next stage of the study.

1.4 Strategic case

1.4.1 The North continues to lag behind the South in terms of its economic performance. Employment rates[5] and productivity levels[6] are both lower in the North than they are in the South, with the gap in productivity widening over time. The Northern Transport Strategy report (*The Northern Powerhouse: One agenda, One economy, One North*[7]) recognises that the North of England has a number of medium-sized cities that perform well individually, but lack the transport connectivity needed to drive improved output and employment. This is essential to creating a single and well-connected economy in the North, which is a key objective of the Northern Powerhouse.

1.4.2 The *National Policy Statement for National Networks*[8] sets out a vision for national networks that is based on:

- creating the capacity, connectivity and resilience needed to support economic activity and to facilitate growth in employment
- improving journey quality, reliability and safety
- delivering strategic economic goals
- joining up communities

1.4.3 The DfT and TfN have both identified a new major road link under the Pennines between Manchester and Sheffield in their strategic plans.[9] The northern city regions' *One North*[10] report by the City Regions of Leeds, Liverpool, Manchester, Newcastle and Sheffield presents a strategic proposition for transport in the North that aims to transform connectivity for economic growth through agglomeration of markets, improving access to skilled labour and stimulating business investment.

1.4.4 The case for action set out in the highways plan of the *One North* report, recognises that the number, capacity and reliability of east-west road connections is a constraint on the economy and acknowledges that there are areas of severe congestion on the existing network, together with a high level of demand for freight from northern ports.[11]

1.4.5 In the *One North* report, TfN cite the routes across the Pennines between Manchester and Sheffield as one of the main gaps in connectivity in the North of England. Existing roads have low average speeds and a poor record of collisions; they cross the PDNP;

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[5] ONS. *Nomis: Official labour market statistics*, 2015

[6] ONS. *Sub-regional productivity tables*, August 2015

[7] TfN. *The Northern Powerhouse: One agenda, One economy, One North, A report on the Northern Transport Strategy*, March 2015

[8] DfT. *National policy statement for national networks*, December 2014

[9] DfT. *Road investment strategy: overview,* December 2014 and TfN. *The Northern Powerhouse: One agenda, one economy, one North, A report on the Northern Transport Strategy*, March 2015

[10] Leeds, Liverpool, Manchester, Newcastle and Sheffield city councils. *One North: A proposition for an interconnected North,* July 2014

[11] TfN. *The Northern Powerhouse: One agenda, One economy, One North, A report on the Northern Transport Strategy*, March 2015

and because of their altitude, they are affected by inclement weather throughout the year and other resilience pressures.[12]

1.4.6 More recently, in November 2015 and in March 2016, TfN published its update of the *Northern Transport Strategy*. Both reports highlight the need for increasing capacity and improved major road links east-west across the Pennines. Amongst the priorities for future investment in the North's strategic road network they identify the key strategic road link between Greater Manchester and the Sheffield City Region, The Trans-Pennine Tunnel.

1.4.7 The case for change is therefore based on the interrelated transportation and economic needs of the North. A new route is expected to improve connectivity, promote growth, improve capacity and safety, offer significant improvements in resilience, and reduce the impact of traffic on the high-quality environment of the National Park. Importantly, if the wider policy towards creating a Northern Powerhouse is successful, then the constraints on connectivity between Manchester and Sheffield, and their impact on the wider transport network in the North, will hold back growth across the region.

1.4.8 We have, therefore, defined the objectives of the *Trans-Pennine Tunnel Study* as follows:

Objective 1 – To provide a safer, faster, and more resilient road connection between Manchester and Sheffield, creating more capacity and an additional east-west connection.

Objective 2 – To fulfil the aims of the Northern Transport Strategy to deliver a scheme that will contribute to the transformation of the economy in the North.

Objective 3 – To protect and improve the natural environment by reducing through-traffic in the Peak District National Park and by getting the right traffic onto the right roads.

Objective 4 – To support wider socio-economic needs and leave a long-term legacy of improved road connectivity, better access to labour markets, wider employment opportunities, better land use, and more effective integration between transport modes.

1.5 Economic case

1.5.1 We have undertaken an initial TAG (Transport Analysis Guidance) economic assessment that does form the core part of the economic case. The initial Transport User Benefit Appraisal (TUBA) indicates that there could be substantial user benefits for all corridors in the study area. We are developing a transport model to undertake a full appraisal in the final stage of the study.

1.5.2 Our assessment has begun to consider the wider economic benefits that could occur when towns and cities are brought closer together in terms of travel times and costs, potentially creating larger and more diverse labour and product markets, or greater 'economic mass', than individual towns and cities can achieve in isolation. Recent work in this area commissioned by the DfT notes that there are potentially significant links between improved transport connectivity and increases in economic output and employment.[13] The scale of the impacts are however context-specific and their estimation requires an understanding of how people and business are affected by, and respond to, transport investment. From this initial analysis, using Wider Impacts

[12] DfT & Highways England. *Trans-Pennine routes feasibility study - Stage 1 report*, March 2015

[13] DfT. *Transport investment and economic performance: Implications for transport appraisal,* December 2014

in Transport Appraisal (WITA) principles, we believe that these impacts could be significant given the transformative nature of this scheme.

1.5.3 We are at too early a stage in the design of a potential scheme to present robust analysis on any of the economic costs and benefits of a scheme. However while there needs to be detailed transport and economic modelling, the initial modelling suggests that there could be the potential for significant benefits, including:

- Significant reductions in travel time of up to 30 minutes for both passenger and freight traffic between Manchester and Sheffield, with potential knock-on implications for travel times on other parts of the network as travel patterns change in response to changing network capacity and quality (in general, we would expect traffic congestion on other parts of the network to reduce as capacity increases but there may be increased pressure on local roads that provide access to the new route)
- Likely significant increases in reliability and resilience for existing users of roads across the Pennines, as these roads are frequently out of action during periods of poor weather
- Reduced travel over the Pennines, which would in itself have positive impacts on the environment
- Increasing the attractiveness of the North to inward investment arising from improved access to labour markets, suppliers, business accommodation, distribution centres and warehousing
- Contributing to the range of Northern Powerhouse-related cross-sector investments, which could result in projects having a larger impact than they would as stand-alone investments, as the Northern Powerhouse is about putting together a whole programme of investments where complementary projects are packaged and where their interactions result in higher returns than individual projects alone

1.5.4 The potential for wider economic benefits will be considered further in the final stage of this study and will consider the potential for:

- increased productivity from static agglomeration impacts (increased competition), potential for technology spill-overs, economies of scale, increases in productivity of the labour force and specialisation of service industries
- increased inward investment and employment arising through dynamic agglomeration impacts

1.5.5 The means by which this new strategic route will be funded have not yet been considered. One option might be to introduce road-user tolls, although this would have an impact on the economic case for the scheme. The effects of tolling will be considered in the final stage of the study, although a decision on whether or not to toll the road is outside the scope of the current study.

1.6 Traffic considerations

1.6.1 The Highways England Trip Information System (TIS) and the DfT's Trafficmaster system together provide up-to-date origin/destination information for traffic flows across the UK. We are currently using these datasets to undertake a coast-to-coast assessment of movements in the Northern Powerhouse region that will inform the analysis in later stages of the study.

1.6.2 Our initial analysis, which has looked at 'coast to coast' movements, shows that daily movements between Sheffield and Manchester are far lower than those between

Manchester and Leeds or between Leeds and Sheffield; further analysis is required to determine how the Pennines is creating a barrier to movement between Manchester and Sheffield.

1.6.3 The journey between the urban centres of Manchester and Sheffield via the Pennine routes is approximately 40 miles and takes an average of 75 minutes (although this can increase greatly as a result of accidents and poor weather); the same journey is around 75 miles in length via the M62 motorway and takes 95 minutes. This is reflected in the fact that as a result only around 10% of trips between the two cities are via the M62 and that, despite the lower average speeds, most travellers still choose to use the Pennine routes, which highlights the importance that travellers place on a direct route between the two cities.[14]

1.7 Construction considerations

1.7.1 The construction of a new strategic road link between Manchester and Sheffield is technically feasible, and will include a tunnel (or series of tunnels) that could be longer than any road tunnel constructed in Europe to date. The geology of the Pennines is generally suitable for construction of bored tunnels, but the diameter of tunnel bores would be limited to around 15 metres using present-day tunnel boring machines (TBMs).

1.7.2 The road is likely to comprise a dual carriageway built to motorway or expressway standards. However, we are considering other, less conventional, solutions for the tunnel sections which will explore the opportunities presented by emerging future technologies.

1.7.3 The new highway will not only need to serve motorists on the strategic network (by connecting to the M60 and M1 at the edge of the study area), but it may need to connect to the local road network within the study area. Additional junctions may therefore be required along the route to permit access to, and from, the new road, and it is anticipated that all junctions will be grade-separated.

1.7.4 In the next stage, a junction strategy will be developed so that junctions do not become too closely spaced and interfere with the smooth flow of traffic, creating a large amount of weaving, and reducing the overall safety of the route.

1.7.5 Driver behaviour in long sections of tunnel is an important consideration. Studies have been carried out to explore this issue and there are various examples around the world of long tunnels in which innovative forms of tunnel lighting and design have been used. However, with only a small number of very long road tunnels in the world, it is clear that further research will be needed to investigate this issue.

1.7.6 We are considering the implications of emerging technologies in vehicle automation, connectivity, propulsion methods and real-time navigation systems on tunnel design and operation. As the scheme will need to be designed for an operational life of 120 years, we must anticipate radical changes in technology and tunnel use.

1.7.7 Considerable investment is being made in rail in the North, but even when the current programme is completed, there will be a lack of capacity on routes into city centres and across the Pennines. Therefore, this study includes an assessment of potential synergies with rail-based solutions in a common transportation corridor. Our initial conclusion is that, in tunnel sections, additional bores would be required to accommodate rail alongside road. Light rail could, in principle, share road space with highway traffic, but low operating speeds and the fact that this mode is more suited to dense urban areas, may make it undesirable. We have not yet explored the

[14] Based on analysis of Trafficmaster journey time data for centres of gravity for Manchester and Sheffield.

rationale or logistics of combining road and rail in a single corridor outside tunnel sections, but this can be considered when route options are being developed.

1.8 Operation and maintenance considerations

1.8.1 The operation and maintenance of a new strategic road link between Manchester and Sheffield, which involves long lengths of tunnel is technically feasible, although current standards and methods of operation will need to be reviewed if we are to develop a workable solution that meets the needs of road users, emergency services, tunnel maintenance workers and operators.

1.8.2 Safety and security in tunnel sections is an important consideration. Further consultation will be needed with tunnel operators, maintenance workers and emergency services to identify tunnel design requirements to fully address these issues.

1.8.3 Tunnel design will need to incorporate low-maintenance systems and products in order to minimise the frequency of operations and to eliminate unnecessary or hazardous activities. We will also consider robotic and automated maintenance solutions.

1.8.4 Intelligent transport systems will be required to monitor traffic conditions and manage traffic movement, to identify incidents and to provide road users with relevant information. Again, we will consider the emerging technologies in these areas when evaluating possible solutions.

1.8.5 Whilst the design of systems and processes for tunnelled sections is likely to drive innovation, it is important that improvements in the operational and maintenance performance of the entire link are considered when we evaluate options.

1.9 Environmental considerations

1.9.1 The PDNP is an area of protected status, the aim of which is to conserve and enhance natural beauty, wildlife and cultural heritage. The surrounding countryside includes open areas that are designated as Green Belt and many villages are designated as Conservation Areas (CAs).

1.9.2 There are numerous Air Quality Management Areas (AQMAs) on the fringes of the study area (mainly around Sheffield and Manchester) and there are recognised noise issues adjacent to existing roads and railways.

1.9.3 There are many potential environmental constraints, but also some important opportunities, and in the final stage of this study we will assess environmental impacts and benefits in more detail. For example, there may be the opportunity to re-designate existing roads at a lower grade as a large proportion of traffic through the National Park would be diverted onto the proposed new route. This would allow better provision for local people, tourists and non-motorised users (NMUs).

1.9.4 Environmental impacts and benefits have formed an important part of our analysis regarding corridor and route options. We have been able to gain a more detailed understanding of these issues, through contributions from stakeholders. In the final stage of the study we will explore the potential impacts and benefits further with more focused technical working groups.

1.10 Option assessment

1.10.1 Based on the positive findings from the first two stages of this study we have looked to develop potential indicative route options for a strategic link and to identify a short list of better performing options.

1.10.2 It was necessary to follow a structured, incremental sifting process, in line with the DfT's *Transport Analysis Guidance* (TAG). This included a high level assessment of route corridors using the DfT's Early Assessment and Sifting Tool (EAST) and an assessment of route options using the Option Assessment Framework (OAF).

1.10.3 In collaboration with stakeholders five broad corridors were identified:

- Northern Corridor (A)
- A628/A616 Corridor (B)
- Central Corridor (C)
- Southern Corridor (D)
- Overlapping Corridor (E)

1.10.4 A set of viability assumptions were developed in order to both guide the development of corridors/options, and to act as a high level check to ensure that any proposed corridors/options met key study criteria. The viability assumptions are as follows:

- Fits the project scope, specifically a strategic link connecting Manchester and Sheffield under the Pennines
- Corridors and routes are largely within the study area boundary
- Corridors and routes do not involve construction of a surface route within the PDNP and its wider setting

1.10.5 These viability assumptions were debated and challenged by both the study team and stakeholders to ensure that they were appropriate and did not prematurely rule out any corridors/options that were worth assessing.

1.10.6 The outcome of the initial EAST assessment shows that Corridor B, along the existing route of the A628/A616, and to a lesser extent corridors A and C, appear to have greater advantages over the other corridors and construction may be easier and take less time.

1.10.7 The EAST analysis concludes that corridors D and E score less well in terms of meeting the objectives of the study, and should not be prioritised for further assessment for the following reasons:

- Corridor D fails the viability test that the route "does not involve construction of a surface route within the PDNP and its wider setting".
- Corridor D has additional environmental challenges, for example heritage features, ecological designations and noise issues that would make delivery more difficult.
- Corridor E is estimated to deliver materially less economic benefits and less additional output to the UK than the other corridors.
- Time saving within Corridor E would be lower than for the other corridors.
- Corridors D and E could have longer tunnel lengths than Corridors B and A, and offer no discernible benefits in terms of connectivity, wider journey times, and economics.
- A longer tunnel will cost substantially more, and be proportionately less likely to provide a business case for investment. This would also mean more embedded carbon, greater maintenance costs per annum, more excavated material to dispose of and more ventilation shafts to be constructed within the PDNP.

1.10.8 As Corridors A, B and C were identified as the better performing corridors we identified route options within these three corridors including ideas suggested by stakeholders. Thirty-six routes were identified, and following a consolidation process which involved identifying routes with similar characteristics (same start and end points, similar lengths and alignments) these were refined down to twelve distinct route options.

1.10.9 The twelve routes were assessed and sifted using the OAF in order to develop a shortlist of route options which will then be assessed in more detail in the next stage of the study.

1.10.10 Based on that analysis it was considered that, whilst in some areas the differentiation was marginal in places, there were sufficient strengths and weaknesses between the twelve route options to refine down to five shortlisted options.

1.10.11 The analysis concluded that routes 7, 8, 9 and 10 are the better performing route options in terms of the following:

- These four routes present the best fit in terms of providing a greater degree of beneficial impacts, particularly in terms of the strategic case and the impacts on the economy.
- These four routes have the fewest adverse impacts environmentally and have some positive impacts within the PDNP.
- These four routes are seen to be more deliverable and acceptable to the public.

1.10.12 The analysis also concludes that some options are worthy of further consideration on the basis of their anticipated relative costs. In this case, route option 4 has some merit because of its cost relative to options with the same or higher score.

1.10.13 Therefore, **route options 4, 7, 8, 9 and 10** are those which will be taken forward for further analysis within the next stage of the study.

1.11 Next steps

1.11.1 In the next stage of the study, Stage iii(c) we will assess each of the shortlisted options and consider the impacts and benefits of each one. This stage will provide a cost estimate for each option and consider the extent to which it offers synergy with rail and/or light-rail options.

1.11.2 We will consider further significant external factors including:

- Other strategic studies, including the Manchester North West Quadrant Study
- Northern Freight Strategy
- Northern Powerhouse scenario (likely change to economic conditions)
- Other proposals, for example, a proposed link connecting the M1 and the M18 through Barnsley and Doncaster

1.11.3 We will undertake further work on the strategic and economic case for each of the shortlisted options, considering the transport, environmental and socio-economic benefits of the scheme and testing the testing the sensitivities and robustness around technology and tolling.

1.11.4 We will revisit the technical work undertaken in the first stage of the study and consider issues in more detail. This includes tunnel configuration, tunnel safety and security, impact on local road network, driver behaviour and opportunities presented by future technologies.

1.11.5 The work will be completed in October 2016 and our findings will be presented in a final report to the Secretary of State.

2 Introduction

2.1 Background

2.1.1 The North of England is home to 15 million people – nearly a quarter of the UK's population – and generates £290 billion in economic output,[15] accounting for more than a fifth of our GDP. It has abundant natural and physical assets, and its educational institutions are among the best in the country.[16] Individually, the economies of the northern city regions are strong. Despite this, the North continues to lag behind London and the South East. The region's physical assets are under-utilised and it is losing skilled workers to the more prosperous South. Central to these trends are: relatively low worker productivity and wages, unfavourable demographics, low employment rates and a weak investment climate.

2.1.2 One of the key recommendations of The Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA)[17] Cities Growth Commission's October 2014 report *Unleashing Metro Growth* was to enhance physical connections between the UK's 15 major metropolitan regions, including Greater Manchester, West Yorkshire, South Yorkshire and Merseyside.

2.2 Trans-Pennine strategic link study

2.2.1 As part of its *Road Investment Strategy: Investment Plan, December 2014* (*RIS*)[18], the DfT announced that it would be exploring the feasibility of a major new road link under the Pennines between Sheffield and Manchester and outlined the requirements for a study, which we describe in this report.

2.2.2 The *Northern Transport Strategy,*[19] published in March 2015, commits to develop the next generation of major road schemes to dramatically improve east-west connectivity and fully supports this study.

2.2.3 The update to this strategy published in March 2016[20] continues to support this study and identified the Trans-Pennine Tunnel as one of the key priorities for investing in the future strategic road network in the North.

2.2.4 This study is jointly sponsored by the DfT and TfN, but there are other important stakeholders and we will continue to involve them as the study progresses. The purpose of this updated interim report is to build upon the work undertaken in the first stages of the study, to consider the strategic need and economic case further. It looks to identify and develop potential indicative route options for a strategic link and to assess the benefits and dis-benefits of these options. This has been undertaken from a long list of corridors (as shown in Figure 2-1) which have been narrowed down to a short list of route options.

2.2.5 The corridor concept has been agreed with stakeholders and the assessment of those corridors and route options within those corridors is outlined in more detail within later sections of this report.

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[15] ONS. *Statistical bulletin, regional gross value added (income approach)*, December 2014

[16] Two of the top 10 universities in the UK for 2015/16 are located in the north of England (Manchester ranked 8th and Durham 9th). Source: *The Times Higher Education World University Rankings 2015,* September 2015

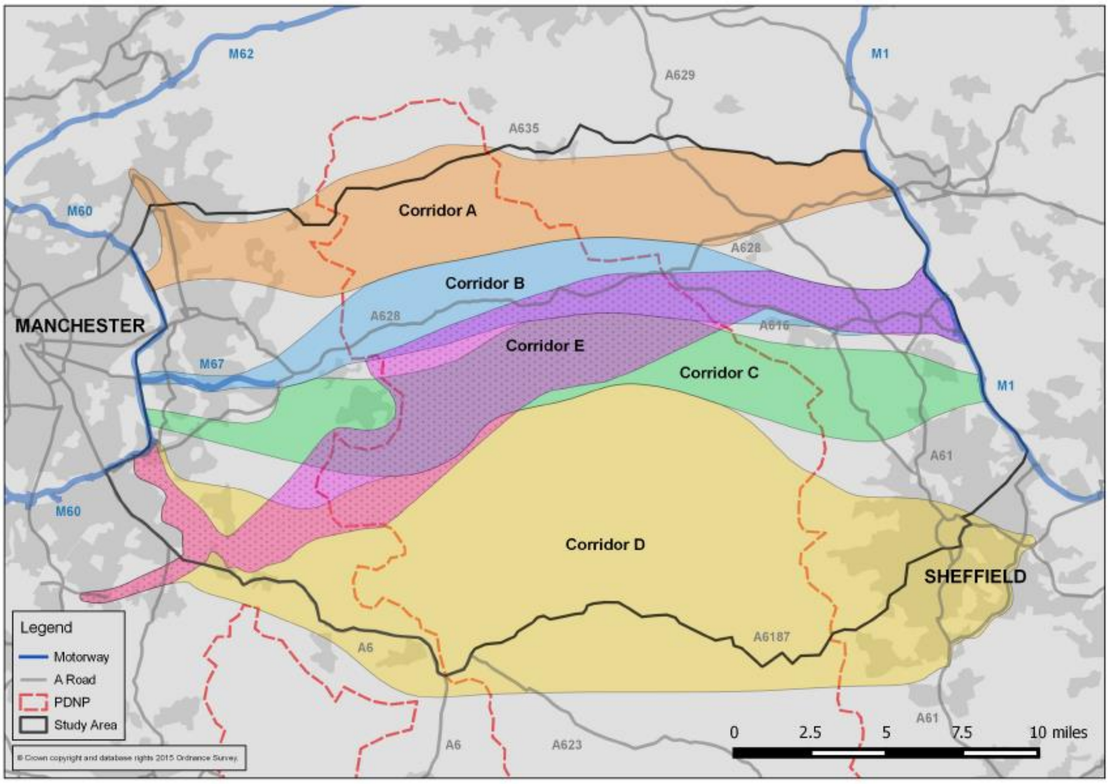
[17] Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA), City Growth Commission final recommendations. *Unleashing metro growth*, October 2014

[18] DfT. *Road investment strategy: Investment plan and statement of funds available,* December 2014

[19] TfN. *The Northern Powerhouse*: *one agenda*, *one economy*, *one North – a report on the Northern Transport Strategy*, March 2015

[20] *TfN and DfT, Northern Transport Strategy spring report, March 2016*

Figure 2-1 – Corridor options



2.3 Project team and reporting

2.3.1 In this report, we describe work carried out so far by Highways England on behalf of DfT and TfN on the Trans-Pennine Tunnel Study. Highways England commissioned a joint venture, consisting of Mouchel and Arcadis (supported by KPMG), to act as study consultant. Highways England appointed Mace as project manager for the work.

2.3.2 There are three stages to this study, which are summarised as follows:

- Stage (i) comprised a review of existing feasibility studies and an examination of the strategic and economic case for developing a new strategic road link across the Pennines. It also sought to establish the technical feasibility of constructing such a link in a safe and economic manner, considering that the solution is likely to involve a tunnel or tunnels beneath the PDNP.
- Stage (ii) included an assessment of construction issues associated with delivering this strategic road link, together with problems likely to arise from the operation and maintenance of the new infrastructure. This stage also considered issues associated with long tunnel sections (including driver behaviour, safety and security, vehicle recovery, and emergency access and evacuation) and the interconnectivity of the new strategic link with the surrounding network, the standard of road that should be provided, and potential synergies with rail or light-rail solutions.
- Stage (iii)a builds upon work done in previous studies and the analysis in Stages (i) and (ii) of this study. It identifies five route corridors between Manchester and Sheffield which have been assessed and recorded using the EAST.
- Stage (iii)b has followed on directly from the prioritisation of corridors identified in Stage (iii)a. A shortlist of five route options have been identified

which can be assessed in more detail in Stage (iii)c. The shortlist has been developed by undertaking a more detailed assessment using the OAF.

- Stage (iii)c will assess each of the shortlisted options and consider the impacts of each one using more detailed modelling of costs and benefits. This stage will provide a cost estimate for each option and consider the extent to which it offers synergy with rail and/or light-rail options.

This report focuses on reporting progress in relation to stages (iii)a and (iii)b of the study.

2.4 Study area

2.4.1 This study explores road-based solutions for a new route between Manchester and Sheffield. In Section 5 we have considered opportunities for combining this study with solutions involving rail. Other transport and non-transport investments may also contribute to economic growth in the North of England, but these are outside the scope of this study.

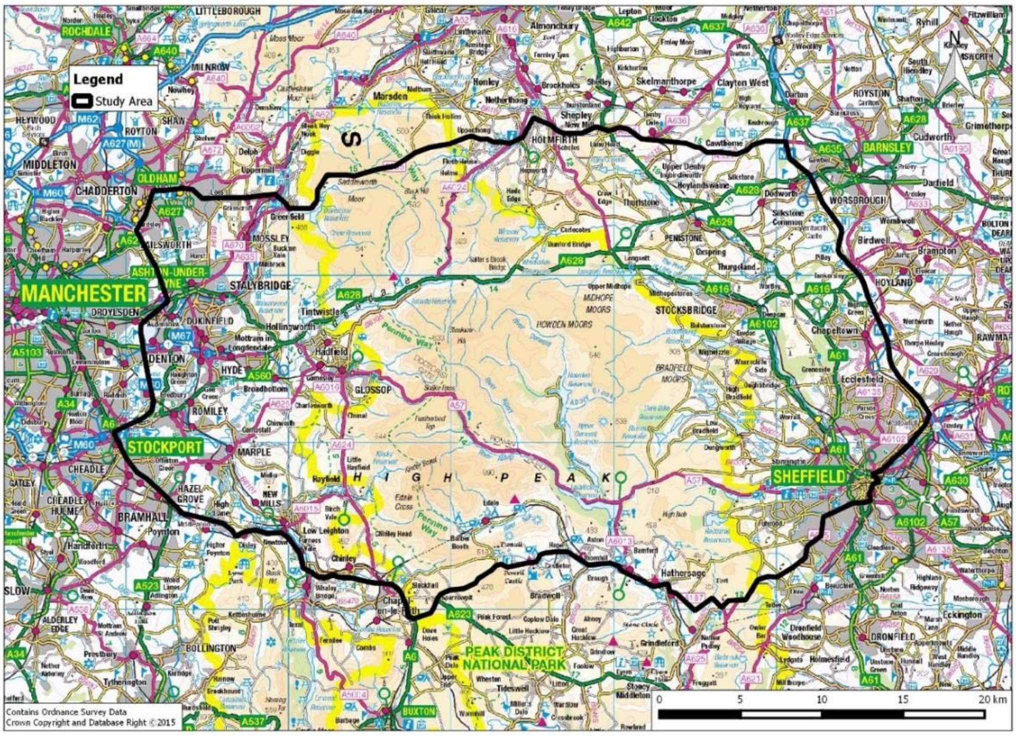
2.4.2 We consider road-based solutions to improve connectivity east to west in the study area shown in Figure 2-2. The study area is bounded to the west by the M60 Manchester orbital motorway and to the east by the M1 motorway. It is bounded to the north by the town of Holmfirth and extends south to Chapel-en-le-Frith. The rationale for choosing this study area for scheme options is that:

- the M60 and M1 motorways provide clearly defined borders and provide links to the strategic road network
- the A635 is the most northerly direct road link between Manchester and Sheffield
- the A623 and A6 similarly provide the most southerly direct road link between Manchester and Sheffield

North and south of these two boundaries the potential routes would become much less direct and significantly less desirable and will not capture enough traffic from the existing routes.

2.4.3 A wider study area, which includes and extends beyond, the entire Northern Powerhouse area, has been used to consider the economic and traffic impacts of the scheme.

Figure 2-2 – Geographical scope of study (for potential route options)



2.5 A tunnel solution

2.5.1 The RIS states that "the invaluable landscapes and ecological significance of the Peak District National Park rule out a surface link. The only credible solution may be to construct a tunnel under the central part of the Pennines".

2.5.2 A tunnelled solution would offer increased reliability and significant improvements in resilience for road users travelling between Manchester and Sheffield to overcome challenges of adverse weather and other operational resilience issues (availability of alternative routes).

3 Strategic case

3.1 Introduction

3.1.1 DfT guidance[21] states that the strategic case should provide a clear rationale for making any investment and should detail how the investment will further the aims and objectives of the promoting organisation and other key stakeholders. It should also demonstrate its strategic fit with local, regional and national policies.

3.1.2 This section of the report presents our preliminary analysis of the strategic case for a strategic road link between Manchester and Sheffield. The case:

- identifies the challenges and opportunities facing the region which highlight the case for change
- considers the available options to address the issues
- describes the possible outcomes arising from investment/intervention

3.1.3 The strategic case centres on the ability of the scheme to contribute to the Government's vision to rebalance the UK economy and establish the North as a global economic powerhouse that builds on the existing strengths of Northern city regions, attracts and retains the brightest and best talent and attracts investment from overseas.

3.2 Challenges and opportunities

3.2.1 The challenges facing the UK economy and the opportunities arising from the creation of a Northern Powerhouse are set out below. The analysis considers the relative economic performance of the North, the strength of the transport network between towns and cities in the North and the implications of poor transport connectivity on economic growth.

Economy of the North

3.2.2 The five main city regions in the North - Greater Manchester, Leeds, Sheffield, Liverpool and the North East - are home to a sixth of the population of the UK and nearly a fifth of the population of England. They provide jobs for 4.2 million workers and generate £201 billion in economic output, equivalent to around 12% of the UK's total output.[22]

3.2.3 There are, however, significant differences in rates of employment and economic productivity between the five city regions and London, including the fact that:

- London employs 4.7 million workers from a population of 8.2 million compared with 4.2 million workers from 10.1 million people in the five city regions
- London generates £364 billion in economic output compared with £201 billion in the five city regions

3.2.4 In addition, analysis by the Centre for Cities shows there are also differences in the types of employment with workers in London more likely to be employed in financial services and knowledge-intensive business services (KIBS).[23] The total number of KIBS jobs in the city centres of the five major urban centres in the North is less than 150,000, compared with nearly 630,000 in the centre of London. Importantly, these types of jobs are more concentrated and closer to each other in London than they are

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[21] DfT, *The transport business cases*, January 2013

[22] ONS GVA December 2015 release, BRES 2015 release, and Census population data, 2011

[23] Centre for Cities. *Fast track to growth: transport priorities for stronger cities,* 2014

in the North, which gives businesses a larger market to trade and compete with, and significantly more scope for knowledge transfer and sharing of resource (Table 3-1).

3.2.5 The UK Commission for Employment and Skills notes that the financial and knowledge-based sectors have grown most rapidly in recent years and are expected to drive growth in both economic output and employment in the UK over the coming decade.[24] The role of the main urban centres is, therefore, set to become even more important in driving the economy of the UK.

Table 3-1 – KIBS jobs in London and northern cities

City	City-centre wide private KIBS 2011 (jobs)	Density of KIBS jobs 2011 (jobs/hectares)	KIBS jobs as a share of all city-centre private sector jobs (%)	City-centre KIBS jobs as a share of all KIBS jobs in the city (%)
London	629,816	194	51	51
Manchester	51,710	99	53	34
Leeds	37,788	73	52	51
Liverpool	20,843	40	38	54
Newcastle	18,863	36	38	38
Sheffield	15,377	30	46	42
Hull	7,034	35	34	66

Source: Centre for Cities (2014). Fast track to growth.

3.2.6 A key outcome of this dispersed activity is that productivity in the North, measured as gross value added (GVA) per worker, is less than the national average and well below that of London. Another concern is that productivity in the North has also been falling relative to the national average (see Table 3-2). The size and scale of the London market is central to its own success and to those cities in the South that are well connected to the capital, such as Reading, Cambridge and Oxford. Meanwhile, despite relatively short physical distances, the North lacks an economy with a similar scale.

Table 3-2 – GVA per job relative to national average, 2002-2013

NUTS level	Geography	Index (Average for England = 100)		
		2002	2013	Change
NUTS3	Greater Manchester South	94.0	95.0	+1.0
NUTS3	Greater Manchester North	82.1	80.0	-2.1
NUTS2	Greater Manchester	89.7	89.8	+0.1
NUTS3	Sheffield	87.4	88.6	+1.2

[24] UK Commission for Employment and Skills. *Working futures 2012-2022*, 2014

NUTS level	Geography	Index (Average for England = 100)		
		2002	2013	Change
NUTS2	South Yorkshire	83.1	82.5	-0.6
NUTS3	Leeds	97.4	95.4	-2.0
NUTS2	West Yorkshire	90.2	89.4	-0.8
NUTS3	Liverpool	90.9	90.4	-0.5
NUTS2	Merseyside	90.3	88.2	-2.1
NUTS3	Tyneside	86.4	87.8	+1.4
NUTS2	Northumberland and Tyne & Wear	87.5	85.3	-2.2
NUTS3	Kingston upon Hull	79.9	81.0	+1.1
NUTS2	East Yorkshire and Northern Lincolnshire	87.3	86.1	-1.2
NUTS2	Inner London	143.6	154.8	+11.2
NUTS2	Outer London	106.4	102.6	-3.8
NUTS3	Cambridgeshire	100.0	104.0	+4.0
NUTS2	East Anglia	93.0	94.3	1.3
NUTS3	Berkshire (Reading)	138.8	136.1	-2.7
NUTS3	Oxfordshire	105.8	102.6	-3.2
NUTS2	Berkshire, Buckinghamshire and Oxfordshire	122.8	120.9	-1.8

Source: ONS Sub-regional Productivity Tables, August 2015, Table B2

3.2.7 A further outcome of this dispersion of activity is the fact that Northern city regions are less specialised in specific economic sectors. Based on employment quotients, which measure the proportion of employment by economic sector relative to the national average, only West Yorkshire is highly specialised in finance and insurance. The remaining city regions have a high concentration of public sector and industrial employment relative to the national average.[25] This is not to undermine the importance of industry and manufacturing to the national economy, where the North will continue to play a leading role, and where transport will be crucial; it is more about the likely drivers of future employment growth, which are expected to come from the labour-intensive, service-based sectors.

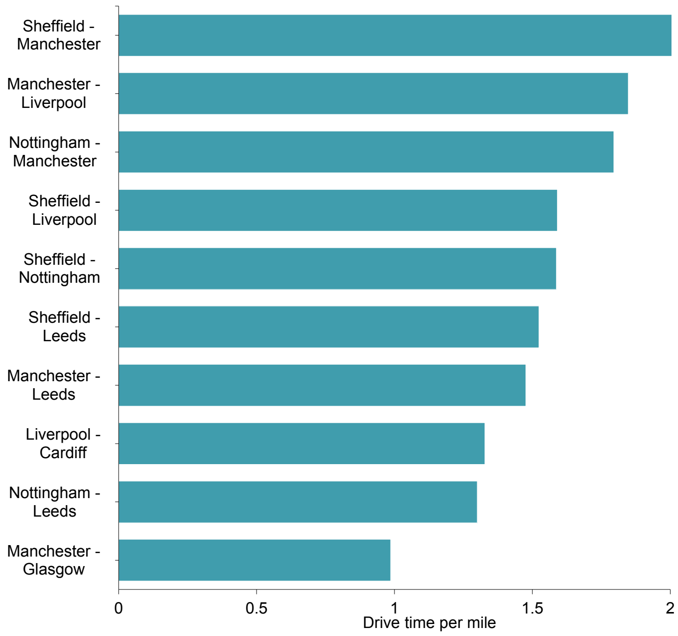
3.2.8 The consequence of these economic imbalances is rising pressures in London and the South East, potentially constraining growth, while the North has under-utilised capacity.

[25] ONS. *Sub-regional productivity tables*, August 2015; and KPMG analysis

Inter-urban transport networks

3.2.9 The fact that economic activity in the North is scattered around a number of urban centres is not by itself a constraint on growth. Indeed, networks of city economies can perform well if transport connections between them do not present significant barriers to trade.[26] Figure 3-1 however shows that of the UK city pairs with the worst average drive time per mile travelled, most are in the North, with drive times between Manchester and Sheffield being worst of all.

Figure 3-1 – City centre to city centre drive times per mile (in minutes)



Source: KPMG Analysis of Google Data

3.2.10 Furthermore, the majority of the best connected local authorities in England and Wales are found in the South East; there are only 4 (out of 50 nationally) in the North West, and none east of the Pennines.[27]

3.2.11 Specific challenges for the strategic road network between Manchester and Sheffield include:

- Delays and network stress on existing key routes, which have a negative impact on connectivity between the two city regions (the *Trans-Pennine Routes Feasibility Study: Stage 1 Report* (March 2015)[28] revealed that peak-hour journeys on the Highway's England route between Manchester and Sheffield are between 126% and 140% of the baseline (free-flow) journey time – adding up to 14 minutes to the journey), which links to the point below about reliability
- Limited connectivity, resulting in low levels of business-to-business road trips between South Yorkshire and Greater Manchester and restricted opportunity to increase economic activity, as the distance between Manchester and Sheffield is around 40 miles, but despite this, the journey between the two

[26] Meijers, E.J., Burger, M.J. and Hoogerbrugge, M.M. *Borrowing size in networks of cities: city size, network connectivity and metropolitan functions in Europe, regional science,* 2015

[27] Association of Train Operating Companies. *Accessibility Statistics*, 2010

[28] DfT & Highways England. *Trans-Pennine routes feasibility study*, March 2015

cities takes an average of 75 minutes (representing an average journey speed below 35 mph)

- Road traffic collisions and safety, which have been identified for decades as a significant challenge for trans-Pennine routes, leading to problems of journey-time reliability and maintenance. The South Pennines Route Strategy highlights trans-Pennine trunk roads as routes where collision risks are particularly high.[29] This study also found that a higher than average number of accidents occur during adverse weather conditions, compared to the national average. The Trans-Pennine Routes Feasibility Study report stated that, on average, the strategic route, incorporating the A57/A628/A616/A61, experiences a road closure every 11 days, with 36% of closures being longer than five hours.[30] This means that on average, there is one road closed for five hours or more every month.
- Capacity and capability constraints of the rail network, which limit potential for rail freight growth. Rail North's Long Term Rail Strategy (2014)[31] states, "Rail provides poor regional-centre-to-regional-centre connectivity for business-to-business trips, reducing the prospects for business agglomeration benefits." Passenger surveys[32] have highlighted quality, overcrowding and airport access as significant problems. These constraints are compounded by limitations to road freight, due to delays, poor reliability and network resilience.
- Connectivity to Manchester Airport, which is a challenge for the Sheffield City Region, Derbyshire, Nottinghamshire and Hull, and the importance of these connections is likely to increase with the proposals for an Airport City and Enterprise Zone, where businesses will be offered incentives to locate in order to create jobs and stimulate economic growth locally, regionally and nationally. The Manchester *Strategic Economic Plan (SEP)* highlights the potential for the High Speed Two (HS2) airport station to deliver massive growth and regeneration benefits for the wider area.
- Future residential and development proposals with anticipated impacts on the networks. These aspirations/targets are outlined later in Section 3.

3.2.12 The poor connections across the Pennines have wider consequences as traffic distributes itself across a limited number of alternative roads of varying standard. This results in increased congestion and capacity issues across the road network in the North, with particular problems on higher standard roads, such as the M62, which is the only major east-west road link in the North, and on the A628 further south. The Greater Manchester Transport Strategy 2040[33] specifically identifies the need for a new trans-Pennine route.

3.2.13 The city regions on either side of the Pennines have significant plans for growth in terms of housing and employment over the coming decades and beyond. This is outlined later in this section of the report. This will increase the demand for travel across the Pennines. Previous studies have demonstrated that sections of the existing road network, particularly some junctions, are already operating at, or beyond, capacity during peak periods. Combined with the existing poor network

[29] Highways England. *South Pennines route strategy,* April 2015

[30] DfT & Highways England. *Trans-Pennine routes feasibility study*, March 2015

[31] Rail North. *Long Term Rail Strategy – Final version – with updates*, August 2014

[32] Passenger Focus. *Northern and TransPennine franchises – passenger research*, 2012

[33] *TfGM, Greater Manchester Combined authorities and Greater Manchester LEP, Greater Manchester Transport Strategy 2040, our Vision, due to be published in 2016*

resilience, further growth will have significant journey-time and reliability impacts on the existing road networks.

Implications of poor connectivity

3.2.14 Poor connections between cities in the North and across the Pennines in particular have wider consequences as traffic distributes itself across alternative routes leading to increased congestion on higher standard roads such as the M62.

3.2.15 Table 3-3 provides a comparison of commuting flows between the cities in the North and cities in the Randstad in Holland, where there is significantly more commuting between city regions. This is further confirmed by the work for the Northern Way which outlined that commuting between Manchester and Leeds is 40% less than what would be expected from regions of a similar size and proximity.

Table 3-3 – Comparative commuting patterns in the North and in the Randstad, 2011

	Area of work			
Area of residence	**Leeds**	**Manchester**	**Sheffield**	**Liverpool**
Leeds	783,428	11,692	16,011	845
Manchester	8,916	904,361	1,707	19,010
Sheffield	28,281	4,544	582,739	510
Liverpool	1,539	22,375	480	464,599
	Area of work			
Area of residence	**Flevoland**	**Utrecht**	**Noord-Holland**	**Zuid-Holland**
Flevoland	106,300	11,400	48,600	3,600
Utrecht	5,500	455,600	65,100	31,100
Noord-Holland	15,100	49,900	1,142,500	48,100
Zuid-Holland	3,100	47,400	81,100	1,484,900

Source: Dutch Statistical Office. Census, 2011

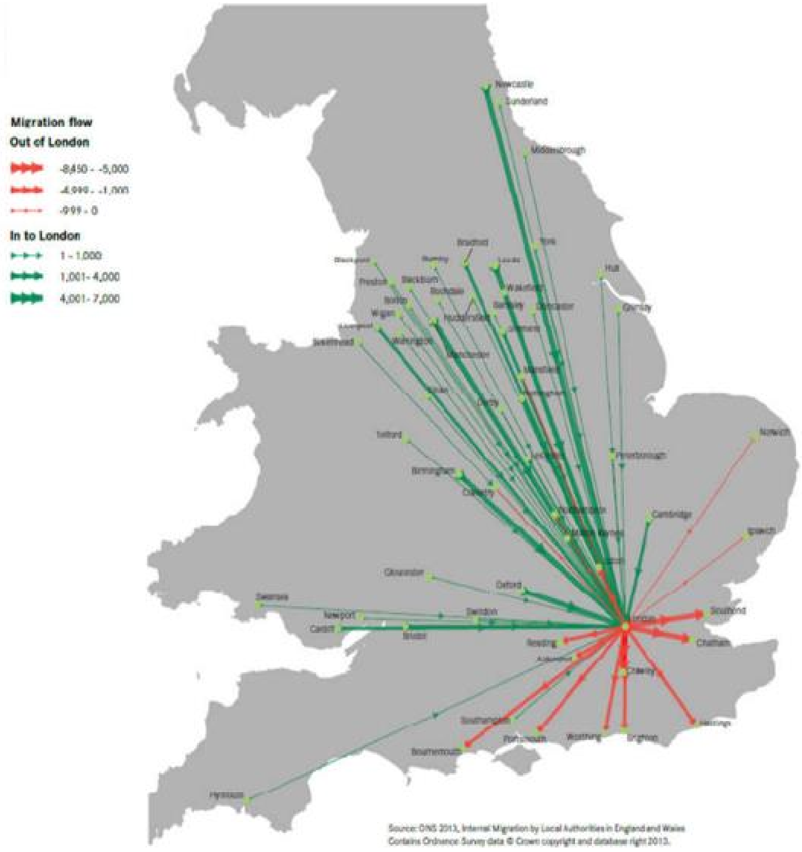
3.2.16 Poor connectivity between cities also has an impact on trade. A study by EKOS Consulting on behalf of Manchester and Sheffield City Councils found that:

- Sheffield's suppliers are more commonly located in London and internationally, than in Manchester.
- The majority of businesses in Sheffield identified local competitors within South Yorkshire rather than in Manchester.
- Manchester is not a common market place for Sheffield companies with seven out of ten businesses stating that no sales or income was generated in Manchester.

Implications of weaker economic performance

3.2.17 The implications of relatively weak economic performance is that the economies of the North are left with spare productive capacity, resulting in higher levels of unemployment (7.3% in Greater Manchester and 7.7% in Sheffield, compared to the national average of 6%) and higher levels of outward migration. Figure 3-2 shows relatively high levels of net migration to the London and the South East, particularly among the young population.

Figure 3-2 – Net Migration Flows in the UK, 2009 to 2012

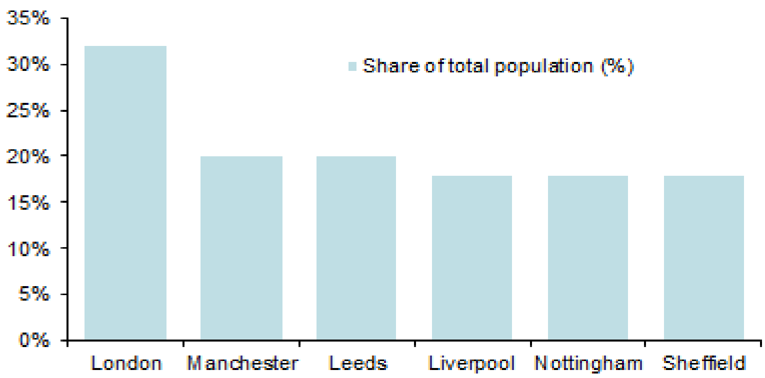


Source: Centre for Cities. Cities Outlook, 2015

3.2.18 The migration patterns are depriving the North of much needed skilled labour. This is despite the fact that much of the highly skilled workforce in the UK is actually educated in the universities of the North.

3.2.19 The fact that graduates tend to head to London and the South East means that businesses in those regions have access to a higher proportion of skilled labour than those in the North (Figure 3-3).

Figure 3-3 – Graduates living within 11 miles of the city centre

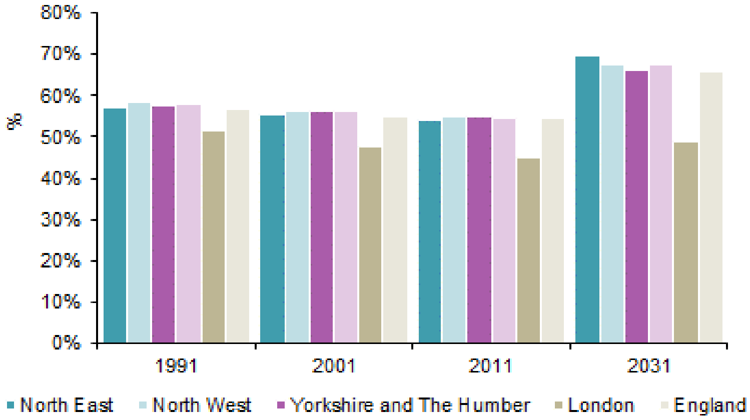


Source: Centre for Cities. Cities Outlook, 2015

3.2.20 Outward migration of young people means that regions in the North are forecast to see higher levels of dependency (measured as those of working age – 16 to 64 –

divided by children under 16 and those over 64) impacting on the Public Accounts for these regions and the attractiveness of the location to business.

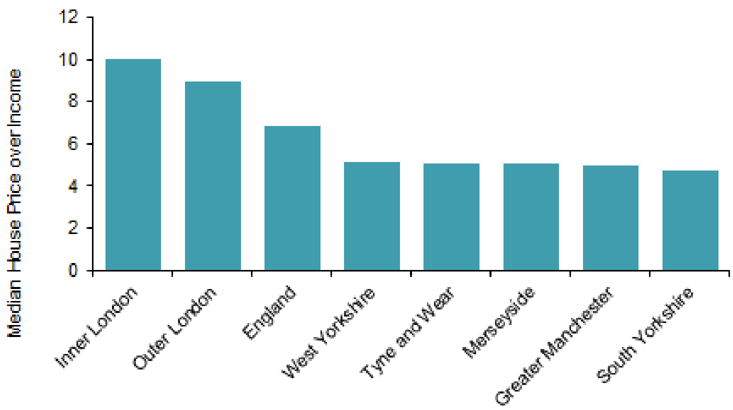
Figure 3-4 – Dependency ratio by Government Office Region (actuals and forecasts)



Source: ONS and KPMG Analysis

3.2.21 Lower levels of economic performance result in lower demand for assets. Compared with median incomes, house prices are much lower in the North than in London and the South East, and the country as a whole (see Figure 3-5).

Figure 3-5 – House prices as a proportion of income, 2012



Source: Department for Communities and Local Government. National planning policy framework, March 2012

3.2.22 At the same time, demand for commercial space is also lower as manifested in the rateable values for all types of commercial space in the North compared with London and the South East. Data in Table 3-4 show the gap in rateable values between the different government office regions, where the Northern regions have some of the lowest achievable rates in the country across most property types, specifically office space.

Table 3-4 – Commercial rateable values by type, 2012

Region	Industrial	Office	Retail	Other
East	42	113	145	70
East Midlands	32	70	108	53
London	68	280	235	131
North East	25	85	128	43
North West	30	98	133	57
South East	50	114	156	68
South West	37	100	138	58

Region	Industrial	Office	Retail	Other
West Midlands	33	102	123	62
Yorkshire And The Humber	29	98	128	55
England	37	155	150	68

Source: Valuation Office Agency, 2012

3.2.23 The fact that construction costs are only up to 10% lower in the cheapest construction market in the UK (the North West) compared with the most expensive market (London)[34] means that development is significantly less attractive in the North overall given the prices that can be achieved for these investments.

3.3 Policy options

3.3.1 Relatively poor inter-urban transport networks resulting in relatively poor levels of economic connectivity contribute to relatively weak economic performance in the North. The strategy to support the vision of balanced economy will need to include a package of measures including:

- Investing in a world class transport system to link individual towns and cities and local networks to enable all parts of the North to connect, compete and collaborate
- Supporting wider socio-economic development by investing in skills, support for business and urban regeneration
- Protecting the natural environment and improving the built environment to promote the North's towns and cities as amongst the best in the world to live and work

3.3.2 The economic imbalances in the country have spurred successive governments into action. At the heart of plans to boost economic output in regions outside of London and the South East is significant investment in infrastructure with the prime aim of addressing relatively low productivity.

Fixing the foundations: Creating a more prosperous nation

3.3.3 In July 2015, the Government set out its plan to address the UK's long-term productivity problem detailing policy reforms aimed at delivering long-term economic stability.[35] The framework proposed focuses on raising productivity around two pillars: long term investment in economic capital and a dynamic economy encouraging innovation and the flow of resources.

3.3.4 Long-term investment in Infrastructure is essential to expand the productive capacity of the economy. The Government has committed £100 billion investment in infrastructure by 2020, securing long-term certainty and increased funding to the most productive areas of infrastructure spend, delivering a modern transport system by improving transport connectivity, and increasing trade across the nation and internationally. The government invested over £40 billion in transport over the last Parliament, and has committed to over £56 billion in transport infrastructure for this Parliament.

Rebalancing the economy

3.3.5 The Government's plans to address the productivity challenge builds on previous work where it set out that a fundamental pillar of a truly national recovery is through a rebalancing of the British economy based on the following:

[34] Turner and Townsend. *International construction market survey*, 2015

[35] HM Treasury. *Fixing the foundations: Creating a more prosperous nation*, July 2015

- Investment across the regions
- Growth driven by the private sector
- Further devolution to increase local decision making

3.3.6 Rebalancing the economy is core to the Government's economic strategy and an agreed priority with city leaders across the North. Significant efforts have been made to achieve this through increasing the distribution of economic success more evenly, both spatially and by sector, in response to the instability of the UK economy that was exposed during the financial crisis.[36]

3.3.7 The 2015 Summer Budget put economic security as a high priority and emphasised that more needs to be done to strengthen every part of the UK. Critical to this is bringing together the cities and counties of the North of England, and supporting other vital regional economies such as the Midlands and South West.[37] Successful rebalancing will not be achieved by pulling down London but building up the Northern Powerhouse and creating strong city regions. This was reinforced in the 2016 budget, which stated that "Regional economic disparities have long been a problem, with London and the South East having higher growth than the UK average for decades. The government is determined to rebalance the economy by building the Northern Powerhouse".

The Northern Powerhouse

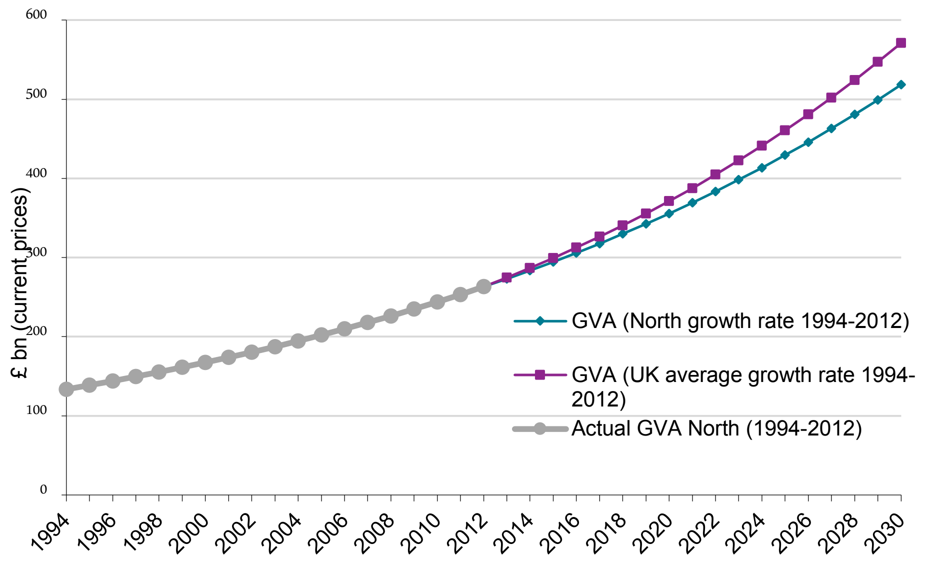
3.3.8 In the last Parliament, the Government committed to building a Northern Powerhouse based on the premise that while the individual cities and towns of the North are strong, if they are enabled to pool their strengths, they could be stronger than the sum of their parts creating an interconnected single economic area.

3.3.9 In August 2014, the Chancellor set out a clear pathway for the Northern Powerhouse setting out the growth targets that realise the Government's ambition to rebalance the UK economy. There are significant gains if a Northern Powerhouse grows in line with the rest of the UK over the next 18 years (approximately 4.6% according to the Office for Budget Responsibility forecast), which compared to historical performance the Northern Powerhouse would be worth an additional £56 billion in nominal terms or £44 billion in real terms.

[36] HM Treasury. *Reducing the deficit and rebalancing the economy*, April 2015

[37] HM Treasury. *Summer Budget*, 2015

Figure 3-6 – GVA forecasts for the North



3.3.10 A fundamental part of achieving these objectives will be through enhancing connectivity between the different regions of the North. This is in line with the DfT's Strategic Priorities. In summary, these aim to provide world-class connectivity for our towns and cities, both nationally and internationally, meeting the needs of people and businesses for safe, secure, reliable and accessible transport, and building a competitive transport sector that is efficient and innovative, while also protecting the environment[38].

Northern Transport Strategy

3.3.11 The Northern Transport Strategy[39] sets out how transport is fundamental in transforming Northern growth, rebalancing the economy and delivering the Northern Powerhouse. The strategy focuses on using transport to aid change in future patterns of land use and economic growth, with the goal of creating a single economy in the North. Importantly, it aims to increase the scale and quality of commuter networks around cities in the North to strengthen and widen their accessible skills markets to allow talent to move between cities on a daily basis and support the knowledge economy.

3.3.12 The strategy includes the creation of TfN, a statutory body with statutory duties, underpinned by £30 million of additional funding over 3 years.[40] The two key objectives are highlighted as follows:

- Improved east-west major road links will ensure better and more reliable journey times between the major cities within the North. This will also ensure that the North can begin to operate as a single economic area and improve access to local employment as well as markets for goods and services.

[38] DfT. *Annual report and accounts, 2014 to 2015*

[39] TfN. *The Northern Powerhouse: One agenda, One economy, One North - A report on the Northern Transport Strategy,* March 2015

[40] IPPR North. *Transport for the North: A blueprint for devolving and integrating transport powers in England*, 2015

- Ensuring the efficient movement of freight, fuels and raw materials is vital to the prosperity of the northern economy. There is a need for an integrated freight and logistics network focused on delivering east-west rail freight capability linking the major port estuaries and north-south rail routes. This intervention has the potential to reduce the industry's trading cost base and improve links to the country's major ports in the North of England. Recognising the importance of freight TfN has commissioned a freight strategy. We will integrate the findings of the Northern Freight Study in the next iteration of the report.

3.3.13 The DfT and TfN have outlined their vision for transforming connectivity in the North through their *One North, One Agenda* report.[41] The report was compiled by the northern city regions, HM Government and the national delivery agencies and sets out how enhancing transport linkages between northern cities are essential to boosting productivity, investment and employment, and delivering the Northern Powerhouse.

3.3.14 The case for action in the Northern Powerhouse Highways Plan[42] puts forward two key arguments:

- The number, capacity and reliability of east-west road connections is a constraint on the northern economy
- There are areas of severe congestion on the road network, with high demand for freight from northern ports

3.3.15 This plan also includes a shared roads vision for the future, which includes:

- Improved east-west major road links to ensure better, more reliable journey times between the major cities in the North
- A core free-flow network with mile-a-minute journeys becoming increasingly typical on expressways and motorways in the North of England
- Effective road connections to the country's major ports in the North of England
- Future-proofing the northern road network so that it can support the next generation of low-emission vehicles
- Better planning of investment in road enhancements, maintenance and renewals between the different organisations

3.3.16 Another key objective for TfN is to create a more environmentally sustainable transport network by ensuring that steps are taken to reduce the environmental impact of all modes of transport. Currently, large volumes of heavy goods vehicles (HGVs) and other traffic flow through the PDNP, damaging natural heritage. The potential removal of strategic through-traffic currently crossing the National Park on existing routes would offer significant local benefits.

3.3.17 The DfT also identifies linkages across the Pennines as one of the main gaps in connectivity in the North. Current road linkages between two of the main urban centres, Manchester and Sheffield, are among the worst in the country in terms of

[41] Leeds, Liverpool, Manchester, Newcastle and Sheffield city regions, One North*: A proposition for an interconnected North,* July 2014

[42] DfT. *The Northern Powerhouse: One agenda, one economy, one North, A report on the Northern Transport Strategy*, March 2015

capacity, journey times, safety and reliability.[43] This is made worse by the fact that rail connections between the two cities are also considered to be too slow.

3.3.18 The DfT's strategy to enhance connectivity in the North (including links across the Pennines), is aligned with its overall strategy for transport investment in that these should provide capacity and connectivity between cities, while ensuring environmental objectives are also met. It is also aligned with wider Government policy and regional economic strategies, including:

- HM Treasury's *Reducing the Deficit and Rebalancing the Economy*,[44] which explores spatial patterns of investment and employment in the North and seeks improvements by plugging infrastructure gaps
- HM Treasury's Fixing the Foundations,[45] which is specifically focused on boosting productivity in the UK through infrastructure investment, in particular road infrastructure

3.3.19 In November 2015, TfN presented a six-month update on the progress made against each element of the Strategy, and a look ahead to the work expected by spring 2016. The report confirmed TfN's vision for roads in the North, including the concept of a core free-flow network of motorways and expressways offering reliable 'mile a minute' journey times, linked to local networks and to key locations including ports, airports and other logistics hubs. The report states that central to achieving this vision is 'increased capacity and improved major road links east-west across the Pennines.'

3.3.20 In March 2016 TfN, alongside DfT published its *Northern Transport Strategy Spring 2016 report*[46] which reaffirmed the Government's commitment to improving transport links between major cities in the North, putting this at the heart of its plans to build a Northern Powerhouse. It identified the priorities for future investment in the North's strategic road network and indicated the Trans-Pennine Tunnel as one of the key strategic link/priorities.

3.3.21 At a sub-national level, the Sheffield City Region's *SEP*[47] sets out the region's ambitions for boosting economic growth, setting targets to narrow the economic gap over the next 10 years through the creation of 70,000 jobs, increasing GVA by 10% (or £3 billion) and creating 6,000 additional businesses beyond their baseline growth rates. It also includes aspirations for the following:

- Reducing the amount of productive time lost on the SRN
- Improving the resilience and reliability of the SRN
- Improving surface transport linkages to international gateways
- Promoting efficient and sustainable means of freight distribution

3.3.22 Greater Manchester's *SEP*,[48] which identifies priorities for growth and regeneration, also has transport sitting at the heart of its ambitions to boost economic growth, well-being and the environment. The Plan for Growth and Reform in Greater

[43] DfT. *Trans-Pennine routes feasibility study*, March 2015

[44] HM Treasury. *Reducing the deficit and rebalancing the economy*, April 2015

[45] HM Treasury. Fixing the foundations: creating a more prosperous nation, July 2015

[46] *TfN and DfT, Northern Transport Strategy Spring Report, March 2016*

[47] Sheffield City Region LEP. *Sheffield City Region's strategic economic plan,* March 2014

[48] Greater Manchester LEP and Greater Manchester Combined Authority. *Stronger together: Greater Manchester strategy,* 2013

Manchester,[49] indicates the potential to create another 80,000 jobs during the period to 2020, while the Greater Manchester *SEP* highlights the potential to deliver an additional 120,000 new jobs over the next 20 years and includes a target to deliver more than 60,000 new homes between 2013 and 2020. It also has similar aspirations with regard to the transport network, as outlined by the Sheffield City Region Local Enterprise Partnership (LEP) and in the *Greater Manchester Transport Strategy 2040 – Our vision* document.[50]

Implications for the Trans-Pennine Tunnel

3.3.23 The key point here is whether a tunnel under the Pennines fits with overall national policy. Based on the above, the following factors suggest that a tunnel could:

- bring two of the major urban centres in the North (Manchester and Sheffield) effectively closer through significantly reducing journey times and the overall cost of travel, as well as relieving congestion on other routes, which would impact positively on productivity in the North through agglomeration benefits (as per HMT's *Fixing the Nation*)
- impact on the spatial patterns of investment and employment in the North through closing one of the most challenging gaps in connectivity in the North (as per HMT's *Reducing the Deficit and Rebalancing the Economy*)
- contribute to a single economic area in the North through enabling more commuting and trade between Manchester and Sheffield (as per the Chancellor's vision for a Northern Powerhouse and DfT's *Northern Transport Strategy*)
- provide capacity and much needed connectivity between two major cities, as well as improve east-west connectivity (as per the DfT's strategic objectives for transport investments)
- contribute to the aspirations of the northern regions to transform connectivity in the North and maximise economic benefits (as per the *Northern Way* and the *One North* vision)

3.3.24 The next section considers how investment in transport infrastructure can lead to increases in economic productivity.

3.4 Potential outcomes arising from the Trans-Pennine Tunnel

3.4.1 There are important challenges to overcome but there are also opportunities. The development of a new trans-Pennine route presents opportunities in terms of:

- Connectivity – through reduced journey times and improved journey reliability between the two city regions and the wider North and through contributing significantly to the aims of the *Northern Transport Strategy*
- Capacity – through potentially reducing delays and queues that occur on the existing routes and network, particularly during the peak periods, and through creating a realistic additional route to the M62

[49] Greater Manchester Combined Authority, Greater Manchester LEP & Association of Greater Manchester Authorities. *A plan for growth and reform in Greater Manchester*, March 2014

[50] *TfGM, Greater Manchester Combined authorities and Greater Manchester LEP, Greater Manchester Transport Strategy 2040, Our Vision, due to be published in 2016*

- Safety – through potentially reducing the number of collisions on exiting roads, and their associated costs and impacts on lives, and also reducing their impacts on network performance
- Resilience – as a result of reducing the number of road closures, often resulting from inclement weather, there would be a significant improvement in resilience between Manchester and Sheffield
- Environment – through building tunnels, there will be an opportunity to avoid unacceptable impacts on the PDNP, and through active traffic management, there will be reduced traffic on completed routes

3.4.2 The challenges and policy objectives described earlier are wide ranging and will require different interventions across skills, business support, digital and physical infrastructure to be fully addressed. Transport can often have an important role to play in supporting economic development but it cannot solve every problem. Generally, transport investment is an enabler of economic growth helping to promote economic development where the conditions and potential are already in place. It can also have wider effects on the structure and performance of an economy.

Understanding the links between transport and the economy

3.4.3 By investing in local, regional, national and international transport networks, the associated reduction in transport costs will:

- enable businesses to serve markets further afield and be more competitive in markets that they currently serve
- make it easier for businesses to connect more easily with potential suppliers, allowing them to access inputs of higher quality and/or lower cost
- provide consumers with improved access to a wider range of suppliers, offering quality improvements and/or lower prices
- improve the functioning of the labour market, increasing the effective size of the market and allowing skills to be better matched to employment opportunities

3.4.4 In turn, reduced transport costs reduce barriers to trade, enabling markets to function more efficiently, stimulating competition and driving improvements in productivity. Those areas that are better connected could benefit from larger 'effective market sizes', leading to economies of agglomeration and increased specialisation, which in turn could generate productivity gains over and above the transport cost efficiencies.

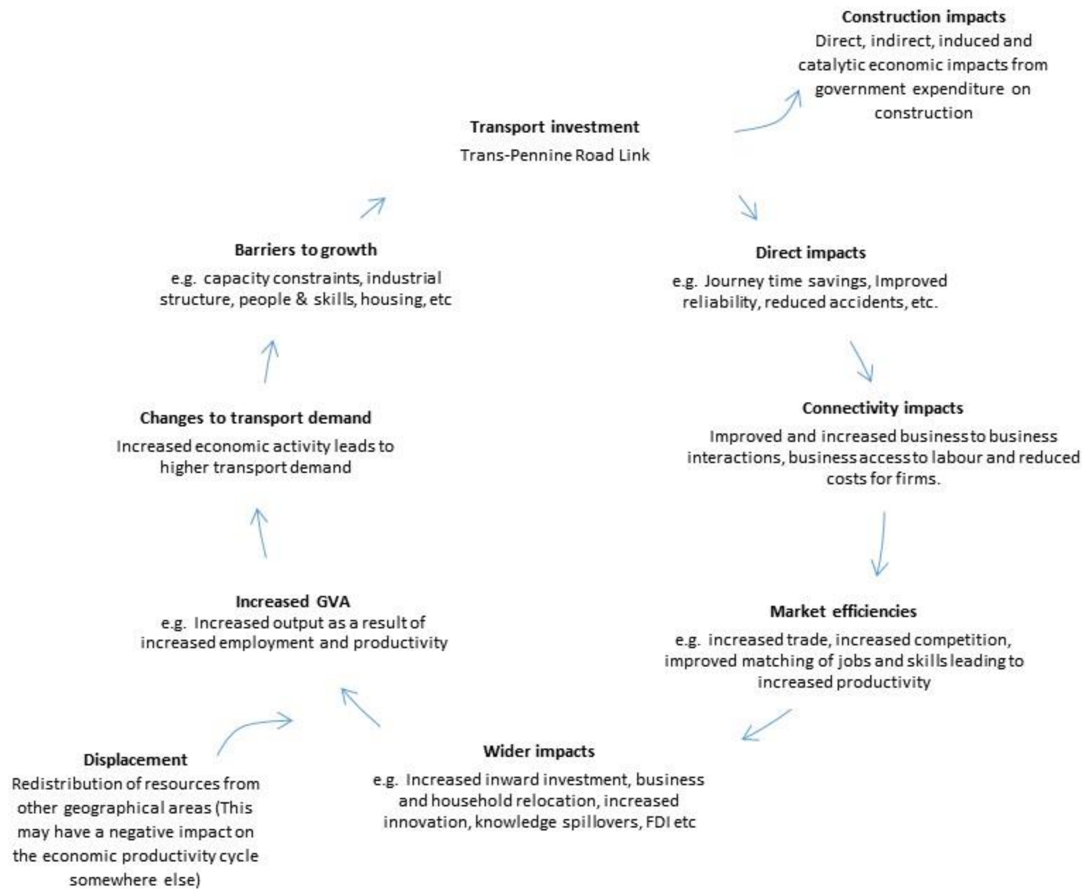
3.4.5 Changes in transport connectivity driven by increased capacity and reduced journey costs can lead to increased levels of economic productivity through:

- specialisation of labour and specialisation within supply chains
- matching of skills to jobs, and suppliers to customers
- sharing of inputs with a minimum efficient scale
- learning through knowledge spill-overs

3.4.6 These benefits arise through urban agglomerations but they are also present in networks of city economies which "borrow size" from each other.

3.4.7 Figure 3-7 sets out the mechanisms under which transport investment can drive economic outcomes. The flow highlights how direct impacts from a transport investment such as the Trans-Pennine strategic road link could create market efficiencies leading to investment and relocation decisions which, in turn, can grow the economy. This continues until transport demand generated by increases in economic output lead to new barriers to growth, which need to be addressed by further investment in infrastructure and other policy measures.

Figure 3-7 – Economic Productivity Cycle



3.4.8 The relationships between transport investment and economic performance (TIEP) are complex and can be quite wide ranging. Following Venables, Laird and Overman[51] these impacts can be structured under:

- Direct impacts – time and cost saving change traffic flows in the network, leading to increased flows in some parts of the network and possibly less traffic elsewhere
- Market efficiencies – transport investment can increase proximity by reducing the effective distance between firms and workers, which can generate economies of scale and density, increasing productivity and reducing costs
- Investment and relocation – at a wider spatial scale there may be changes in the level and distribution of investment, and hence in the spatial pattern of employment and incomes in the economy. Importantly, inward investment and relocation decisions may have a negative impact on economic performance elsewhere and resources are displaced

3.4.9 In addition to potentially changing the structure and performance of the local economy over the long term, the construction of large infrastructure projects provides an injection of resources during construction. If there are underutilised local resources

[51] DfT. *Transport investment and economic performance: Implications for project appraisal,* December 2014

such an injection could have positive impacts on the Northern Economy, raising local employment and output.

3.4.10 The impacts of increased connectivity as a result of market efficiencies are more difficult to define. Creating new linkages and improving the overall accessibility of a location gives individuals and businesses a wider range of choice over where to live, work and do business, which in turn generates economic benefits through increased productivity and spill-over effects. Productivity gains associated with agglomeration can be one of the most significant impacts of increased connectivity.

3.4.11 A lack of overall connectivity within and between the northern regions has been highlighted as one of the main transport and economic policy objectives for the North. The overall capacity of the transport network between Manchester and Sheffield (and other cities) has also been highlighted as a constraint on the transport network and economic linkages of the northern city regions. The Trans-Pennine Tunnel could therefore generate significant wider impacts through the mechanisms described above. This is one of the areas to be investigated.

3.5 Strategic fit of the scheme with wider policy goals

3.5.1 In this section of the report we consider the strategic fit of the Trans-Pennine scheme to wider government policy. To that end Table 3-5 shows a clear and strong fit between national, sub-national and local policies, strategies and plans against the objectives of the scheme. We have reviewed and developed the following objectives, based on the case for change and taking into account comments received from the Stakeholder Reference Group:

- **Objective 1**: To provide a safer, faster, and more resilient road connection between Manchester and Sheffield, creating more capacity and an additional east-west connection.
- **Objective 2**: To fulfil the aims of the *Northern Transport Strategy* to deliver a scheme that will contribute to the transformation of the economy in the North.
- **Objective 3**: To protect and improve the natural environment by reducing through-traffic in the Peak District National Park and by getting the right traffic onto the right roads.
- **Objective 4**: To support wider socio-economic needs and leave a long-term legacy of improved road connectivity, better access to labour markets, wider employment opportunities, better land use, and more effective integration between transport modes.

Table 3-5 – Summary of key policies, strategies and plans

Policy/strategy/study	Relevance to Trans-Pennine Tunnel Study	Scheme Objectives			
		Objective 1	Objective 2	Objective 3	Objective 4
Northern Transport Strategy: Spring 2016 Report	Identified the priorities for future investment in the North's strategic road network including the key strategic road link between Greater Manchester and the Sheffield City Region, the 'Trans Pennine Tunnel'.	✓	✓	✓	✓

Policy/strategy/study	Relevance to Trans-Pennine Tunnel Study	Scheme Objectives			
		Objective 1	Objective 2	Objective 3	Objective 4
Northern Transport Strategy: Autumn 2015 Report	Confirmed TfN's vision for roads in the North. The report states that central to achieving this vision is 'increased capacity and improved major road links east-west across the Pennines	✓	✓	✓	✓
Pan-Northern Connectivity: A Catalyst for Growth in the North, January 2016, Barnsley Metropolitan Borough Council and Doncaster Metropolitan Borough Council	Calls for an eastern extension to the proposed trans-Pennine link through the Dearne Valley to the M18 near Doncaster in order to provide an alternative trans-Pennine route between the North West and the Humber ports and provide transformative economic benefits to South Yorkshire.	✓	✓		✓
Greater Manchester Transport Strategy 2040 Our Vision, July 2015, Transport for Greater Manchester (Greater Manchester LEP and Greater Manchester Combined Authority)	States need for improved trans-Pennine routes and identifies requirement of a new trans-Pennine route	✓	✓		✓
Transport for the North, March 2015, Ed Cox and Luke Raikes, Institute for Public Policy Research	Transformations to an interconnected powerhouse and need for strategic investment	✓	✓		✓
The Northern Powerhouse: One agenda, one economy, one North – A report on the Northern Transport Strategy, March 2015, March 2015,DfT, HS2, Highways England, Transport for the North	Identifies TfN's vision to address the gap in economic performance. Highlights the need to address east-west connection constraints	✓	✓	✓	✓
Trans-Pennine Routes – Feasibility Study (Stage 1 Report) February 2015, Highways England	Improvements to connectivity locally and between cities and regions are seen as fundamental to the future of the northern economies. Clearly identifies challenges and directs towards the need to consider longer-term solutions	✓	✓	✓	✓
National Infrastructure Plan, December 2014, HM Treasury	States the need to consider improvements to trans-Pennine connectivity as "*an historic opportunity to link two of our great northern cities; this work will be taken forward with Transport for the North*". Highlights the significant positive effect new infrastructure	✓	✓	✓	✓

Policy/strategy/study	Relevance to Trans-Pennine Tunnel Study	Scheme Objectives			
		Objective 1	Objective 2	Objective 3	Objective 4
	can have on productivity, growth and the wider economy				
National Policy Statement for National Networks, December 2014, DfT	Sets out the need for, and Government's policies to deliver, nationally significant infrastructure projects. Strategic objectives are related to connectivity; resilience; facilitating growth; reliability; safety; low-carbon economy; joined-up communities	✓	✓	✓	✓
Great North Plan, November 2014, IPPR North	"*The North of England needs infrastructure projects capable of genuinely transforming the northern economy as it makes the journey from an industrial past to a dynamic, diverse, and sustainable economic future*."	✓	✓	✓	✓
One North: A Proposition for an interconnected North, July 2014, City regions of Leeds, Liverpool, Manchester, Newcastle and Sheffield	Advocates better connectivity, journey-time reliability and travel quality to strengthen the economy. Identifies the need for transformational change	✓	✓		✓
Transport – an engine for growth, August 13, DfT	Confirms the Government's intention to provide a broad and balanced investment package: striking a balance between maintaining the UK's existing transport assets and developing new schemes, and in geographical terms by supporting a wide range of benefits in all parts of the country	✓	✓	✓	✓
Investing in Britain's Future June 2013, HM Treasury	Describes the road network as fundamental to the UK economy. Sets out the Government's commitment to major investment in the road network, but also makes clear that improvements to the road network must be brought forward in a way that supports the nation's overall quality of life and environment	✓	✓	✓	✓
National Planning Policy Framework (NPPF), March 2012, Department for Communities and Local Government	Highlights the Government's commitment to ensuring that the planning system does everything it can to support sustainable economic growth			✓	✓

Policy/strategy/study	Relevance to Trans-Pennine Tunnel Study	Scheme Objectives			
		Objective 1	Objective 2	Objective 3	Objective 4
Peak District National Park Sustainable Transport Action Plan (2012 – 2017)	A strategic document that outlines the Peak District National Park Authority and its partners' aspirations for transport in the Peak District			✓	✓
Peak District National Park – Local Development Framework, Peak District National Park, *adopted in October 2011*	Identifies cross-Park traffic as a continuing challenge. High-accident rates on routes lead to the pressure for new road infrastructure			✓	✓
The Plan for Growth, March 2011, HM Treasury	Identifies the improvement of links that help to move people and goods around as an important factor in helping to build the balanced, dynamic, low-carbon economy that is essential for the UK's future prosperity	✓	✓	✓	✓
Creating Growth, Cutting Carbon – Making Sustainable Local Transport Happen, January 2011, DfT	States the need for improved trans-Pennine routes and identifies requirement of a new trans-Pennine route	✓	✓		✓

3.6 Strategic case summary

3.6.1 Our preliminary analysis of the strategic case for a strategic road link between Manchester and Sheffield:

- identifies the challenges and opportunities facing the region
- considers the available options to address the issues
- describes the possible outcomes arising from investment/intervention

3.6.2 Relatively poor inter-urban transport networks resulting in relatively poor levels of economic connectivity contribute to relatively weak economic performance in the North. The Government's strategy to support the vision of a balanced economy will need to include a package of measures:

- Investing in a world class transport system to link individual towns and cities and local networks to enable all parts of the North to connect, compete and collaborate
- Supporting wider socio-economic development by investing in skills, support for business and urban regeneration
- Protecting the natural environment and improving the built environment to promote the North's towns and cities as amongst the best in the world to live and work

3.6.3 In light of these trends, the Government and the authorities in the North have unveiled their vision for unlocking growth in the region and creating a Northern Powerhouse. The programme of investment is focused on infrastructure, skills and innovation. The

DfT and TfN have set out their vision for transport in the North within The Northern Powerhouse: One Agenda, One Economy, One North.

3.6.4 Investment in a strategic trans-Pennine link (with a long section of tunnel) is central to achieving the strategic objectives of Government and of the authorities of the North in terms of facilitating regeneration and unlocking growth in the Northern Powerhouse and delivering the *One North* vision – it is strongly aligned to national, sub-national and local policy objectives.

3.6.5 The case for change is clear in that many of the transport interventions required to deliver the Northern Powerhouse are about improving east-west connectivity on both the road and rail networks. The current transport routes across the Pennines between Manchester and Sheffield are among the poorest in the country, limiting opportunities for economic interactions between two of the major urban centres in the North and adding pressure on other parts of the transport network.

3.6.6 In the main, the strength of the case centres on the ability of the scheme to contribute to the Government's vision to rebalance the UK economy and establish the North as a global economic powerhouse that builds on the existing strengths of Northern city regions, attracts and retains the brightest and best talent and attracts investment from overseas.

4 Economic case

4.1 Introduction

4.1.1 In the previous section, we outlined the Strategic Case for a new trans-Pennine strategic road link and how poor transport connections have resulted in lost opportunities for the North, reducing growth and economic welfare. This section discusses further the types of impact that a strategic road link between Manchester and Sheffield might have and we describe the potential for such a solution to increase growth and welfare by removing constraints.

4.2 Potential economic impacts of a strategic link across the Pennines

4.2.1 A strategic road link between Manchester and Sheffield could have a number of benefits, although it is too early to estimate specific impacts. These will be assessed in the final stage of this study, once more detailed scheme options have been identified and shortlisted.

4.2.2 We will be considering benefits of the link in line with *WebTAG*, which sets out the potential benefits that might arise:

- User benefits – Reducing journey times and costs, improving safety and increasing journey time reliability could generate direct benefits to individuals and businesses using a new strategic road link between Sheffield and Manchester as well as releasing network capacity and improving network conditions on other parts of the road network
- Wider economic benefits – Reducing journey times and costs, improving safety and increasing journey time reliability could lead to wider economic benefits from increased productivity, inward investment and increased employment through what are referred to as static and dynamic agglomeration impacts as part of functional urban areas and poly-centric metropolitan regions

4.2.3 The transformative nature of the investment into a strategic road link between Manchester and Sheffield means that the wider economic impacts could be considerable. For example, there are a number of travel constraints between Sheffield and Manchester (delays on existing routes, lack of capacity for overall east/west movements, resilience during periods of inclement weather, impacts on the National Park, large number of collisions - which have been discussed in more detail within Section 3; The Strategic Case) that stop economic centres becoming better connected and experiencing large productivity gains. Another example is how investment in the strategic road link could lead to significant changes in transport costs between Sheffield and Manchester, which in turn, could attract substantial new investment to the area, leading to a step change in employment, output and prosperity.

4.3 User benefits from faster, cheaper, safer and more reliable journeys

4.3.1 The starting point for the estimation of the economic impact of the changes arising from the investment is in developing a clear view of the potential impact of the investment on the transport network.

4.3.2 As the study progresses, the economic analysis will be supported by a strategic traffic analysis that is currently being undertaken using a comprehensive set of traffic information. The primary datasets for this analysis are the Highways England interim TIS (Trip Information System) and the DfT Trafficmaster data. These provide complete datasets for March 2015 for national origin-destination movements and travel times.

4.3.3 The initial analysis from the Trafficmaster data shows that the average distance and travel time between Manchester and Leeds, and vice versa, is around 45 miles and 65 minutes, and the overwhelming majority of observed trips use the M62. The distance between Manchester and Sheffield via the M62 is around 75 miles and the average travel time, in both directions, is 95 minutes. This clearly highlights the relative accessibility of Leeds and Sheffield to Manchester.

4.3.4 The average distance and travel time between Manchester and Sheffield via other trans-Pennine routes is around 40 miles and 75 minutes without traffic, in both directions. The distribution of trips using the M62 compared to other routes reflects this. Only around 10% of total trips between the urban areas of Sheffield and Manchester use the M62.[52]

4.3.5 The TIS data has been analysed to determine the current trip patterns between Greater Manchester, West Yorkshire and South Yorkshire. The volumes of observed movements are indicative of the economic interactions between these regions. The interaction between Greater Manchester and West Yorkshire is around 50% of that between West Yorkshire and South Yorkshire. What is most noticeable is that the interactions between South Yorkshire and Greater Manchester are only 10% of those between South and West Yorkshire. The observed data further highlights the relatively low levels of interaction between the Manchester and Sheffield regions.

4.3.6 The TIS data will be analysed in more detail during the next stage of the project and will be supplemented with inputs from TAG and a suite of regional models, including PLANET. This will enable a set of option-specific traffic forecasts to be developed for Stage (iii)c of the project.

4.3.7 The construction of a strategic road across the Pennines will create a high standard link that will complement the M62 between the M1 and the motorway system to the east of Manchester. At this stage of the study we have not developed a specific route alignment; however we have been able to quantify journey time savings, resulting from a new strategic link, at the corridor level using a notional route within each corridor. The journey time savings are outlined in more detail within Section 9 of the report and show that despite the fact that there are different origin and destination pairs the volumes for each of the five corridors is very similar.

4.3.8 The observed journey times on surface roads over this section of the Pennines are 50 minutes, implying an average speed of 30mph. These speeds are likely to deteriorate as future growth in the corridor leads to further congestion over time. By contrast, we have assumed that a new strategic link will have an operating speed of 60mph. Based on the same distance as the surface roads, the journey time would be around 25 minutes. This implies a journey-time saving of around 30 minutes when we allow for growth and further increases in future years. The journey-time savings need to be verified at the next stage; however, a working assumption of a saving of 30 minutes across the National Park is appropriate for the scenario analysis undertaken at this stage.

4.3.9 Transport user benefits from journey time savings generally contribute a significant component to the economic benefits of a scheme. A transformational change of this order could generate significant social user benefits. In addition, a high quality strategic link could also generate significant reliability and safety benefits that will contribute to the economic case. The scheme could also have an impact on business users and transport providers and contribute positively to the economy. In particular,

[52] Based on analysis of Trafficmaster journey time data for centres of gravity for Manchester and Sheffield.

the freight industry could benefit from capitalising on cost reductions for long distance trips, rerouting and significant improvements in reliability.

4.4 Potential for wider economic benefits

4.4.1 By reducing journey times and costs, improving safety and increasing the reliability of journeys between Sheffield and Manchester, a new strategic road link would reduce impedances to travel and improve connectivity between people and places. In turn, this could lead to:

- increased productivity from static agglomeration impacts including: increased competition, potential for technology spill-overs, economies of scale from access to larger markets, increases in productivity of the labour force through better matching of skills to employer needs and specialisation of service industries that reflect increased trading opportunities from growing product markets
- increased inward investment and employment arising through dynamic agglomeration impacts involving a relocation of households and businesses to locations that offer better commercial opportunities and improved quality of life

4.4.2 In support of these observations, we note the following:

- The scheme is expected to deliver very large travel time saving between Manchester and Sheffield (up to 30 minutes), considerably larger than for other improvements to the strategic road network. For example, evaluation evidence from the 2016 Post-Opening Project Appraisal (POPE) meta-analysis suggests average peak-time saving of around 3 minutes for Strategic Road Improvements. As a consequence it seems plausible to assume that a trans-Pennine tunnel could generate wider benefits by increasing the number of businesses and households located in Manchester and Sheffield.
- The scheme is mostly within the hinterland to the core functional urban areas of Manchester and Sheffield. WebTAG Unit A2.1 defines the core of a functional urban area as an area with 'a minimum working population (of 60,000) together with a minimum job density (of 7 jobs per hectare) for each ward' and the hinterland as the area around the core where 'more workers in the ward commute to that core than to any other core and a minimum 10% of the working population commutes to that core'. This Unit recommends that 'agglomeration impacts are most significant for transport schemes located within, or near, large and dense employment centres' (that is, those within the core or hinterland areas). As a consequence, it seems plausible that the Tunnel may generate agglomeration benefits by improving connectivity between Manchester and Sheffield.
- The scheme is expected to deliver travel time saving of up to 30 minutes, reducing travel times from the current 85 minutes to nearer 55 minutes.[53] Evidence from Rice, Venables and Pattachini[54] suggests that agglomeration benefits tail off for travel times over 45 minutes, roughly equal to average travel times between Manchester and Sheffield with the Tunnel. As a

[53] Based on the generalised cost (expressed in minutes) for the PLANET Long Distance model origin-destination pair of Manchester-Sheffield.

[54] Rice, P. G., Venables, A.J. and Pattachini, E., Spatial determinants of productivity; Analysis for the UK regions, Regional science and urban economics, 2006

consequence, it seems possible that the Tunnel may generate agglomeration benefits by improving travel times between Manchester and Sheffield.

4.4.3 The following sections consider the potential for wider economic impacts in more detail following a 'theory of change' tracing the impact of the new strategic link on travel times, the change in connectivity, the impact on productivity (static agglomeration), the impact on investment and employment (dynamic agglomeration) and the impact on economic output.

4.5 Impact of a new strategic road link on travel times

4.5.1 A new strategic link between Manchester and Sheffield affects the calculated values of economic mass for each modelled zone (geographical area), by changing journey times between pairs of zones. Changes in journey times estimated from the traffic analysis are translated into generalised cost saving, and so change the economic mass or connectivity of individual zones.

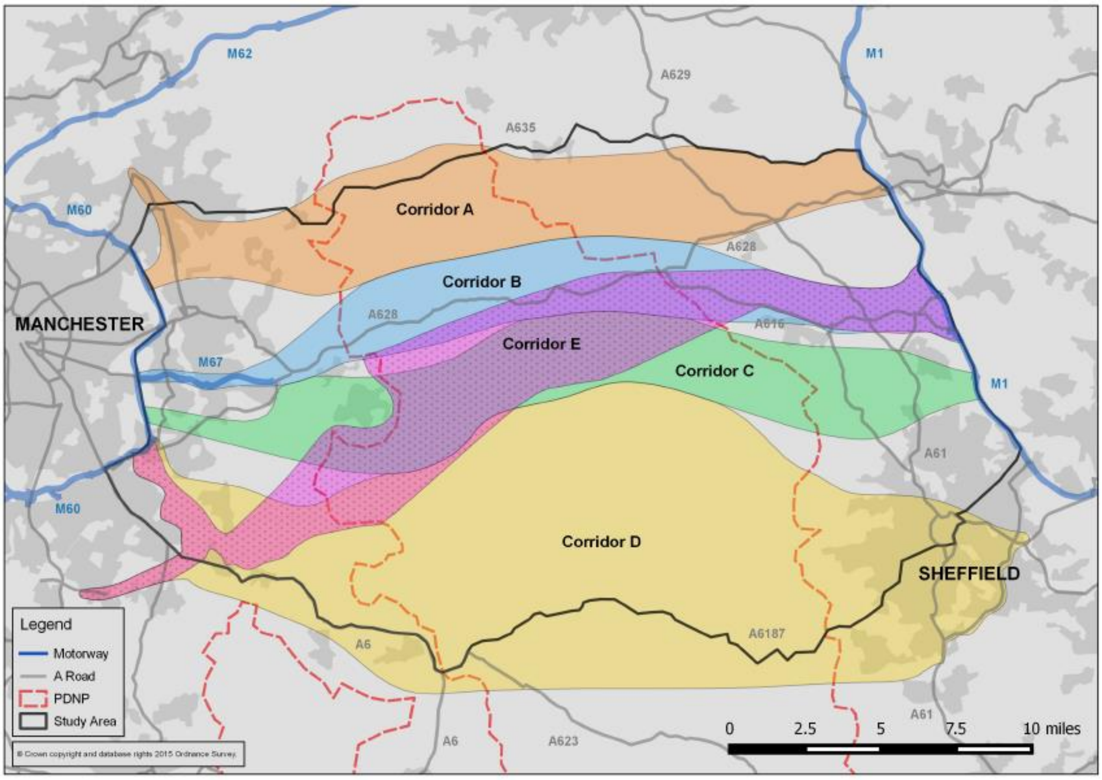
4.5.2 It is important to note in relation to the traffic analysis that:

- at this stage the traffic model only considers first order time saving, it does not consider impacts on journey reliability or feedbacks such as congestion (or decongestion) created by changes in traffic flows, which could materially affect the overall results
- the traffic modelling is based on the transport network in 2010, and that by 2037 (our year of analysis) without a new strategic link between Manchester and Sheffield the network is likely to be more congested, and so time saving will be greater
- the traffic model provides journey times between 16 sectors, covering the whole of the UK, whilst the time saving is disaggregated into the PLANET[55] zone pairs based on distribution of employment, which results in the data on time saving by zone are relatively coarse and means that the model may be over or under counting time saving in some zones

4.5.3 The journey time savings have been estimated for each of the five alternative corridors in Figure 4-1. In brief, for every minute of journey time saved by Corridor D, 53 seconds are saved on Corridor C, 50 seconds on Corridor B, 47 seconds on Corridor A and 46 seconds on Corridor E.

[55] *PLANET is a model developed by HS2 Ltd. as a tool to forecast the demands for and benefits of HS2, and provides information in changes in public transport use over time.*

Figure 4-1 – Trans-Pennine corridor options



4.6 Impact of a new strategic road link on connectivity

4.6.1 The distribution of economic activity will also respond to the increases in connectivity afforded by the new link, as businesses move to take advantage of the new link. These land use changes will result in changes to the economic mass of places, and therefore will affect overall productivity. The economic sector mix of places will also change, creating a further impact on productivity.

4.6.2 At present the modelling does not account for these impacts, but in so far as the new link leads to the clustering of economic activity, land-use change will magnify the productivity benefits of a new trans-Pennine link. This analysis will need to be consistent with the economic scenarios developed by the DfT to support the analysis of the Northern Powerhouse once they have been further developed.

Table 4-1 – Average change in connectivity by area in 2037 after investment

Region	Corridor				
	A	B	C	D	E
Greater Manchester	1.67%	2.33%	2.41%	2.13%	2.09%
South Yorkshire	2.60%	3.81%	3.92%	4.20%	3.63%
West Yorkshire	0.13%	0.07%	0.03%	0.00%	0.03%
East Midlands	0.80%	1.08%	1.10%	1.11%	0.99%
East Yorkshire	0.05%	0.07%	0.07%	0.08%	0.10%
Merseyside	0.97%	1.16%	1.19%	1.72%	1.44%
Tyne and Wear	0.14%	0.23%	0.24%	0.13%	0.04%
Great Britain	0.22%	0.31%	0.31%	0.31%	0.27%

4.6.3 Table 4-1 shows the change in connectivity by areas in 2037 with the investment, where connectivity is measured following the approach adopted by SERC (Spatial

Economics Research Centre). This is simple but it skews the analysis in favour of shorter distance trips and therefore may not be as appropriate for the analysis of this scheme as measures based on observed travel patterns. As discussed below, further sensitivity testing will be undertaken on the use of alternative decay curves in Stage (iii)c.

4.6.4 As expected, a new trans-Pennine road link will have the greatest impact on connectivity for Greater Manchester and South Yorkshire but other areas are also likely to experience significant improvements, especially those areas for which trans-Pennine movements are important including Merseyside and the East Midlands. Corridors in the south of the study area are estimated to have a greater impact on overall connectivity than corridors in the north of the study area which compete more with existing road links.

4.7 Impact of changes in connectivity on changes in economic productivity

4.7.1 The impact of changes in connectivity on changes in economic productivity is uncertain and much depends on the nature of the scheme or programme and the assumptions made relating to the underlying economic effects.

4.7.2 The analysis will therefore consider a range of alternative assumptions on the specification of the measure of connectivity (especially the distance decay curve) and the range of elasticities tested:

- Those recommended in WebTAG
- Those recommended in TIEP
- Those included in the SERC report

4.7.3 As part of this sensitivity testing it will be necessary to make alternative assumptions relating to the inclusion of 'people' effects (skills, experience and other characteristics) and the impact of dynamic agglomeration (see below).

4.7.4 Estimates of elasticities are highly uncertain. Methodological and data issues make robust analysis challenging and have led to considerable debate over the integrity of the resulting elasticity estimates. Given that at this stage we only report a ranking of results we have not explored scenarios around elasticities to reflect this uncertainty. This is because the magnitude of the elasticity will not affect rankings. Non-linearity in elasticity would affect both the magnitude and ranking of the results, however further research needs to be done to enable a sufficiently robust approach to non-linear elasticities to be applied.

4.8 Impact of changes in connectivity on investment and employment

4.8.1 If the Northern Powerhouse growth objectives are achieved, the levels of economic interactions between the different parts of the North will look very different from what they are today. In particular there is the potential for the investment – by improving links – to lead to housing and commercial developments being unlocked. The economic value of housing would be in the form of the effective labour market that is available for business, which is now widely acknowledged by Government as essential to unlocking growth. Transport investment allows more workers to access jobs in locations where they can be more productive. Land use will also change and the amount of labour able to access jobs will increase further. Since this is closely linked to patterns of investment, it will be addressed accordingly. Evidence for this is from business surveys and academic research,[56] which describes labour markets as a key factor in business location and investment decisions. The second is specifically

[56] DfT. *Transport investment and economic performance: Implications for project appraisal,* December 2014

concerned with the employment capacity that comes through commercial development in the way that transport makes locations more attractive for investment.

4.8.2 There is also the potential to increase the attractiveness of locations across the North for business investment into the North leading to higher levels of output and jobs. These impacts will be estimated at a later stage of this study, once a better understanding is reached on the specific developments that are likely to be unlocked by the investment and the wider transport network effects are taken into account.

4.8.3 It should be acknowledged that not all investment and employment that comes to the North as a result of investment in a trans-Pennine tunnel will be additional to the UK economy. Some investment and jobs will come at the expense of other regions. Even so this could be beneficial if other areas are overheating. For example, it is often argued that the UK economy is unbalanced, with shortages of labour in the South East leading to inflationary wage pressures and high prices for accommodation. In such a case, a shift of jobs to the North may well result in a better balanced economy, which is less subject to overheating. Again, the degree to which this might be the case is an empirical issue and will need to be investigated in later stages of the study.

4.8.4 It will therefore be important to understand in future analysis:

- the degree to which investment and jobs are additional to the UK
- where that investment and jobs have come from
- to what extent the transfer of investment is a good or bad thing

4.8.5 The economic literature suggests that one of the main mechanisms by which national impacts could be additional is through attracting international investment. In this context, growth in Manchester and Sheffield generated through enhanced international competitiveness is less likely to result in offsetting reductions in employment or economic density elsewhere in the country.

4.8.6 Data collected annually from UK Trade and Investment suggests that foreign direct investment contributed to 25% of all jobs in the UK between 2004/5 and 2012/13 – both newly created and safeguarded jobs. This is directly linked to the investment that will be unlocked by the land-use developments associated with the investment and so will be explored in more detail in Stage (iii)c of this study.

4.9 Impact of changes in economic productivity on Gross Value Added

4.9.1 The productivity change for each zone (arising from static agglomeration impacts only) is applied to its productivity in the do-minimum scenario for 2037. Productivity is multiplied by the number of workers in that year to give gross value added (GVA). The overall impact is given by the difference between the do minimum and the trans-Pennine link scenarios. This is repeated for all corridor options.

4.9.2 The do-minimum scenario reflects economic conditions for each zone in 2037 in the absence of the new trans-Pennine link. Productivity and employment are projected forward and for the purpose of this work, we have assumed that the additional growth is generated through improvements in productivity (output per worker).

4.9.3 The government and authorities in the North are considering future scenarios for the Northern Powerhouse and it is anticipated that this work will be reporting early in 2016. In future iterations of this analysis, we can incorporate the scenarios that emerge since these may shed more light on the mix of employment, population and output growth in the North.

4.9.4 However, we are able to draw on existing research on the Northern Powerhouse to run sensitivities on our analysis. The model framework includes a do-minimum with the realisation of the Northern Powerhouse vision and one which reflects growth more closely aligned to historical performance. In this case the North (covering the North West, North East and Yorkshire and the Humber) are assumed to grow faster than the historic rate.

4.9.5 The Northern Powerhouse assumptions used in this modelling framework are shown in Table 4-2 below, these are based on a recent data release by DfT. However, it is important to note that the choice of the Northern Powerhouse scenario does not affect the overall ranking of the corridors, but does affect the overall magnitude of the results.

Table 4-2 – Northern Powerhouse assumptions

Average annual change in employment		2015-2020	2020-2025	2025-2030
Policy on	North average forecasts	1.3%	0.8%	0.5%
	UK forecast	0.8%	0.4%	0.2%
Policy off	NTEM North	0.3%	0.3%	0.2%
	NTEM GB	0.4%	0.3%	0.2%

4.10 Discussion of the results

4.10.1 Our analysis provides a ranking of the five potential corridor options for the trans-Pennine road link, these are shown in Table 4-3 below. At this stage of the study we have not considered in detail the differential land use impacts for the corridors or the full set of sensitivities, including those relating to elasticities, decay curves, and the potential for economic growth.

4.10.2 Providing a ranking of these economic outcomes, provides a consistent basis to assess the potential benefits as a result from each corridor. However, it is important to note that the results are driven primarily by magnitude of time saving, and the corridors ranked more highly generally show higher overall time saving.

Table 4-3 – Corridor ranking and relativity for GVA benefits

	Corridor				
	A	B	C	D	E
GVA benefit relative to Corridor D	0.90	0.92	0.97	1	0.78

4.10.3 Overall, this analysis suggests that investment could generate additional output for the UK economy. These productivity benefits accrue to all regions, with the strong gains in Greater Manchester and South Yorkshire.

4.10.4 Corridor D ranks the best but the differences between schemes are not marked and may change as the modelling scope and assumptions are updated and plans for the Northern Powerhouse evolve. A and E emerge as lowest in the ranking of corridors. The differences between Corridor D and Corridor C are very small and the ranking is sensitive to input assumptions on the propensity to travel (the decay curve). Corridor E is estimated to deliver materially less economic benefits that the other corridors. However, the pattern of time saving across places is also important – as using a decay curve that gives more weight to longer journeys, leads to a change in the ranking of routes C and D owing to the differences in patterns of time saving.

4.10.5 This analysis is summarised alongside other factors as part of the corridor assessment in Section 9 of this report. It is important to recognise that Corridor D fails one of the viability assumptions (that is, construction of a surface route in the PDNP).

4.10.6 Some of the limitations of the modelling have been outlined above, and these results should be understood in the context of those limitations. Particularly, it should be born in mind that a more (spatially) granular analysis of time savings for each route could lead to a re-ordering of options and a change in the order of magnitude of saving.

4.10.7 However, the potential distribution of economic impacts stimulated by investment in the strategic road link depends on the ability of businesses and people to respond to changes in connectivity. The methodology employed makes the implicit assumption that transport connectivity is the only supply-side constraint to business location. In practice, there could be other constraints that could inhibit the potential location effects, such as the availability of skilled labour and land in a given location. Therefore, in order to realise the potential forecast impacts on business location across Britain, there may be a need for complementary changes to create an environment in which businesses can develop. However, the analysis assumes that the overall gains in output come from more efficient use of resources, rather than the use of new resource inputs, so the increased need for investment in areas to which businesses move is balanced by a reduced need for such investment in areas that they move from.

4.10.8 It is also important to recognise that these results are considered the first step in assessing the overall productivity impacts of investment in a new trans-Pennine road link on the UK economy and the distribution of total economic output across the country. There are a number of areas that merit further analysis to strengthen the analytical approach; the scope for addressing these continues to be developed, particularly the impacts of investment in scheme on prices, rents and wages in specific locations, and how this could affect the forecast impacts on both productivity and business location. Along with the methodology, the design of the scheme and the use of capacity on the existing road network continue to be refined. In that sense, the results presented should be treated as provisional.

4.11 Next steps

4.11.1 The key requirement for the next stage of the work is to build on the analysis undertaken at the corridor level and determine in more detail the transport impacts, including the impact on the wider transport network in the North. Alongside this, the other key next steps are as follows:

- Working with Government and authorities in the North to determine the future scenarios for the Northern Powerhouse – ‘do minimum’ scenario. As shown in the initial economic analysis, the shape of the economy in the North, for example in Manchester and Sheffield, will be a key driver of the actual benefits of the scheme – this is especially the case if the scheme becomes focused on ensuring that growth is not held back by constraints in the transport network once the Northern Powerhouse proposals start to take shape. Essentially this is about setting the future baseline for the North and a number of scenarios around it.
- Working with authorities in the North to determine the specific land-use interventions that are likely to be impacted directly by the scheme. The second key dimension to the work is the degree to which the investment will impact on investment and employment, and hence the spatial distribution of activity in the North.
- Liaising with the other strategic studies, in particular the Northern Freight Study, to start getting a sense of what the emerging conclusions are and how they can be integrated with this work. Coordination with other studies has already begun and we expect to include any relevant analysis in the Final Report.

5 Design and construction

5.1 Introduction

5.1.1 We have investigated the feasibility of building a new strategic link across the Pennines, including a long tunnel section under the PDNP between Manchester and Sheffield.

5.1.2 We have assumed that local communities, on either side of the tunnel, will want to be able to connect to the strategic link to allow them to realise benefits of the project, but this will be explored further in subsequent stages of this study.

5.1.3 We have explored ground conditions, assessed construction constraints and explored possible synergies with improved rail links across the Pennines.

5.1.4 We have assumed that a new strategic link will open 20-25 years from now and that the tunnel will be designed for an operational life of 120 years, in line with the existing design standards for highway structures.

5.1.5 Acknowledging the radical changes that will occur in this period, we will prioritise the likelihood of emerging technologies that impact on design requirements. We will consider changes in vehicle technology and in vehicle propulsion over the design period as they may result in different design responses. However, we will need to gather strong evidence for this future technology and its effect before any major changes to design assumptions are made.

5.2 Road standards and status

5.2.1 Forecast traffic flows are unavailable at this stage of the study and assumptions have to be based on likely predicted flows. The *Trans-Pennine Routes Feasibility Study*[57] assumed a base year annual average daily traffic (AADT) of 15,000 vehicles along the A628. From this, a potential opening year AADT of 20,000-35,000 vehicles was assumed as the tunnel will have the potential to generate significant additional trips.

5.2.2 Based on these flows, it is anticipated that the proposed cross section for the strategic road will be a dual carriageway and will need to have a minimum of two lanes in each direction. This will be reviewed in Stage (iii)c of the study, once further work on forecasting traffic flows has been undertaken.

5.2.3 The assumed operating speed for the strategic road would be 60mph. This is based on the assumption that vehicles will travel slower than the typical speed limit for such a road type (70mph) owing to the volume of traffic. This assumption is also based on the Highways England “mile a minute” objective and the likelihood that in tunnelled sections a speed limit which is less than the national speed limit may be applied.

5.2.4 Assuming that the route will operate as an expressway then, using today's standards, there are a number of core design features that would be required:

- Emergency refuge areas (ERAs), typically spaced between 800 and 1,500 metres apart
- Reduced size, variable message signs for incident management, signing/carriageway signalling and customer information, collocated with ERAs
- Full grade separation of junctions
- Above-ground incident detection system for queue protection
- Monitoring systems (CCTV)

[57] DfT & Highways England. *Trans-Pennine routes feasibility study*, March 2015

- Prohibition of NMUs (similar to prohibitions in the tunnel section)
- Provision of variable mandatory speed limits (VMSLs)

5.2.5 These standards are based on current vehicle technology and we recognise that future developments could change these.

5.2.6 We have made a high level assessment of theoretical locations where a route could connect to the existing motorway network to give an indication of tunnel lengths that will be required, depending on which part of the National Park the strategic link crosses.

5.2.7 We have assumed that the new strategic link will need to connect with the motorways at the edges of the study area (M60 and M1), and we have reviewed the capacity of the existing strategic links of the A616 and A628 between Flouch Roundabout and the M1.

5.2.8 We have explored possible connections with existing villages and roads. At either end of the tunnel, access to the local network will be needed to link into local communities. Additional junctions between the strategic link and the local network will be required along the route to permit access to, and from, the new road. Junctions will be grade-separated.

5.2.9 As part of Stages (iii)a and (iii)b of this study we have assessed a long-list of route options for the strategic link in more detail, and how these would connect to the SRN. Joining either end of the link with the existing SRN remains one of the key challenges in Stage (iii)c of the study.

5.2.10 More detailed discussions will take place with local highway authorities to consider the potential impact and benefits on local roads. We will also develop a junction strategy in Stage (iii)c so that junctions are spaced appropriately, but can serve local communities effectively. Junctions that are too closely spaced would interfere with the smooth flow of traffic, creating a large amount of weaving of vehicles and reducing overall safety.

5.3 Tunnel capacity and cross section

5.3.1 Our preliminary analysis suggests that the cross section through the tunnel will be dual carriageway and we need to have a minimum of two lanes in each direction. This analysis is based on current traffic flows and operational and safety factors.

5.3.2 The capacity of the road through the tunnel will need to have a similar capacity, and be of a similar standard, to the links on either side. This will be required to avoid increasing flows on the existing SRN and creating a bottleneck when entering or leaving the tunnel.

5.3.3 However, in determining the tunnel cross section we must also consider future demand as it would be difficult to modify the geometry following construction.

5.3.4 The width of the tunnel not only depends on the volume of traffic, but we also need to take into account ventilation, lighting, and drainage. We will also consider safety requirements, such as those relating to smoke extraction and access for emergency vehicles.

5.4 Ground conditions

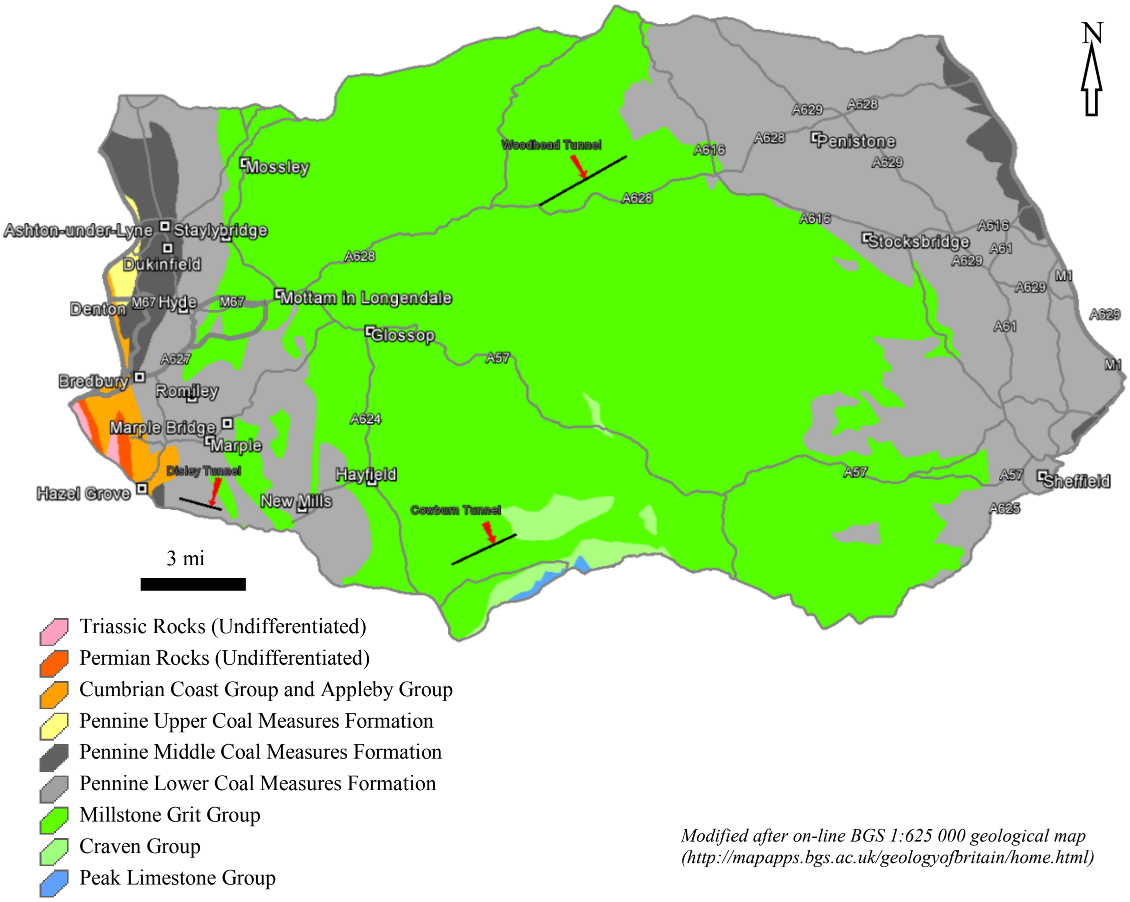
5.4.1 Figure 5-1 illustrates the bedrock geology of the study area and shows that the Pennines largely comprise rocks of the Millstone Grit and Pennine Coal Measures groups. Millstone Grit is generally suitable for constructing large-diameter tunnels and there have been previous tunnels constructed through the Pennines in this area, for example the Woodhead railway tunnel. The high level of consistency in ground conditions across the study area will make it easier when choosing appropriate tunnelling methods.

5.4.2 When constructing tunnels, a number of ground condition issues are typically anticipated. In the defined study area these include:

- Unforeseen ground conditions
- Landslides
- Fault zones
- Weak clay strata
- Fractured rock mass
- Ground gases
- Historical coal and non-coal mine workings (abandoned mine shafts and galleries)
- Existing infrastructure

5.4.3 Of these issues historical mining works and ground gases would appear to pose the greatest risk in the study area, but it should be possible to select a tunnel route where this risk is low or negligible. It is anticipated that all these potential hazards can be mitigated during the planning, design and construction phases of the project.

Figure 5-1 – Bedrock geology of the study area



Modified after on-line BGS 1:625 000 geological map (http://mapapps.bgs.ac.uk/geologyofbritain/home.html)

5.5 Construction

5.5.1 The new strategic road link between Manchester and Sheffield ranges from 23-36 miles long and will be dependent on the route options taken forward in Stage (iii)c. It will involve the construction of a number of above-ground structures, bridges, retaining walls and earthworks, as well as the need to improve the existing highway infrastructure (including signage). The new link will include a tunnelled section, which could range from between 10-19 miles, making it one of the longest road tunnels ever built.

5.5.2 We will need to consider the following issues as we plan the construction of the new road link:

- Interface with the existing road network
- Ground conditions, particularly in areas with a legacy of historical mine workings
- Constraints of working in and under the National Park
- Need for new structures (bridges, culverts, earthworks) outside of the PDNP
- Materials supply
- Re-use of materials generated during the construction works, with consideration given to the earthworks balance
- Industry capacity
- Design standards

5.5.3 The construction of long tunnels has been made possible by advances in construction techniques and in particular the development of high-performance Tunnel Boring machines (TBMs). However, we believe that the ground conditions beneath the Pennines make it technically feasible to build the tunnel using either the conventional method of drilling and blasting to excavate material or using TBMs.

5.5.4 The typical method of constructing long tunnels is to divide the route into sections of less than 6-7 miles of relatively consistent ground conditions (where possible) and we would expect to adopt a similar approach here. Each section is separated by launch and arrival sites for tunnelling activities and, once the tunnelling is completed, these sites could then be used as shafts and adits for ventilation and emergency/maintenance access. These sites could also be excavated in the form of caverns, which could be used for TBMs during construction and later used as areas for breaking up journeys once the tunnel is open, which is an approach taken at the Lærdal Tunnel in Norway.

5.5.5 If TBMs are used, we would need additional areas for storage of materials and ancillary plant. Ideally, these would be sited close to the portals and to existing transport infrastructure to reduce transport costs, although there are likely to be environmental constraints associated with building intermediate accesses and working areas in a National Park.

5.5.6 The two longest road tunnels in the world are: Lærdal Tunnel (one bore of 15 miles) in Norway, which opened in November 2000; and Zhongnanshan Tunnel (two bores each 11 miles) in China, which opened in January 2007. The experiences and knowledge gained from constructing these long road tunnels are being applied to this study.

5.5.7 There are examples of railway tunnels, built in a range of ground conditions, which are much longer than the trans-Pennine tunnel we are considering. In terms of construction, there are no significant differences between them except that road tunnels generally have a larger cross section.

5.5.8 Notable examples of long train tunnels include the Channel Tunnel (31 miles), completed in 1994, and Gotthard Base Tunnel in Switzerland (35 miles), which is due to open in 2016. Lessons learned, particularly from an operational/safety perspective have been used to inform this study.

5.6 Excavation

5.6.1 The mechanised method using TBMs operating for 24 hours a day and seven days a week is widely accepted as the preferred option for excavating long tunnels due to the speed of construction. The exception is where tunnels have a very large cross section, which makes TBMs less suitable.

5.6.2 In good ground conditions, the machines can advance up to 100m per week compared with just 15m per week in more difficult conditions.

5.6.3 The TBM for the project would be designed according to anticipated rock and soil characteristics, presence of gases, groundwater conditions and depth of cover. Based on information available at this stage, we consider that the earth pressure balance machine, slurry machine and the open-face shield TBM are likely to be required. However, the type of TBMs ultimately selected will depend on the tunnel alignment and its ground conditions (rock mass strength and hydrogeological conditions). According to geological and geotechnical data available, a major part of the tunnel should be excavated in moderately strong rocks and locally weak rocks, including fault zones; soils should not be encountered, except for a short section of the tunnel close to the portals.

5.6.4 Once excavated, the tunnel lining is likely to be composed of precast concrete segments installed at the rear of the TBM. Assuming an excavation diameter around 11-15m, the lining thickness will be around 0.5-0.7m.

5.6.5 As much of the excavated materials as possible will be re-used. Further assessments starting at the beginning of the preliminary design, and continuing during the detailed design will be undertaken to try to maximise use of the excavated materials (either for this scheme or stored for later use). The volume of the excavated materials will vary with the length of the tunnel for different options. Assuming twin road tunnels with excavation diameter of about 15m and an expansion factor of 1.25 to 1.3 for extracted materials, then the extracted material could be between 10 to 15 million cubic metres. A more detailed estimation will be undertaken during Stage (iii)c.

5.7 Constraints on construction

5.7.1 Options for the above-ground sections of the strategic link must consider:

- large housing conurbations at both ends of the route, and the need to weave a route through any built-up areas; which may be more straightforward at the Manchester end (although it will be difficult to construct any new junction with the M60). At the eastern end, these considerations will depend on whether the route goes directly to Sheffield or to the M1
- the impact on communities of the new strategic link, including the issues of severance and local access for NMUs, particularly in built-up areas at either end of the route
- ground conditions
- the local highway network
- environmental constraints and impacts

- drainage and hydro-geology
- road geometry and design speeds

Some of these factors have been taken into consideration for assessing route corridors and options in Stages (iii)a and (iii)b of the study.

5.7.2 Options for the tunnel (specifically) must consider:

- Tunnel alignment
- Horizontal and vertical alignments
- Drainage requirements, ease of construction and ventilation
- Highway design standards, and rail standards (which are typically more rigorous) if synergies are to exploited
- Cover (that is, the distance between the tunnel lining and the surface), which will be greater than one half to one times the excavation diameter for mechanised methods and greater than one to two times the excavation diameter for conventional TBM methods
- Diameter of excavation – large diameters could lead to front stability issues, which must be mitigated, and in general, the larger the excavation diameter, the higher the risk of face instability
- Environmental concerns – the PDNP presents a significant environmental constraint and is likely to restrict the possibilities of constructing an intermediate access from the existing road network and the location of shafts
- Existence of historical coal mines – abandoned mine shafts and mine excavations within the Coal Measures present the main hazard to tunnel construction using a TBM and could lead to movement and water ingress. However, with careful planning and route selection, it may be possible to select a tunnel alignment that avoids areas affected by mining. If we cannot totally avoid these areas, we will carry out detailed ground investigation during different stages of design, which should provide the necessary data to enable mitigation works to be carried out. Furthermore, the TBM will be equipped with tools for forward investigation of ground conditions as well as tools for soil treatment
- Driver environment – The need to provide a design that helps to maintain concentration and provides interest, which is discussed in further detail within Section 6 of this report

5.8 Synergies with rail – operational issues

5.8.1 There is significant investment currently taking place in rail in the Northern Hub programme of works centred on Manchester and in the North West, and in the Midland Mainline and trans-Pennine electrification programmes. However, despite this investment, significant capacity constraints will remain both on the routes into city centres and also on the trans-Pennine routes.

5.8.2 The proposed HS2 scheme will link Manchester with the South. It will also link Leeds and Sheffield with the South through separate routes on either side of the Pennines. Without further intervention, this will not improve trans-Pennine links.

5.8.3 To address the shortfall in capacity on the existing network, the Northern Powerhouse report[58] proposes a new trans-Pennine route linking the two legs of HS2 and providing improved east-west connectivity.

5.8.4 The new trans-Pennine rail route is being developed for DfT and TfN by HS2 and we anticipate that any route will need to be tunnelled.

5.8.5 In addition to the synergies with HS2, Network Rail has been commissioned by TfN and DfT to explore options to upgrade and transform (including where appropriate options for substantial by-passes and new lines) the existing corridors, to improve connectivity between Manchester and Sheffield city centres and also between Manchester and Leeds city centres, to help deliver the *Northern Transport Strategy* vision.

5.8.6 In March 2016 TfN published its *Northern Transport Strategy, Spring 2016 report*[59]. In the report they outline the emerging and developing options for Northern Powerhouse Rail and recognise that there is a need to go further than committed investments in the existing routes to achieve the vision for faster journeys and more frequent services between Manchester and Leeds and Manchester and Sheffield.

5.8.7 Also published recently, the National Infrastructure Commission report, *High Speed North*[60], recognises that whilst the infrastructure delivered by HS2 will not offer opportunities to improve connectivity between Sheffield and Manchester directly, there is the potential for it to contribute to reduced travel times on the corridor indirectly. The suggestion is that when HS2 phase 1 is complete in 2026, rolling stock could be used on the rail route between these two cities, if electrification were to be delivered in the future.

5.8.8 The report also includes a recommendation that funding be provided to further develop the long-term plans for HS3 (vision for a network of transformed inter-city rail links in the North). It calls for a high capacity rail network, rather than a single piece of entirely new infrastructure which must be fully integrated with proposals for maximising the benefits from currently planned investments. It goes on to recommend that the first phase of HS3 should be the upgrade of the Manchester to Leeds link and initial analysis of possible interventions includes a focus on the Diggle route (via Huddersfield) including options involving the construction of new tunnels.

5.9 Synergies with rail – construction issues

5.9.1 There are some key issues that need to be considered in delivering a combined corridor:

- Construction of tunnels of this length require substantial compound areas both at the portals and at the intermediate shaft locations. By aligning road and rail routes, the impact on the local environment will be reduced if both are needed.
- Construction access requirements for deliveries and removal of material from the excavated tunnels will be significant. We believe that, by combining the locations of portals and intermediate shafts to suit both road and rail routes, the overall traffic impact during construction will be reduced.
- Adopting a common tunnel alignment to address ventilation, service and escape requirements would offer advantages.

[58] TfN. *The Northern Powerhouse: one agenda, one economy, one North – a report on the Northern Transport Strategy*, March 2015

[59] TfN, Northern Transport Strategy, *Spring 2016 report*, March 2016

[60] National Infrastructure Commission, *High speed North*, March 2016

- Operational and maintenance benefits.

5.9.2 The risks to the development of a combined corridor include the following:

- There may be differences in the strength of the business case for the two modes, which could lead to delays if one scheme is dependent on the other. This could be addressed if a combined business case is provided.
- The different operational requirements of the two modes will require different vertical and horizontal alignments. This may mean that the benefits of a parallel tunnel alignment are not fully realised.
- The different operational requirements of the two modes could result in the portals being located in different locations.

5.10 Heavy rail

5.10.1 Heavy rail and highway traffic would require segregation in a tunnel, either vertically or horizontally. The resulting tunnel diameter required with vertical segregation would not be feasible with current TBMs. The width required for horizontal segregation is likely to result in a tunnel span that would be at the extreme end of what is feasible even for much slower drill-and-blast construction techniques.

5.10.2 We believe that with today's technology it would be necessary to construct additional tunnel bores to accommodate a heavy rail route. The required cross section for a rail tunnel is dependent on a number of factors, including line speed, operational and safety requirements. The tunnel could be either a larger bi-directional single bore or a twin, smaller bore arrangement. The total number of tunnel bores for a combined road/rail corridor could affect the scale of the portal areas. However, as discussed above, the rail portal may not be located in the same position as the road portal.

5.11 Light rail

5.11.1 Manchester and Sheffield have well established light rail networks. Light rail offers significant benefits for short journeys with closely spaced stops and is generally adopted for commuter routes into city centres. The journey time between Manchester and Sheffield would be substantial and we believe this would not make it attractive to passengers travelling directly between the two cities. The journey time through a trans-Pennine tunnel would present a substantial proportion of any journey time between communities in the east and west.

5.11.2 Light rail systems are typically prevalent in built up urban areas with frequent stops. They share road space with highway traffic in city centres and speeds are usually limited to less than 30mph for safety reasons – primarily to allow the light-rail vehicles to react to changes in traffic speed. It is usual to segregate light rail and road users when speeds are greater than 30mph, which would be applicable in a tunnel solution.

5.11.3 Allowing light-rail and highway traffic to share road space on a strategic link and within a tunnel would require the adoption of technological advances and development of a robust safety case. These could include adaptive cruise control and automatic braking systems. Managing the issues associated with road vehicles travelling on the rails would be more difficult to overcome. Allowing light rail and road to share space within the tunnel may increase the size of the tunnel bore in order to incorporate the overhead electrification system.

5.11.4 It is unlikely that light rail could provide a practical solution, although the tram/train trials (currently being considered between Sheffield and Rotherham) might be worthy of more detailed consideration.

5.12 Summary

5.12.1 The construction of a new strategic road link involving a substantial length of tunnel is technically feasible. Modern tunnelling techniques can accommodate a dual carriageway tunnel and the geology of the Pennines is generally suitable for constructing large diameter bores. Various tunnelling methods are available, including the use of TBMs for diameters up to around 15m, drill-and-blast techniques and, potentially, cut-and-cover sections. We will consider the cost and environmental impacts of these tunnelling methods for each potential route option.

5.12.2 The construction of overland sections at either end of the tunnel and on the fringes of the National Park to connect the new route with the strategic road network presents a number of technical challenges but is technically feasible.

5.12.3 The tunnel is likely to be longer than most other road tunnels in Europe, and the psychological aspects of travelling through a tunnel of this length are broadly understood. However, it is appreciated that we will need to undertake further work to understand driver behaviour and to consider how advances in technology and appropriate tunnel design could help to mitigate this issue.

5.12.4 The integration of road and rail solutions within the same transport corridor would provide a number of operational benefits. Equally there are a number of risks to consider.

5.12.5 For heavy rail, the diameter required (vertically or horizontally) would be at the extreme end of what is feasible, based on current techniques. We therefore consider that it would be necessary to construct additional tunnel bores to accommodate a heavy rail route.

5.12.6 Light rail systems already share road space with highway traffic. However, this is in towns and cities so sharing road space on a strategic link and within a tunnel would require the adoption of technological advances and development of a robust safety case.

5.13 Next steps

5.13.1 The key requirement for the final stage of this study, is to explore in more detail the shortlisted options and in this regard re-visit some of the technical design and construction considerations established in Stages (i) and (ii) of this study. This will include but not be limited to:

- reviewing the road standards required and assessing how the shortlisted route options would connect with the strategic and local route network through a considered junction strategy, which will also need to include and consider issues of severance and impacts on NMU's
- challenging the assumptions around the tunnel configuration, which will include the size of the bores, need for and size of any service tunnel, number of cross sections, use of caverns and size and detail of ventilation shafts
- closer and more intensive working with the various inter-connected studies, (rail, freight, Manchester North West Quadrant) particularly as options are identified for those studies
- gaining a greater understanding of ground conditions, including mine workings, water courses, etc.

5.13.2 All design and construction considerations will explore opportunities for future technologies to influence and improve the shortlisted options. Technical Working Groups are being established to focus some of these activities in the final stage of the study.

6 Operations and maintenance

6.1 Introduction

6.1.1 We have undertaken a review of best practice for operating and maintaining the strategic link, although the focus has been on the tunnel section. We have identified the following priorities for the operation of a long road tunnel:

- Promoting safe tunnel operation at all times in order to reduce the likelihood of incidents occurring and recognising that technology has a key role to play in this, both now (in terms of traffic management, information, emergency services, communications, etc.) and in the future (automation, etc.)
- Ensuring that efficient co-ordination and communication with the emergency services and local highway authorities is in place at all times
- Minimising damage to the tunnel structure and engineering assets from vehicles and general wear and tear
- Mitigating potential traffic congestion and limiting delays to the travelling public
- Mitigating potential damage to the environment

6.1.2 From this initial examination and understanding of what the requirements are for the safe operation of a long tunnel, we have concluded that it would be feasible to operate.

6.2 Standards

6.2.1 The legal and regulatory requirements for operating road tunnels are contained in the *UK Design Manual for Roads and Bridges* (DMRB),[61] EU Directive 2004/54/EC on the safe operation of road tunnels[62] and the UK Road Tunnel Regulations 2007/2009.[63] The proposed length of the tunnel will mean that both current operating standards and construction standards will have to be reviewed. For example, gaps in the central bore dividing walls will be necessary to facilitate routine maintenance and the management of incidents. These are used in the Channel Tunnel to allow sections of the operational railway to be taken out of service during quiet hours for maintenance.

6.2.2 Innovation will be critical to the operability of the tunnel and new equipment and tunnel maintenance systems will need to be developed to reduce or eliminate routine maintenance. Innovation will also be driven by operational needs and potential operational hazards, for example the risks caused by combustible fuels (petrol and diesel) will require specific types of fire detection and ventilation systems. We would expect to challenge the existing design, operating and maintenance standards throughout the design process. Benefits will be derived from the appropriate operational solution.

6.3 Prohibited users

6.3.1 The effects of a fire or explosion are much greater in a tunnel, so early consideration will be given as to whether to restrict or prohibit particular types of vehicles. Consideration will also be given to monitoring hazardous loads on the tunnel approaches and in the tunnel. Appropriate control measures, such as Automatic Hazardous Load Recognition, will be used, which will enable the emergency services

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[61] DfT. *Design manual for roads and bridges,* 2015

[62] European Parliament and Council. *Directive 2004/54/EC on minimum safety requirements for tunnels in the trans-European road network*, April 2004

[63] The Stationary Office. *Road tunnel safety regulations,* 2007 (amended 2009)

to respond to an incident appropriately. Certain types of vehicles are already prohibited from using motorways so additional signage may not be necessary, depending on the classification of the road. However, appropriate signs and possible diversions would be necessary if non-motorway traffic was allowed on the strategic link road on either side of the tunnel.

6.4 Incident management

6.4.1 Key to the management of tunnel incidents is early detection and an appropriate response by tunnel operators. Tunnel operators will undertake the management of tunnel incidents, including vehicle fires and spillages of toxic materials. Cameras will be an important tool to monitor the tunnel, and additional incident detection equipment will be installed to identify stopped vehicles and pedestrians. If an alarm is raised, the operator will need to respond according to incident procedures.

6.4.2 Appropriate intelligent transport systems will monitor traffic conditions across the whole link (including the tunnel) to manage traffic flow, identify incidents and provide information for customers. These will include (as a minimum) monitoring systems and variable message signs, but may also use floating vehicle detection (using real-time electronic fleet data to identify traffic flows) and wireless communications linked directly with the technology in motor vehicles.

6.4.3 The tunnel will have a service building at each portal. These will house the tunnel control centre and the tunnel maintenance facility, as well as providing an area for the emergency services to assemble when responding to incidents.

6.5 Routine and non-routine maintenance

6.5.1 Maintenance teams will require access into the tunnel for planned activities, including structural and highway maintenance, mechanical/electrical principal inspections and wall washing. In shorter tunnels (1 to 2.5 miles), it is usual (where no alternative routes are available) to close one bore for maintenance and place the other bore in contraflow with suitable traffic management, signs/signals, lane control and central separation of traffic. However, in a longer tunnel section, these traditional methods may not be appropriate. Alternatives are explored later in this section of the report.

6.5.2 The design process will consider and develop engineering and operational safety systems that reduce the need to access the tunnel for maintenance and statutory inspections. We will adopt a process of ‘design for low maintenance’. As far as is reasonably practicable, engineering systems, such as the communications network, will be located in the service tunnel. Other technologies, for example video surveillance, will be used remotely to monitor tunnel systems.

6.5.3 Constructing a central service tunnel will reduce the need to close the tunnel for maintenance. Engineering systems, sign controllers, cabling etc. will reside outside the operating bores and allow the maintenance teams to access tunnel equipment located in the service/escape bore with minimum disruption to traffic.

6.5.4 Responding to faults in tunnel equipment quickly and appropriately will also help to avoid disruption to traffic for access. Modern tunnels have varied and complex systems installed to provide appropriate safety levels for users. These systems must meet the designed operational standards and include:

- Ventilation
- Lighting
- Communication and control
- Signs and signals
- Mobile phone feeders

6.5.5 Our challenge will be to develop new methods of planned and non-planned maintenance to reduce the impact on traffic and the Park through a co-ordinated asset management plan, for example:

- Undertaking routine maintenance at night when traffic flows are lower
- Ensuring resilience and reliability of tunnel systems
- Selecting wall finishes to reduce the number of washes needed
- Minimising equipment installed within the tunnel
- Providing openings in the central wall to establish short sections of contraflow working
- Locating site equipment (where possible) in ERAs so that there is no maintenance in the live operating environment (as per the Smart motorway programme)
- Developing automatic traffic management systems that will reduce the time required to close sections of the tunnel for routine and non-planned maintenance

6.6 Safety

6.6.1 The operational safety systems and associated engineering will be designed to ensure the trans-Pennine strategic link and tunnel can operate safely, to protect the travelling public during normal running and to provide an incident management response.

6.6.2 The tunnel/road network control room operator will supervise and observe traffic behaviour and flow rates. To assist in this role, operators will typically use the SCADA (Supervisory, Control and Data Acquisition) system, to monitor equipment condition/functionality, tunnel outstations (which monitor tunnel environmental conditions), incident systems and CCTV.

6.6.3 Appropriate design of any road and tunnel is vital to ensure that the link, and especially the tunnel, is operationally flexible and safe. It is also vital that the tunnel can be evacuated in an emergency.

6.6.4 Specific tunnel safety systems and considerations include:

- Ventilation and the ability to manage smoke if a fire were to result from a traffic incident
- Lighting to ensure visibility in the tunnel during emergencies
- Communications network to ensure equipment and systems are available for plant, signs and signals control
- Incident detection
- Signs and signals to manage traffic and communicate with the road users
- Public address system for major incidents
- Firefighting capability, particularly with regard to response times (for example, the Mont Blanc Tunnel in the Alps has its own fire station)
- Hazardous loads (use of a thermal imaging scanners can detect hot spots in loads or engine/gearboxes that could potentially ignite)
- Operational procedures, including evacuation

6.6.5 Safety considerations on the strategic link include:

- Prevention of accidents through design
- Procedures for undertaking emergency repairs
- Safety of people working in road traffic control and management

6.7 Security

6.7.1 For any important piece of infrastructure on a primary transportation link security is a key consideration. Therefore, during the design process we will consider the design of the tunnel structure and equipment and, how to mitigate the harm caused by security risks, for example by reducing or eliminating combustible equipment such as gas or oil pipelines.

6.7.2 Intelligent Transport systems will be used to provide monitoring systems. Incident detection systems can identify stopped vehicles on the approaches to, and inside, the tunnel. Alarms can be raised in the tunnel operations centre and motorway control centres to automatically activate CCTV systems to monitor activities on a stopped vehicle or an incident. Procedures will be developed to enable appropriate responses to a police-led incident.

6.7.3 Further consideration of security matters will be addressed in the final stage of the study, with more detailed input from security professionals.

6.8 Driver behaviour

6.8.1 Driver behaviour is a key factor influencing the use of a long road tunnel. Drivers will need to be confident when approaching the tunnel that their journey will be stress free; that their time in the tunnel will be incident free; and that, if there is an incident or disruption to their journey, they will be kept safe from harm.

6.8.2 Factors to be considered include:

- Visibility and lighting
- Orientation
- Atmosphere (exhaust fumes)
- Maintaining a constant speed, especially where there are changes in vertical alignment within the tunnel
- Steering and lane discipline

6.8.3 Some of these factors can be alleviated through appropriate highway design, lighting and the overall tunnel ambience. The Lærdal Tunnel in Norway and the Zhongnanshan Tunnel in China provide examples of how this can be done.

Figure 6-1 – Lærdal Tunnel lighting and cavern

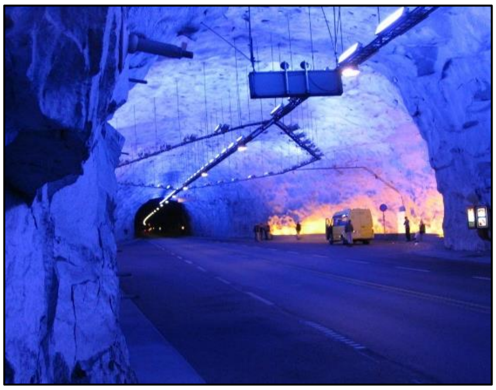
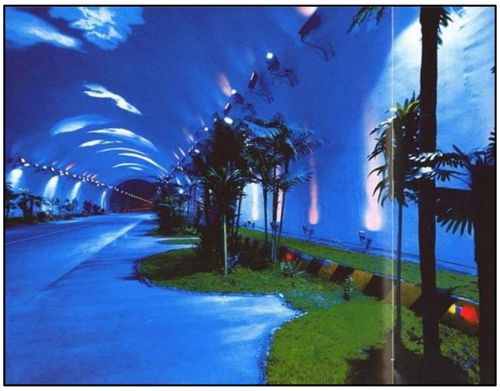


Figure 6-2 – Zhongnanshan Tunnel lighting



6.8.4 SINTEF, an independent research organisation based in Scandinavia, looked into driver behaviour in tunnels prior to construction of the Lærdal Tunnel and found that proper use of cavern spaces is one of the most effective ways to relieve travellers' fears and that the colours, lighting and patterns used in the tunnel help to mitigate the effects of claustrophobia, disorientation and tiredness. Similar solutions have been adopted in the Zhongnanshan Tunnel. Other options include: using appropriate lane width, ventilation, tunnel width and curvature, and separation of carriageways.

6.8.5 We have undertaken an initial review of driver behaviour and perceptions when using tunnels. As the study progresses, we will carry out further research in this area to help assess the impact of driver behaviour on a potential tunnel under the Pennines, for example by developing simulators to test driver responses.

6.8.6 We recommend that the design considerations include a UK-based research project on driver behaviour in a long tunnel. The findings will help designers to provide a sympathetic tunnel profile, lighting etc. and a better, safer driving experience. Initial discussions have already been held with a number of potential providers, including Transport Research Laboratory.

6.9 Technical innovation and tunnel operations

6.9.1 The scheme would have an operational design life of 120 years (in line with current design standards on highway structures) so it is important that potential solutions take into account emerging technologies in vehicle design, in highway design and operations, and in network information.

6.9.2 With the rapid change in highways technology and the development of connected and autonomous solutions, it is difficult to predict market-led change. However, these changes are potentially significant and are supported by a number of investment programmes, so the ultimate design solution must take into account such technological solutions and their potential benefits, both in terms of design options and operational, safety and customer benefits.

6.9.3 We have identified five broad areas in which technological innovations might add value to the scheme. These will require further examination and scrutiny during the design/development of the solution and technologies will need to be clearly proven and have an identifiable route to mainstream market for them to justify a major design change.

- Automation – the increasing ability of vehicles to undertake the more mundane and emergency aspects of driving, such as automatic braking systems and adaptive cruise control. These advances will reduce driver error and improve safety, allowing for narrower lanes.

- Connectivity – the sharing of data between drivers and infrastructure operators in order to give advance warning of disruption, congestion or maintenance. This will provide benefits to road users and operators.
- Robotics – the use of robotic equipment for routine inspections and maintenance tasks, such as tunnel cleaning and waste. Robotic traffic management will also eliminate the dangers inherent in current systems of traffic management for large-scale maintenance schemes.
- Propulsion – the shift from oil-derived combustion to electric, hydrogen and other fuel sources will reduce the need for ventilation shafts to remove exhaust fumes.
- Aggregation – the emergence of systems to aggregate and process data sources to provide real-time and predictive network operations, journey planning and other data will inform customers and help balance demand and capacity.

6.9.4 Other changes that are more difficult to quantify, but which might have a bearing on road use and traffic and thereby influence operations, include:

- Changing attitudes and behaviours of private and business users towards road travel
- Business, economic and social factors, which might modify the need for movement
- Demographic changes in Northern England
- Role and form of public transport provision

6.10 Summary

6.10.1 The operation and maintenance of a new strategic road link involving a substantial length of tunnel is technically feasible, although changes in technical standards and methods of working are likely to be needed to provide a safe and efficient solution. Considerations will include the way in which planned, routine and emergency maintenance is carried out; the way in which incidents are managed; and the way in which traffic is controlled and monitored. Fire safety, tunnel security and the health and welfare of the workforce are also important considerations as is the future role of robotics in tunnel maintenance.

6.11 Next steps

6.11.1 Some early discussions have been held with a number of stakeholders (Highways England Network Development, emergency services and existing tunnel operators) who have an interest in the operational and maintenance aspects of such a structure and as part of the final stage of this study (assessing in more detail a short list of possible route options for the new strategic road) we will ensure that operational considerations are part of the thinking and assessment process. We will consider the most effective way that these priorities can be delivered throughout design, taking account of evidence and identifiable technological change during the mobilisation of the tunnel and how it operates as part of the wider strategic and local road network. For this we will draw in additional knowledge and expertise to guide the operational understanding, this will include security professionals, and wider tunnel operational experience from across the continent, particularly Scandinavia.

6.11.2 We will carry out further work to understand driver behaviour (talking to tunnel operators across the world and academics who have studied this topic in detail) and the new operational standards that will be required. We will also consider commissioning a UK-based research project on driver behaviour in long tunnels and have already had an initial dialogue with suitable research partners.

6.11.3 As with the design and construction considerations we are currently exploring the establishment of a number of technical working groups to influence the detail and the thinking around issues such as safety, security, management and operational resilience. Once again opportunities for future technologies will form a key consideration within all of these discussions.

7 Potential environmental impacts

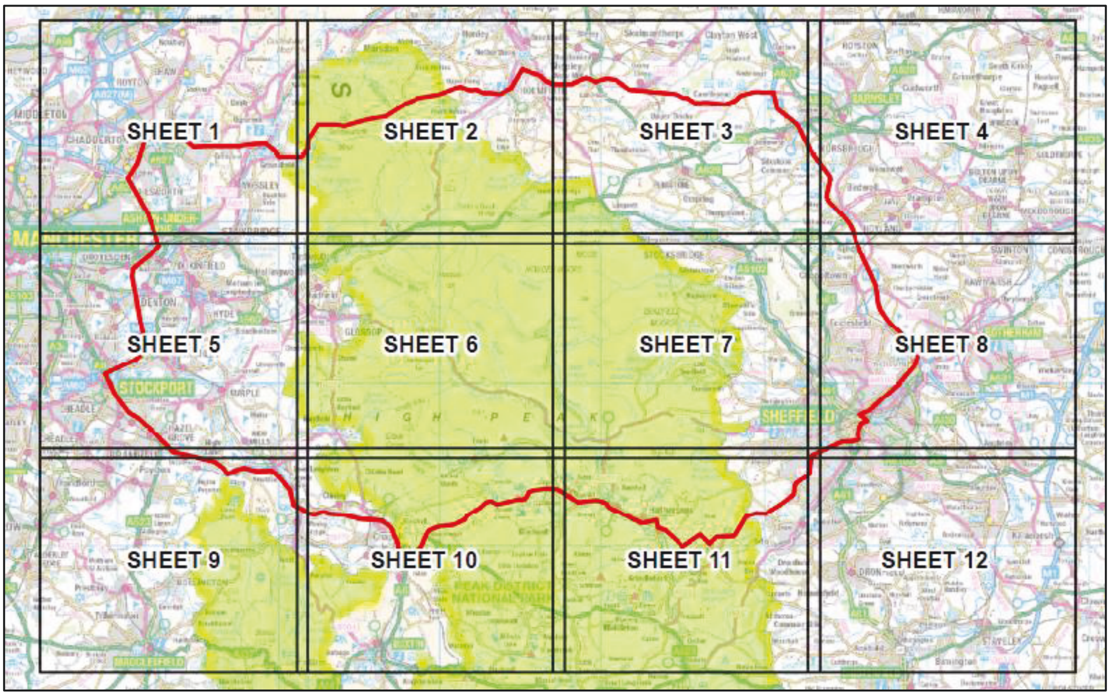
7.1 Introduction

7.1.1 A review of environmental constraints that exist in the study area has been undertaken in order to understand the potential environmental impacts and opportunities associated with developing a strategic road link under the PDNP and across the surrounding parts of Derbyshire, Barnsley, Sheffield and Greater Manchester.

7.1.2 An initial screening has been completed which looks at the potential environmental impacts and opportunities of the strategic road link. This has been undertaken against the full range of environmental topics covered by DfT's *DMRB*,[64] as we felt that some topics were not covered by TAG – for example, materials and waste, geology and soils – and that they should be highlighted, even if they are not likely to be assessed until later stages of the scheme's development.

7.1.3 The study area covers approximately 430 square miles and has been divided into 12 sections, as shown in Figure 7-1. Given the large study area, potential environmental constraints have been identified at Stages (i) and (ii), with a further list of additional potential environmental constraints to be considered at Stage (iii), when the focus will be across a narrower area. Agricultural land and groundwater resources have been considered on a whole-study-area level.

Figure 7-1 – Study area and sections (sheets)



7.2 Key environmental constraints

7.2.1 The PDNP is an area of protected status. Its role is to conserve and enhance natural beauty, wildlife and cultural heritage; and to promote opportunities for the understanding and enjoyment of its special qualities by the public. Other open areas surrounding the National Park are designated Green Belt. There are three key trails within the area: The Pennine Bridleway, Pennine Way and The Trans-Pennine Trail; among hundreds of other public rights of way (PRoW) within and outside the National Park. There are also Country Parks within the study area.

[64] DfT. *Design manual for roads and bridges,* 2015

7.2.2 There are seven Air Quality Management Areas (AQMAs) to the western and eastern extents of the study area on the existing road network. These are concentrated mainly around Sheffield and Manchester, as well as smaller conurbations within their suburbs. Finding the right location for a tunnel portal and any new road infrastructure will be important in avoiding exacerbating existing air quality problems or creating new ones.

7.2.3 There are nationally important heritage features, such as Scheduled Monuments, throughout the study area. These are located more toward the south-eastern extent of the study area than to the north and west, and they vary from relatively modern monuments (such as the WWII training ground at Ladybower Reservoir), to Roman and medieval structures, including several castles. There are 88 Conservation Areas (CAs) within settlements throughout the study area. These constraints suggest a rich and colourful history worthy of preservation.

7.2.4 Listed buildings are present throughout the study area and registered parks and gardens are present in urban areas on the west and east of the National Park.

7.2.5 The National Park is heavily constrained ecologically, with a Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC) and Special Protection Area covering most of the Park within the study area. The Kinder Scout National Nature Reserve (NNR) is located to the south of the study area, and there are 32 local nature reserves (LNRs) and 22 SSSIs outside the National Park.

7.2.6 There are Noise Important Areas (NIAs) on existing roads within the study area. These are mainly within urban areas or associated with major routes, such as the M60, A627, M67, A628, A57 and A6018, although some are within the National Park.

7.2.7 There are settlements of all sizes within the study area, both rural and urban, which might experience severance as a result of new infrastructure associated with a new trans-Pennine link. However, there would also be reduced severance within smaller villages if some of the traffic in, and on the edges of, the National Park can be diverted.

7.2.8 The area under the PDNP that may be tunnelled contains groundwater. There are also main rivers within the study area (Tame, Etherow, and Don), plus tributaries, that are known to flood at various points, although we have not considered flooding in detail at this stage. There are also several reservoirs – Woodhead, Ladybower and Howden – which are likely to form a significant constraint to shallow tunnelling at these locations.

7.2.9 Agricultural land classification mapping shows the highest grade within the study area to be Grade 3, with the majority of the Park either Grade 5 or 4 (towards the fringes).

7.2.10 We have not considered geology and soils, materials sourcing, reuse and waste disposal constraints from an environmental perspective at this stage.

7.3 Potential environmental impacts and benefits

7.3.1 The potential environmental impacts and benefits of the project have been summarised in Table 7-1 below.

Table 7-1 – Potential environmental impacts and benefits of the project

DMRB topic	Potential impacts	Potential benefits and opportunities
Air quality	Constructing additional road links may introduce air quality problems into entirely new locations. Additional traffic generated as a result of the tunnel could create new, or exacerbate, air quality impacts on the existing road network. Changes to traffic patterns on the existing road network could result in new air quality impacts. This may be a particular problem on existing roads entering Manchester and Sheffield where AQMAs exist. Dispersal characteristics at tunnel portals are relatively unpredictable and would require specialist modelling, but good design could mitigate potential impacts to an acceptable level. Impacts of ventilation may introduce new air quality issues, particularly in the National Park.	Consistent road speeds, reduced acceleration and shorter journey distances would reduce overall emissions per individual journey and help to avoid air quality impacts due to traffic growth. There is also the opportunity to address air quality problems on the existing road network where new infrastructure is created. This may also take traffic away from residential areas and other sensitive locations. Changes to traffic patterns on the existing road network could improve existing air quality impacts. . New methods of ventilation may allow emissions to be treated before they are released into the atmosphere. Separating HGVs and lighter traffic flows may allow targeted treatment to be more effective.
Cultural heritage	Infrastructure along new routes may result in loss of some heritage features or impact on their setting.	New sections of road network may reduce traffic through small villages and towns, particularly those containing CAs, potentially improving the setting of some heritage features.
Landscape	Impacts of lighting around tunnel portals. Modelling of spill impacts would likely be required; however good design could mitigate to an acceptable level. Impact on landscape of new sections of road in order to link the tunnel to the existing network. Some of these may be within the National Park to provide access to intermediate shafts/ventilation stacks for maintenance. Impact of introducing new ventilation stacks into the National Park landscape. Adverse impacts related to construction, particularly where areas are required within the	A tunnel may reduce future traffic growth in the National Park and the Special Landscape Area, which might otherwise alter the character of these areas and reduce visual amenity. There is an opportunity to create new landscape features (such as heritage style barns) within the landscape to screen ventilation stacks. There is an opportunity to minimise light pollution in the National Park by reducing the visual impact of heavy traffic flows on existing roads through the National Park.

DMRB topic	Potential impacts	Potential benefits and opportunities
	National Park and/or for extended periods of time.	
Townscape	Impact on townscape of increased traffic on parts of the existing road network, particularly on sensitive CAs. Impact on townscape of new sections of road network through urban areas in order to link the tunnel to the existing road network.	New sections of road network may reduce traffic travelling through small villages and towns, particularly those with CAs. The tunnel may reduce future growth in traffic that would pass through the National Park and its settlements. It may also avoid future road upgrades, which might alter the character of the area.
Biodiversity	Potential for loss of biodiversity from any new infrastructure. Potential for impacts on bats as a result of lighting around tunnel portals. Potential indirect impacts on designated sites.	There is the opportunity to create new habitats within the National Park where ventilation stacks are required (for example heritage-style barns with suitable habitat for bat or bird species), as well as from generation of excavated material.
Geology and soils	Impacts on geological or geomorphological features. Impacts on geological strata, indirectly altering the hydrogeology of an area, diverting underground stream flows, or preventing aquifer recharge.	Opportunities to develop contaminated land within urban areas.
Materials	It is likely that there would be substantial waste material created through tunnelling, for which a suitable disposal route would need careful consideration. Availability of construction materials in the area may be limited and requires further consideration.	Opportunities for using the waste hierarchy (avoid, reduce, reuse, recycle, dispose) should be identified as early as possible. Opportunities may be available for beneficial reuse within the scheme itself or other regional projects, providing that excavated material is suitable. Opportunities for landscape enhancement/mitigation with generated excavated material to be identified as early as possible.
Noise	Constructing additional road links may introduce noise issues into new locations. Additional traffic generated as a result of the tunnel could exacerbate, or create new, noise impacts on the existing road network. Noise characteristics at tunnel portals are relatively unpredictable and would require specialist modelling, but good design could mitigate impacts to an acceptable level.	Opportunity to avoid future noise impacts within the National Park due to traffic growth, which may protect the tranquillity of the area. Opportunity to address noise problems on the existing road network where new infrastructure is created. This may also take traffic away from residential areas. Changes to traffic patterns on the existing road network could improve existing noise impacts.

DMRB topic	Potential impacts	Potential benefits and opportunities
	Construction-related noise issues may arise, especially within the National Park and portal areas. Construction traffic impacts associated with removal of excavated material may be significant.	
Vehicle travellers	Views from the road, driver stress and journey amenity within the tunnel would need further consideration. Potential impact on views from the road as a result of introduced ventilation stacks within the National Park. Potential for poor or no views from the road where new roads are introduced in a cutting or in low lying areas. The tunnel could increase fear of accidents and/or driver stress.	Opportunity to improve or maintain journey amenity along existing roads within the National Park by reducing traffic growth rate. Opportunity to create lighting displays within the tunnel to create features along the tunnel route for journey amenity.
Pedestrians, cyclists and equestrians	Additional traffic on some areas of the road network, increasing severance and/or accidents. Impact on PRoW, increasing journey length and/or amenity.	Opportunity to improve safety and journey amenity on the existing A57/A628 route, and possibly other routes, for cyclists.
Community and private assets	Loss of agricultural land, demolition of private property, loss of land used by communities and loss of future development land as a result of links to the existing road network. Potential for severance from community services through increased traffic flows, road upgrades or new road links.	Opportunity to avoid future development of additional above-ground routes.
Water environment	Risk of flood or groundwater ingress to the construction and operation of the tunnel. Impact on hydrology and water quality in areas where new sections of road may be introduced. Impact on hydrogeology of the area as a result of the tunnel. Potential for contamination of groundwater through leakage from the tunnel.	The tunnel element would have no impact on surface water run-off.

7.4 Summary of environmental opportunities and challenges

7.4.1 The exercise undertaken indicates the study area has environmental sensitivities within the PDNP, and also at the edges of the Park. Environmental mitigation is likely to be required, particularly where new elements of road or tunnel infrastructure are introduced.

7.4.2 Some stakeholders may welcome the opportunity to reduce the impact of traffic within the National Park and its protected sites, by avoiding the need for future road upgrades in this area in the medium term. Diverting traffic through the tunnel would also help to reduce noise levels in trunk-road related NIAs, some of which are within the National Park and to protect the functions of the National Park for conservation, recreation and tourism, ensuring that these remain for future generations.

7.4.3 However, there are many potential environmental constraints that we will need to take into account when developing options for tunnel portal locations, ventilation shaft functionality and locations, additional road infrastructure to link to the existing network, and construction methods and programmes to minimise construction-related impacts within the National Park. In addition, we will need to develop feasible options for excavated waste reuse or disposal as early as possible. There is the potential for environmental impacts to be realised across all DMRB environmental topics.

7.5 Next steps

7.5.1 The establishment of the key environmental challenges and opportunities, within Stages (i) and (ii) of the study has provided the basis by which the potential environmental impacts have been assessed within Stages (iii)a and (iii)b of this study. This is outlined in sections 9 and 10 of this updated report.

7.5.2 In the final stage of this study, use will be made of more detail (for example, forecast traffic flows), to assess and quantify (where possible) the potential environmental impacts and benefits of each of the shortlisted route options.

8 Options Assessment

8.1 Summary of Stages (i) and (ii)

8.1.1 The preceding chapters have outlined the high level case and feasibility of constructing a new strategic trans-Pennine link.

8.1.2 In summary, sections 1 to 7 demonstrate that:

- objectives for the road scheme align with government policy and there is a case for change as part of developing ambitions for a Northern Powerhouse
- constructing a new route between Manchester and Sheffield under the Pennines is technically feasible, although the most effective route options are yet to be considered
- operating and maintaining the new road link – a considerable proportion of which would be tunnel – presents challenges, but is feasible in principle
- whilst early findings are positive, further work needs to be undertaken in order to develop the economic case

8.1.3 Based on the above conclusions, we deem there to be a strong case for continuing to develop the study.

8.2 Option assessment exercise

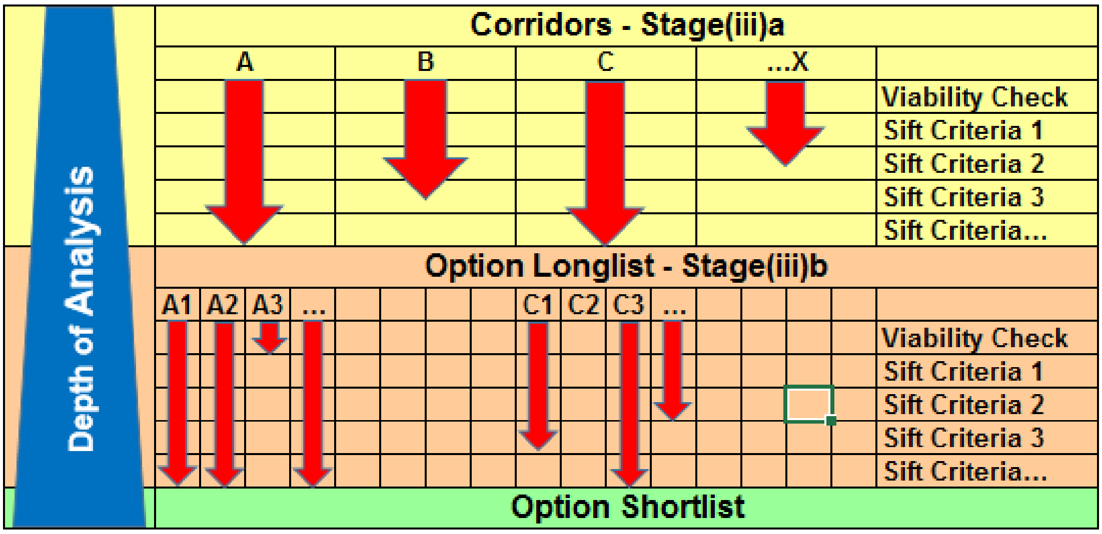
8.2.1 Stage (iii) of the *Trans-Pennine Tunnel Study* looks to develop potential indicative route options for a strategic link, and to assess the benefits of these options.

8.2.2 In order to determine the better performing route options, a structured sifting process was followed, in line with the DfT's TAG.

8.2.3 Based on the study team's previous experience of sifting assessments, an incremental approach to sifting was proposed, as this is the most efficient method to developing a shortlist of options from a longlist. Undertaking a sifting exercise on a large number of options is a resource intensive exercise, and therefore it was agreed that a proportionate approach would be undertaken

8.2.4 Figure 8-1 illustrates the proposed overall approach for Stage (iii), highlighting the initial assessment of corridors, Stage (iii)a, in order to identify better performing corridors using the DfT's EAST (Early Assessment Sifting Tool). This is followed by subsequent sifts at the option level, Stage (iii)b, using the OAF (Options Assessment Framework) in order to develop a shortlist of route options which can be progressed for more detailed analysis in the final stage of this study. The figure demonstrates the incremental build-up of evidence and depth of analysis as the study progresses from the corridor level towards a shortlist of options and as a more rigorous level of evidence is developed.

Figure 8-1 – Stage (iii) Sifting Approach



8.2.5 The advantage of this proportionate approach is that analysis at the corridor level may demonstrate that one or more corridors perform significantly better or worse than others, allowing the subsequent development and assessment of route options to be more focused on particular corridor(s).

8.2.6 The sifting approach adopted was in line with the *Transport Appraisal Process* TAG unit, both in terms of the use of EAST for an initial sift, and the use of OAF for subsequent sifting of options. The following two sections of the report outline the process of developing options for a strategic route and sifting these in order to develop a shortlist of better performing options.

8.2.7 Sections 9 summarises the development of corridors and their assessment using the EAST, while Section 10 summarises the development of route options and their assessment using the OAF.

9 Corridor Development and Assessment

9.1 Overview of corridor development approach

9.1.1 Workshops were organised with stakeholders and by the study team. The aim of these workshops was to develop potential corridors for a strategic link (including tunnel) between the Manchester and Sheffield areas which would then be analysed as part of the initial stage of the sifting process (Stage (iii)a).

9.1.2 At both workshops, the development of corridors was guided by both the viability assumptions (outlined below) and a set of key considerations relating to the potential geological, environmental, highway and planning aspects within the study area (as outlined in the preceding sections of the report). Proposals were presented and the assumptions and reasoning behind the proposals were challenged. This work allowed the study team to define a broad set of corridors for the study area and ensured that stakeholders had an active role in the development of corridors and options.

9.2 Viability assumptions

9.2.1 As outlined above, a set of viability assumptions was developed in order to both guide the development of corridors/options, and to act as a high level check to ensure that any proposed corridors/options met key study criteria. The viability assumptions are that the corridor/option:

- fits the project scope, that is, a strategic link connecting Manchester and Sheffield under the Pennines
- is largely within the study area boundary
- does not involve construction of a surface route within the PDNP and its wider setting

9.2.2 These viability assumptions were debated and challenged by both the study team and stakeholders to ensure that they were appropriate and did not prematurely rule out any corridors/options that were worth assessing.

9.3 Proposed corridors

9.3.1 The study team reviewed the proposals emerging from both the internal and stakeholder workshop and consolidated these into the following five broad corridors:

- **Northern Corridor** (A) – The corridor follows the northern boundary of the study area, and crosses the PDNP, at the narrowest point. The corridor is also defined by a number of valleys to the south of Holmfirth. To the west the corridor extends as far north as the A627 (M) and as far south as Ashton-under-Lyne. At the Eastern end the corridor extends towards Barnsley and to the M1 in the area between the A635 and the A628 at junction 37.
- **A628/A616 Corridor** (B) – This corridor broadly follows the line of the existing strategic route under the PDNP following the M67, A628, and the A616. To the west the corridor broadly follows the alignment of the M67 corridor as a connection to the M60. In the east, the corridor extends as far as the M1 in the area around the A616 and A61 at 35A and 36 respectively.
- **Central Corridor** (C) – In the west, the corridor begins near the M60 via the gap between Denton/Hyde and Romiley/Bredbury near the River Tame, between junction 24 and 25. At the eastern side of the study area the corridor joins the M1 in the area of junction 35. The corridor passes to the north of the River Derwent Valley.

- **Southern Corridor** (D) – The corridor is broadly defined by the presence of Derwent Valley and Ladybower Reservoir. In the west, the corridor meets the M60 around junction 25 and also extends toward the Manchester Airport Eastern Link Road (MAELR) corridor, to the south of Manchester. At the eastern end the corridor covers the A57/A630 dual carriageway and the area to the south of Sheffield.
- **Overlapping Corridor** (E) – The corridor starts in the south of the study area heading south east, before turning north east and passing to the north of Stocksbridge, crossing the peak district on a diagonal. This corridor connects around J25 of the M60 and also extends toward the MAELR corridor, to the south of Manchester. In the east, the corridor extends as far as the M1 in the area around the A616 and A61 at 35A and 36 respectively.

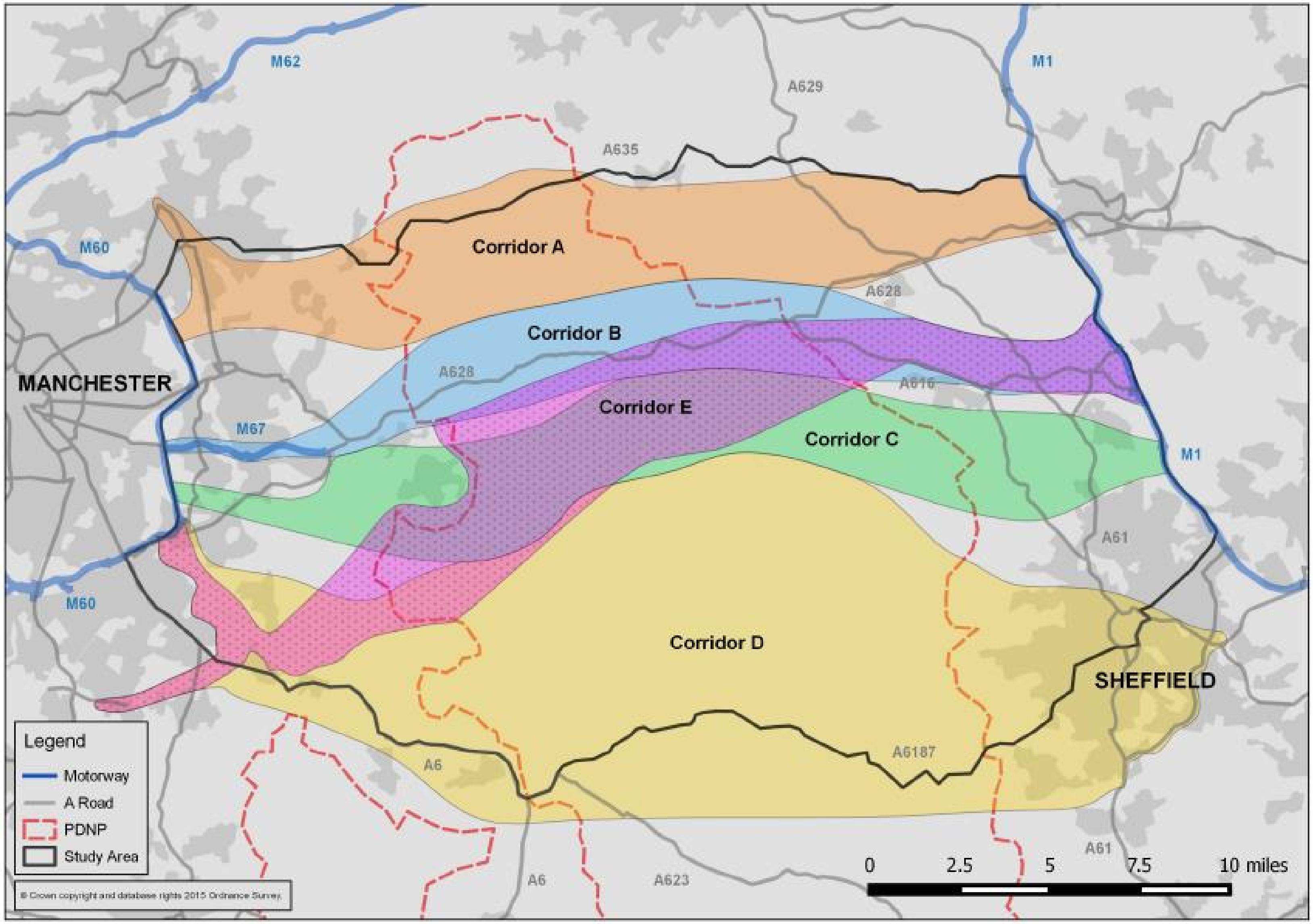
9.3.2 Figure 9-1 illustrates the five corridors. In addition, Table 9-1 summarises the range of lengths for a strategic link within each corridor, both in terms of overall length and specific tunnel length. At this stage lengths of tunnel and the strategic link in full, were assessed at the broad corridor level and it was understood that these would require refinement as the assessment progressed.

Table 9-1 – Corridor length ranges (miles)[65]

Corridor	Tunnel length		Strategic link length	
	Min	Max	Min	Max
Northern (A)	11	16	23	31
A628/A616 (B)	10	13	28	29
Central (C)	13	20	24	30
Southern (D)	14	19	23	36
Overlapping (E)	15	17	32	34

[65] The lengths ranges for both the strategic link and tunnel section are based on the dimensions of the individual options proposed within each corridor. For example, Corridor A ranges are based on the length for options A1, A2.1, A2.2. A3. As a result, it is important to note that the corridor bounds are not consistent across corridors (that is, not all options within each corridor provide a complete M60 to M1 strategic link.

Figure 9-1 – Trans-Pennine Tunnel Study corridors



9.4 Corridor assessment methodology

9.4.1 The EAST was used to undertake the sifting of corridors at Stage (iii)a. The EAST was developed by the DfT in order to support decision making. It enables the user to quickly summarise and present evidence on potential interventions in a clear and consistent format, whilst ensuring that a robust audit trail for the sifting process is maintained. The tool allows proposals to be considered at an early stage of development.

9.4.2 The tool has been designed to be consistent with the DfT's *Transport Business Case* principles, based around the best practice, five case model[66] approach:

- **Strategic Case** – proposals are supported by a robust case for change that fits with wider public policy objectives
- **Economic Case** – proposals demonstrate Value for Money (VfM)
- **Financial Case** – proposals are financially affordable
- **Management Case** – proposals are achievable
- **Commercial Case –** proposals are commercially viable

9.4.3 The EAST assessment aims to identify, at a high level, the nature and extent of all the economic, environmental and social impacts of the options. The analyst is required to draw on the available evidence to make informed judgments as to the impact of a proposal on a range of indicators within each case. As part of the Economic Case, the guidance includes a decision tree in order to provide a guide to the issues that need to be considered when forming a view about the likely impact of each option on the economy, carbon emissions, socio-distributional impact and the regions, local environment and wellbeing.

9.4.4 Within each of the five cases, there are a range of indicators. Whilst the majority of the assessment is qualitative in nature, a number of indicators draw on analysis undertaken using the high level strategic model. In order to generate estimates of traffic flows and journey time changes for each corridor, which feed into the analysis of several indicators within the Economic Case, it has been necessary to adopt a notional route within each corridor. These notional routes have been tested using the high level strategic model developed specifically for this study in order to provide traffic results which act as a proxy for the impact of any route within the corridor.

9.4.5 It is important to note that the *Transport Appraisal Process* TAG unit states that the EAST tool "does not make an overall recommendation as to whether an option should be progressed, instead, it is for the analyst to identify their own criteria or threshold for determining which options 'pass' or 'fail' this stage of the process". The criteria were agreed by the wider study team including the consultants, and representatives from Highways England, DfT and TfN.

9.4.6 The following sections outline a summary of the results of the EAST assessment for each of the five corridors for the five cases: Strategic, Economic, Financial, Management and Commercial. There is more detailed work sitting behind this analysis including the decision trees and the full EAST tables.

[66] HM Treasury. *The Green Book: appraisal and evaluation in central government*, October 2015

9.5 Strategic Case

9.5.1 Table 9-2 summarises the results of the assessment of corridors against the EAST Strategic Case indicators.

Table 9-2 – Strategic Case assessment

Indicator	Scale	Corridor				
		A	B	C	D	E
Scale of impact	1 (small) to 5 (significant)	5	5	5	4	4
Fit with wider transport and government objectives	1 (low) to 5 (high)	4	4	4	4	4
Fit with other objectives	1 (low) to 5 (high)	4	4	4	4	4
Key uncertainties	Text field	Timescales of other studies. Construction in PDNP. Mining constraints. SRN capacity. Ventilation.				
Degree of consensus over outcomes	1 (little) to 5 (majority)	2	2	2	2	2

9.5.2 Scale of impact regards each corridors impact on the four key objectives established within the Interim Report and draws on the analysis of a number of other indicators within the EAST assessment. Each objective is discussed individually in the following paragraphs.

***Objective 1** – To provide a safer, faster, and more resilient road connection between Manchester and Sheffield, creating more capacity and an additional east-west connection*

9.5.3 **Objective 1** draws on the analysis of journey time savings and resilience summarised within the Economic Case (Section 9.7). This analysis indicated that Corridors A-D offered similar levels of journey time saving (11,000-11,500 hours per day), whilst savings for Corridor E were approximately 15% lower. All corridors provide an additional east-west connection offering increased capacity and deliver significant improvements in resilience, by removing a substantial proportion of traffic from existing trans-Pennine routes, although Corridor E is less good. In addition, a new strategic link itself, designed to the latest dual carriageway standards and incorporating grade separated junctions outside of the tunnel, would also significantly increase resilience, especially to the weather elements, given the tunnel section.

***Objective 2** – To fulfil the aims of the Northern Transport Strategy to deliver a scheme that will contribute to the transformation of the economy in the North*

9.5.4 The assessment of each corridors impact on **Objective 2** is based on a strategic economic assessment. This economic analysis is based on the productivity modelling framework, linking changes in access to economic mass or connectivity (by car) to changes in productivity. It is within this framework that the GVA benefits of each of the corridors are assessed.

9.5.5 The analysis suggests that investment in any corridor could generate additional output for the UK economy. These productivity benefits accrue to all regions, with the strongest gains in Greater Manchester and South Yorkshire. Based on the preliminary analysis, Corridors A to D offer a similar level of overall impact, whilst Corridor E is estimated to deliver materially less economic benefits than the other corridors.[67]

***Objective 3** – To protect and improve the natural environment by reducing through-traffic in the PDNP and by getting the right traffic onto the right roads*

9.5.6 In terms of **Objective 3**, all of the corridors remove a significant proportion of traffic from existing routes within the PDNP, contributing to getting the right traffic on the right roads. In terms of improving the natural environment, the environmental EAST indicator demonstrates that Corridor D scores lower than Corridors A, B, C and E across a range of environmental indicators (see Section 9.7).

***Objective 4** – To support wider socio-economic needs and leave a long-term legacy of improved road connectivity, better access to labour markets, wider employment opportunities, better land use, and more effective integration between transport modes.*

9.5.7 There are several elements to consider within **Objective 4**. All corridors would leave a long-term legacy of improved road connectivity, although analysis has indicated that the journey time saving associated with Corridor E is notably less than those for Corridors A to D. Furthermore, whilst all corridors are envisaged to offer better access to labour markets and wider employment opportunities, Corridor E is anticipated to offer lower Wider Economic Benefits than Corridors A to D. The impact on integration between modes and the degree to which corridors impact on land use and wider socio-economic needs has not been assessed in detail at this stage.

9.5.8 Based on each corridors impact on the 4 objectives, it is apparent that Corridor D and E have a lower scale of impact than Corridors A, B and C.

9.5.9 A number of national and regional policies and strategies have been reviewed in order to determine how well each corridor aligns with strategic objectives. All corridors align well with key policies and strategies:

- A new strategic link would improve the capacity, connectivity and significantly improve the resilience of the network between Manchester and Sheffield, supporting national and local economic activity, facilitating growth, joining up communities, creating jobs, as well as supporting and improving journey quality, reliability and safety, all of which are policy drivers.
- Another key tenet of these documents is to support a low carbon economy. Further work is required to understand, in more detail, how well a new strategic link between Manchester and Sheffield would align with this objective.

9.5.10 There are a number of key uncertainties, at this stage (which may change as the study progresses), that affect the study and are therefore equally applicable to all corridors:

[67] The results of the analysis should be understood in the context of the limitations of the modelling. Particularly, it should be noted that a more (spatially) granular analysis of time savings for each route could lead to a change in the order of magnitude of saving.

- There are a number of other studies that will impact on the study area. These include TfN *Freight Study*, DfT *Trans-Pennine Rail Study*, *Manchester North West Quadrant Study*, *Northern Trans-Pennine Routes Study* and the impacts of the Northern Powerhouse. It will be necessary to make assumptions regarding the outcomes and cumulative impacts of those studies in our assessment.
- The assumption is that whilst seeking to avoid large scale construction in the PDNP, some works within the PDNP (for example, ventilation shafts) could be permitted so long as the visual impact of these can be mitigated through appropriate design and location to ensure character of the area is retained.
- All recorded and non-recorded mining constraints have the potential to be overcome with the appropriate treatment measures to stabilise the workings.
- The SRN and the local road network can cope with redistributed traffic flows resulting from the new link.
- Tunnel ventilation systems can treat vehicle emissions to an acceptable level to comply with requirements in terms of air quality and potential impacts on air quality-linked SAC in PDNP.
- The starting year of construction is assumed to be 2025, but this may change.
- The analysis of the economic impacts is partial, in that material economic impacts are omitted. Many of the benefits of the scheme could arise from improvements to local infrastructure to improve surface access. The impact of the scheme on local traffic will not be picked–up until the scheme is developed in more detail and more detailed traffic analysis is undertaken.
- Design not sufficiently developed to fully assess impact of the scheme against objectives.
- The 120 year design life is likely to see significant changes in highway and vehicle technology. It is difficult to determine exactly how these changes will impact on highway design, operation, maintenance and the customer experience. This is the subject of further work.

9.5.11 In terms of degree of consensus over outcomes, some stakeholder engagement has taken place regarding the concept of a new strategic link between Manchester and Sheffield, both as part of the initial *Trans-Pennine Routes Feasibility Study* and this *Trans-Pennine Tunnel Study* itself (via Stakeholder Reference Groups). To date there has been considerable engagement which at this stage is aimed at seeking information and informing stakeholders.

9.6 Economic Case

9.6.1 Table 9-3 summarises the results of the assessment of corridors against the EAST Economic Case indicators. This assessment of this case use a 5 point scale (Red, Red/Amber, Amber, Amber Green and Green), with green being more beneficial and red less beneficial/adverse.

Table 9-3 – Economic Case assessment

Indicator	Scale	Corridor				
		A	B	C	D	E
Economic growth	RAG scale	Green	Green	Green	Green	Green

Indicator	Scale	Corridor				
		A	B	C	D	E
Carbon emissions		Amber	Amber	Amber	Amber	Amber
Socio-distributional impacts and the regions		Amber/ Green	Amber/ Green	Amber/ Green	Amber/ Green	Amber/ Green
Local environment		See Table 9-5				
Wellbeing		Amber/ Green	Amber/ Green	Amber/ Green	Amber/ Green	Amber/ Green
Expected VfM	1 (poor) to 5 (very high)	Not able to assess at the corridor level				

Note: EAST RAG Scale: Red, Red/Amber, Amber, Amber/Green, Green

Economic Growth – Volumes and travel time savings

9.6.2 Based on the EAST Red-Amber-Green (RAG) scoring assessment, all corridors would score a Green rating, as they each demonstrate an improvement in connectivity, reliability and resilience.

9.6.3 Analysis using the high level traffic model has demonstrated that all of the corridors provide relief to existing trans-Pennine routes of approximately 10%. However, there are subtle differences in the breakdown of this. Whilst all four corridors remove similar amounts of traffic from a number of existing routes (M62: 10%; A57: 45%; A628: 85-95%), Corridor A also removes 90% of traffic from the A635, whereas the other corridors remove only 15-25%. Table 9-4 summarises the traffic relief by corridor for these four existing trans-Pennine routes.[68] This shows that the order of benefits could be lower for Corridor E.

Table 9-4 – Relief to existing trans-Pennine routes by corridor

Route	Relief to Existing trans-Pennine route AAWT* 2015				
	A	B	C	D	E
M62	9,500 (10%)	10,000 (10%)	10,000 (10%)	10,000 (10%)	9,500 (10%)
A628	13,600 (90%)	15,000 (95%)	13,600 (90%)	13,300 (85%)	13,300 (85%)
A57	2,000 (45%)	2,100 (45%)	2,000 (45%)	2,100 (45%)	2,000 (45%)
A635	2,300 (90%)	700 (25%)	400 (15%)	300 (15%)	300 (15%)

**Annual Average Weekday Traffic*

9.6.4 In addition, the provision of a new strategic link itself, designed to the latest dual carriageway standards and incorporating grade separated junctions, would also increase reliability and significantly improve resilience, especially to the weather elements, given the tunnel section.

[68] Other existing trans-Pennine routes experience traffic relief as a result of the implementation of a new strategic link. However, these four routes receive the largest portion of reductions.

9.6.5 In terms of overall journey time saving, all corridors offer a substantial reduction in travel time. Corridors A and B result in overall saving estimated at 11,500, vehicle hours per day whilst Corridors C and D offer saving estimated at 11,000 vehicle hours per day. Corridor E has noticeably lower saving of 9,500.[69]

9.6.6 Table 9-5 summarises the time saving in vehicle hours by corridor for those origin destination pairs which have seen the largest changes. The table below does not contain all of the origin destination points (these are grouped together in “other sectors and are too many to list in here), just the key indicators which show the greatest change.

Table 9-5 – Vehicle hours by key origin/destination by corridor

Origin/destination	Vehicle hours saved				
	A	B	C	D	E
Manchester – Sheffield	500	450	500	850	300
Manchester – South Yorkshire	1,000	950	1,000	600	900
Sheffield – Greater Manchester	750	800	950	1,500	600
Greater Manchester – South Yorkshire	2,250	2,200	2,100	1,250	2,000
Greater Manchester – West Yorkshire	950	100	100	-	50
Greater Manchester – Nottinghamshire	800	1,150	900	850	750
Greater Manchester – Derbyshire	500	550	550	850	450
Greater Manchester – The South	650	700	750	700	650
South Yorkshire – Cheshire, Shropshire, Staffordshire	550	650	650	650	700
Sub-total	**7,950**	**7,550**	**7,500**	**7,250**	**6,400**
Other sectors	3,550	3,950	3,500	3,750	3,100
Absolute total	**11,500**	**11,500**	**11,000**	**11,000**	**9,500**

9.6.7 The table demonstrates that the largest vehicle hour saving for Corridors A, B, C and E is for trips between Greater Manchester and South Yorkshire (approximately 20% of the total saving for each corridor respectively). For Corridor D, the largest vehicle hour saving is for trips between Sheffield and Greater Manchester. However, it should be noted that the assessment of Corridor D was based on a notional route which included a tunnel section under the urban area of Sheffield, which would provide substantially faster journeys than by using the existing network. Conversely, there is no direct link to the SRN at the eastern extents of the study area.

9.6.8 In terms of Manchester/Greater Manchester to Sheffield/South Yorkshire overall saving in vehicle hours, Corridors A, B and C demonstrate saving of 4,400-4,550, whilst that of Corridor D is 4,200 and Corridor E, 3,800.

[69] All journey time saving figures are for an average weekday 24-hour period, and are derived using 2015 figures.

9.6.9 The table also demonstrates that Corridor A offers a substantial saving in vehicle minutes between Greater Manchester and West Yorkshire (approximately 10% of the total vehicle hours saved for Corridor A).

9.6.10 Analysis indicates that the vast majority (95%) of the overall journey time saving for each corridor are broadly realised within the Northern Powerhouse area[70], which could help to address the geographical imbalance in the UK's economy by contributing to the Northern Powerhouse plan's objective of improved connectivity in the North.

9.6.11 A methodology has been developed in order to enable a high level analysis of the core transport user benefits. These benefits are derived for the notional route within each corridor and draw on the traffic information developed using the high level strategic transport model developed for this study.

9.6.12 The analysis has demonstrated that the level of transport user benefits generated by each corridor is broadly the same, therefore, there is no differentiation between corridors in terms of user benefits.

9.6.13 Furthermore, the analysis also indicated that approximately 75% of the benefits were attributable to business users and 25% to consumer users[71]. The core user benefit analysis is based on the assumption that traffic growth ceases at 2041.

9.6.14 At this stage, no account has been taken of the Northern Powerhouse scenario, which could impact on the overall level of benefits for each corridor.

Economic growth – Wider economic benefits

9.6.15 Although at this stage of the study a full analysis of wider benefits using the standard WebTAG approach (WITA) had not been undertaken there was some analysis undertaken regarding GVA impacts from static agglomeration benefits. These benefits are additional to the user benefits and are discussed in more detail within sections 4.6 to 4.9 of this report.

9.6.16 This showed that there could be significant increases in connectivity between regions which could lead to productivity effects. From this analysis we see that Corridors A to D have a similar level of overall impact, with Corridor E estimated to deliver materially less economic benefits.

9.6.17 These figures are indicative and may change under different assumptions around agglomeration and decay parameters and with the development of the transport model.

Carbon emissions

9.6.18 Based on the EAST RAG (Red, Amber, Green) scoring assessment, all corridors would score an Amber rating. At this stage, changes in activity (vehicle/miles) cannot be assessed, due to the lack of detailed traffic modelling, although it is likely that whilst some origin destination journeys would benefit from reduced distances/costs and more efficient operation, the tunnel would generate new traffic that would contribute to increased emissions.

9.6.19 The tunnel will lead to improved fuel economy as trips switch to use the new strategic link, both from more efficient and regulated operation within the tunnel and reduced congestion and associated idling on existing trans-Pennine routes.

9.6.20 Whilst the level of embedded carbon cannot be estimated at the corridor level of assessment, it can be assumed that Corridors D and E would result in more

[70] 16 sectors used within the high level traffic model.

[71] Consumer user benefits are split – 30% commuting, 70% other

embedded carbon than Corridor B, given the potential for a longer tunnel section of route, see Table 9-1.

Socio-distributional Impacts

9.6.21 Based on the EAST RAG scoring assessment all corridors would score an Amber/Green rating. Given the early stage of the assessment, it is not possible to carry out a full distributional assessment of the user benefits, noise, air quality, accident, severance, security, accessibility, or affordability impacts on vulnerable groups or spatial areas at this stage.

9.6.22 In terms of regeneration, there are a differing number of regeneration areas within or in close proximity to each corridor, however at this stage it is not possible to determine the impact any one corridor would have on these.

Local environment

9.6.23 Table 9-6 summarises the results of the assessment of corridors against the EAST Local Environment indicators. Although it is anticipated that the impacts will be more positive within the PDNP, at the corridor level the analysis does not differentiate between the potential impact within the PDNP and outside the PDNP. This more detailed analysis is covered in Section 10 of this report.

Table 9-6 – Local Environment Assessment

Indicator	Scale	Corridor				
		A	B	C	D	E
Air quality	RAG scale	Red	Red	Red	Red	Red
Noise		Red/ Amber	Red	Red/ Amber	Red	Red
Biodiversity		Green	Green	Amber/ Green	Red/ Amber	Green
Heritage/Townscape		Amber/ Green	Amber/ Green	Amber	Red/ Amber	Amber
Landscape		Amber	Amber/ Green	Amber	Red/ Amber	Amber

Note: EAST RAG Scale: Red, Red/Amber, Amber, Amber/Green, Green

9.6.24 In terms of air quality, all corridors have the potential to have a negative effect on air quality[72] as a result of traffic generation. Despite the fact that all corridors have been scored negatively, it is assumed that air quality will improve within the PDNP as a result of the reduction in vehicles travelling on surface routes through the PDNP. This is based on the assumption that any scheme taken forward will include suitable equipment for the treatment and removal of airborne pollutants from ventilation shaft exhaust.

9.6.25 For the assessment of noise, all corridors have the potential for significant impacts as a result of traffic generation, however Corridors A and C pass through fewer existing built up areas. It is assumed that noise associated with existing routes within

[72] There is uncertainty surrounding this relating to technology trends. Trends in vehicle manufacture and efficiency lead us to believe that air quality issues from road traffic will not be as significant a problem in future years.

the PDNP will improve due to the reduction of vehicles passing through the PDNP, and the fact that ventilation shafts will be suitably baffled.[73]

9.6.26 Biodiversity has also been considered, with all corridors presenting an opportunity to conserve sensitive habitats in comparison to a ‘Do-Minimum’ situation. Corridors A, B, C, and E are anticipated to provide significant benefits to international and national constraints, although a route in Corridor C may directly impact on ecological designations and the potential for mitigation is uncertain. Corridor D is the most heavily constrained corridor with respect to the potential impact on ecological designations, and the potential for mitigation is also uncertain. Whilst it may provide benefits to international and national constraints in operation, this may be reduced where open areas of new road are introduced into the PDNP.

9.6.27 The heritage/townscape assessment has identified that routes within Corridors A and B would be less likely to impact on heritage assets. Meanwhile, direct impacts on those assets in Corridors C and E would be more likely, with mitigation opportunities uncertain. Corridor D is the most heavily constrained in terms of heritage assets, with one asset covering the entire width of the corridor. This means that any new link is very likely to have a direct impact on heritage/townscape, and opportunities for mitigation are uncertain. This asset is also present within Corridor E. All corridors could potentially introduce additional traffic onto existing roads through Conservation Areas (CAs), although this could be mitigated with careful consideration of route alignments, portals and localised improvements.

9.6.28 With regard to landscape, all corridors will contribute to the conservation of the PDNP by minimising the amount of construction and infrastructure that would be required within the PDNP in a ‘Do-Minimum’ situation to accommodate current and future traffic demands. Corridor D would potentially introduce new viaducts into the PDNP and require more construction activity within the PDNP (that is, a surface route in the PDNP), which fails one of the agreed viability assumptions. Corridor B could potentially maximise the use of the existing road network. Corridor E would make maximum use of the existing road network on the eastern side of the PDNP, but would require new construction in relatively open areas of the countryside on the western side. In the case of Corridors A, C, D and E, opportunities for mitigation are uncertain.

Wellbeing

9.6.29 Based on the EAST RAG scoring assessment, all corridors would score an Amber/Green rating. However, there are some subtle differences between corridors. A new strategic link within the corridors would reduce traffic levels on existing trans-Pennine surface routes, easing severance issues for communities on these routes and also improving accessibility. Whilst all five corridors remove similar amounts of traffic from a number of existing routes (M62: 10%; A57: 45%; A628: 85-95%), Corridor A also removes 90% of traffic from the A635, whereas the other corridors remove 15-25%.

9.6.30 The anticipated reduction in journey times between key origins and destination would also provide an improvement to accessibility (see Section 9.2).

9.6.31 Reduced traffic on existing trans-Pennine routes may encourage increased levels of physical activity (more people visiting and using the PDNP for leisure), but this is likely to be consistent across corridors.

9.6.32 It is anticipated that the reduction in traffic on the existing routes and the shift in traffic to a new strategic link which has been designed to the latest standards, would result

[73] Sound baffles are construction or devices which reduce the strength (level) of airborne sound.

in an overall reduction in accidents. However, it is not possible to distinguish between the levels of accident reduction for corridors at this stage.

9.6.33 Given the scale of the proposed tunnel, irrespective of the corridor, safety and security is of obvious concern as it would be with any other piece of major infrastructure in the UK (for example, the Humber Bridge or Hinckley power station). This is a complex issue which will need to be addressed with specialist input at the design stage.

Value for Money

9.6.34 The VfM has not been developed at this stage because the estimation of costs and benefits is at too early a stage for rigorous assessment.

9.7 Financial Case

9.7.1 Table 9-7 summarises the results of the assessment of corridors against the EAST Financial Case indicators. Affordability has not been assessed as the amount of funding available is currently unknown. At the corridor level of assessment, it is not possible to generate cost profiles, therefore this indicator was not assessed.

Table 9-7 – Financial Case assessment

Indicator	Scale	Corridor				
		A	B	C	D	E
Affordability	1 (not affordable) to 5 (affordable)	Not assessed				
Capital cost (£m)	1 (£1000m+) to 10 (£0m)	1	1	1	1	1
Revenue cost (£m)	1 (£1000m+) to 10 (£0m)	Not known at this stage				
Cost profile	Qualitative assessment	Not assessed				
Overall cost risk	1 (high risk) to 5 (low risk)	1	1	1	1	1

9.7.2 At the corridor level, it is not possible to develop estimates of the capital cost, given that the start and end point of any strategic link, together with the length of the actual tunnelled section, could vary substantially within the corridor extents. However, it can safely be assumed that the capital cost of a strategic link within any of the corridors would be well in excess of £1 billion (the extent of the EAST scoring range). Similarly, it is not possible to develop revenue (maintenance / operation) costs for corridors.

9.7.3 In terms of cost risk, a high degree of risk exists for all corridors because capital and revenue costs are not yet known.

9.7.4 Furthermore, research into other tunnel schemes around the world found that there were often variances between the final costs and the estimates.[74] It also demonstrated that, the difference between the estimates and final costs was significantly lower in Europe than it is in the rest of the world.

9.7.5 Analysis of the corridor length range (Table 9-1) demonstrated that strategic links within Corridors D and E could be expected to have a longer length of tunnel than Corridors B and A, which would result in both higher capital and maintenance costs. Furthermore, longer tunnel sections would require extra ventilation shafts and generate more excavated material, both of which would also be likely to increase the

[74] Worcester Polytechnic institute / AECOM, *Analysing international tunnel costs*, February 2012.

costs of strategic links in these corridors. In terms of Corridor D, any route crossing Ladybower reservoir would be likely to require a viaduct,[75] adding to the cost and impacting on the PDNP, or alternatively, would be longer in length if diverting horizontally or vertically to avoid Ladybower Reservoir.

9.8 Management Case

9.8.1 Table 9-8 summarises the results of the assessment of corridors against the EAST Management Case indicators.

Table 9-8 – Management Case assessment

Indicator	Scale	Corridor				
		A	B	C	D	E
Implementation timetable	1 (10+ years) to 7 (0-1 month)	1	1	1	1	1
Public acceptability	1 (low) to 5 (high)	3	4	3	2	3
Practical feasibility	1 (low) to 5 (high)	3	4	3	2	2
Quality of supporting evidence	1 (low) to 5 (high)	3	3	3	3	3
Key risks	Text field	Funding availability. Level of public support. Level of stakeholder support. Scheme cost estimates. Adverse environmental impacts. Obtaining statutory powers. Impact of future technological advances. Existing network capacity.				

9.8.2 It is not possible to develop an estimate of construction time, given that the start and end point of any strategic link, together with the length of the actual tunnelled section, could vary substantially within the corridor extents. However, as an indication, it is reasonable to assume that construction, for any corridor could take approximately 10 years. Whilst the tunnel sections of Corridors D and E are longer than that of Corridor B, it cannot be assumed that they would necessarily take longer to construct, as extra TBMs could be used, although this would affect the cost and possibly public acceptability due to the need to move the machines within environmentally sensitive areas.

9.8.3 To date, whilst there has been significant engagement there has been no formal public consultation regarding the proposals. Proposals within any corridor would generate a high degree of interest given the sensitivity of both the national park and surrounding Green Belt - areas to the west of Sheffield are particularly well used for outdoor activity and by tourists. Surface measures within the park and potential for traffic increases on links are likely to be other areas for concern, while improved connectivity, journey times, resilience, and economic growth are anticipated to be key areas for support. Overall, it is anticipated Corridor B would have a higher degree of public acceptability, given the opportunity to make use of existing surface infrastructure (M67, A616). Corridor D has the lowest score, given that the environmental impacts could be greater and the potential for construction of a viaduct

[75] The design brief for any potential viaduct within the PDNP would establish the need for it to be an 'iconic structure'.

within the PDNP. In addition, construction of tunnels under the Sheffield urban area or surface links to the west of Sheffield, are likely to be controversial.

9.8.4 In terms of practical feasibility, there is evidence of successful construction and operation of long road and rail tunnels around the world. There are a number of construction constraints that are common across all corridor options, including environmental, geological, maintenance and operational considerations, as well as the effect on the existing SRN. However, generally speaking, Corridor B is likely to require a shorter tunnel length, therefore creating less excavated material, requiring the construction of less ventilation shafts within the national park and having less maintenance requirements. Landslides (deep rotational slips) are a consideration for Corridors B, D and E (Woodhead and Hope Valley). Furthermore, Corridors B, C, D and E have good access to the rail network via existing and abandoned alignments at both western and eastern edges of the national park, for removing excavated material by rail, whereas Corridor A only has access at the western extent. Overall, we feel that Corridor B is the most practically feasible, and therefore scores highest. Conversely, Corridors D and E score lowest, primarily given the longer length of tunnel that would be required.

9.8.5 The quality of supporting evidence informing the analysis of corridors is considered to be appropriate at this stage.

9.8.6 There are a number of key risks common to all corridors including the fact that funding is not guaranteed and that TfN is developing a strategy which will lead to the prioritisation of interventions across the North which may or may not identify this or other trans-Pennine transportation interventions as a priority for capital spending. There is a strong risk of objection to the scheme due to the sensitivity of the area. Furthermore, the long timescale of the project increases the potential for changes in support from local and central governments. Future technological advances may also result in the need and design of the scheme changing significantly. There is also concern about how other sections of the highway network (strategic and local) will be able to cope with increased traffic flows. At the corridor level, in addition to differences in tunnel route distances and amounts of excavated material, Corridor D also presents the potential need for a viaduct to cross the Ladybower Reservoir or a horizontal/vertical diversion around the reservoir (that is, surface construction within the PDNP). Corridor D also may potentially need a tunnel under the Sheffield urban area, and on the eastern side of the study are near Sheffield it may not offer linkages to the SRN that are as direct as in other corridors. Corridors A and B may also offer better connections in the west towards Merseyside.

9.9 Commercial Case

9.9.1 Table 9-9 summarises the results of the assessment of corridors against the EAST Commercial Case indicators. Given the early stage of assessment, looking at broad corridors, many of the aspects associated with commercial viability are as yet, unknown. Consequently, only one indicator (Where is funding coming from) has been considered at this stage.

Table 9-9 – Commercial Case assessment

Indicator	Scale	Corridor				
		A	B	C	D	E
Flexibility of option	1 (static) to 5 (dynamic)	Not assessed				
Where is funding coming from	Text field	Funding uncertain. Specific procurement route unknown. Tolling to be considered in Stage (iii)c				
Income generated	Yes / no / don't know	Not assessed				

9.9.2 At this stage, the means by which any new strategic link between Manchester and Sheffield would be funded is uncertain. It is also too early to assess whether developer or third party contributions could be anticipated.

9.9.3 The specific procurement route taken may impact on the timescales, cost and the balance sheet for any specific option although it is too early for a preferred procurement route to be established for any corridor.

9.9.4 To date, a toll option has not been considered. It is intended that one tolling option alternative (still to be defined) will be considered in Stage (iii)c of the study, once a shortlist of preferred options has been derived. Furthermore, the decision on whether or not to toll the road is outside the scope of the current study, as is the tolling strategy and associated technology.

9.9.5 In summary, there is no difference between corridors in terms of their Commercial Case and we are not in a position to form a view about the degree to which such a strategic link could be delivered.

9.10 Overall summary of EAST corridor assessment

9.10.1 Table 9-10 summarises the results of the EAST analysis by corridor.

Table 9-10 – Summary of EAST corridor assessment

Case	Indicator	EAST Score				
		A	B	C	D	E
Strategic	Scale	5	5	5	4	4
	Fit with wider transport and government objectives	4	4	4	4	4
	Fit with other objectives	4	4	4	4	4
	Key uncertainties	Timescales of other studies. Construction in PDNP. Mining constraints. SRN capacity. Ventilation.				
	Consensus over outcomes	2	2	2	2	2
Economic	Economic growth	G	G	G	G	G
	Carbon emissions	A	A	A	A	A
	Socio-distributional impacts	A/G	A/G	A/G	A/G	A/G
	Air Quality	R	R	R	R	R
	Noise	R/A	R	R/A	R	R
	Biodiversity	G	G	AG	R/A	G
	Heritage/Townscape	A/G	A/G	A	R/A	A
	Landscape	A	A/G	A	R/A	A
	Wellbeing	A/G	A/G	A/G	A/G	A/G
	Expected VfM	Not able to assess at the corridor level.				
Financial	Capital cost (£m)	£1000m +	£1000m +	£1000m +	£1000m +	£1000m +
	Revenue cost (£m)	Don't know	Don't know	Don't know	Don't know	Don't know
	Overall cost risk	1	1	1	1	1
Management	Implementation timetable	10+ years	10+ years	10+ years	10+ years	10+ years
	Public acceptability	3	4	3	2	3

Case	Indicator	EAST Score				
		A	B	C	D	E
	Practical feasibility	3	4	3	2	2
	Quality of supporting evidence	3	3	3	3	3
	Key risks	Funding availability. Level of public support. Level of stakeholder support. Scheme cost estimates. Adverse environmental impacts. Obtaining statutory powers. Impact of future technological advances. Existing network capacity.				
Commercial	Where is funding coming from?	Funding uncertain. Specific procurement route unknown. Tolling to be considered in Stage (iii)c.				

Note: The scoring scale varies between cases and indicators as follows:

- Strategic Case: 1 (low) to 5 (high) scale for all indicators
- Economic Case: 6 point Red, Amber, Green (RAG) scales for all indicators
- Financial Case: 1 (low) to 10 (high) scale for 'capital' and 'revenue' costs and 1 (low) to 5 (high) scale for 'cost risk'
- Management Case: 1 (low) to 5 (high) scale, except for 'implementation timetable' which has a 1 (low) to 7 (high) scale
- Commercial Case: 1 (low) to 5 (high) scale

9.10.2 At the corridor level of assessment, some of the EAST indicators are not able to provide differentiation between corridors, however, as the study progresses into the final stage of the study (see analysis in Section 10 of this report), it is anticipated that greater differentiation will be possible for using these indicators, as individual options are considered.

9.10.3 The outcome of the initial EAST assessment shows that Corridor B, along the existing route of the A628/A616, and to a lesser extent Corridors A and C, appear to have greater advantages over the other corridors and construction may be easier and take less time to construct.

9.10.4 **Strategic Case** – In terms of 'Scale of Impact', how each corridor meets the four objectives of the study, outlined in the Interim Report, Corridors D and E again score lower than Corridors A, B and C.

9.10.5 **Cost** – Based on expectations of tunnel length, it is likely that Corridors A and B will be the cheapest. Longer tunnels would also require more ventilation shafts, potentially creating a more negative impact on the environment of the PDNP. Corridors A and B provide the shortest tunnel under the Park, and can make use of existing alignments both for construction traffic and for the route itself. Construction waste can be disposed of using the existing road, or potentially by recommissioning the disused railway line that runs parallel to the route. Easier access to the middle of the site could also allow faster construction. Corridors D and E both have longer tunnel lengths, they would incur higher construction and maintenance costs. Further cost analysis is underway and will inform future decisions.

9.10.6 **Economy** – The analysis (outlined principally in Section 4 of this report) suggests that investment in any corridor could generate additional output for the UK economy. These productivity benefits accrue to all regions, with the strongest gains in Greater Manchester and South Yorkshire. Based on the preliminary analysis, Corridors A to D offer a similar level of overall impact, whilst Corridor E is estimated to deliver materially less economic benefits than the other corridors.

9.10.7 **Journey time savings** – All corridors offer substantial reductions in journey times of around thirty minutes on the Manchester-Sheffield journey, although Corridor E performs least well. All corridors would provide relief to the existing road network, improving both reliability and resilience for the network as a whole, and removing similar amounts of traffic from existing trans-Pennine routes.

9.10.8 **Environment** – All corridors avoid the worst potential environmental impact by tunnelling through the PDNP. All options are likely to increase noise pollution and have some landscape impacts away from the Park itself. However, Corridor D has the lowest environment score of the set, reflecting the potential need for a short viaduct section over Ladybower reservoir. Corridor D is most constrained by existing noise problems at the eastern side of the PDNP. It should be noted that noise and air quality within the PDNP will be improved based on the fact that there will be a reduction in vehicles passing through the PDNP on surface routes, as well as the assumptions that there will be suitable equipment for the treatment and removal of airborne pollutants from ventilation shaft exhaust and that ventilation shafts will be suitably baffled.

9.10.9 In terms of biodiversity, all corridors should provide significant benefits to international and national constraints. However, Corridor D is the most heavily constrained corridor with respect to ecological designations. Furthermore, Corridor D is the most heavily constrained with respect to heritage features, and also scores poorly for public acceptability given that a viaduct across Ladybower Reservoir (surface route, which fails one of the viability assumptions agreed with stakeholders) may be needed, or to divert horizontally or vertically to avoid the feature, both of which would add to costs.

9.10.10 **Practical feasibility** – Corridors C, D and E would have a longer tunnel length than Corridor B and offer no discernible benefits in terms of connectivity, journey times or economics. The propensity for a longer tunnel length is likely to result in more embedded carbon, greater capital investment costs (as tunnel cost/mile are far greater than those for surface links), greater maintenance costs per annum, more excavated material to dispose of, and more ventilation shafts to be constructed within the PDNP. Landslides (deep rotational slips) are also a constraint for Corridors D, and E.

9.10.11 **Public acceptability** – Corridor B, and to a lesser extent Corridors A and C emerge as being more favourable, given that they are considered to be more acceptable to the public as a result of the opportunity to make use of existing surface infrastructure, limiting the impact that new surface construction may have on communities and the environment, and as it is viewed as having a greater level of practical feasibility (shorter tunnel length than Corridors D and E and better rail access for removing excavated material).

9.10.12 Based on this initial sift, using the EAST assessment tool, it is recommended that Corridors A, B and C are the better performing corridors and that these should be progressed to the final stage of the study for more detailed analysis.

10 Route option development and assessment

10.1 Overview of route option development approach

10.1.1 As outlined in Section 9, the initial sift, using the EAST, concluded that Corridors A, B and C were the better performing corridors that would progress to a further sifting stage, (Stage (iii)b), using the OAF. At the OAF stage, it was envisaged that route options would be assessed. However, the initial stakeholder workshops generated a large number of possible routes within each corridor which were variations on a common theme and displayed many similar characteristics. (The complete set of consolidated routes for Corridors A, B and C generated from the workshops are shown in Figure 10-1). It was therefore important to undertake a consolidation process in order to generate a smaller number of distinct route options.

10.2 Proposed routes

10.2.1 The initial process for determining the route options was to sketch approximate route options on to a plan enabling the study team to amalgamate multiple routes with similar characteristics in to a single route option. This amalgamation process gave a total of 36 route options, as shown in Figure 10-2.

10.2.2 The second stage of determining route options considered the start and end points of the thirty-six route options in more detail. For the purposes of assessing the options at Stage (iii)b, the exact alignment was not crucial, as each of the route options would vary from its initial position if preliminary or detailed design were to be undertaken. Where route options had the same start and end point, and were fairly similar in length and alignment, a further consolidation of route options was undertaken. This approach reduced the number of route options to twelve. Figure 10-3 shows the final twelve route options derived from this process.[76]

10.2.3 In addition, Table 10-1 summarises the lengths for each route option within each corridor, both in terms of overall length and the specific tunnel length.[77] It should be noted that the length of tunnels and the strategic link in full, have changed slightly from the numbers presented in Section 9 of this report (corridor assessment). The reason for this is because at this stage of the assessment we moved away from assessing corridors, where potential routes within each corridor were looked at on a much broader basis, to moving towards a more refined identification and assessment at the route options level. This allowed the study team to consider, in more detail, factors such as topography, environmental and geological considerations and take on board further comments and observations from stakeholders, particularly in relation to the location of tunnel portals relative to not just the PDNP boundary but other important local considerations.

[76] It is important to note that options that were originally proposed are not discarded. For instance option B1 is shown passing to the north of Torside and the other reservoirs alongside the A628, but this route could equally pass to the south. The line shown on the drawing is purely indicative and is aimed at giving a general idea of the route being assessed; the option itself is actually a sub corridor.

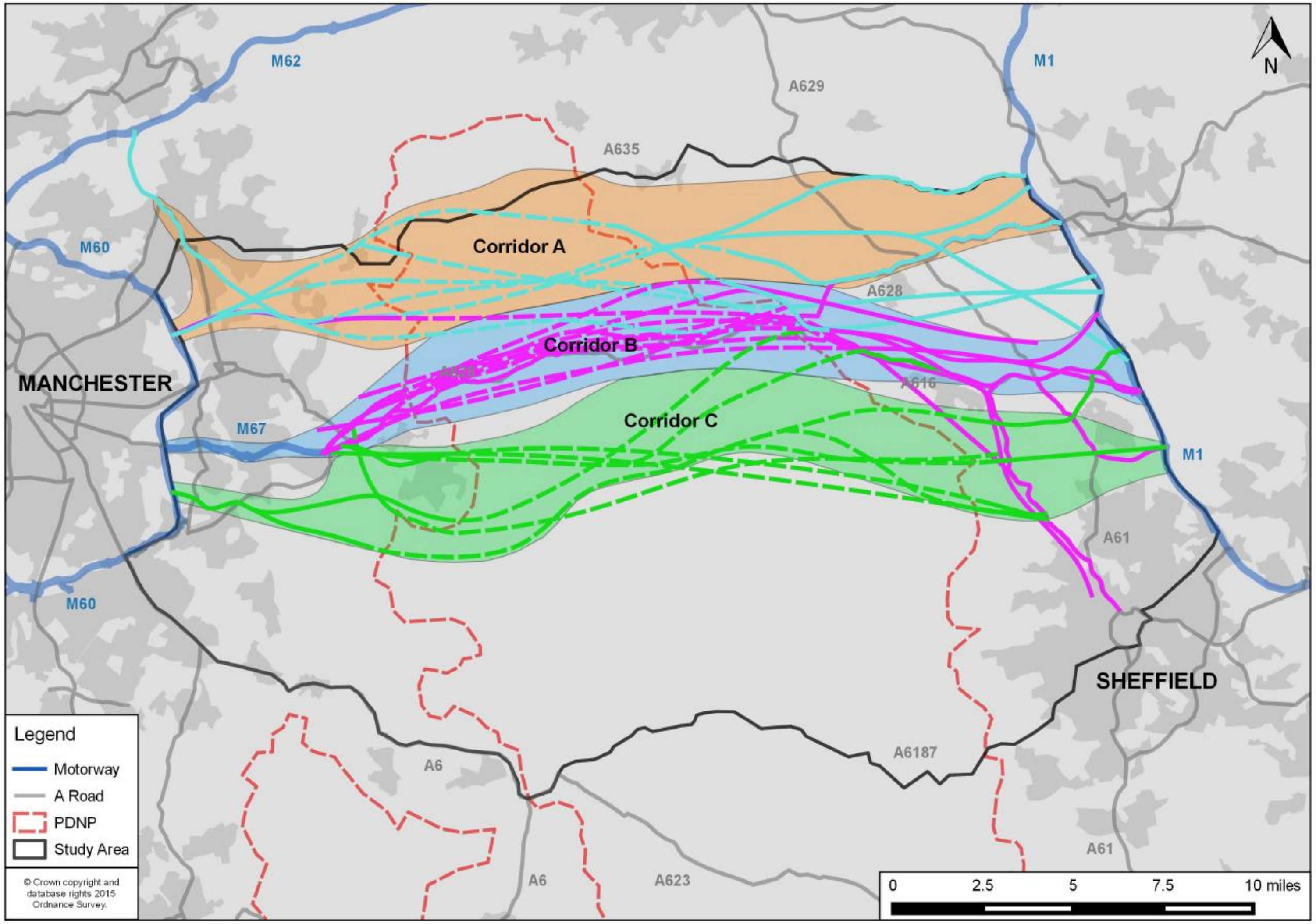
[77] In Section 9, the corridor length ranges indicated that Corridor B had potentially the shortest tunnel length. However, following the consolidation process, the required section of tunnel/surface links were revisited. The results demonstrate that route options 1, 2 and 3 within Corridor A have the shortest tunnel lengths.

Table 10-1 Corridor length ranges (miles)

Corridor	Route Option	Tunnel Length (miles)	Strategic Link Length (miles)
A	**1**	10	25
	2	10	29
	3	10	30
	4	11	25
	5	11	28
	6	14	28
B	**7**	11	25
	8	14	25
C	**9**	16	24
	10	16	24
	11	18	29
	12	18	29

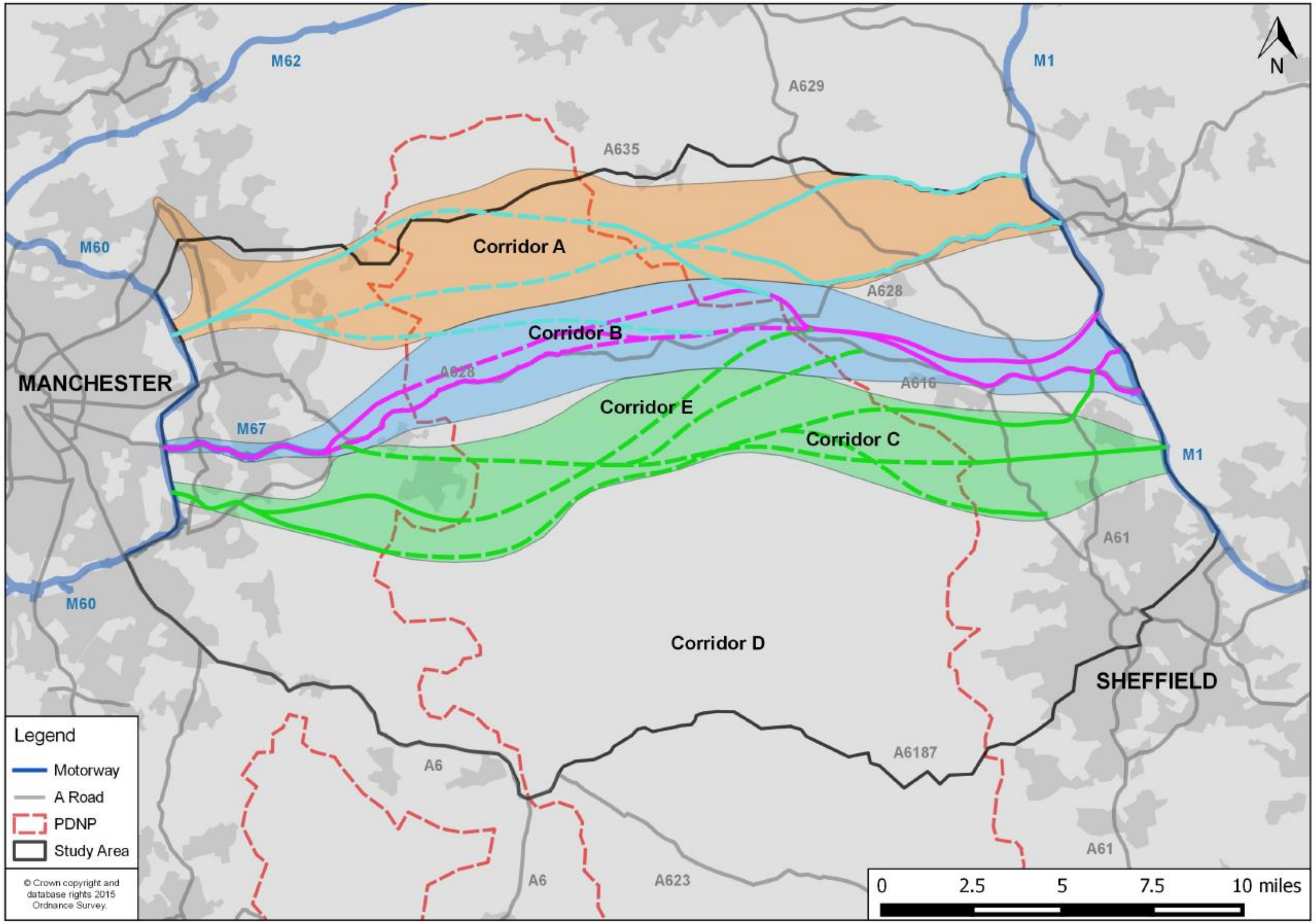
10.2.4 This approach offers flexibility to refine and develop an option, should it be taken forward for more detailed appraisal. The approach still retains the level of certainty required to assess that option for the OAF assessment and associated sift.

Figure 10-1 – Consolidated routes within Corridors A, B and C



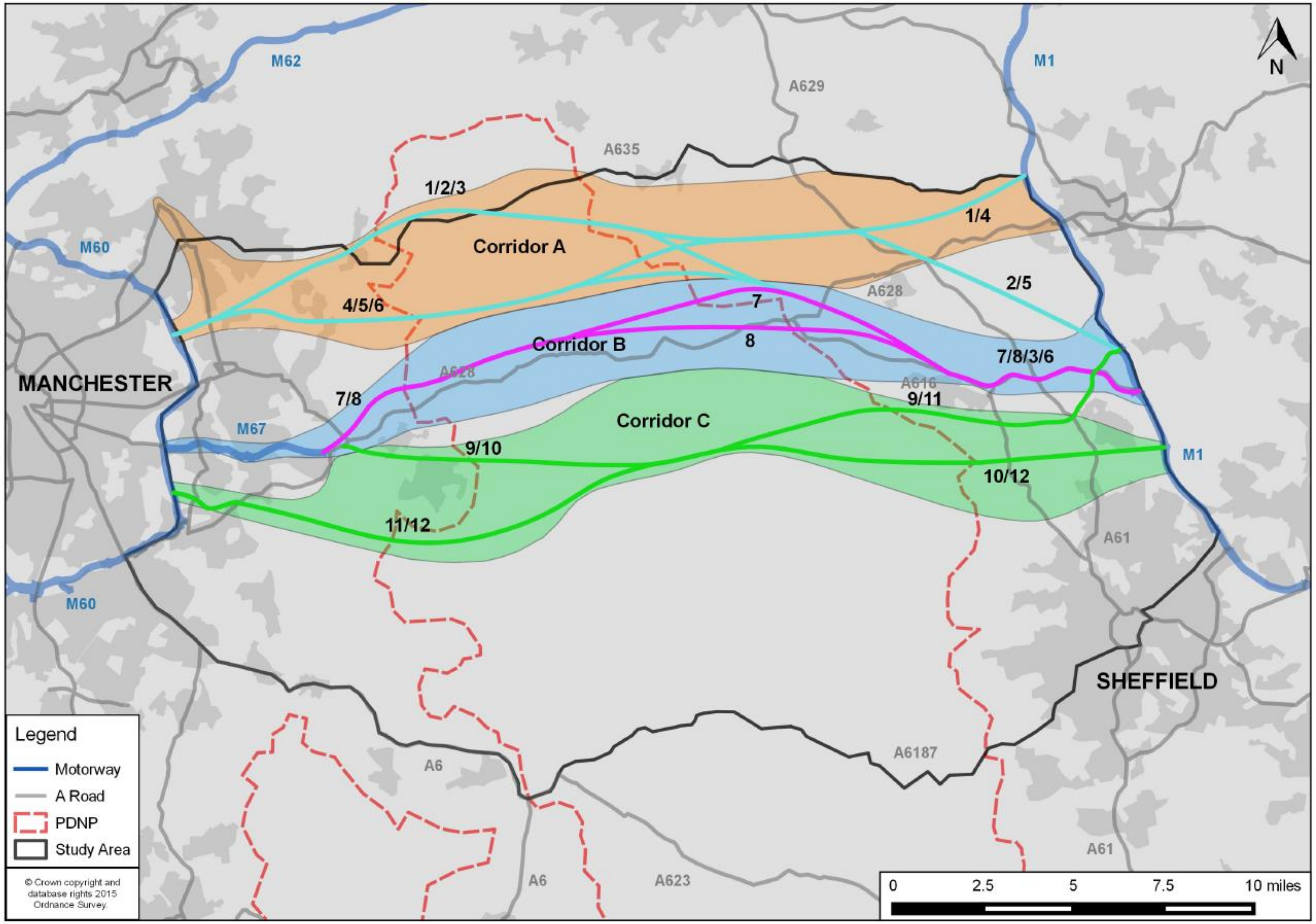
Note: The figure displays all of the individual routes within corridors A, B and C, developed by both the study team and stakeholders at the two workshop events

Figure 10-2 – Initial consolidation of 36 route options



Note: There are 36 potential route options given the multiple start / end points and variations in tunnel alignment

Figure 10-3 – Proposed 12 route options for Stage (iii)b assessment



10.3 Route option assessment methodology

10.3.1 The Stage (iii)b, route option sifting has been conducted using the OAF approach, outlined in the *Transport Appraisal Process* TAG unit[78]. As with the EAST sifting approach in the previous stage, the OAF is consistent with the DfT's *Transport Business Case* principles, based around the Treasury's best practice five-case model:

- **Strategic Fit** – proposals are supported by a robust case for change that fits with wider public policy objectives
- **Value for Money** – proposals demonstrate VfM
- **Financial Case** – proposals are financially affordable
- **Delivery Case** – proposals are achievable
- **Commercial Case** – proposals are commercially viable

10.3.2 Adopting the OAF approach at the route option level of assessment adds to the depth of analysis and provides an increased level of assurance.

10.3.3 There are a range of assessment areas within each of the five cases, the majority of which were analysed at the route option level in Stage (iii)b. These were either new assessment areas, that were not considered at the corridor level sift (Stage (iii)a), or areas where the corridor level analysis could be built upon, in order to achieve differentiation between route options.

10.3.4 It should be noted that a number of assessment areas were not analysed because the corridor level assessment had already demonstrated that they were not differentiators, at this stage of the study, which is the key purpose of each stage of the sifting process.

Scoring system

10.3.5 The majority of the assessment areas use a seven-point qualitative scoring scale, highlighted in Table 10-2.

Table 10-2 – Seven-point qualitative scoring scale

Large Beneficial
Moderate Beneficial
Slight Beneficial
Neutral
Slight Adverse
Moderate Adverse
Large Adverse

10.3.6 The only exceptions to this are the following three assessment areas, where costs have been normalised and the results presented in relative terms:

- Cost to broad transport budget

[78] Appendix A of the Transport Appraisal Process TAG unit outlines the OAF, summarising the type of analysis, key input data and tools, and data outputs to be used in the assessment of potential options.

- Outturn cost to implement
- Operating and maintenance costs

10.4 Strategic Case assessment results

10.4.1 Table 10-3 summarises the results of the analysis of route options against the OAF Strategic Case assessment areas.

Table 10-3 – Strategic Case assessment summary

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Regional Policy Alignment	Large Beneficial											
Local Policy Alignment	Slight Beneficial											
Scheme Objectives Fit	SB	SB	SB	MB	SB	SB	SB	MB	MB	MB	SB	SB

Note: SB = Slight Beneficial; MB = Moderate Beneficial

10.4.2 A number of national and regional policies and strategies have been reviewed in order to determine how well each route option aligns with strategic objectives. Overall, all route options were considered to have a strong fit with national and regional policies' objectives. Any new strategic link is anticipated to improve the capacity, connectivity, resilience, reliability, quality and safety of the network, whilst also supporting national and regional economic activity, facilitating growth, joining up communities and creating jobs, all of which are key policy drivers. There are a number of adverse environmental impacts associated with the construction of a new strategic link (See later sections) which would conflict with a number of objectives that focus on improving the environment. In particular, a key tenet of some of a number of the policy documents is to support a low carbon economy. However it is also worth noting that whilst the overall assessment, at this stage, indicates an overall adverse effect the impact on the PDNP could in places be largely beneficial particularly in terms of noise and air quality. At this stage, it is not clear how well a new strategic link between Manchester and Sheffield would align with this objective. The overall impact of the scheme on carbon emissions will be assessed in more detail in Stage (iii)c.[79]

10.4.3 Table 10-3 demonstrates that all route options have a 'slight beneficial' alignment with local policy objectives as the concept of a new strategic link between Manchester and Sheffield supports a number of the objectives within the local transport plans and strategies of Greater Manchester, Sheffield City Region and Derbyshire.

10.4.4 As part of the study process, four key objectives were set:

[79] Consideration will also be given to the use of emerging carbon capture technology

Objective 1 *– To provide a safer, faster, and more resilient road connection between Manchester and Sheffield, creating more capacity and an additional east-west connection.*

Objective 2 *– To fulfil the aims of the Northern Transport Strategy to deliver a scheme that will contribute to the transformation of the economy in the North.*

Objective 3 *– To protect and improve the natural environment by reducing through-traffic in the PDNP and by getting the right traffic onto the right roads.*

Objective 4 *– To support wider socio-economic needs and leave a long-term legacy of improved road connectivity, better access to labour markets, wider employment opportunities, better land use, and more effective integration*

10.4.5 The OAF analysis has drawn on the analysis for a number of other assessment areas in order to determine how well each route option meets the 4 study objectives.

10.4.6 All route options align strongly with **Objective 1**. A new strategic link will provide additional east-west connectivity, offering increased capacity and significant improvement in resilience as it removes a substantial proportion of traffic from existing trans-Pennine routes. The new link would be designed to latest standards, and the tunnel section also offers greatly improved weather resilience. Route options provide journey time savings of 11,000-11,500 vehicle hours per day on trans-Pennine trips, with additional journey time savings on local trips and trips made on the M62. Any adverse impacts at link connections with the new route will be offset by benefits realised by the redistribution of traffic and reduced journey times.

Investment in a new strategic link on this route could generate additional output for the UK economy. Productivity benefits could accrue to all regions, with the strongest gains realised in Greater Manchester and South Yorkshire. As such, all route options align strongly with **Objective 2**.

10.4.7 Each route option includes a tunnelled section through the PDNP, which will be part of the SRN and be designed to the latest 'Expressway Standards'. It will remove a significant proportion of traffic from existing routes within the PDNP. These two factors contribute to the objective of getting the right traffic onto the right roads. However, there are a significant number of adverse environmental impacts associated with the development of the link, both within the PDNP and with the surface sections on either side of the PDNP. These impacts are detailed later in this section. In summary, all route options are shown to have an overall adverse impact on Noise, Air Quality, Landscape, Townscape, Historic Environment, Biodiversity and Water Environment assessment areas. However, the impact arising from route options 4, 8, 9 and 10 is not as adverse as for other route options for some assessment areas, therefore they score better against **Objective 3**.

A new strategic link on this route would deliver a long-term legacy of improved road connectivity, with journey time savings of 11,000-11,500 vehicle hours per day forecast for trans-Pennine trips and additional journey time savings on local trips and trips made on the M62. Any adverse impacts at link connections with the new route will be offset by benefits realised by the redistribution of traffic and reduced journey times. **Objective 2** has already outlined that productivity benefits could accrue to all regions, indicating that better access to labour markets and wider employment opportunities are likely to occur. It is considered that all route options align strongly with **Objective 4.**

10.4.8 The analysis demonstrates that overall, whilst all of the route options align well with the scheme objectives, route options 4, 8, 9 and 10 score more highly, primarily as a result of having a less adverse environmental impact than other route options.

10.5 Value for Money Case results

Economy

10.5.1 Table 10-4 summarises the results of the assessment of route options against the OAF assessment areas for the Economy.

Table 10-4 – Economy assessment summary

Assessment Area	Route Option											
	A						B		C			
	1	2	3	4	5	6	7	8	9	10	11	12
Business Users	Previously assessed at corridor level. Not a differentiator.											
Reliability	Large Beneficial											
Regeneration	SB	MB	MB	SB	MB	MB	MB	MB	MB	MB	MB	MB
Wider Impacts	Moderate Beneficial											

Note: SB = Slight Beneficial; MB = Moderate Beneficial

10.5.2 The Stage (iii)a corridor level TUBA assessment demonstrated that there was no relative difference between corridors A, B and C in terms of business user benefits. As such, business users' benefits are not considered to be a differentiator between route options, at this stage of the study.

10.5.3 The assessment of reliability demonstrated that all route options had a large beneficial impact, (the corridor based assessment had previously demonstrated that a route option within Corridor A, B and C would reduce traffic on existing trans-Pennine routes by approximately 10%[80]). This would greatly improve the reliability of these existing routes.

10.5.4 Furthermore, all of the route options would be designed to the latest expressway standards, incorporating a similar number of grade separated junctions with the existing highway network, therefore providing a good dispersal network should an incident occur on the strategic link.[81]

10.5.5 The majority of route options are anticipated to result in a moderate beneficial impact on regeneration, as they each offer a similar number of interchanges with the existing network, improving access to a large number of regeneration areas at both the eastern and western extents of the study area. The scores for route options 1 and 4 are only slight beneficial, due to the connection with the M1 at the eastern side of the study area. Whilst serving Barnsley well, they are less well suited to serving the regeneration areas of Sheffield and Doncaster compared to other route options.

[80] There are subtle differences in the breakdown of this overall saving. Whilst all 12 routes options remove similar amounts of traffic from a number of existing routes (M62: 10%; A57: 45%; A628: 85-95%), route options 1-6 also remove 90% of traffic from the A635, whereas the other 6 options remove only 15-25% of traffic from the A635. However, this is only a small percentage of the overall relief offered by option 1-6, and is therefore not considered to be a differentiator.

[81] It should be noted that providing interchanges along the strategic link may adversely affect the reliability of the route.

10.5.6 The assessment of wider impacts drew on the analysis of time savings, completed at the corridor level of assessment, which demonstrated that overall saving was very similar for corridors A, B and C[82] (see Table 9-5 in previous section of the report). In addition, an exercise was undertaken to assess the time saving associated with the key origin destination sector movements (those with >5% saving) which demonstrated that some corridors were better for particular movements than others.[83] The key origin destination sector time saving was then weighted by the population[84] of the corresponding sectors to determine whether there was a differentiator. The assessment concluded that there was no differentiation between route options.[85]

Environment

10.5.7 Tables 10-5 to 10-8 summarise the results of the assessment of route options against the OAF assessment areas for Environment. The analysis for the Environmental Assessment is split down into four area-based categories. Tables 10-5, 10-6 and 10-7 present the results for 'West of the PDNP', 'Within the PDNP' and 'East of the PDNP', respectively, which demonstrates that there could be positive and negative potential impacts associated with some environmental topics within each area. However, the category noted for the overall environmental assessment is taken to be the Summary score shown in Table 10-8, which is based on the worst score of the three areas for each criteria.

Table 10-5 – Environment assessment summary (West of the PDNP)

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Air Quality	Moderate Adverse											
Noise	Moderate Adverse											
Greenhouse Gases	Previously assessed at corridor level. Not a differentiator.											
Landscape	LA	LA	LA	LA	LA	LA	MA	MA	MA	MA	LA	LA
Townscape	LA	LA	LA	MA	MA	MA	SB	SB	MA	MA	SA	SA
Historic Environment	LA	LA	LA	MA	MA	MA	SA	SA	LA	LA	LA	LA
Biodiversity	MA	MA	MA	LA	LA	LA	SA	SA	SA	SA	MA	MA
Water Environment	Slight Adverse											

Note: LA = Large Adverse; MA = Moderate Adverse; SA = Slight Adverse; SB = Slight Beneficial

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[82] Overall journey time savings range from 11,000-11,500 vehicle hours.

[83] For example, Corridor A provides a higher saving for movements between Greater Manchester and West Yorkshire than other corridors

[84] The wider impacts have been weighted by population centres for this analysis. The GVA analysis at Stage (iii)c will establish the wider impacts to business.

[85] The highest score has been limited to 'Moderate Beneficial' due to the fact that minimum journey times remain at 30 minutes, with improvements to journey times being linear and providing access along a corridor from one direction. Additionally, at this stage no account has been taken of the Northern Powerhouse scenario.

Table 10-6 – Environment assessment summary (Within the PDNP)

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Air Quality	Large Beneficial											
Noise	Moderate Beneficial											
Greenhouse Gases	Previously assessed at corridor level. Not a differentiator.											
Landscape	SA	SA	SA	MA	MA	MA	SA	SA	MA	MA	MA	MA
Townscape	Slight Adverse											
Historic Environment	N	N	N	N	N	N	N	N	SA	SA	SA	SA
Biodiversity	MA	MA	MA	MA	MA	MA	SA	SA	LA	LA	LA	LA
Water Environment	Slight Beneficial											

Note: LA = Large Adverse; MA = Moderate Adverse; SA = Slight Adverse; N = Neutral

Table 10-7 – Environment assessment summary (East of the PDNP)

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Air Quality	SA	SA	MA	SA	SA	MA	MA	MA	MA	MA	MA	MA
Noise	SA	MA	LA	SA	MA	LA	LA	MA	SA	MA	SA	MA
Greenhouse Gases	Previously assessed at corridor level. Not a differentiator.											
Landscape	MA	MA	LA	MA	MA	LA	LA	MA	MA	MA	MA	MA
Townscape	Slight Adverse											
Historic Environment	SA	LA	LA	SA	LA	LA	LA	LA	SA	SA	SA	SA
Biodiversity	SA	SA	MA	SA	SA	MA	MA	LA	MA	MA	MA	MA
Water Environment	Slight Adverse											

Note: LA = Large Adverse; MA = Moderate Adverse; SA = Slight Adverse

Table 10-8 – Environment assessment (Overall summary)

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Air Quality	Moderate Adverse											
Noise	MA	MA	LA	MA	MA	LA	LA	MA	MA	MA	MA	MA
Greenhouse Gases	Previously assessed at corridor level. Not a differentiator											
Landscape	LA	LA	LA	LA	LA	LA	LA	MA	MA	MA	LA	LA
Townscape	LA	LA	LA	MA	MA	MA	SA	SA	MA	MA	SA	SA
Historic Environment	LA	LA	LA	MA	LA	LA	LA	LA	LA	LA	LA	LA
Biodiversity	MA	MA	MA	LA	LA	LA	MA	LA	LA	LA	LA	LA
Water Environment	Slight Adverse											

Note: LA = Large Adverse; MA = Moderate Adverse; SA = Slight Adverse

10.5.8 The assessment of Noise has determined that all strategic route options could result in an increase in noise associated with above ground routes but could bring about a moderate beneficial effect within the PDNP. There are existing NIAs on both sides of the PDNP, which could be exacerbated. Overall, route options 3, 6 and 7 would result in a large adverse impact, whilst the potential impact of all other route options would be moderate adverse.

10.5.9 The assessment of Air Quality has concluded that all strategic route options are anticipated to result in a moderate adverse impact. All strategic routes being considered could relieve the A57/A628 to some extent through the re-routing of traffic, therefore offering relief to the AQMAs and other sensitive receptors. In addition, it is assumed that a large benefit would be realised within the PDNP in relation to the removal of emissions and benefit to sensitive ecological sites. However, the additional traffic at the western and eastern extents of the strategic route options has the potential to result in poor air quality.

10.5.10 The Stage (iii)a corridor level TUBA assessment demonstrated that there was no relative difference between corridors A, B and C in terms of greenhouse gas impacts. As such, greenhouse gas impacts are not considered to be a differentiator between route options.

10.5.11 The Landscape assessment anticipates moderate adverse impacts associated with the development of strategic route options 8, 9 and 10 and large adverse impacts for all other strategic route options. Potential impacts within the PDNP are minimised for route options 1-4, 7 and 8, which would have shorter tunnel lengths (requiring fewer ventilation stacks) and where there is existing road infrastructure on the surface which could be used for access during construction. There are sensitive landscapes beyond the boundary of the PDNP which would be more considerably affected by the introduction of new road infrastructure.

10.5.12 All strategic route options are likely to have slight adverse impacts within and to the east of the PDNP, as settlements tend to be smaller and more sparsely distributed, such that they could be avoided by new road infrastructure. Overall, route options 1, 2 and 3 would result in a large adverse impact, route options 7, 8, 11 and 12 would result in slight adverse impacts, and route options 4, 5, 6, 9 and 10 would result in moderate adverse impacts due to the more built up areas these route options pass through to the west of the PDNP.

10.5.13 In terms of the impact on Historic Environment, route option 4 is expected to have a moderate adverse impact whilst all other route options are expected to result in a large adverse impact. This is based on an assessment of the impact on features such as listed buildings, registered parks and gardens, conservations areas, scheduled monuments and designated heritage features. There are very few designated assets within the PDNP, and some route options are considered 'neutral' (1-8) whilst the rest are considered to have the potential for slight adverse effects within the PDNP.

10.5.14 It has been assumed with all strategic route options that an improvement in air quality within the PDNP would have a beneficial effect on the European protected sites in the area. The potential impacts of each route option vary considerably both within the PDNP and to the east and west of the PDNP, reflecting the number and types of protected sites they would be likely to affect. The Biodiversity assessment concluded that route options 1, 2, 3 and 7 would have a moderate adverse impact, whilst all other route options would have a large adverse impact.

10.5.15 In terms of Water Environment, it is possible that a decrease in traffic within the PDNP on surface routes could improve water quality. All route options cross known areas of flood risk. This would need to be incorporated into the design of any new above ground routes to ensure flood risk was not increased as a result. It is possible that new surface routes outside the PDNP would bring about a decrease in water quality associated with new pollutant sources; however, the design should incorporate suitable mitigation for this. It is assumed potential impacts would be slight adverse at this stage.

10.5.16 The Greenhouse Gases assessment area, as the corridor level assessment demonstrated that this was not considered to be a differentiator.

Impact on Society

10.5.17 Table 10-9 summarises the results of the assessment of route options against the OAF assessment areas for Impact on Society.

Table 10-9 – Impact on Society assessment summary

Assessment Area	**Route Option**											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Non-Business Users	Previously assessed at corridor level. Not a differentiator.											
Physical Activity	Previously assessed at corridor level. Not a differentiator.											
Journey Quality	Not Assessed											
Accidents	SB	SB	SB	SB	SB	SB	MB	MB	MB	MB	MB	MB
Security	Previously assessed at corridor level. Not a differentiator.											

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Access to Services	Previously assessed at corridor level. Not a differentiator.											
Affordability	Previously assessed at corridor level. Not a differentiator.											
Severance	LB	LB	LB	LB	LB	LB	MB	MB	MB	MB	MB	MB
Option Values	Not Assessed											

Note: LB = Large Beneficial; MB = Moderate Beneficial; SB= Slight Beneficial

10.5.18 The Stage (iii)a corridor level TUBA assessment demonstrated that there was no relative difference between corridors A, B and C in terms of non-business user benefits. As such, non-business users' benefits are not considered to be a differentiator between route options.

10.5.19 The corridor level assessment concluded that a reduction in traffic on existing trans-Pennine routes through communities and rural recreational areas, such as the National Park, is expected to improve the likelihood of people partaking in outdoor physical activities. However, all corridors offered a similar level of traffic reduction on existing trans-Pennine routes. Consequently, physical activity is not considered to be a differentiator between route options.

10.5.20 Journey Quality[86] was not assessed as it was not considered to be a differentiator.

10.5.21 In terms of accidents, a new strategic link between Manchester and Sheffield will result in a reduction in traffic on existing trans-Pennine surface routes, which in turn, is likely to lead to a reduction in injury accidents on these routes. Furthermore, any new strategic link will be designed to the latest standards, with the operational safety of both surface and tunnelled sections given the utmost consideration. It is expected that a switch in traffic from existing trans-Pennine routes to the new strategic link would result in an overall reduction in accidents, and a large monetised benefit, despite the likelihood of a degree of induced traffic.

10.5.22 However, at this stage, it is not possible to quantify the actual accident benefits, this will be undertaken at Stage (iii)c. However, in order to inform the sifting of route options, an assessment has been made regarding the relative performance of route options based on the number and type of interchanges along the route. The assessment demonstrated that route options 1 to 6 score less well, in terms of the performance of interchanges along the routes.

[86] Journey quality incorporates the assessment of 'Traveller Views', 'Traveller Stress', and 'Traveller Care':

Traveller views: New sections of surface route on the approach to tunnel portals would offer views of the PDNP. The view within the tunnel is an important consideration in relation to driver behaviour. Both factors are applicable to all route options.

Traveller stress: All routes provide a similar reduction in traffic on existing trans-Pennine routes, providing some reduction in driver frustration and fear of accidents. The horizontal and vertical alignment of existing trans-Pennine routes will remain challenging to some travellers. The new link will be dual carriageway, designed to the latest standards and signed appropriately, reducing any issues regarding driver frustration (due to increased overtaking opportunities) and route uncertainty. Some drivers may experience increased traveller stress at the prospect of travelling in a long section of tunnel.

Traveller care: Tunnel sections for all route options would include caverns with facilities designed to the latest standards.

10.5.23 The corridor assessment concluded that crime, or the perception of crime, would not be affected by the proposals. Security is an important issue for any large piece of infrastructure. This is a complex issue which will need to be addressed with specialist input at the design stage. Security risk will be a key consideration during the design of any option, however, it is not considered to be a differentiator at the route option level.

10.5.24 The assessment is focused around the development of a 'highway' strategic link between Manchester and Sheffield and is not anticipated to directly impact on the routing of Public transport services. At this stage, the potential integration with Public Transport and potential for changes in routes served by Public Transport has not been considered in detail. Furthermore, the opportunities for Public Transport integration would be equally applicable to any route option. As such, Access to Services is not considered to be a differentiator between route options.

10.5.25 In terms of affordability, a new strategic link between Manchester and Sheffield is anticipated to result in reduced travel costs for highway users. However, this is not considered to be a differentiator at the route option level of assessment.

10.5.26 The OAF analysis considered new severance, resulting from the implementation of a new strategic link, as well as the impact on existing levels of severance due to traffic flow changes. In terms of new severance, it was concluded that any issues could be designed out (tunnel section does not introduce any severance issues).

10.5.27 Severance scores were therefore based on the degree to which each route option relieved existing severance. The volume of traffic removed from existing trans-Pennine routes and the total population of communities along these existing routes was analysed. This determined that route options 1 to 6 performed better overall.

10.5.28 The assessment is focused around the development of a 'highway' strategic link between Manchester and Sheffield. Whilst such a highway link would, in its own right, provide travellers with an additional route option, the assessment of 'Option Values' is focused around the addition or withdrawal of Public Transport services. At this stage, the potential integration with Public Transport has not been considered in detail. Furthermore, the opportunities for Public Transport integration would be equally applicable to any route option. As such, Option Value is not considered to be a differentiator between route options.

Public Accounts

10.5.29 Table 10-10 summarises the results of the assessment of route options against the OAF assessment areas for Public Accounts.

Table 10-10 – Impact on Public Accounts assessment summary

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Cost to Transport Budget	1.00	1.01	1.02	1.14	1.15	1.39	1.11	1.41	1.61	1.61	1.81	1.81
Indirect Tax Revenues	Previously assessed at corridor level. Not a differentiator.											

Note: Cost estimates have been normalised ad presented as relative values. Route option 1 is the lowest cost estimate.

10.5.30 A high level estimate of the anticipated Present Value Costs[87] (PVCs) for each route option have been developed based on the application of unit rates for various tunnel and surface link components. These cost estimates have been converted into ratios, relative to the lowest cost route option.[88] Table 10-10 demonstrates that route options 9, 10, 11 and 12 have PVCs 60-80% higher than route option 1, which is the lowest cost option. For route options 4, 5, 6, 7 and 8, the outturn implementation costs are 10-40% higher than those for route option 1.

10.5.31 As outlined in Table 10-10, indirect taxation revenues were shown not to be a differentiator at the corridor level of assessment, therefore they have not been assessed further at the route options level.

10.5.32 The Stage (iii)a corridor level TUBA assessment demonstrated that there was no relative difference between corridors A, B and C in terms of indirect taxation revenues. As such, indirect taxation revenues are not considered to be a differentiator between route options.

Distributional Impacts

10.5.33 Distributional impacts are not considered to be key differentiators between route options. However, it will be important to assess the various distributional impacts for preferred options, therefore, they will be considered in more detail at Stage iii(c).

Indicative Benefit Cost Ratio (BCR)

10.5.34 It has not been possible to provide an indication of the cost to the private sector, at this stage. Further work needs to be carried out on the benefits and costs.

10.5.35 NPV and BCR will not be assessed until Stage (iii)c.

10.6 Financial Case

10.6.1 Table 10-11 summarises the results of the assessment of route options against the OAF Financial Case assessment areas.

Table 10-11 – Financial Case assessment summary

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Outturn Cost to Implement	1.00	1.01	1.02	1.14	1.15	1.40	1.11	1.41	1.63	1.63	1.82	1.82
Operating / Maintenance Costs	1.00	1.03	1.04	1.10	1.13	1.31	1.08	1.29	1.43	1.44	1.61	1.62
Funding Allocation	Not Assessed											

Note: Cost estimates have been normalised ad presented as relative values. Route option 1 is the lowest cost estimate.

[87] Estimation of capital and operating/maintenance costs based on application of standard unit rates. Application of credible worst case inflation and optimism bias in line with relevant guidance and discounted consistent with TAG to derive present values.

[88] Route option 1 has both the lowest outturn cost for implementation and operating and maintenance costs. This is predominantly as a result of the shorter tunnel length associated with this route option.

10.6.2 A high level estimate of the anticipated outturn, operating, and maintenance costs for each route option have been developed based on the application of unit rates for various tunnel and surface link components. These cost estimates have been converted into ratios, relative to the lowest cost route option.[89] Table 10-11 demonstrates that route options 9, 10, 11 and 12 have outturn implementation costs 60-80% higher than route option 1, which is the lowest cost option. Similarly, the operating and maintenance costs for route options 9, 10, 11 and 12 are 40-60% higher than those for route option 1. For route options 4, 5, 6, 7 and 8, the outturn implementation costs are 10-40% higher and the operating and maintenance costs are 10-30% higher than those for route option 1.

10.6.3 'Funding Allocation' has not been assessed, given that the means by which a new strategic link between Manchester and Sheffield would be funded has not yet been considered in any detail.

10.7 Delivery Case

10.7.1 Table 10-12 summarises the results of the assessment of route options against the OAF Delivery Case assessment areas.

Table 10-12 – Delivery Case assessment summary

Assessment Area	Route Option											
	Corridor A						Corridor B		Corridor C			
	1	2	3	4	5	6	7	8	9	10	11	12
Likely Delivery Agents	SB	SB	SB	SB	SB	SB	MB	MB	MB	SB	N	N
Stakeholder Acceptability	Neutral											
Public Acceptability / Interest	MA	MA	SA	SA	MA	N	SB	MB	MB	SB	N	N

Note: MB = Moderate Beneficial; SB = Slight Beneficial; N = Neutral; SA = Slight Adverse; MA = Moderate Adverse

10.7.2 The Likely Delivery Agents assessment area includes consideration of not only the level of delivery agent interest, but also the complexity of delivery for each route option. In terms of delivery agent interest, it is considered that there would be a high level of interest for all route options. In terms of the complexity of delivery, a number of areas have been considered, including:

- Quantity of excavated material
- Nearest rail access from tunnel, for removal of excavated material
- Number of ventilation shafts
- Number of interchanges
- Number of structures
- Proportion of tunnel section within a coal mining affected area

10.7.3 Whilst all route options are considered to be deliverable and there are no showstoppers, there are some factors which increase the level of complexity for

[89] Route option 1 has both the lowest outturn cost for implementation and operating and maintenance costs. This is predominantly as a result of the shorter tunnel length associated with this route option.

certain route options. Overall, route options 7, 8 and 9 are considered to have a lower level of complexity of delivery.

10.7.4 A ‘neutral’ level of stakeholder acceptability has been assigned to all route options. Whilst a substantial amount of engagement has taken place with the Stakeholder Reference Group, it is too early to have a clear picture of the overall level of support or refute.

10.7.5 A number of issues were considered as part of the assessment of public acceptability,[90] including those which were anticipated to be viewed positively (including improved connectivity, resilience and reliability) and those anticipated to be viewed negatively (construction in PDNP, surface construction, tunnel length). Route options 1-5 received adverse scores, predominantly due to the long lengths of surface construction required. Conversely, route options 7, 8, 9 and 10 are considered to be more acceptable to the public, again, predominantly due to the shorter lengths of new surface construction required.

10.8 Commercial Case

10.8.1 The Commercial Case considers the level of challenge that may be faced whilst procuring an intervention. This assessment area is not considered to be a differentiator, as it is too early in the process to be able to assess procurement options[91] for a strategic link between Manchester and Sheffield.

10.8.2 It is anticipated that a large number of delivery agents, stakeholders and contractors would be involved in the development of a strategic link, no matter which route option is selected. Furthermore, the means by which a new strategic link between Manchester and Sheffield would be funded has not yet been considered in any detail.

10.9 Summary

10.9.1 Stage (iii)a and Stage (iii)b of the study have involved a process to generate and sift a range of proposals likely to achieve the objectives as refined following the completion of Stages (i) and (ii). The process has also included discussions with a number of public sector stakeholder organisations to ascertain views on the option selection and sifting process.

10.9.2 The main output from Stage (iii)a and (iii)b of the study has been a narrowing of the corridor options and shortlisting of the best performing route options to be investigated in more detail in Stage (iii)c of the study. The assessments for the route options are shown in Table 10-13. In summary these show that:

10.9.3 **Strategic case** – There are similar qualitative scores in terms of the alignment of each route option with local and national policies. Differentiators come when assessing against agreed scheme objectives. Route options 4, 8, 9 and 10 perform better against Objective 3 (to protect and improve the natural environment).

10.9.4 **VfM case (Economy)** – There is little differentiation, although 2 route options in Corridor A (1 and 4) perform less well under regeneration. All route options provide good access to regeneration areas at the western extent of study area. At the eastern extent of the study area, route options 2, 3, 5, 6, 7, 8, 9, 10, 11 and 12 all come out

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[90] Note that no public consultation has taken place regarding the concept of a strategic link between Manchester and Sheffield. The assessment of public acceptability is based on the study team’s assumptions on areas which may be viewed positively or negatively by the public.

[91] The specific procurement route taken (Public Private Partnerships, for example), may impact on the timescales, cost and balance sheet.

in a central position on the M1, providing good access to Sheffield, Barnsley and Rotherham regeneration areas. Route options 1 and 4 join the M1 further north, so, whilst providing good access to Barnsley regeneration areas, they are further from Sheffield and Rotherham regeneration areas.

10.9.5 **VfM case (Environmental)** – The analysis is split down into four categories: 'West of PDNP'; 'Within PDNP', 'East of PDNP' and 'Overall summary'. The assessment shows that for some of the environment indicators there are positive impacts 'Within the PDNP'. However, the adverse impacts either side of the PDNP mean that the overall score is adverse. Route options 4, 7, 8, 9 and 10 perform better on environmental impacts than route options 1, 2, 3, 5 and 6, which have more large adverse impacts. All route options have a beneficial effect within the PNDP in terms of Air Quality, Noise and the Water Environment indicators.

10.9.6 **VfM case (Impact on society)** – The six route options in Corridor A perform marginally less well in terms of accidents but marginally better in terms of severance. Accidents have been analysed on the basis of the potential number and type of interchanges on the new route. Severance is based on the relief to existing trans-Pennine routes and the population living along those routes.

10.9.7 **VfM case (Public accounts)** – Each route option is scored relative to route option 1, which is estimated to have the lowest total cost to the broad transport budget. Costs are construction and maintenance costs and are based on the application of unit rates for various tunnel and surface link components. It is estimated that route options 11 and 12 cost 81% higher, route options 9 and 10 are 61% higher. Route option 7 is 11% higher and route option 8 is 41% higher. Cost for route options 2, 3, 4 and 5 are very similar to the cost for route 1 (all within 15%), whilst route option 6 is estimated to be 39% higher than route option 1. This is predominantly driven by the length of the tunnel in each route option.

10.9.8 **Financial case** – A high level estimate of the anticipated outturn, operating, and maintenance costs for each route option have been developed based on the application of unit rates for various tunnel and surface link components. These cost estimates have been converted into ratios, relative to the lowest cost route option, which is route option 1. The analysis demonstrates that both the outturn implementation and operating and maintenance costs for route options 11 and 12 are 80% higher than route option 1, whilst those for route options 6, 8, 9 and 10 are 40-60% higher. Route options 2, 3, 4, 5, 6 and 7 all have outturn implementation and operating and maintenance costs that are within 15% of the lowest cost route option.

10.9.9 Similarly, the operating and maintenance costs for route options 9, 10, 11 and 12 are 40-60% higher than those for route option 1. For route options 4, 5, 6, 7 and 8, the outturn implementation costs are 10-40% higher and the operating and maintenance costs are 10-30% higher than those for route option 1.

10.9.10 **Delivery case (Delivery agents)** – Complexity of delivery is seen as a differentiator (ease of excavating material, number. of ventilation shafts, number of structures and interchanges, proportion of route in coal measures area). The assessment shows that route options 7, 8 and 9 are the least complex to deliver.

10.9.11 **Delivery case (Public acceptability)** – Based on a range of factors (improvements to journey times, improved resilience, connection to road network, construction in PDNP and/or other environmentally sensitive areas, relative length in tunnel/surface, tunnel length (cost, driver behaviour). Route options 8 and 9 are assessed as being the most acceptable, with route options 7 and 10 marginally behind. Route options in

Corridor A (1 to 5) are assessed as being moderately adverse or slight adverse and clearly less acceptable than route options 8 and 9. Route option 4 has a less adverse score than routes 1, 2 and 5 but not as strong a score as routes 6 to 12.

10.9.12 Overall, based on the OAF analysis, route options 7, 8, 9 and 10 are the better performing route options within Corridors A, B and C and route option 4 has some merit because of its low cost relative to route options with the same or higher level of potential benefits. All route options are likely to offer similar levels of travel time benefits. Route options 4, 7, 8, 9 and 10 also perform better on environmental impacts than 1, 2, 3, 5 and 6 – something of key importance for the study area. Route options 7, 8, 9 and 10 are likely to be much more acceptable to the public and therefore easier to deliver. Route options 11 and 12 are significantly more expensive than other route options and so are less likely to be affordable, less acceptable to the public and consequently not as easy to deliver.

10.9.13 Figure 10-4 highlights the preferred route options 4, 7, 8, 9 and 10.

Figure 10-4 – Better performing route options

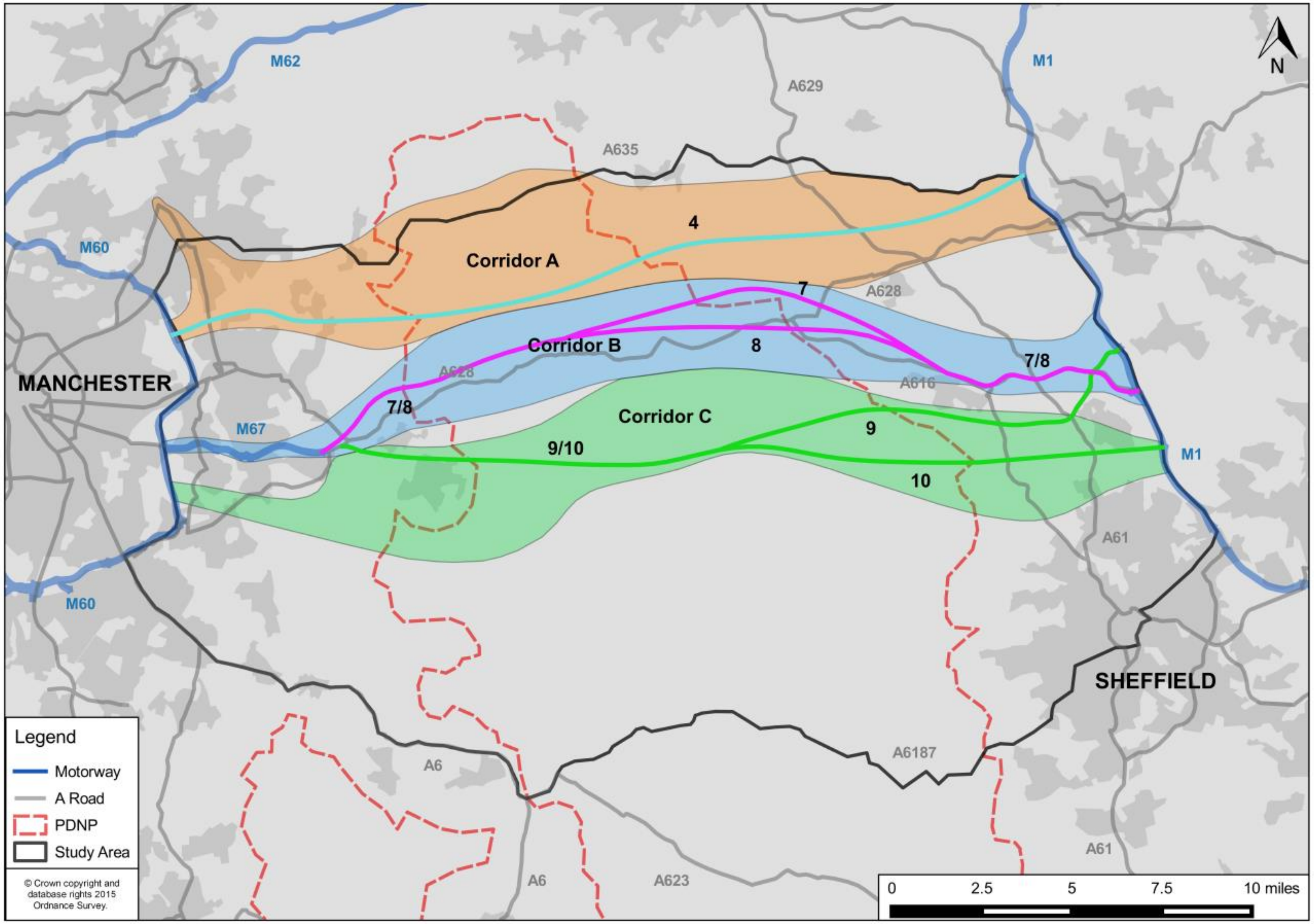

Table 10-13 – Stage (iii)b Option Assessment Framework results

Corridor			A				B				C			
Route Option			1	2	3	4	5	6	7	8	9	10	11	12
Strategic Case		Regional Policy Alignment	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial
		Local Policy Alignment	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial
		Scheme Objective Fit	Slight Beneficial	Slight Beneficial	Slight Beneficial	Moderate Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Slight Beneficial	Slight Beneficial
Value for Money Case	Economy	Business Users and Transport Providers	Previously Assessed											
		Reliability	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial
		Regeneration	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial
		Wider Impacts	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial
	Environmental	Noise	Moderate Adverse	Moderate Adverse	Large Adverse	Moderate Adverse	Moderate Adverse	Large Adverse	Large Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
		Air Quality	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
		Greenhouse Gases	Previously Assessed											
		Landscape	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Large Adverse	Large Adverse
		Townscape	Large Adverse	Large Adverse	Large Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Slight Adverse	Slight Adverse	Moderate Adverse	Moderate Adverse	Slight Adverse	Slight Adverse
		Historic Environment	Large Adverse	Large Adverse	Large Adverse	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse
		Biodiversity	Moderate Adverse	Moderate Adverse	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	Moderate Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse	Large Adverse
		Water Environment	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
	Impact on Society	Non-Business Users	Previously Assessed											
		Physical Activity	Previously Assessed											
		Journey Quality	Not Assessed											
		Accidents	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial
		Security	Previously Assessed											
		Access to Services	Previously Assessed											
		Affordability	Previously Assessed											
		Severance	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial
		Option Values	Not Assessed											
		Cost to Broad Transport Budget	1.00	1.01	1.02	1.14	1.15	1.39	1.11	1.41	1.61	1.61	1.81	1.81

Corridor			A				B				C			
Route Option			1	2	3	4	5	6	7	8	9	10	11	12
	Public Accounts	Indirect Tax Revenues	Previously Assessed											
	Distributional Impacts	(User Benefits; Noise; Air Quality; Accidents; Security; Severance; Accessibility; Affordability)	Not Assessed											
	Indicative Benefit Cost Ratio	Cost to Private Sector	Not Assessed											
		Indicative Net Present Value	Not Assessed											
		Indicative Economic BCR	Not Assessed											
Financial Case	Capital and Revenue Costs	Outturn Cost to Implement	1.00	1.01	1.02	1.14	1.15	1.40	1.11	1.41	1.63	1.63	1.82	1.82
		Operating and Maintenance Costs	1.00	1.03	1.04	1.10	1.13	1.31	1.08	1.29	1.43	1.44	1.61	1.62
	Funding Assumptions	Funding Allocation	Not Assessed											
Delivery Case		Likely Delivery Agents	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Moderate Beneficial	Slight Beneficial	Neutral	Neutral
		Stakeholder Acceptability	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
		Public Acceptability / Interest	Moderate Adverse	Moderate Adverse	Slight Adverse	Slight Adverse	Moderate Adverse	Neutral	Slight Beneficial	Moderate Beneficial	Moderate Beneficial	Slight Beneficial	Neutral	Neutral
Commercial Case		Route to Market	Previously Assessed											

Glossary

AADT – Annual Average Daily Traffic

AAWT – Annual Average Weekday Traffic

AQMA – Air Quality Management Area

BCR – Benefit Cost Ratio

CA – Conservation Area

DfT – Department for Transport

DMRB – Design Manual for Roads and Bridges

EAST – Early Assessment and Sifting Tool

ERA – Emergency Refuge Area

GDP – Gross Domestic Product

GVA – Gross Value Added

HGV – Heavy Goods Vehicle

HS2 – High Speed Two – a planned high-speed railway to link the city centres of: London, Birmingham, Leeds and Manchester

IPPR – Institute for Public Policy Research

KIBS – Knowledge-Intensive Business Services

LEP – Local Enterprise Partnership

LNR – Local Nature Reserve

MAELR – Manchester Airport Eastern Link Road

NMU – Non-Motorised User

NNR – National Nature Reserve

Northern Powerhouse – “The Northern Powerhouse is the bringing together of the northern cities, creating modern high speed transport links between those cities, making sure that they have strong civic leadership, bringing investment to them, and as a result creating a North of England that is greater than the individual parts.” Rt Hon George Osborne MP, Building a Northern Powerhouse, Chengdu, China, 24 September 2015

NPPF – National Planning Policy Framework

NUTS – Nomenclature of Territorial Units for Statistics

OAF – Option Assessment Framework

PRoW – Public Right of Way

RAG – Red, Amber, Green (Indicator scale used in EAST assessment)

RIS – Road Investment Strategy

SAC – Special Area of Conservation

SEP – Strategic Economic Plan

SERC – Spatial Economics Research Centre

SRN – Strategic Road Network

SSSI – Sites of Special Scientific Interest

TAG – Transport Analysis Guidance

TBM – Tunnel Boring Machine

TfGM – Transport for Greater Manchester

TfN – Transport for the North

TIEP – Transport Investment and Economic Performance

TIS – Trip Information System

TUBA – Transport Users Benefit Appraisal

VfM – Value for Money

VMSL – Variable Mandatory Speed Limit

WITA – Wider Impacts in Transport Appraisal

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