HS2

Whitmore Heath to Madeley Tunnel Report

15th March 2018

Contents

1 Executive Summary

1.1.1 This report reviews the HS2 Phase 2a West Midlands to Crewe ('Phase 2a') route in the Whitmore Heath to Madeley Community Area 4 ('CA4'). This includes a summary of the design included in the Phase 2a West Midlands to Crewe Bill (the 'Proposed Scheme'), which includes two short tunnels at Whitmore Heath and Madeley. In addition, an alternative 6.4km tunnel option between Whitmore Heath and Madeley (the 'Single Tunnel') is presented. The report describes, in outline, the Proposed Scheme and the Single Tunnel to inform an understanding of the two options in respect of engineering, environment, construction and cost.

1.1.2 The route announced by the Secretary of State in November 2015 proposed two short tunnels at Whitmore Heath and Madeley. Following a review of the route selection alternatives in 2016, the two short tunnels were taken forward into the Proposed Scheme, subject to further design refinement. A single tunnel option was considered as part of the route section alternatives but not selected. This was because the environmental benefits were not judged to be sufficient to justify the additional costs associated with the single tunnel scheme. Following the deposit of the Phase 2a Bill in July 2017, further work has been undertaken to understand the potential advantages of an alternative single tunnel option

1.2 The Proposed Scheme

1.2.1 The Proposed Scheme is described in the Phase 2a Environmental Statement: Volume 2 and illustrated in the Volume 2: Map Book, drawings, which illustrate the engineering features and land required for the Proposed Scheme.

1.2.2 Key engineering challenges of the Proposed Scheme involves complex construction activities associated with the two, twin-bore tunnels, the cut and cover section of Whitmore tunnel, tunnel fit out, pumping stations, the construction of four tunnel portals and a section of retained cut. The construction of a viaduct across the West Coast Main Line is particularly complex and will require potentially disruptive railway possessions.

1.2.3 The main environmental impacts of the Proposed Scheme will result in the need to demolish properties (three residential, one barn and five outbuildings) and will introduce visual, noise and vibration and amenity impacts in Whitmore Heath and Bar Hill during the construction and operation phases. The Proposed Scheme will result in the loss of agricultural land and holdings and the loss and fragmentation of ecological habitat, including a loss of approximately 6.7h ancient woodland in total within CA4 (including approximately 6.0ha (34%) of the ancient woodland at Whitmore Wood and 0.2ha (4%) of the ancient woodland at Barhill Wood). There would be an impact on

the local landscape character in the area, cultural heritage, surface and groundwater - including potentially protected ground water abstraction.

1.2.4 A number of mitigation measures have been incorporated into the Proposed Scheme including planting and habitat creation compensation for the loss of environmental features (including ancient woodland) and provision of noise barriers. Some significant residual effects will remain during both construction and operation phases. Most of the significant residual effects are temporary although loss of ancient woodland, loss of agricultural land and impact on valuable agricultural holdings are permanent residual effects that occur during construction. Ground-borne noise effects would result from the operation of the Proposed Scheme.

1.3 Single Tunnel

1.3.1 The option described in this report is a 6.4km long twin bored tunnel with porous portals, two shafts and at minimum safe depth below the tracks of the West Coast Main Line railway. The concept plans for the Single Tunnel Scheme are presented in Appendix D.

1.3.2 Overall the Single Tunnel benefits from reduced complexity of construction activities, by removing two portals, reducing cut to fill earthwork activities (mass haul requirement), cut retaining structures and construction of significant structures such as the River Lea Viaduct. The location of the southern porous portal would move south of the A53, removing the need for realignment of the highway and construction of the A53 overbridge. The Single Tunnel also removes the need for surface features such as: viaducts, highway diversions and surface drainage features. A single tunnel will reduce the number of 24/7 tunnel work sites from two to one, though the overall duration of intensive use of the single site will increase.

1.3.3 Tunnel ventilation and intervention shafts add complexity to the engineering design required for the Single Tunnel, which is arguably offset by the reduction of tunnel portals from four to two. Two shafts would be required to meet design standards based on the current portal positions. There will be compounds, buildings, hardstanding and rescue areas at the shafts. The Single Tunnel will increase traction power requirements, introducing modifications to the provision for the system incorporated into the Proposed Scheme. In addition, there is an increment of electrical power load as a result of the additional requirements for the tunnel ventilation system and traction systems, compared to the two short tunnels. The Single Tunnel alignment option assessed leads to a moderate worsening of operational headways (minimum time interval between trains that allows them to run at full speed), which could affect the operational performance of the wider high speed network.

1.3.4 The Single Tunnel is expected to reduce adverse impacts on the local road network compared to the Proposed Scheme. The assessed peak month flows in the Proposed Scheme are expected to be lower, however, the overall duration for which traffic conditions remain at a 'busy' period[1] is expected to increase on the A53 adjacent to the southern portal. The railway systems construction programme is affected by the additional fit out works in the tunnel and the ventilation shafts, with the track laying slower in the tunnel than the open section of the Proposed Scheme. The construction of the tunnel would take longer than the Proposed Scheme but construction impacts are likely to be offset by removal of significant construction activities associated with the Proposed Scheme. There remains a risk that the single tunnel could affect the overall works duration for this part of the route.

1.3.5 There are additional risks associated with the single tunnel option. The main additional risks are associated with the shaft design and construction, the potential settlement effects as the tunnel passes below the WCML and the potential requirement for installation of additional traction power cables which may require some viaducts to be widened.

1.3.6 The Single Tunnel would result in the removal of elements of the Proposed Scheme and operating trains from the surface between the northern and southern portals. This results in the avoidance of demolition of buildings, avoidance of road diversion and disruption, reduction in loss of agricultural land, habitat and landscape (including ancient woodland). It would remove or reduce both construction and operational noise and vibration impacts. Environmental dis-benefits of the single tunnel orientate around the visual impact of the shafts, the loss of approximately 0.3ha ancient woodland, additional disposal of spoil during construction and an increase energy usage (greenhouse gas effects) both in construction and operation.

1.4 Option Comparison

1.4.1 The comparative cost analysis of both options is summarised in Appendix H and take into consideration construction costs, rail systems costs and land and property purchase, legal and other costs.

1.4.2 The comparative analysis assessment for engineering highlighted the impact of the Single Tunnel scheme to be 'Major Worsening' compared to the Proposed Scheme. This was primarily due to construction cost which was estimated to be significantly above the Proposed Scheme, together with additional requirements within some engineering disciplines including the railways systems and operational planning, with the requirement for two shafts and changes to the traction power system.

[11] A 'busy period' is considered to be a period when traffic volumes are 50% or more of the peak volume.

1.4.3 The outcome of the comparative analysis for environment was that the Single Tunnel scheme was a 'Major improvement' on the Proposed Scheme. Environmental benefits derive from the removal of construction effects, the removal of operating trains at surface level between the tunnel portals that were present in the baseline scheme. Between the portals, most landscape and visual, heritage, biodiversity and agricultural adverse impacts along the tunnel's route would be removed, notably there would be the retention of approximately 6.4ha of ancient woodland (including approximately 6.0ha (34%) of the ancient woodland at Whitmore Wood and 0.2ha (4%) of the ancient woodland at Barhill Wood). There would be a residual loss of 0.3ha ancient woodland at an unnamed wood south of Hey Sprink Ancient Woodland Inventory (AWI) site and Wrinehill Wood (east of) Biodiversity Alert Site (BAS).

1.5 Conclusion

1.5.1 Overall there are environmental and engineering benefits of the Single Tunnel option compared to the Proposed Scheme. Some elements of engineering challenges would remain and some engineering aspects are major worsening compared to the Proposed Scheme. A Single Tunnel introduces operational robustness disbenefits compared to the proposed scheme. In addition, some of the environmental impacts will remain. There is a significant estimated cost increase between the Proposed Scheme and the Single Tunnel option as detailed in Appendix H. This may increase further with detailed design due to engineering risks still to be to be addressed in detail. A full evaluation of influence on construction programme is still to be undertaken but it may result in some programme reduction that would benefit the project further, including potential reduction in indirect cost. It is considered that one of the major impacts of the Proposed Scheme is loss of ancient woodland and the Single Tunnel option avoids the loss of 6.4ha of ancient woodland throughout CA4, and removes impacts on Whitmore Wood ancient woodland.

2 Abbreviations and descriptions

AOD – Above Ordnance Datum

ATFS – Auto-Transformer Feeder Station

ATS – Auto Transformer Station

AWI – Ancient Woodland Inventory

AWIS – Ancient Woodland Inventory Site

BAS – Biodiversity Alert Site

BMV – Best and Most Versatile (agricultural land)

CA4 – Community Area 4 of Phase 2a, Whitmore Heath to Madeley

CoCP – Code of Construction Practice

EFATS – Express Feeder Auto Transformer Station

EIA – Environmental Impact Assessment

HGV – Heavy Goods Vehicle

LCA – Landscape Character Area

LWS - Local Wildlife Site

MSA – Minerals Safeguarding Area

NMU – Non-Motorised User

PRoW – Public Right of Way

SEQS – Summarised Earthworks Quantities Schedule

SOAEL – Significant Observable Adverse Effect Level

SPZ – Source Protection Zone

TBM – Tunnel Boring Machine

TSI – Technical Specification for Interoperability

WCML – West Coast Main Line

3 Introduction

3.1 Report overview

3.1.1 This report reviews the HS2 Phase 2a route alignment in the Whitmore Heath to Madeley area. This includes a summary of the design included Phase 2a West Midlands to Crewe Bill (hereafter referred to as the 'Proposed Scheme') which includes two twin-bore short tunnels each less than 1km long at Whitmore Heath and Madeley. In addition, an alternative single, twin-bore, longer tunnel, approximately 6.4km long between Whitmore Heath and Madeley (hereafter referred to as the 'Single Tunnel') is presented and compared to the Proposed Scheme. The Single Tunnel section considers a route alignment from the Whitmore Heath Tunnel southern portal, (located close to where the route crosses the A53 Newcastle Road) to the northern portal of Madeley Tunnel, located north of Madeley. The report compares the Proposed Scheme and the Single Tunnel with respect to engineering, construction, environment and cost.

3.1.2 The details of the Proposed Scheme design are presented in the Phase 2a Environmental Statement[2] and summarised in Section 5 of this report. Overview plans and longitudinal sections for the Proposed Scheme are included in Appendix A.

3.1.3 The Single Tunnel features that have been designed to meet the engineering and environmental challenges of the Whitmore Heath to Madeley section of route are presented in Section 6. An overview Plan and Longitudinal Section for the Single Tunnel is included in Appendix A.

Limitations of the comparison study

3.1.4 The overall level of development of the Single Tunnel described in this report is considered to be a concept design. This means that interpretation of the comparison of the Single Tunnel with the Proposed Scheme should take into consideration that the Proposed Scheme is at a more advanced stage of engineering development. If a Single Tunnel is to be adopted, prior to AP3 the design will be progressed to Interim Preliminary Design stage and appropriate environmental appraisal will be undertaken to inform the Environmental Statement.

[2] High Speed Rail (West Midlands – Crewe) Environmental Statement, Volume2: Community Area report CA4: Whitmore Heath to Madeley (July 2017). Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/627567/E16_CA4_Whitmore_Heath_to_Madeley_WEB.pdf

3.1.5 The length of the tunnel shown on drawings within the Appendices varies slightly, which reflects the various stages of design development when these drawings were created. For the purpose of comparison to the Proposed Scheme, a Single Tunnel option of approximately 6.4km between the tunnel portals) is described in this report.

3.2 Route characteristics for Whitmore Heath to Madeley area

3.2.1 The Whitmore Heath to Madeley area is predominantly rural in character, with agriculture being the main land use. This is interspersed with woodland, including ancient woodland, small villages and a scattering of isolated dwellings and farmsteads. Much of the area encompasses gently undulating lowland and settled river valley landscapes, with occasional lowland bog and floodplain pasture at lower levels. A context map for the Whitmore Heath to Madeley area is provided in Appendix A.

3.2.2 The settlements of Baldwin's Gate and Madeley Park Wood lie to the west of the Proposed Scheme, and Whitmore lies to the east of the Whitmore to Madeley area. The settlement of Madeley is located to the north-east of the Whitmore to Madeley area. The Proposed Scheme passes under Whitmore Heath (in tunnel) and through Whitmore Wood on the surface. The route alignment enters the valley of the River Lea, through which the West Coast Main Line (WCML), the Madeley Chord and the Stoke to Market Drayton Railway pass. There are a number of designated heritage assets including the Grade II listed building Hey House and the scheduled monument of Old Madeley Manor in the area. The floor of the River Lea valley is around 120m above Ordnance Datum (AOD) in the south of the area, falling to 80m AOD in the north, at Wrinehill.

3.2.3 The route alignment continues towards the village of Madeley, passing Bar Hill, the Lea Head moated site scheduled monument and a number of listed buildings, including the farmstead of Aston Cliff and Lea Head Manor. It will also pass through part of Barhill Wood, an ancient woodland. The sandstone plateau at Bar Hill is at a height of around 165m to 170m AOD with steep valley sides to the River Lea, the Meece Brook and the Checkley Brook.

3.2.4 To the east and north of Whitmore Village there are several detached rural properties along the A53 Newcastle Road. To the east of Madeley village there are several large isolated farmsteads set back from the A525 Bar Hill Road, including Moor Hall Farm, Bower End Farm, Beechfields and Bar Hill House Farm.

4 Summary of design development

4.1 Overview

4.1.1 Prior to 2015 the features of the route alignment at Whitmore and Madeley were developed over time taking into consideration engineering requirements, outputs of environmental appraisal and public consultation and stakeholder engagement, as set out in the 2015 High Speed Rail: Preferred Route to Crewe Sustainability Report[3]. The route announced by the Secretary of State in November 2015 proposed two short tunnels at Whitmore Heath and Madeley. This proposal was incorporated within the Phase 2a design following it being found to be the recommended option in a comparative assessment against three alternative options. Since the hybrid Bill deposit further consideration of a single tunnel design has run in parallel to the development of the Proposed Scheme.

4.2 Comparative analysis supporting the Proposed Scheme

4.2.1 During the design development process, between the announcement of the Proposed Scheme by the Secretary of State (November 2015) and deposit of the Phase 2a hybrid Bill (July 2017), further consideration of the route alignment between Whitmore Heath and Madeley was undertaken. The sensitivity of this location, particularly the residential communities in and around Whitmore Heath, Baldwin's Gate and Madeley, potential for traffic and transportation disruptions, landscape character, presence of ancient woodland, and impacts on agricultural land and farm holdings, were key considerations in design development during this period.

4.2.2 Design development also considered, as appropriate, feedback provided through stakeholder engagement and consultation responses received on the working draft Environmental Impact Assessment (EIA) Report[4].

[3] Temple-RSK, (2015), Sustainability Report – Phase Two Post-Consultation Update: West Midlands to Crewe. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/480667/Sustainability_Report_Phase_Two_Post-Consultation_Update_West_Midlands_Crewe.pdf

[4] HS2 Ltd., (2016), *West Midlands- Crewe Working Draft Environmental Impact Assessment Report.*

4.2.3 Relevant comments received from the consultation on the working draft EIA consultation included, in summary:

- Meece Brook viaduct – height, visual impact, operational noise from trains;
- A53 Newcastle Road overbridge – height, visual impact, construction traffic;
- Baldwins Gate Village – tranquillity during construction, construction traffic, realignment and closure of footpaths;
- Whitmore Heath tunnel – ground conditions unsuitable for tunnelling, requirement for ground investigation;
- Whitmore Heath tunnel – sound noise and vibration during construction and during operations;
- Snape Hall Road – severance, construction traffic and activities, heavy goods vehicles (HGV) effects;
- Whitmore Heath Ancient Woodland – loss of ancient woodland, effects on white deer population during train operations;
- Lea Valley – height of viaduct, operational noise on Manor Road and Madeley Park Wood, construction traffic;
- Bar Hill – construction traffic, noise and disturbance, HGVs, construction and operational effects of drainage on the reservoir and LWS at Bar Hill; and
- Red Lane (Madeley Bridleway 1) severance for non-motorised users (NMUs).

4.2.4 A comparative analysis of four options took place in May 2016 and is described in the Volume 2, CA4 of the Phase 2a Environmental Statement (Section 2.5)[2]. It considered the engineering requirements, costs and potential environmental impacts of the four options which were:

- the 'original baseline' (Option D9-11.0a) with two short twin-bored tunnels totalling 1,360m in length plus 238m cut and cover tunnel;
- a 'refined baseline' (Option D9-11.0b) with two longer twin-bored tunnels totalling 2.6km in length;
- a horizontal diversion option (Option D9-11.1) with two longer twin-bored tunnels totalling 3.2km in length; and also
- a single, longer (6.4km) twin-bored tunnel (Option D9-11.3).

4.2.5 A description of each option and the engineering and environmental analysis is provided in Volume 2, CA4 of the Phase 2a Environmental Statement[2]. Appendix B includes the comparative analysis matrix from this appraisal. It is noted that the comparative analysis summaries in Appendix B are based on an early concept design at the time of the analysis in 2016. They are not representative and sometimes vary from the current Proposed Scheme and the Single Tunnel design, which has undergone further design development since this early appraisal (presented later in this report).

Summary outcome of comparative analysis supporting the Proposed Scheme

4.2.6 The preferred option taken forward from the 2016 comparative analysis into the Proposed Scheme was option D9-11.0a, a cut and cover tunnel approximately 240m in length, which would continue into a twin bore tunnel, approximately 690m in length. Although the other alternative options provided some environmental benefits in comparison to Option D9-11.0a, the benefits were not considered sufficient to justify the significant additional costs associated with the other options. These issues are discussed further below.

Consideration of the single tunnel option D9-11.3 compared to the Proposed Scheme

4.2.7 Option D9-11.3, a 6.4km long twin bored tunnel was not selected as the Proposed Scheme. The construction of Option D9-11.3 was considered to be significantly less complex than the preferred option. It was considered that highways works would be significantly reduced and operational disruption to the WCML during construction would potentially be avoided. Environmental benefits were also identified, associated with avoiding demolitions, reduced loss of agricultural land, reduction of impacts on woodland, ancient woodland, watercourses, heritage assets and reduction in noise, visual and amenity impacts on residents of Whitmore Heath and Bar Hill. Some environmental impacts remained, associated with effects on the setting of Hey House Grade II listed building. Scope for refinement (to minimise impacts on Hey House) was considered to be constrained by the flood plain.

4.2.8 Option D9-11.3 however represented a significant cost increase compared to Option D9-11.0a (the Proposed Scheme), being more expensive to construct and with higher costs for maintenance during operation. Based on the level of knowledge and detail of the scheme at the time, the environmental benefits were not judged to be sufficient to justify the additional costs associated with the scheme. Option D9-11.0a was therefore taken forward into the Proposed Scheme.

4.3 Further development of the Single Tunnel post Bill deposit

4.3.1 As part of a further design development specifically looking at provision of a single tunnel between Whitmore Heath and Madeley, further consideration of single tunnel options was undertaken following the submission of the Phase 2a Bill (July 2017 to present), as instructed by the Secretary of State. The single tunnel options that were developed in 2017 included more detail than was previously available in 2016, for example with respect to understanding of the environmental baseline, tunnel ventilation and construction traffic, which resulted in a different outcome than was recorded in 2016. A single tunnel option was designed to a concept design level and evaluated qualitatively in terms of engineering and environmental benefits/dis-benefits and cost variance, to enable a more detailed comparative study with the Proposed Scheme. The Single Tunnel is described further in Section 6 of this report.

5 Description of the Proposed Scheme

5.1 Overview

5.1.1 The southern portal of Whitmore Heath tunnel is located where the route alignment crosses the A53 Newcastle Road, requiring its realignment over the route on an overbridge. The route alignment passes beneath Whitmore Heath in a cut and cover tunnel for approximately 240m in length, which continues into a twin bore tunnel, for approximately 690m in length and a depth of up to 50m. The northern portal of Whitmore Heath tunnel is located where the route alignment crosses Snape Hall Road, which would be permanently closed at either side of the Proposed Scheme.

5.1.2 On leaving Whitmore Heath tunnel, the route alignment continues through a section of Whitmore Wood in a cutting up to 13m in depth with a retaining wall of 577m length on the north-east side. The route alignment then continues on an embankment and passes over the River Lea, the WCML, the Stoke to Market Drayton Railway and the Madeley Chord on a viaduct approximately 785m in length and up to 21m in height. The route alignment then passes underneath Manor Road and the A525 Bar Hill Road which will both be realigned to cross the route on overbridges.

5.1.3 The route alignment then continues into a second twin bore tunnel (Madeley tunnel) for approximately 670m and a depth of up to 38m as it passes under Bar Hill.

5.1.4 Between the southern portal of Whitmore Heath tunnel and the northern portal of Madeley tunnel, the track spacing is widened to provide 18m between the track centrelines. This is in order to facilitate safe construction of the twin bore tunnels and the housing of equipment in cross passages between the tunnels. The track spacing is maintained at 18m as the route alignment crosses the WCML and other surface features in between the two tunnels.

5.1.5 As the Proposed Scheme is included in the Bill deposit, the basis of design and the standard requirements are not presented in this report.

5.1.6 The Proposed Scheme is described in the Phase 2a Environmental Statement: Volume 2 Community Area report CA4: Whitmore Heath to Madeley[2] and illustrated in the Volume 2: Map Book[5] CT05 and CT06 drawings which illustrate the engineering features and land required for the Proposed Scheme. The drawing that shows the

[5] High Speed Rail (West Midlands – Crewe) Environmental Statement Volume 2: Map book CA4: Whitmore Heath to Madeley July 2017. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/628318/E21_VOL2_CA04_WATERMARKED.pdf

scheme in plan and in longitudinal section (Plan Profile) is provided in Appendix A of this report.

5.2 Key engineering challenges of the Proposed Scheme

The Proposed Scheme involves complex construction activities associated with the two, twin bore tunnels, four tunnel portals, the cut and cover section of Whitmore tunnel, tunnel fit out, pumping stations and the construction of tunnel portals. There would be high maintenance requirements during operation associated with: tunnel drainage, ventilation systems and mechanical, electrical and plumbing systems. Three highway realignments will be required (A53 Newcastle Road, Manor Road and A525 Bar Hill Road). Snape Hall Road will be permanently closed on either side of the northern portal of Whitmore Heath tunnel. There will also be several temporary and permanent public right of way (PRoW) diversions. The construction of the River Lea viaduct where it crosses over the WCML at a high skew, is particularly complex and will require railway possessions. It could also result in some disruption to rail services on the WCML because of the proximity of these works to the WCML. The Proposed Scheme route primary characteristics are included in the table in Appendix C.

Railway systems

5.2.1 The two tunnels in the Proposed Scheme, at Whitmore Heath and Madeley, require a number of railway systems and safety measures needed for the railway operation. These include cross-passages, tunnel ventilation system, power supply, overhead line electrification, train control and communication equipment.

5.2.2 Both tunnels will require fan based ventilation systems and portal arrangements. Due to the length of these tunnels, intervention and ventilation shafts are not required.

5.2.3 The tunnel ventilation system serves multiple functions primarily providing emergency smoke control during a train fire incident, fresh air to the tunnel environment during congested train operations and acceptable conditions during maintenance operations.

5.2.4 Traction power auto-transformer stations will be provided along the route of the Proposed Scheme. They accommodate switchgear, transformers and associated equipment for communications and non-traction power systems; these sites require road access. In the Proposed Scheme Whitmore North auto-transformer station is located just north of Whitmore Heath northern tunnel portal. Heading north, the next auto-transformer station proposed is adjacent to Madeley Tunnel northern tunnel portal building.

5.2.5 Electrical power is also required for other railway systems (train control, communications, etc.), emergency lighting and the operation of mechanical and electrical equipment in tunnels. In addition, tunnels will have the following features at each portal:

- surface buildings housing services such as power, telecommunications.
- road access for maintenance and emergency services;
- hardstanding for parking vehicles;
- water supply, drainage and ventilation equipment;
- mechanical ventilation;
- evacuation routes; and
- an area for passengers in the event of an emergency.

5.3 Key environmental impacts of the Proposed Scheme

5.3.1 The Proposed Scheme will result in the need to demolish properties (three residential, one barn and five outbuildings) and will introduce visual, noise and amenity impacts in Whitmore Heath and Bar Hill. It will result in the loss of agricultural land and holdings and the loss and fragmentation of ecological habitat, including a loss of approximately 6.7ha ancient woodland within CA4, including approximately 6.0ha at Whitmore Wood and 0.2ha at Barhill Wood. There would be an impact on the local landscape character in the area, most notably around the A53 Newcastle Road, Whitmore Wood and Barhill Wood.

5.3.2 There would be impacts on cultural heritage including an impact on the setting of the Grade II listed Hey House and visual intrusion on other Grade II listed buildings, including a cluster within Madeley Conservation Area. The route alignment would cross a number of historic landfills reported to contain a variety of unknown, household, industrial and commercial wastes, which presents a risk of contamination.

5.3.3 Additionally, there would be impacts on a number of watercourses and tributaries. The tunnels have the potential to impact upon groundwater abstractions and springs. The route alignment is in the immediate vicinity of the Severn Trent Water Whitmore groundwater abstraction boreholes and is within the Source Protection Zone (SPZ). Most of the route alignment through this section is within a Mineral Safeguarding Area (MSA).

5.4 Mitigation incorporated into the Proposed Scheme

Design solutions contributing to reduced environmental effects

5.4.1 The sensitivity of the Whitmore Heath to Madeley area in terms of local communities, landscape character, and historic and ecological interest has been a key consideration in the development of the design for the Proposed Scheme.

5.4.2 As part of the iterative design and assessment process a number of mitigation measures have been incorporated into the Proposed Scheme and include:

- provision of a retaining wall (up to 13m high and 577m long) along the north-east of Whitmore North cutting to reduce the area of land within Whitmore Wood required for construction of the Proposed Scheme and the consequential loss of ancient woodland and habitat;
- the realignment of the A525 Bar Hill Road, which has been designed to minimise the impacts and visual, ecological and impacts to agricultural holdings and heritage assets;
- provision of the Meece Brook viaduct and the River Lea viaduct will avoid direct impacts on the Meece Brook and the River Lea respectively and allow free passage of wildlife beneath them during operation; and
- tunnels at Whitmore Heath and Madeley will reduce direct impacts on a number of receptors including residential properties, agricultural land, broadleaved semi-natural woodland and semi-improved and improved grassland.

Environmental mitigation adopted in the Proposed Scheme

5.4.3 As is commonplace with major infrastructure works, the scale of the construction activities in a predominantly rural setting means that works will have the potential to give rise to significant temporary and sometimes permanent effects. Where it is concluded that the Proposed Scheme will result in a significant change to the existing baseline conditions found within and around the route, mitigation measures have been included where reasonably practicable in the design to either minimise or reduce the effect. These are described in full in the Phase 2a Environmental Statement.

5.4.4 Examples of specific mitigation incorporated into the Proposed Scheme in CA4 include:

- partial compensation for the loss of ancient woodland through a range of measures, including the planting of native broadleaved woodland;
- approximately 8.1ha of further woodland habitat creation will be undertaken to compensate primarily for adverse effects upon non-ancient woodland;
- approximately 22.3ha of grassland habitat creation to maintain populations of protected and notable species;
- approximately 19.9km of new hedgerows will be planted and the species composition will be characteristic of the surrounding area;
- at least one pond will be created for every pond lost within the Proposed Scheme;
- design of earthworks to tie the engineering earthworks for embankments and cuttings into their wider landscape context and to mitigate views of structures and overhead line equipment from sensitive receptors where reasonably practicable;
- provision of noise barriers and bunds to avoid or reduce noise effects on residential and non-residential properties. Barrier heights vary dependant on form (i.e. fence or bund) but are typically designed to provide equivalent performance to a noise fence barrier with a top level 3m above the top of the rail and 5m to the side of the outer rail. Locations of noise mitigation include:
  - Whitmore Heath;
  - Madeley Park; and
  - Madeley.

5.5 Residual significant effects of the Proposed Scheme

5.5.1 Notwithstanding the design measures and mitigation incorporated into the Proposed Scheme, some significant residual effects will remain during both construction and operation phases. Most of the significant residual effects are temporary in nature, although loss of ancient woodland, loss of agricultural land and impact on valuable agricultural holdings are permanent residual effects that occur during construction. Residual significant effects during construction and operation in the Whitmore Heath to Madeley area are described below.

Construction effects

- loss of best and most versatile (BMV) agricultural land and impacts on agricultural holdings;
- effects on the amenity of residents at properties in Whitmore and Whitmore Heath, A525 Bar Hill Road and Mallard Close, Moor Hall Farm and Bower End Farm, and visitors of Madeley Cemetery;
- effects on the setting of Grade II listed Hey House and the permanent loss of archaeological assets;
- loss of ancient woodland, veteran trees and hedgerows;
- effects on landscape character and views from PRoW and isolated residential properties in the vicinity of Rectory Lane, Manor Road, north of Madeley Park Wood, Madeley Cemetery, A525 Bar Hill Road and Wrinehill Wood;
- noise effects on residential properties/communities that are closest to construction activity including Whitmore Heath and Bar Hill, Madeley, Bent Lane, Snape Hall Road, Manor Road, the A525 Bar Hill Road, Hey House offices and Madeley Cemetery; and
- delays and congestion for motorised users of the A51 London Road/A53 Newcastle Road and NMUs of footways and PRoW.

Operational effects

- effects on the amenity of residents of properties on Snape Hall Road, A525 Bar Hill Road and Red Lane in Madeley;
- ground-borne noise effects in residential properties above Whitmore Heath tunnel;
- airborne noise effects on receptors that are closest to operational activity including residential properties in Hill Chorlton, Whitmore Heath and Madeley, and Hey House offices and Madeley Cemetery;
- effects on the setting of Grade II listed Hey House;
- effects on landscape character, and views from Manor Road and farmland north of Madeley Park, Madeley Cemetery, Grafton's Wood and Madeley Bridleway 2, which will reduce over time as mitigation planting matures;
- benefits for users of Madeley Bridleway 5 as a result of reduced travel distance;
- increased journey times for NMUs of Snape Hall Road. NMUs of Madeley Bridleway 2 will be affected due to a diversion via a bridge passing under the

route of the Proposed Scheme.

5.6 Further design development of Proposed Scheme

Ground Borne Noise

5.6.1 The HS2 noise policy aims in respect of ground borne noise are set out in HS2 Phase 2a Information Paper E10: Control of ground-borne noise and vibration from the operation of temporary and permanent railways. With respect to the Whitmore to Madeley area three properties are identified as just above 'significant observable adverse effect level' (SOAEL) for ground borne noise as a result of operational noise. The assessment reported in the Environmental Statement is based on worst case ground conditions, which were used in the absence of ground investigation data. Information from the ground investigation surveys will be used to refine the assumptions of the assessment.

5.6.2 It is reasonable to anticipate that, during the detailed design stage, it will be reasonably practicable to design the permanent railway such that the level of ground-borne noise at these properties does not exceed SOAEL.

Ground investigation survey in support of design development

5.6.3 Preliminary ground investigations are currently being planned to provide more detailed information regarding ground conditions along selected sections of the proposed tunnel routes. Preliminary work will focus on two particular locations:

- Whitmore Heath and the adjacent areas (approximately 15 boreholes proposed); and
- Madeley Valley and in particular in the area of the 'glacial channel' (three boreholes proposed).

5.6.4 Geotechnical survey is not due to start until Spring 2018. Initial site data is expected in the second quarter of 2018, based on the programme at the time of writing, with the Ground Investigation Factual Report anticipated to start to be available in the third quarter of 2018. Dates are potentially subject to wider influence such as weather conditions and land access.

5.6.5 The preliminary ground investigations will provide additional information on ground conditions which will enable designers to manage construction risk and the programme for tunnelling works. It is not expected that this information will lead to significant changes of tunnel form or layout.

Opportunities

5.6.6 Following deposit of the Phase 2a Bill (July 2017), further consideration of the Proposed Scheme between Whitmore Heath and Madeley has been undertaken. The sensitivity of this location, landscape character, presence of ancient woodland, and impacts on agricultural land and farm holdings, were key considerations in on-going and current design development activities.

5.6.7 As part of the design development of the scheme, reasonable endeavours will be adopted to deliver mitigation measures that will further reduce any adverse environmental impacts caused by the Proposed Scheme, insofar as these do not add unreasonable costs to the project or unreasonable delays to the construction programme.

5.6.8 Potential design changes which are being considered include:

- lowering of the track alignment southeast of the Whitmore Heath tunnel to reduce visual impact at Meece Brook Viaduct and Meece Embankment;
- lowering of the alignment at the southern portal at Whitmore Heath tunnel, which would enable the portal to be moved south of the A53 Newcastle Road and therefore the realignment of the A53 Newcastle Road and provision of an overbridge across the portal would not be required;
- replacement of the cut and cover tunnel section of Whitmore Heath Tunnel with twin bored tunnel, which simplifies construction methods. Some localised ground improvement may be required to enable the tunnel boring machines to pass beneath the A53 Newcastle Road at shallow depth;
- lowering of the track below Whitmore Heath to deliver reductions in ground borne noise impacts to below SOAEL
- raising of the alignment to the north and east of Whitmore Heath tunnel, through Whitmore Wood, combined with a local horizontal shift of the alignment to the south and west by approximately 10m. This would reduce the height of the retaining wall through Whitmore Wood, further reduce the area of land within Whitmore Wood required for construction of the Proposed Scheme (and the consequential loss of ancient woodland and habitat);
- replace Whitmore Wood Accommodation Overbridge with an underbridge and move its location northwest slightly. This would reduce the visual impact and would be more beneficial to users;

- incorporate a PRoW around the northern porous portal of Whitmore Heath tunnel to maintain connectivity lost by closure of Snape Hall Road;
- change the horizontal alignment and track spacing in order to reduce the track spacing as much as possible to the north and west of Whitmore Heath tunnel. This would further reduce the area of land within Whitmore Wood required for construction of the Proposed Scheme and the consequential loss of ancient woodland and habitat; and reduce the track spacing to 5m between centrelines wherever possible on the surface section of track between Whitmore Heath and Madeley tunnels, but widening the track on approaches to the tunnels to maintain adequate separation through the tunnels. This reduces the width of embankments either side of the River Lea viaduct and the width of the viaduct itself, as well as the length of overbridges such as at Manor Road.

6 Single Tunnel

6.1 Development of the Single Tunnel design

6.1.1 Further to the single tunnel appraisal that took place in 2016 further consideration of the design was undertaken in 2017, after deposit of the hybrid Bill.

6.1.2 During this period, the concept design of the option for a single tunnel was further developed in parallel and independent of the design for hybrid Bill. Two options were developed and assessed. The option that is described in this report is shown in the Plan and Longitudinal Profile sketch in Appendix A.

6.1.3 This appraisal of a single tunnel considered more design detail across a wider range of technical disciplines than was previously available or evaluated in 2016. For example, consideration was given to tunnel ventilation, traction power design, temporary power supplies, utility diversions, shaft construction and construction traffic. The single tunnel option was evaluated against the corresponding section of the Proposed Scheme.

6.1.4 The Proposed Scheme had been developed to a final preliminary design stage for assessment and submission as part of the hybrid Bill. The Single Tunnel options have not been developed to an equivalent level of design detail. Given the level of design required to fully assess any option, it has therefore not yet been possible to undertake environmental impact assessment (EIA) of the Single Tunnel options to an equivalent level of detail as the Proposed Scheme.

6.1.5 The comparison and evaluation of the Single Tunnel design against the Proposed Scheme is based on professional judgement (rather than detailed quantitative assessment). A qualitative appraisal of the environmental and engineering benefits and dis-benefits and cost variance of both options has been undertaken.

6.2 Description of the Single Tunnel

6.2.1 The Single Tunnel is a 6.4km long twin bored tunnel with two 150m long porous portals, two shafts and minimum safe distance between the crown of the tunnel and the tracks of the WCML railway (refer to the concept plans of for the Single Tunnel Scheme presented in Appendix D). This layout is similar to a previously considered Option (D9-11.3) but incorporates a shift in the southern portal to the south, away from the A53 Newcastle Road. This shift avoids the need for the realignment of the A53 (an amendment developed during a design refinement process and is also an opportunity for design development of the Proposed Scheme as discussed in Section 5.6 above).

6.2.2 The route passes beneath Whitmore Heath, Whitmore Wood, the WCML, the River Lea, the Stoke to Market Drayton Railway, the Madeley Chord and Bar Hill in a twin bore tunnel, approximately 6.4km in length. At the deepest point below ground, the railway is approximately 71m below ground level. However, the great majority of the tunnel length is much shallower than this, with the railway between 20m and 40m below ground level. The southern tunnel portal is located approximately 260m south-east of the A53 Newcastle Road and the northern portal is located approximately 150m south-west of Bower End Farm, in an identical location to the northern portal of the Madeley Tunnel in the Proposed Scheme. Due to the length of the tunnel, two ventilation / intervention shafts are required to provide ventilation, maintenance and emergency services access to the tunnel. One shaft would require pumping systems to lift, store and safely discharge water that may enter the tunnels and collect at the tunnel sump. One ventilation and intervention shaft is located to the south and east of the WCML railway and north of Whitmore Wood and the other is located north-west of Manor Road. Refer to Plan profile drawing in Appendix A and detailed concept plans in Appendix D.

6.3 Design requirements and assumptions

Engineering

6.3.1 Details of the engineering design considerations that have been assumed with respect to the Single Tunnel option are included in Appendix E for reference.

Railway systems

6.3.2 Details of rail systems requirements for a single tunnel option highlight a number of considerations as presented in Appendix E.

6.4 Engineering appraisal of the Single Tunnel

6.4.1 Due to the tunnel length, only twin bore tunnels were considered. Ground conditions are considered to be suitable for a viable tunnel solution along the full distance between portals. Some ground improvement may be required locally at the A53 Newcastle Road to enable the tunnels to be safely bored beneath the highway. Particularly careful tunnelling and extensive monitoring for ground movements will be required during the high skew passage of tunnel boring machines (TBMs) under the WCML. Details of preliminary ground investigation survey which will include evaluation of ground risk in support of the Single Tunnel design development is referenced in Section 5.6.3.

6.4.2 The clearance between each of the tunnel bores is a minimum of one tunnel bore diameter. This is to minimise, as far as reasonably practicable, the effect of ground movement on third party structures both above and below ground, and so that additional tunnel strengthening would not be required to take account of secondary loading effects. The alignment of the tunnels with 22m spacing between track centrelines has been developed to comply with this requirement.

6.4.3 The increased track centre-to-centre spacing of 22m in the Single Tunnel (compared to 18m in the Proposed Scheme) in the tunnel sections would require larger earthworks at the approaches to the tunnel portals.

6.4.4 The track vertical alignments for the single tunnel option are similar to, but slightly worse, than those incorporated into the Proposed Scheme due to the increased gradients on the tunnel approaches and the need for a low point and drainage sump within the tunnel.

6.4.5 Overall the Single Tunnel benefits from reduced construction activities associated with cutting and embankment formation and retaining walls.

6.4.6 Construction of the River Lea Viaduct which is a significant and complex structures would be avoided by the Single Tunnel option, however the construction of Meece Brook Viaduct and Checkley Brook Viaduct both become slightly more complex, due to changes in the spacing of the tracks.

6.4.7 In comparison to the Proposed Scheme, the Single Tunnel adopts a different engineering solution for the southern approach. The location of the southern portal would move south of the A53, removing the need for realignment of the highway and construction of the A53 overbridge. As per 5.6.1 this is also being considered as a further design development of the Proposed Scheme.

6.4.8 The Single Tunnel removes the need for surface features such as highway diversions, and surface drainage features (for example four balancing ponds will no longer be required).

6.4.9 Construction impacts associated with the tunnel would be intensified around the tunnel entrances and porous portals where there would be extensive excavation works, plus night time lighting of the tunnel boring works. In comparison to the Proposed Scheme this intensive construction activity takes place at two construction compounds at two tunnel portals, rather than four, albeit for longer durations than in the Proposed Scheme. Single tunnel main surface level TBM support works will occur 24 hours 7 days per week at the Southern portal. For the Proposed Scheme, these works will be split to two 24hours and 7 days per week construction sites, at the Whitmore Heath and Madeley tunnel southern portals.

6.4.10 Tunnel ventilation and intervention shafts add significant complexity to the engineering design required for the Single Tunnel. The HS2 design criteria is for Intervention and Ventilation Shafts to be provided at regular distances (typically up to 3km) along the line of single (twin-bore) tunnels greater than 2km in length.

6.4.11 Two shafts would be required to meet design standards based on the proposed portal positions and as a consequence of the location of the WCML relative to the tunnel portals, which dictates where the shafts can be located. Each shaft would require fitting out with complex mechanical and ventilation equipment including lifts and local electrical systems. One shaft would require pumping systems to lift, store and safely discharge water that may enter the tunnels and collect at the tunnel sump. The shafts would each be completed with a headhouse that will be a new feature in the landscape, in addition to buildings located at the tunnel portals.

6.4.12 A compound will be located at each shaft headhouse building to allow for maintenance and emergency access/egress from the tunnel, drainage tanks and utility connections providing firefighting and tunnel building drainage. A permanent access road will be provided from the public highway to each shaft area.

6.4.13 Shaft depth, connection to tunnels, the requirement for hard standing rescue areas, and their internal arrangement would need to be further detailed and re-assessed for compliance at preliminary design stage. In addition, their architectural form, construction form, and constructability would need to be considered in further detail.

6.4.14 The removal of the River Lea Viaduct (which is a complex structure likely to require significant rail possessions of the WCML) and other structures, is considered to be a major improvement of the Single Tunnel option compared to the Proposed Scheme. In addition, there may be moderate improvement opportunities to reduce on-network railway activities.

Construction and excavated material

6.4.15 It is assumed that closed face tunnel boring machines (TBM) will be used to construct the Single Tunnel. For information on tunnel construction methods refer to HS2, Phase 2a Information Paper F2: Phase 2a Tunnels[6] for further reference.

6.4.16 The bored tunnels will be formed with precast segmental concrete linings that are erected behind a TBM. Each tunnel bore will be driven by its own TBM from the southern portal. On completion of the drive, the TBMs will be withdrawn from the TBM reception chamber at the north portal, disassembled and removed from site by road.

[6] HIGH SPEED TWO PHASE 2a INFORMATION PAPER F2: PHASE 2a TUNNELS (July 2017). Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/628621/F2_Phase_2a_Tunnels_v1.0.pdf

6.4.17 It is proposed that the Single Tunnel would be constructed from a main compound located adjacent to the A53 at the southern portal. All the tunnel construction processes, including segment manufacture and supply, water supply, removal and sorting of tunnel excavated material will be serviced from this compound. Additional compound space would be required at the shafts for construction purposes.

6.4.18 The power supply requirements for TBM driving will need to be assessed against existing utilities in the area and are likely to require additional works to provide the necessary temporary power supplies.

6.4.19 The shafts will be sunk from ground level down to tunnel level. The circumference of each shaft will be formed in concrete. Depending on ground conditions this could be by bored and cast in-situ secant piles walls, or by diaphragm walling. Earth is excavated from within the shaft from the top down and removed from the shaft construction site by road. As excavation of the shaft down to tunnel level progresses, the excavated levels might be horizontally propped until a restraining concrete slab can be formed at the base of the shaft, just below the level of the railway tunnel bores. All materials to construct the shaft and to fit it out are brought to the shaft construction site by road.

6.4.20 The volume of material arising from the construction of the Single Tunnel, including cross passage, shafts and excavation of the porous portals, is approximately 1.28 million m^3. All excavated material from the tunnelling operations will be removed from the tunnel via the southern portal. Much of this material would be either suitable for fill for railway or highway embankments, as landscape fill or to backfill borrow pits. However currently it is assumed that just over 50% of material from the tunnel excavation is likely to be disposed of off-site, via the local road network, since it is surplus to the project requirements for fill. This is determined from a high-level review and would be subject to further review during design development.

6.4.21 A traffic impact assessment for the Single Tunnel option based on the above assumption with regards to material excavated from the tunnel has been undertaken and details of the output for the study can be found in Appendix F. The assessment shows that, although the total volume of material associated with the Single Tunnel increases and the volume taken off site will also increase, the change is not expected to increase the assessed peak month traffic volumes in the area. However, the duration of the busy[7] periods is expected to increase for both the A53 Newcastle Road and A519 Newcastle Road near M6 junction 15. The Single Tunnel is not expected to have an adverse impact on the A525 Bar Hill (and consequently the A51 London Road) over and above that identified for the hybrid Bill. However, although the peak flows are not anticipated to increase as a result of the Single Tunnel option, the increase

[7] The busy period is the period during which HGV traffic will be greater than 50% of the HGV traffic in the peak month

busy period in combination with wider construction works could increase the peak month traffic flows. This will need consideration as part of a full assessment.

6.4.22 It is currently assumed that concrete tunnel segments will be imported by road from an off-site manufacturing facility; a similar arrangement was assumed for the Proposed Scheme.

Railway systems

6.4.23 A review of the rail systems requirements highlights a number of considerations for a Single Tunnel option primarily orientated around safety and greater traction power loading both requiring different surface requirements than the Proposed Scheme in addition to potential impact on operation of the wider high speed network.

6.4.24 Whilst the objectives of the safety measures are similar for long and short tunnels, a longer tunnel means that more physical equipment is needed and the configuration/type of equipment differs slightly. The lengthened tunnel options would require additional consideration and allowance for ventilation and emergency access shafts, additional tunnel cross passages, and more extensive tunnel ventilation system. The Single Tunnel option will require a tunnel ventilation system incorporating two ventilation and intervention shafts and associated head house buildings in addition to further ventilation fans located within the tunnel bore near the portals. in addition to further ventilation fans located within the tunnel bore near the portals. Ground level shaft compounds, with road access and hard standing rescue areas would be associated with each shaft. Ventilation equipment may need to be located above ground. Fire-fighting points and associated infrastructure would be required at both portals to the tunnel.

6.4.25 Cross passages are required in all tunnels to the same minimum spacing requirements to allow passengers to escape into the non-incident tunnel bore in the event of an incident.

6.4.26 There is an increased electrical power demand of the tunnel ventilation system, as well as power for the mechanical and electrical equipment in the additional cross passages, and additional tunnel lighting due to the tunnel length.

6.4.27 The Single Tunnel result in a greater traction power loading (compared to the Propose Scheme) as a result of the resistance encountered by the train when circulating the tunnel and the steep alignment gradient. In order to cater for this loading increase, (potentially) significant upgrades to the Proposed Scheme traction power system arrangement will be required to achieve compliance with the Energy Technical Specification for Interoperability. Initial studies based on early assumptions indicated that this could be addressed by significantly increasing the conductor size of the express feeder cables between Newlands Lane ATFS and Yarlet EFATS (although

practically likely to require the introduction of a second cable in parallel instead). Further development of the tunnel alignment L1 studied and confirmation of assumptions during design development may cause a variation in the traction power solution to be adopted, potentially introducing additional modifications to the system configuration in the Proposed Scheme, which could be in the shape of changes to some auto-transformers sites to accommodate additional loading requirements.

6.4.28 Ground level shaft compounds with road access and hard standing would be required at each shaft. Ventilation equipment may need to be located above ground. Firefighting points and associated infrastructure would be required at both portals to the tunnel. In comparison to the Proposed Scheme there is an increased power demand of the tunnel ventilation system, power for MEPH equipment in the additional cross passages, and additional tunnel lighting.

6.4.29 The operational requirement is that Technical Headways are to be maintained below 120 seconds where possible, and never to exceed 150 seconds, which is permitted only exceptionally and where there is no reasonable alternative. Extended headways (minimum time interval between trains that allows them to run at full speed) associated with long tunnels increase the risk that minor disruption will impact upon a series of trains rather than just the one immediately affected, tending to worsen achievement of performance targets. The Single Tunnel alignment option assessed leads to a 'moderate worsening' to the operational headways. This would need re-assessment as the tunnel design develops as operational headway may vary as a result of design change.

Further details of the outline Railway System requirements for a Single Tunnel option are presented in Appendix G.

Construction Programme

6.4.30 To compare options a slower TBM advance rate has been assumed for the start-up/learning curve and tunnel finish sections of all tunnel boring. For the main drive in between the start-up and tunnel finish sections of the drive a significantly higher weekly progress rate has been assumed. The same average weekly progress rate has been used for both the Single Tunnel and the Proposed Scheme tunnelling construction programmes.

6.4.31 The weekly progress rate was evaluated and considered to be a reasonable average rate of TBM progress in between the start-up/learning curve and tunnel finish sections. It takes account of anticipated ground conditions based on based on the current desk based assessment of geotechnical information. It also takes into account the findings of a high-level comparison against a number of historical, case study, tunnelling projects. These case studies report actual average progress rates achieved for a range of ground conditions and tunnel diameters.

6.4.32 For the Single Tunnel, TBMs will slow down as they approach break-through into each shaft. The machines will then stop tunnelling and be partially disassembled to be dragged across the shaft before they are re-assembled to re-start tunnelling on the opposite side. In addition, down-time to perform deep maintenance of the TBMs and their cutter heads will be need within at least one of the shafts. Slower, cautious tunnelling will also be required beneath the WCML to minimise settlement. The average progress rate in used in cost estimating takes into account these periods of slow or nil tunnel production and assumes higher weekly production rates in other areas in order to achieve the overall average rate. All weekly production rates used in the assessment fall within the range of achieved production rates on previous tunnelling projects.

6.4.33 Using two TBMs starting at Whitmore south end, the tunnelling will progress 24 hours per day, 7 days per week for up to two years.

6.4.34 The comparative analysis showed that utility diversions will be reduced but some will probably still be needed for major utilities that could be affected by tunnel settlement. Significant construction activities are removed from the programme compared to the Proposed Scheme. The time savings on these omissions would largely offset the additional TBM duration to the effect that the overall programme will remain broadly the same for the Single Tunnel as compared to the Proposed Scheme. The conclusion was minor worsening compared to the Proposed Scheme.

6.4.35 In terms of Railway systems, the construction programme is affected by the additional fit out works in the tunnel and the vent shafts. Also, the track laying is slower in the tunnel rather than the open section. This leads to a more constrained construction programme since more activities need to be completed within the same time frame. However, the overall construction programme should not be delayed due to some inherent float in the hybrid Bill programme.

Additional project and operational risk associated with the Single Tunnel

6.4.36 The need for more tunnelling equipment compared to the Proposed Scheme, including assembly on site and commissioning, would increase the time to establish construction compounds.

6.4.37 Longer lengths and durations of tunnel working introduces increased construction and maintenance (operational) risks due to working in longer lengths of restricted spaces compared to the Proposed Scheme.

6.4.38 Two shafts would be required for the Single Tunnel. Design and construction of these shafts would add additional requirements. Shaft sinking/fit-out would add additional complexity to the design and construction of the scheme. The area of land required for the northern intervention shaft is within a Mineral Safeguarding Area for sand and gravel. Additional land would be required around the shaft locations specifically for construction purposes. Long term road access to the shafts for maintenance and emergency vehicle requirements would be required.

6.4.39 For the Single Tunnel passing below the WCML at relatively shallow depth there is a construction risk due to the potential effects of settlement on the WCML. This may result in some mitigation works, or possessions of the WCML, in order to control this risk. This risk is considered more significant because of the geology of the area and the requirement to cross the Madeley Glacial Channel (see the table in Appendix E.1 for further details). Detailed investigation of these effects could drive a requirement to lower the tunnel vertical alignment at this location and provide greater vertical clearance to the WCML and Madeley Glacial Channel.

6.4.40 The Single Tunnel option could result in changes to groundwater flows and require diversion of shallow groundwater behind the southern tunnel portal, because the portal is lower than and at a different location to that in the Proposed Scheme. Construction of the tunnels may require dewatering at some locations, which may have engineering impacts, such as settlement. There is the potential to impact groundwater quality at the Severn Trent Whitmore abstraction borehole (which may become an operational effect), although this would be carefully mitigated in consultation with Severn Trent Water.

Railway Systems risk

6.4.41 Based on experience from HS2 Phase 1, the shallow alignment will most likely result in horizontally arranged tunnel ventilation equipment in a basement level. Further design will need to be completed as part of design development to determine the ground level land take requirements.

6.4.42 The Single Tunnel length increases the likelihood of a stopped train in the tunnel and potentially activate the tunnel ventilation system during normal operating hours.

6.4.43 There is a risk that the likely requirement for the introduction of additional second express feeder cables may require additional lateral space provision at structures, resulting in the need for viaducts widening between Newlands Lane ATFS and Yarlet EFATS.

6.4.44 There is an operational planning risk associated with long tunnels as they typically increase headways. In addition, headways may also increase for deeper alignments, and may affect differently depending on direction of trains (northbound or southbound).

6.5 Environmental appraisal of the Single Tunnel

6.5.1 Due to the present level of design development, the environmental impacts of the Single Tunnel option have not been assessed to the same level of detail as the Proposed Scheme. Environmental appraisal of the Single Tunnel concept design is provided in the qualitative comparative analysis table in Appendix H. The summary below provides a comparison against the Proposed Scheme. The predicted impacts are summarised in the comparison tables in Section 9.2.

6.5.2 The Single Tunnel would result in the removal of elements of the Proposed Scheme and operating trains from the surface route between the northern portal of Whitmore Heath Tunnel and the southern portal of Madeley Tunnel. It would also result in the lowering of the Meece Brook Viaduct that would reduce its visual impact in the Hill Chorlton area. A construction haul route would be required between the portals of the Single Tunnel, as shown on the plans in Appendix D. There would be a new requirement for two Intervention and Ventilation shafts, including headhouse building structures and land associated with shaft construction and access roads. A new ATS would be required at the southern intervention shaft. These would be an additional visual feature in the landscape. Landscape mitigation planting would be required near these structures. Permanent access to the shafts locations from the public highway network would need to be provided.

6.5.3 Construction of the Single Tunnel would reduce the loss of BMV agricultural land and have a reduced impact on land holdings and agricultural buildings, and avoid the need for demolition of properties including residential properties.

6.5.4 Most heritage impacts would be removed if the Single Tunnel were to be adopted. The loss of non-designated heritage assets would be reduced as would the impact on the setting of listed buildings and Madeley Conservation Area. The presence of the ventilation shaft for the Single Tunnel would affect the setting of the Grade II listed Hey House (although the effect may be reduced compared to the Proposed Scheme).

6.5.5 The area of temporary and permanent land required would be reduced as a result of the Single Tunnel option, which would reduce loss and fragmentation of ecological habitats and impacts on protected/notable species. Impacts on Whitmore Wood and other ancient woodlands would be avoided, avoiding a loss of 6.4ha ancient woodland, which would have route wide benefits.

6.5.6 In comparison to the Proposed Scheme, spoil disposal and landfill requirements would lead to construction traffic moderately worse due to the additional surplus excavated material compared to the Proposed Scheme, requiring off-site disposal to landfill.

6.5.7 Most landscape and visual impacts would be removed if the Single Tunnel were to be adopted. There would be reduced construction and operational impact on landscape

character and a reduction of visual effects on residents and users of the PRoW and highway network, as a result of the reduction of infrastructure and construction compounds.

6.5.8 The number of tunnel portals would be halved compared with the Proposed Scheme however they could be more complex due to additional ventilation and emergency equipment and could have worse visual impacts in comparison to the Proposed Scheme.

6.5.9 The removal of surface works in between the Whitmore Heath and Madeley tunnels is likely to remove most of the construction noise and vibration impacts though ground-borne noise and vibration from tunnelling operations could affect a limited number of properties. A few residential properties, community facilities and businesses would experience a reduction in noise, with a reduced number of properties qualifying for noise insulation. There would also be a reduction in amenity impacts and isolation effects. During operation, it is likely that the Single Tunnel would reduce the ground-borne noise and vibration levels at properties above the Whitmore Heath part of the Single Tunnel. Impacts on Madeley Cemetery would largely be removed as the design of fixed sources of noise (including the tunnel ventilation and headhouse equipment) will be designed to achieve a level at which no significant effects are identified. The nearby intervention and ventilation shaft would be assessed once the initial preliminary design of the shaft had been completed.

6.5.10 The three properties which, with the Single Tunnel option, would not be demolished would not be subject to construction or operational noise or vibration significant effects. During construction, the short duration of the tunnelling, and the mitigation included within the temporary construction railway would avoid any likely significant effects. The ground conditions at these properties are such that the predicted operational ground-borne noise impacts at these properties are classified as 'low' and would not therefore result in new or different likely significant effects.

6.5.11 The construction of the Single Tunnel would avoid the closure of Snape Hall Road. Disruption to the A53 Newcastle Road, Manor Road, A525 Bar Hill Road and local PRoW would be reduced or removed. This would reduce impacts to community, health and wellbeing in the area and reduce delays to road users, users of public transport, and non-motorised users (NMU). The Single Tunnel option would avoid disruption of existing infrastructure such as the crossing of the WCML during construction and with respect to asset inspection during operation.

6.5.12 There would be a reduction in HGV movements along some highways throughout the area during construction, benefiting air quality. However, the A53 Newcastle Road would see an increase in duration of the 'busy period' of HGV movements from the transfer nodes around the southern portal. There would be an increase in HGV movements on other parts of the local highway network during the construction

period as a result of the increase in transportation of material to and from the tunnel portals and shafts for a Single Tunnel option. Whilst the overall peak of HGV movements would not increase, the overall duration for which traffic conditions remain at a 'busy' period will increase. The increased HGV movements may result in congestion and traffic delays as well as severance for NMUs. Public rights of way would be affected during both construction and operation, subject to both temporary and permanent diversions, albeit fewer than the Proposed Scheme.

6.5.13 Compared to the Proposed Scheme, there would be moderate surface water improvements from the removal of direct impacts on the River Lea and air quality improvements due to the removal of many baseline construction compounds, above ground works and road realignments. Contaminated sites in the River Lea viaduct area would be avoided.

6.5.14 There would be expected to be an increased impact on groundwater (construction), including the Whitmore Public Water Supply. In comparison to the Proposed Scheme, the Single Tunnel may lead to minor worsening for water and flood risk during operation, due to the deeper cutting close to the Whitmore Public Water Supply, and minor worsening for land quality due to an increased risk of groundwater contamination from the longer tunnel during operation.

6.5.15 During operation, the increased gradients at each end of the Single Tunnel and operation of tunnel systems would increase energy use, specifically traction power, resulting in increased greenhouse gas emissions.

6.6 Further single tunnel options and opportunities

6.6.1 There is an opportunity to reduce the diameter of shafts subject to geotechnical conditions and internal equipment layout requirements, which would reduce their construction impact, cost and visual impact after construction.

6.6.2 Further design refinement based on geotechnical investigation and ground information may cause the tunnel alignment to become deeper than the option presented in this report. As detailed in Section 5.6 further ground investigation survey is planned for Spring 2018 onwards which may inform options or provide additional opportunity with respect influence of ground conditions on tunnelling. Factual data resulting from this further survey work is currently programmed for the third quarter of 2018. It is not expected that increasing the depth of the tunnel alignment would change the overall conclusions of the comparative exercise, nor would it change any of the surface features.

6.6.3 There is a potential for adjustment to the vertical alignment to reduce geotechnical concerns/settlement.

6.6.4 There is a potential for adjustment and refine the landscape/mitigation design to mitigate noise and visual impacts.

6.6.5 There is a potential for adjustment and refine the shafts surface layout and access arrangements.

6.6.6 In case that further single tunnel development brings an overall deeper alignment, further analysis will be required to confirm whether additional ventilation fans will be required at the portals to bolster tunnel ventilation capacity.

6.6.7 A difference in size of shaft compound requirements would be subject to detailed assessment and space planning, ventilation and intervention shafts depth. That is, deeper alignments would potentially require a smaller shaft compound size.

6.6.8 Should further design development lead to deeper single tunnel alignments, these are then expected to have greater effect on the traction power requirements and operational headways.

7 Cost assessment

7.1 Overview

7.1.1 The Single Tunnel development has led to improved understanding of the costs of a Single Tunnel option. In May 2016 the additional civil and rail systems, engineering works cost of a Single Tunnel (Option D9.11.3) compared to the baseline was estimated to be significantly higher than the Proposed Scheme selected. Once further engineering details were developed, greater consideration could be given to key cost drivers. These included the rate of progression of tunnel construction, the impact on mass-haul movement of earthworks, disposal of additional material generated and construction of the intervention and ventilation shafts. The assessment costs in the October 2017 comparison of a Single Tunnel compared to the Proposed Scheme also concluded that the civil and rail systems engineering cost of a Single Tunnel were significantly higher than the Proposed Scheme. The most recent comparative cost assessment for the Single Tunnel option is presented in Appendix H.

7.2 Tunnelling rate

7.2.1 The costs of tunnels are sensitive to the assumptions made around the rate of progression of tunnel boring; the faster the tunnel is formed, generally the lower the cost of construction. Geology and the presence of sensitive structures over the ground above any tunnel are a significant impact on production rates however, since the tunnels of the Proposed Scheme and the Single Tunnel option are generally in the same location and within similar formations, geology will be similar. The Single Tunnel option passes underneath a largely rural area but does also pass beneath the WCML, which would lead to slower progression rates in this location. A hard average rate[8] of 90m per week has been adopted in estimating the cost of the Single Tunnel scheme.

7.3 Disposal of additional material generated

7.3.1 The cost of disposal of export material off site is based on an assumed distance to disposal of 20km, at an appropriate unit rate of cost for transport and with material deposited free of charge at the disposal location.

[8] Hard average rate is the average rate of tunnelling from machine in to machine out

7.4 Land and Property

7.4.1 The Single Tunnel option provides some savings in relation to avoided property costs and, when combined with expenditure incurred for properties already acquired, provides additional support.

8 Comparative analysis 2017

8.1.1 A comparative analysis review was undertaken in October 2017 of the Single Tunnel compared to the Proposed Scheme. The outcome of the comparative analysis, the review matrices are presented in Appendix I.

8.1.2 The comparative analysis assessment for engineering highlighted impact of the Single Tunnel scheme to be 'Major Worsening on the Comparator Scheme' (the Proposed Scheme) impact assessment. This was primarily due to construction cost which had been evaluated to be significantly above the Proposed Scheme, along with worsening within some engineering disciplines including the Railways Systems design and operations, as well as the earthworks balance and inclusion of a single longer tunnels and shafts into the scheme.

8.1.3 The outcome of the comparative analysis for environment was the Single Tunnel scheme was a 'Major improvement on the Comparator Scheme' (the Proposed Scheme). Environmental benefits derive from the removal of construction effects, the presence of the built scheme and presence of operating trains at surface level between the tunnel portals that were present in the baseline scheme. Between the portals, most landscape and visual, heritage, biodiversity and agricultural impacts along the tunnel's route would be removed. Notably the comparative analysis concludes there would be the retention of approximately 6.4ha of ancient woodland from Whitmore Wood and other surrounding AWIS.

9 Comparison summary

9.1 Engineering (and cost) evaluation

9.1.1 The table below present a comparison summary of the key engineering aspects and costs for the Proposed Scheme and the Single Tunnel Option.

Table 9.1: Whitmore to Madeley Alignment Options Engineering and Costs Comparison Summary

Considered Option	Proposed Scheme	Single Tunnel
Section Length (m)	ch229+600 to ch244+300	ch229+600 to ch244+300
Total Cost (£) Rail systems Cost (£) Property Cost Delta from PCR (£)	Reference Appendix H	Reference Appendix H
Key Engineering Issues	Construction scope incorporates multiple construction features making construction logistics more complex with respect to varied requirements to facilitate construction along the alignment at surface level. The scheme incorporates: - - 690m long twin bore tunnel plus 238m long cut and cover tunnel and 150m long porous portals at each end. - 670m long twin bore tunnel c/w 150m long porous portals at each end. - Earthworks including cutting and embankment. Due to surface features the Proposed Scheme requires the following highway scope: - A53 - crosses portal structure/diversion - Snape Hall Road - to be stopped up - Manor Road -high skew overbridge with large approach embankments - A525 -realignment Highway realignments comply with the applicable standards. There are West Coast Main Line (WCML) interface works at River Lea including a viaduct across WCML, which will require possessions of the WCML during construction. Vertical curve in the alignment requires a departure for any rail expansion joints (if required) on the viaduct. In addition there are a number of engineering structures required for the Proposed Scheme solution including: - - Whitmore Wood retaining wall 495m long. - Aqueduct at Madeley.	Many engineering requirements listed for the Proposed scheme are no longer a requirement for the Single Tunnel option. Construction scope incorporates: - 6,400m long twin bore tunnel - 150m long porous portals at each end (lengths subject to ongoing design refinement). - 2no. 43m diameter shafts and associated head houses are required. Scheme omits issues associated with passing over WCML but introduces risk associated with passing below the WCML at shallow depth. Requirement for WCML possessions associated with controlled settlement will need consideration during detailed design. Temporary WCML speed restrictions are likely to be a minimum requirement during construction of the tunnels locally below the WCML.

Table 9.1: Whitmore to Madeley Alignment Options Engineering and Costs Comparison Summary		
Considered Option	Proposed Scheme	Single Tunnel
Rail Systems	The key features of the rail systems for the Proposed Scheme are as follows: Railway systems equipment required for two cross passages per tunnel Fan based ventilation systems at portals. Due to the length of these tunnels, intervention and ventilation shafts are not required. Power supply, mechanical and electrical equipment, overhead line electrification, train control, communication and emergency lighting equipment required for the tunnel operation. Following features at each portal: - surface buildings housing services such as power, telecommunications - road access for maintenance and emergency services; - hardstanding for parking vehicles; - water supply, drainage and ventilation equipment; - mechanical ventilation; - evacuation routes; and - an area for passengers in the event of an emergency.	The rail systems for a Single Tunnel include additional requirements compared to the Proposed scheme: Railway systems equipment required for 18 cross passages Tunnel ventilation system incorporating two ventilation and intervention shafts located within the tunnel bore near the portals and associated head house buildings, in addition to further ventilation fans located within the tunnel bore near the portals. Ground level compounds, road access and hard standing rescue areas would be associated with each shaft. Ventilation equipment may need to be located above ground. Fire-fighting points and associated infrastructure would be required at both portals to the tunnel. Moderate increase in electrical power load for tunnel ventilation loads. In comparison to the Proposed Scheme, the Single Tunnel alignment will result in a greater traction power loading. Either an increase in the conductor size of the express feeder cables between Newlands Lane ATFS and Yarlet EFATS or an introduction of a second cable in parallel. A single tunnel will require additional 25kV switchgear for sectioning and earthing of tunnel Overhead Contact System. Communication and signalling are anticipated to be similar to the Proposed Scheme There would also be cost and programme impacts compared to the current Proposed Scheme due to the additional equipment required for a Single Tunnel option. The Railway Systems construction programme is affected by the additional fit out works in the tunnel and the ventilation shafts, with the track laying slower in the tunnel rather than the open section. This leads to a more constrained construction programme but does not change the overall construction programme duration. The Single Tunnel introduces additional complexity of undertaking maintenance working in 6.4km tunnel (but applicable procedures would be in place). The Single Tunnel leads to increasing headways, depending on direction (northbound or southbound). This worsening is regarded as moderate. Further alignment development may reveal different headway values therefore requiring further measurement.

9.2 Environmental evaluation

9.2.1 The table below presents the key environmental impacts and residual significant effects of the Proposed Scheme in the Whitmore Heath to Madeley area, alongside an indication of predicted impacts as a result of the Single Tunnel scheme in the Whitmore Heath to Madeley area. In the absence of an environmental impact assessment the figures given for the Single Tunnel may be subject to change and are indicative only. The calculated areas of habitat loss are based on the precautionary assumption that all habitat within the land required for the Proposed Scheme and the Single Tunnel scheme are lost. A Red, Amber Green (RAG) rating has been provided, based on professional judgement, to indicate whether the Single Tunnel is 'better' (green), neutral (yellow) or 'worse' (red) than the Proposed Scheme.

Construction

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with single tunnel amendment (predicted, based on appraisal)	RAG rating
Route characteristics (km)				
	Total	9.1	9.2	n/a
	Tunnel	2.2 (Whitmore Heath and Madeley)	6.7 Whitmore Heath to Madeley	n/a
	Cutting	2.4 (Whitmore South, Whitmore North and Madeley)	0.2 Whitmore South	n/a
	Viaduct	1.0 (Meece Brook and River Lea)	0.3 Meece Brook	n/a
	Embankment	3.5 (Stableford North, Meece, Lea South, Lea North and Checkley South)	2.0 (Stableford North, Meece and Checkley South)	n/a
Agriculture, forestry and soils				
	Loss of agricultural land – temporary (ha)	336	216 (all land within land required for the scheme)	
	Loss of agricultural land – permanent (ha)	190	46	
	Loss of BMV land – temporary (ha)	140	78 (all land within land required for the scheme)	
	Loss of BMV land – permanent (ha)	70	22	
	Loss of forestry land – permanent (ha)	24	0.7	
	Impacts on farms and rural holdings – temporary (number)	21	17	
	Impacts on farm and rural holdings affected – permanent (number)	19	10	
	Residual significant effects	• 140ha BMV land required during construction, of which 70ha required permanently; • high magnitude of impact on forestry land; • 12 farm holdings significantly affected during construction; • major adverse effects for four holdings; major/moderate adverse effects for four holdings; moderate adverse effects for four holdings; • nine farm holdings significantly affected permanently; and	• 78ha BMV land required during construction, of which 22ha required permanently; • negligible impact on forestry land; • eight farm holdings significantly affected during construction; • major adverse effects for two holdings; major/moderate adverse effects for three holdings; moderate adverse effects for three holdings; • three farm holdings significantly affected permanently; and	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with single tunnel amendment (predicted, based on appraisal)	RAG rating
		• major adverse effect for one holding; major/moderate adverse effects for three holdings; and moderate adverse effects for five holdings.	• major/moderate adverse effects for two holdings; and moderate adverse effects for one holding.	
Air quality – n/a				
Community				
	Demolitions (number)	Residential: three Commercial: one farm outbuilding Other: five	Residential: none predicted Commercial: none predicted Other: none predicted	
	Impacts on open space	Temporary: noise, visual and HGV impacts on Madeley Cemetery Permanent: noise and visual impacts on Madeley Cemetery	Temporary: noise, visual and HGV impacts on Madeley Cemetery Permanent: none predicted	
	Promoted PRoW affected (number)	Newcastle Way permanently diverted to follow realigned Manor Road	None predicted	
	Residual significant effects	Temporary in-combination effects on: • 29 properties in Whitmore and Whitmore Heath; • 42 properties on A525 Bar Hill Road and Mallard Close; • five properties at Moor Hall Farm and Bower End Farm; and • Madeley Cemetery.	Temporary in-combination effects on: • approximately five properties close to the northern and southern portals; and • Madeley Cemetery and possibly Hey House and Hey Lodge House.	
Cultural heritage				
	Scheduled monuments affected (number)	None	None predicted	
	Grade I and II* structures affected (number)	None	None predicted	
	Grade II structures affected (number)	Six (Snape Hall Farmhouse, Hey House, Offley Well Head, Bridge Cottage, two mileposts)	One predicted (Hey House - visual impacts from construction of the vent shaft)	
	Conservation areas affected (number)	None	None predicted	
	Residual significant effects	• Permanent physical impacts on heritage assets within the land required for the Proposed Scheme; and • Hey House (Grade II listed) will be subject to a permanent change in its setting as a result of the noise of passing trains.	• WHM007 will be partially removed; • WHM083 (Palaeolake) will be impacted by tunnel (depending on depth); • WHM058 (Moor Hall Farm) setting impacted by access road; and • Hey House (Grade II listed) will be subject to a temporary change in its setting as a result of the construction noise from vent shaft (noise to confirm levels).	
Ecology and biodiversity				
	Designated sites affected (number)	Six (Whitmore Wood LWS & AWI, Manor Road Verges BAS, Barhill Wood AWI, unnamed wood south of Hey Sprink AWI, Hey Sprink (wood south-west of) LWS, Wrinehill Wood (east of) BAS)	Two predicted (Wrinehill Wood (east of) BAS), unnamed wood south of Hey Sprink AWI)	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with single tunnel amendment (predicted, based on appraisal)	RAG rating
	Loss of ancient woodlands (number/ha)	Five (Whitmore Wood (6ha), Barhill Wood (0.2ha), Unnamed wood south of Hey Sprink AWI (0.2ha), Hey Sprink (wood south-west of) LWS (0.2ha), Wrinehill Wood (east of) BAS (0.1ha))	Two predicted (Wrinehill Wood (east of) BAS (0.1ha), Unnamed wood south of Hey Sprink AWI (0.2ha))	
	Veteran trees affected (number)	Nine	One predicted (as a result of works associated with the Stableford North embankment, in a field to the east of Bent Lane)	
	Loss of woodland habitat (including ancient woodland) (ha)	33.2	13.9	
	Loss of unimproved and semi-improved grassland habitat (ha)	37.3	30.7	
	Loss of hedgerow (km)	22.7	13.3	
	Loss of ponds (number)	37	24	
	Residual significant effects	Loss of 6.7ha ancient woodland; Net loss of 2.8km hedgerow; and Loss of nine veteran trees	Predicted loss of 0.3ha ancient woodland (from Wrinehill Wood (east of) BAS and unnamed wood south of Hey Sprink AWI); Net loss of hedgerow has not been calculated; and Predicted loss of one veteran tree	
Health				
	Neighbourhood quality	Noise, visual and HGV effects from construction activities that adversely impact on perceptions of neighbourhood quality in Whitmore Heath, Baldwin's Gate, Madeley Park Wood and Madeley.	Predicted impacts on perceptions of neighbourhood quality would be reduced in Whitmore Heath, Baldwin's Gate and Madeley. Removal of neighbourhood quality impacts on Madeley Park Wood and Bar Hill.	
	Access to green space	Amenity impacts on five PRoW including three bridleways. Obstruction or deterrent impacts on NMUs at A53 Newcastle Road, Snape Hall Road and Common Lane between Whitmore Heath and Baldwin's Gate, A525 Bar Hill Road through Madeley.	Predicted amenity impacts on five PRoW including two bridleways and one footpath to be upgraded to bridleway.	
	Social capital	Temporary wellbeing effects associated with the introduction of a temporary construction workforce in areas close to construction compound access points on A525 Bar Hill Road and around Whitmore Heath. Potential for the presence of the temporary workforce to have a beneficial effect on local communities through increased use of local services and opportunities for social interaction.	Temporary wellbeing effects associated with the introduction of a temporary construction workforce and beneficial effects predicted to be similar to Proposed Scheme, as the location of southern tunnel portal and construction access routes would be similar.	
	Residual effects	None	None predicted	
Land quality				
	Sites crossed which may pose a contaminative risk (number)	Nineteen The assessment has shown that none of these would be regarded as resulting in a significant effect during either construction or operation.	Nine predicted	
	Geological SSSI affected (number)	None	None predicted	
	Loss of Minerals Safeguarding Area (MSA) (number)	One	One predicted	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with single tunnel amendment (predicted, based on appraisal)	RAG rating
		MSA for sand and gravel extraction crossed in three locations within CA4. Construction of the Proposed Scheme will lead to temporary sterilisation of the resource where the MSA is affected by construction compounds, and permanent sterilisation where it is affected by the permanent works. However, as a proportion of the total MSA, the permanently sterilised area is less than 1% of the total, and the effect on the MSA is considered to be minor and therefore not significant.	The northern vent shaft is located in an MSA for sand and gravel extraction.	
	Residual significant effects	None	None predicted	
Landscape and visual				
	Residual significant effects	Widespread presence of construction activity and construction plant within the landscape and viewed from surrounding residential receptors, users of PRoW and main roads will remain after construction phase mitigation, resulting in: • major adverse significant effects in relation to three LCAs; • moderate adverse significant effects in relation to four LCAs; • major adverse significant effects at 16 residential viewpoint locations; • major adverse significant effects at six recreational viewpoint locations; • moderate adverse significant effects at five residential viewpoint locations; • moderate adverse significant effects at six recreational viewpoint locations; and • moderate adverse significant night-time effects at one residential viewpoint location.	Construction (and the associated landscape and visual impacts) would be intensified around tunnel entrances, particularly at the southern end near construction of Meece Brook viaduct. There would be localised landscape impacts from construction of southern and northern vent shafts. However, with the exception of the vent shafts and associated access routes, the rural landscape between the tunnel portals would remain intact.	
Socio-economics				
	Businesses affected	One (Unreal Paintball)	None predicted	
	Route wide construction jobs	The twelve satellite construction compounds in the Whitmore Heath could result in the creation of up to 1,620 person years of construction employment opportunities, broadly equivalent to 160 full-time jobs, which are potentially accessible to residents in the locality and to others living further afield.	Employment opportunities associated with the tunnel that are accessible to residents in the locality are likely to be fewer than the Proposed Scheme, due to the reduction in compounds and increased use of specialist tunnelling contractors.	
Sound, noise and vibration				
	Individual residential receptors directly affected (number) *Individual properties subject to airborne noise, ground-borne noise or ground-borne vibration greater than the SOAEL levels defined in Volume 5, Appendix SV-001-00 of the main ES.*	Six (Snape Hall Farm in Whitmore Heath and The Old Barn, The Paddocks, Moor Hall Farm, Swallow Barn, and Bower End Farm in Madeley)	None predicted	
	Community receptors directly affected (number)	Two (Approximately 15 dwellings on Whitmore Heath and approximately 30 dwellings at Bar Hill)	None predicted	
	Non-residential receptors directly affected (number)	Three (Whitmore Village Hall; Office at Hey House (Edland Kennels/Cattery), Manor Road, Madeley; and Madeley Cemetery).	One predicted (Madeley Cemetery)	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with single tunnel amendment (predicted, based on appraisal)	RAG rating
	Residual significant effects	Significant effects on the acoustic character in Whitmore Heath and Bar Hill communities. Significant residual temporary noise effects from specific construction activities at Hey House offices (associated with Edland Kennels / Cattery) and Madeley Cemetery. Significant noise effects from construction traffic on adjacent residential and non-residential receptors on: • Bent Lane between the Proposed Scheme and Whitmore Road; • Snape Hall Road between the northern portal of Whitmore Heath tunnel and the A53 Whitmore Road; • Manor Road, between the junction with Bar Hill Road and A53 Baldwin's Gate; and • Bar Hill Road between the Proposed Scheme and Manor Road.	Significant noise effects from construction traffic on adjacent residential and non-residential receptors on Bent Lane between the Proposed Scheme and Whitmore Road.	
Traffic and transport				
	Highways temporary closures and diversions/realignments (number)	Four (A53 Newcastle Road, Snape Hall Road, Manor Road, and A525 Bar Hill Road)	None predicted	
	Significant traffic-related severance effects for NMUs (number)	Six (A51 London Road between Dog Lane and Checkley Lane, A53 Newcastle Road between the A51 London Road and the A5182 Trentham Road, A525 Bar Hill Road between the A51 London Road and the Proposed Scheme, A525 Bar Hill Road between the Proposed Scheme and Manor Road, Manor Road between the Proposed Scheme and the A525 Bar Hill Road and Snape Hall Road between Common Lane and the Proposed Scheme)	Four (A51 London Road between Dog Lane and Checkley Lane, A53 Newcastle Road between the A51 London Road and the A5182 Trentham Road, A525 Bar Hill Road between the A51 London Road and the Proposed Scheme, A525 Bar Hill Road between the Proposed Scheme and Manor Road)	
	PRoW temporary closures/ diversions/realignments (number)	Eleven (Whitmore Footpath 4, Whitmore Footpath 5, Whitmore Footpath 6, Madeley Footpath 14, Madeley Bridleway 1, Madeley Bridleway 2, Madeley Bridleway 5, Madeley Footpath 7, Madeley Footpath 24, Madeley Footpath 26, Madeley Footpath 28) In addition, NMU users of the A53 Newcastle Road will also be affected.	Five (Whitmore Footpath 6, Madeley Bridleway 1, Madeley Bridleway 5, Madeley Footpath 7, Madeley Footpath 24)	
	Residual significant effects	• Additional congestion and/or increased delays for road users at the A51 London Road/A53 Newcastle Road staggered crossroads junction; • increased traffic related severance for NMUs in six locations; and • increased travel distance and/or additional hindrances to travel during construction on NMUs of seven PRoW.	• Increased traffic related severance for NMUs in four locations; and • increased travel distance and/or additional hindrances to travel during construction on NMUs of five PRoW.	
Water resources and flood risk				
	Major rivers diverted	Meece Brook (6om)	Meece Brook (6om)	
	Length of route through flood zone (m)	256 A section of embankment associated with the River Lea viaduct (Lea North embankment) will extend into the floodplain.	210	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with single tunnel amendment (predicted, based on appraisal)	RAG rating
	Cutting or tunnel through SPZ 1 or 2	Cuttings, embankments, Meece Brook viaduct and the A53 Newcastle Road overbridge are in the vicinity of the licensed public groundwater supply abstraction near Whitmore.	Cuttings, embankments, and Meece Brook viaduct are in the vicinity of the licensed public groundwater supply abstraction near Whitmore.	
	Groundwater abstractions affected (number)	Four (public groundwater supply abstraction near Whitmore; private groundwater abstractions at Hey House Lodge, Hey House Farm, and Bower End Farm)	Four (public groundwater supply abstraction near Whitmore; private groundwater abstractions at Hey House Lodge, Hey House Farm, and Bower End Farm)	
	Residual significant effects	• Major adverse temporary effect associated with impacts on the licensed public groundwater abstraction near Whitmore; and • moderate adverse temporary effect on the River Lea due to impacts associated with dewatering of the borrow pit west of Netherset Hey Farm.	• Major adverse temporary effect associated with impacts on the licensed public groundwater abstraction near Whitmore; and • moderate adverse temporary effect on the River Lea due to impacts associated with dewatering of the borrow pit west of Netherset Hey Farm.	

Operation

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with Single tunnel amendment (predicted, based on appraisal)	RAG Rating
Agriculture, forestry and soils – n/a				
Air quality – n/a				
Community				
	Residual significant effects	Permanent in-combination effects on: • seven properties on Snape Hall Road in Whitmore Heath; • fourteen properties on A525 Bar Hill Road and Red Lane in Madeley; and • Madeley Cemetery.	Permanent in-combination effects on Madeley Cemetery.	
Cultural heritage				
	Residual significant effects	Hey House (Grade II listed) will be subject to a permanent change in its setting as a result of the noise of passing trains.	None predicted	
Ecology and biodiversity – n/a				
Health				
	Residual effects on neighbourhood quality	Residents of Hill Chorlton, Whitmore Heath, and Bar Hill are likely to experience noise, visual and permanent features of the Proposed Scheme as changing the quality of their neighbourhood, and to regard these changes as adverse, in reducing the sense of rural character and tranquillity. Noise and visual impacts from passing trains on the Meece Brook viaduct and loss of landscape features will affect neighbourhood quality in area north of Hill Chorlton. Closure of Snape Hall Road north of Whitmore Heath and widening of Snape Hall Road west of Whitmore Heath will change the layout and visual appearance of the area. Outside space from some properties will be permanently required for the widening of this road. Madeley cutting, Madeley tunnel portals and the A525 Bar Hill Road realignment will be in proximity to properties on Bar Hill. Noise from passing trains will be noticeable in private gardens on the A525 Bar Hill Road and Red Lane.	Impacts on neighbourhood quality north of Hill Chorlton are predicted to be similar to Proposed Scheme.	
Land quality – n/a				
Landscape and visual				
	Residual significant effects	Significant effects will reduce over time as the proposed mitigation planting matures and reaches its designed intention. However, the following likely residual significant effects will remain following year 15 of operation: • moderate adverse significant effects in relation to four LCA; • major adverse significant visual effects at two recreational viewpoint locations; • moderate adverse significant visual effects at 11 residential viewpoint locations; and • moderate adverse significant visual effects at three recreational viewpoint locations.	With the exception of the vent shafts and associated access roads, the rural landscape between the tunnel portals would remain intact. Visual receptors around Whitmore Heath and Madeley Park Wood would be unaffected. Landscape and visual impacts around the tunnel portals are predicted to be similar to the Proposed Scheme.	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with Single tunnel amendment (predicted, based on appraisal)	RAG Rating
Socio-economics – n/a				
Sound, noise and vibration				
	Individual residential receptors directly affected (number)	Noise: six (Snape Hall Farm, Woodbury, Foxdene, Hey House, 86 Bar Hill Road, Wrinehill Hall Farm) Ground-borne vibration: three (The Brackens on Heath Road, West Ridge on Birch Tree Lane and Wyndways on Heath Lane, Whitmore Heath).	Noise: one predicted (Wrinehill Hall Farm) Ground-borne vibration: none predicted	
	Community residential receptors directly affected (number)	Airborne noise increase from new train services: three (Hill Chorlton, Whitmore Heath and Bar Hill) Ground-borne noise increase from new train services: one (Whitmore Heath)	Airborne noise increase from new train services: one predicted (Hill Chorlton) Ground-borne noise increase from new train services: one predicted (Whitmore Heath) NOTE: This is extremely close to avoiding the community effect, but pending assessment we have erred on the side of caution and left the community effect in)	
	Non-residential receptors directly affected (number)	Two (Hey House Cattery, Madeley Cemetery)	None predicted	
	Residual significant effects	A likely residual significant adverse ground-borne noise effect is identified at three individual residential properties in Whitmore Heath. Residual likely significant adverse airborne noise effects around the following communities: • Hill Chorlton: occupants of residential properties in the vicinity of Kennels Lane; • Whitmore Heath: occupants of residential properties in the vicinity of Snape Hall Road and Birch Tree Lane; and • Bar Hill, Madeley: occupants of residential properties in the vicinity of the A525 Bar Hill Road, Mallard Close and Red Lane located closest to the Proposed Scheme. Residual significant adverse ground-borne noise due to HS2 trains passing through the Whitmore Heath tunnel at dwellings in the vicinity of Heath Road, Birch Tree Lane and Heath Rise that are located directly above the Whitmore Heath tunnel. A potential significant airborne noise effect at Hey House offices associated with Edland Kennels / Cattery and Madeley Cemetery.	Residual likely significant adverse airborne noise effects around Hill Chorlton: occupants of residential properties in the vicinity of Kennels Lane. Residual significant adverse ground-borne noise due to HS2 trains passing through the Whitmore Heath tunnel at dwellings in the vicinity of Heath Road, Birch Tree Lane and Heath Rise that are located directly above the Whitmore Heath tunnel.	
Traffic and transport				
	Highways permanent widening, realignment, diversion or extension (number)	Seven (Bent Lane, the A53 Newcastle Road, Common Lane; Snape Hall Road, Manor Road, the A525 Bar Hill Road, and Bower End Lane)	Four predicted (Bent Lane, Common Lane, Snape Hall Lane and Bower End Lane)	
	PRoW permanent widening, realignment, diversion or extension (number)	Eleven	Five	

Topic	Comparator (impacts or residual significant effects)	CA4 presented at Hybrid Bill (based on EIA of the Proposed Scheme)	CA4 with Single tunnel amendment (predicted, based on appraisal)	RAG Rating
		(Whitmore Footpath 4, Whitmore Footpath 6, Madeley Bridleway 1, Madeley Bridleway 2, Madeley Bridleway 5, Madeley Footpath 6, Madeley Footpath 7, Madeley Footpath 24, Madeley Footpath 26, Madeley Footpath 28, Madeley Footpath 14)	(Whitmore Footpath 6, Madeley Footpath 14, Madeley Footpath 24, Madeley Footpath 26, Madeley Bridleway 5)	
	Residual significant effects	• Minor beneficial severance effect due to reduced travel distance for NMUs of Madeley Bridleway 5; • moderate severance adverse effect due to increased travel distance on NMUs of Snape Hall Road; and • minor adverse severance effect as a result of diversion via an underbridge on NMUs of Madeley Bridleway 2.	• Minor beneficial severance effect due to reduced travel distance for NMUs of Madeley Bridleway 5.	
Water resources and flood risk – n/a				

10 Conclusion

10.1.1 Overall there are environmental and engineering benefits of the Single Tunnel option compared to the Proposed Scheme. Some elements of engineering challenges would remain and some engineering aspects are major worsening compared to the Proposed Scheme. A Single Tunnel introduces operational robustness disbenefits compared to the proposed scheme. In addition, some of the environmental impacts will remain. There is a significant estimated cost increase between the Proposed Scheme and the Single Tunnel as detailed in Appendix H. This may increase further with detailed design due to engineering risks still to be to be addressed in detail. A full evaluation of influence on construction programme is still to be undertaken but it may result in some programme reduction that would benefit the project further, including potential reduction in indirect cost. It is considered that one of the major impacts of the Proposed Scheme is loss of ancient woodland and the Single Tunnel option does provide a considerable level of improvement to this impact.

11 References

Title	Reference
High Speed Rail (West Midlands – Crewe) Environmental Statement, Volume2: Community Area report CA4: Whitmore Heath to Madeley (July 2017)	ES3 .2.1.4
High Speed Rail (West Midlands – Crewe) Environmental Statement Volume 2: Map book CA4: Whitmore Heath to Madeley July 2017	ES 3.2.2.4
Temple-RSK, (2015), Sustainability Report – Phase Two Post-Consultation Update: West Midlands to Crewe	C331-TRK-EV-REP-210-000001
HS2 Ltd., (2016), West Midlands- Crewe Working Draft Environmental Impact Assessment Report	
High Speed Two Phase 2a Information Paper E10: Control of Ground Borne Noise and Vibration from the Operation of Temporary and Permanent Railways (July 2017)	
High Speed Two Phase 2a Information Paper F2: PHASE 2a Tunnels (July 2017)	

Appendices

Appendix A – Overview Plans

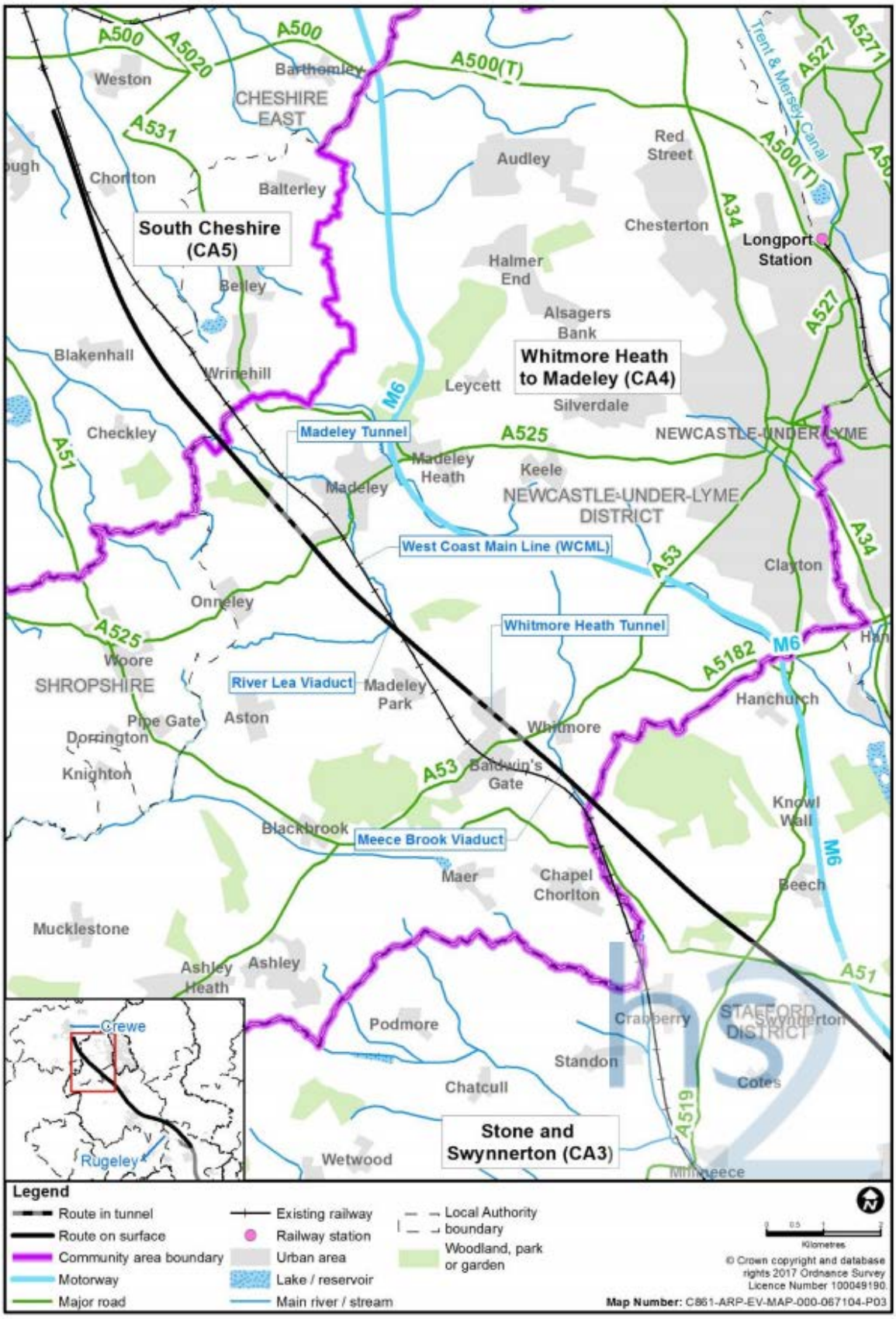
A.1 CA4 Area Context Map

A.2 Plan and longitudinal section of Proposed Scheme

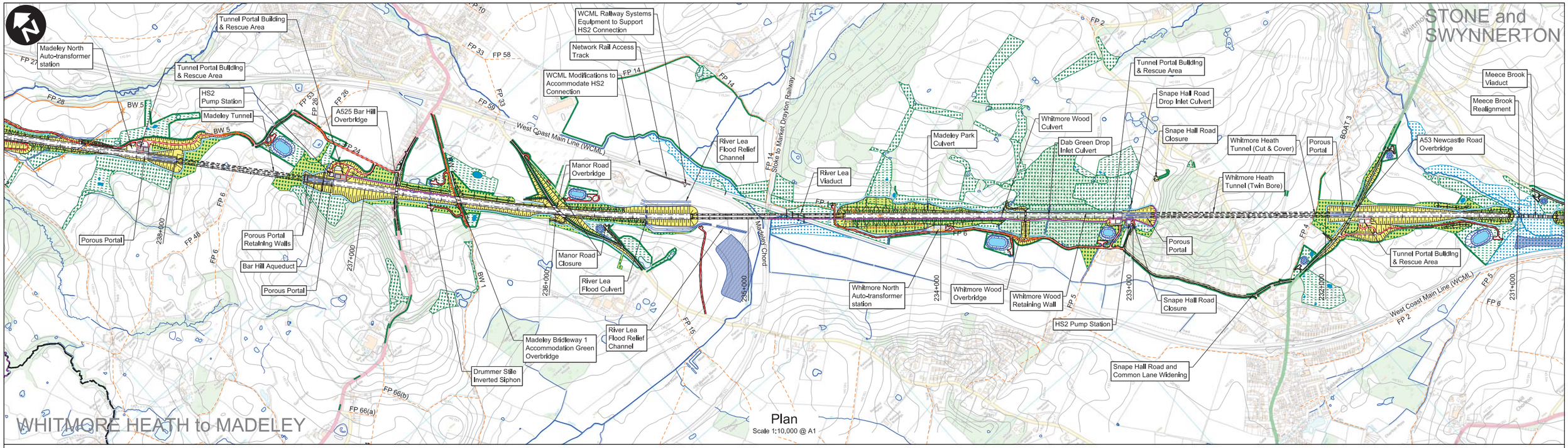
A.3 Plan and longitudinal section of the Single Tunnel Option

A.1 CA4 Area Context Map

Figure 3: Area context map



Appendix A.2 Plan and Long Section of Proposed Scheme



Profile
Scale H:1:10,000 V:1:1000 @ A1

Work-in-progress

METRES @ 1:10000 0 100 200 500 1000

METRES @ 1:1000 0 10 20 50 100

Rev	Description	Drawn	Checked	Con App	HS2 App
P01		DW 22/02/2018	TE 22/02/2018	TE 22/02/2018	

Legends/Notes:

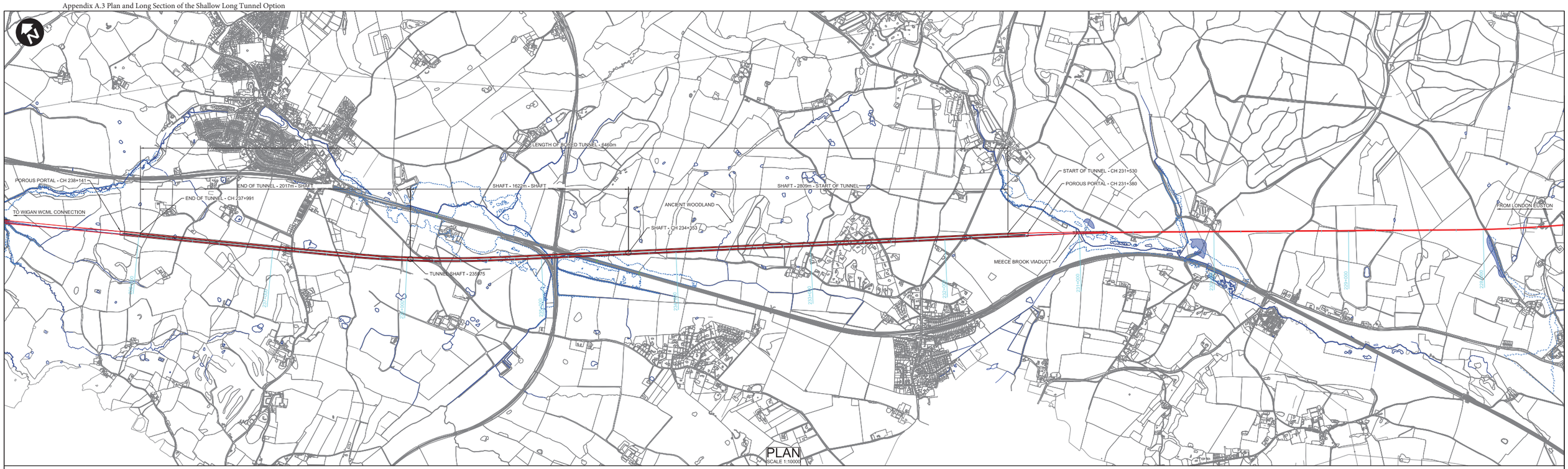
- Depot, station, headhouse or portal building
- Tunnel portal
- Electricity substation
- Land drainage area
- Ecological mitigation pond
- Balancing pond
- Replacement floodplain storage
- Woodland habitat creation
- Wetland habitat creation
- Grassland habitat creation
- Landscape mitigation planting (scrub / woodland)
- Grassed areas
- Sustainable placement
- Public realm/Replacement community facility
- Hedgerow habitat creation
- UT — Main utility works
- Engineering earthworks
- Landscape earthworks
- Rail alignment formation
- Returned to suitable development use
- County boundary
- Borough / District boundary
- Community Area boundary
- Watercourse diversion
- or — Existing watercourse
- Ditches - new
- Existing Woodland
- Existing Buildings
- Existing Inland Water
- 130.0m Existing Contours
- HS2 Access road
- Noise fence barrier
- HS2 Mainline Rail alignment
- 10+000 Chainage (e.g. 10+000)
- Existing public right of way (PRoW)
- New, diverted or realigned PRoW
- Stopped-up PRoW
- Tunnels external extent

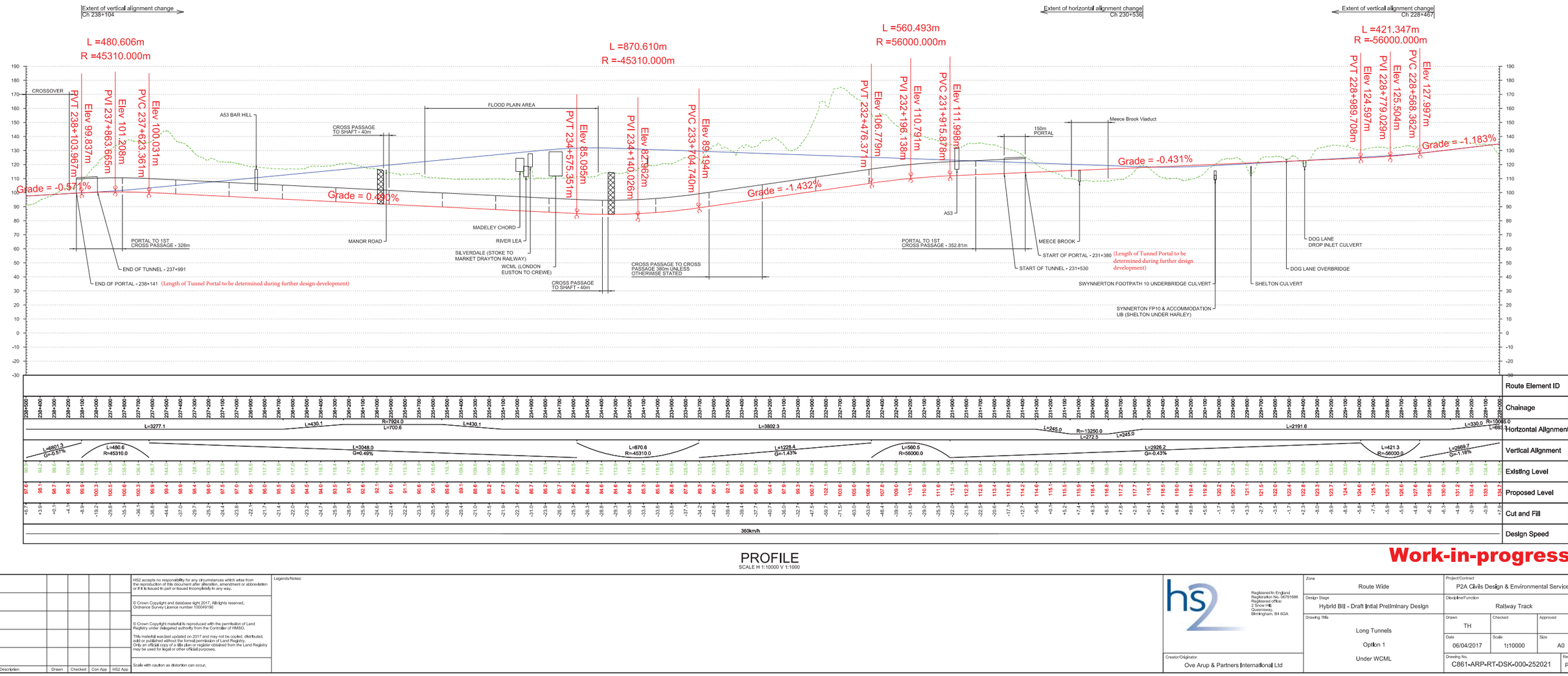
Registered In England Registration No. 06791686
Registered office: 2 Snow Hill, Queensway, Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Hybrid Bill - Interim Preliminary Design
Drawing Title	Long Tunnel Study Whitmore Madeley Proposed Scheme Chainage 231+000 to 238+500
Project/Contract	P2A Civils Design & Environmental Services
Discipline/Function	Civil
Drawn / Checked / Approved	DW / TE / TE
Date / Scale / Size	21/02/2018 / AS SHOWN / A1
Drawing No. / Rev.	C861-ARP-CV-DSK-000-200011 / P01

Appendix A.3 Plan and Long Section of the Shallow Long Tunnel Option





PROFILE
SCALE H 1:10000 V 1:1000

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App

Legends/Notes:

Registered in England Registration No. 09791686 Registered office: 2 Snow Hill, Queensway, Birmingham, B4 6GA

Creator/Originator: Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Hybrid Bill - Draft Initial Preliminary Design
Drawing Title	Long Tunnels Option 1 Under WCML
Project/Contract	P2A Civils Design & Environmental Services
Discipline/Function	Railway Track
Drawn	TH
Checked	
Approved	
Date	06/04/2017
Scale	1:10000
Size	A0
Drawing No.	C861-ARP-RT-DSK-000-252021
Rev.	P00.2

Appendix B - Comparative Analysis Supporting Proposed Scheme (2016)

B.1 Comparative analysis Matrix supporting the proposed scheme*

* Note on Comparative Analysis Supporting Proposed Scheme (2016): The comparative analysis summaries in Appendix B are based on an early concept design at the time of the analysis in 2016. They are not representative and sometimes vary from the current Proposed Scheme and the Single Tunnel design comparison (i.e. the comparison analysis presented in Appendix D), which benefits from further design development since this early appraisal.

Appendix B.1 Sift Supporting Proposed Scheme (May 2016)		Study Areas 9/10/11 - Whitmore Tunnel, WCML Crossing & Madeley Tunnel							
Option name and description:		Sift D - Route realignment options							
Request number(s)									
OPTIONS CONSIDERED:		D9-11.0a		D9-11.0b		D9-11.1		D9-11.3	
OPTION DESCRIPTION		Baseline (CP1 design)		Refined baseline - Sift A/B/C output		Realignment to west to avoid Whitmore Wood		Long bored tunnel	
Headings	Appraisal criteria	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
Strategic Fit	Capture whether an option meets the Project Specification	Highway realignments comply with the applicable standards. Vertical curve in the alignment requires a departure for any rail expansion joints (if required) on the viaduct.	O	Highway realignments comply with the applicable standards. Realignment over WCML crossing allows for some possible rail expansion joints at northern end of viaduct.	+	Highway realignments comply with the applicable standards. Den Lane realignment would create a low point below the underbridge which would be a flooding risk. It may be possible to improve this realignment to mitigate this flooding risk. Crossing underneath the WCML eliminates issues associated with the vertical curve over the viaduct.	O	Highway realignments comply with the applicable standards. Crossing underneath the WCML eliminates issues associated with the vertical curve over the viaduct.	+
Construction Feasibility	Assess the relative complexity of construction	Construction scope incorporates: - 690m long twin bore tunnel c/w 238m long cut and cover tunnel and 150m long porous portals at each end. - 670m long twin bore tunnel c/w 150m long porous portals at each end. - Highway scope, including: - A53 - crosses portal structure - Snape Hall Road stopped up - Manor Road - A525 - WCML interface works at River Lea. - Whitmore Wood retaining wall 495m long. - Siphon at Whitmore Wood. - Aqueduct at Madeley.	O	Construction scope incorporates: - 1.379km long twin bore tunnel c/w 150m long porous portals at each end. - 1.239km long twin bore tunnel c/w 150m long porous portals at each end. - Omits highway scope: - A53 - A525 - WCML interface works at River Lea as per baseline. - Whitmore Wood retaining wall extended to 560m long. - Siphon at Whitmore Wood becomes an aqueduct. - Aqueduct at Madeley omitted. Overall assessed as a minor improvement against the comparator scheme in construction complexity due to the omission of two major highway realignment schemes (A53 and A525). This is offset slightly by the increased length of the Whitmore Wood retaining wall. The height of retaining wall (up to 25m) poses some design and construction problems.	+	Construction scope incorporates: - 1.911km long twin bore tunnel c/w 150m long porous portals at each end. - 1.298km long twin bore tunnel c/w 150m long porous portals at each end. - Omits highway scope: - A53 - Snape Hall Road - A525 - WCML interface omitted by crossing under in tunnel. - Silverdale branch crossing at River Lea viaduct but simplified as no 'live' NR interface. - Whitmore Wood retaining wall omitted. - Siphon at Whitmore Wood omitted. - Aqueduct at Madeley omitted. Overall assessed as a moderate improvement against the comparator scheme in construction complexity due to the omission of two major highway realignment schemes (A53 and A525) and one minor (Snape Hall Road). The omission of any interface with the WCML is also a significant benefit, however there is still a viaduct to be constructed over the River Lea and Silverdale branch. The Whitmore Wood retaining wall is also omitted.	+ +	Construction scope incorporates: - 6.373km long twin bore tunnel c/w 150m long porous portals at each end. - Omits highway scope: - A53 - Snape Hall Road - Manor Road - A525 - WCML interface omitted by crossing under in tunnel. - Whitmore Wood retaining wall omitted. - Introduces 2no. 30m diameter shafts and associated head houses. - Siphon at Whitmore Wood omitted. - Aqueduct at Madeley omitted. Overall assessed as a major improvement against the comparator scheme in construction complexity due to the following: - Reducing the tunnel boring mobilisation operations from two independent twin bore tunnels to a single twin bore tunnel. - Omission of three major highway realignment schemes (A53, Manor Road and A525) and one minor (Snape Hall Road). - Omission of any interface with the WCML. - Omission of the Whitmore Wood retaining wall. - There is an offset to be noted that the two 30m diameter shafts to be constructed as new additions.	+ + +
	Assess the relative construction programme			Additional tunnel length will increase the tunnelling programme but will be offset by the reduced surface earthworks scope. Also programme benefit by the reduction of highway realignment works.		Additional tunnel length will increase the tunnelling programme but will be offset by the reduced surface earthworks scope. Also programme benefit by the reduction of highway realignment works.		Additional tunnelling length will increase the tunnelling programme but this will be offset by the reducing of TBM mobilisation requirements and reduced surface earthworks scope. Also programme benefit by the reduction of highway realignment works.	
	Assess the relative disruption to existing infrastructure, e.g. rail, highways etc.	There is insufficient clearance for the Silverdale Line to remain viable. Temporary diversion of the A53 and permanent diversion of the A525 required.	O	The increased HS2 level at the River Lea viaduct provides adequate clearance for the Silverdale Branch to remain viable. Diversions of the A53 and A525 are avoided.	+	Removes all interface with the operational WCML, interface with the Silverdale Branch is maintained but this may be treated as non-operational. There is insufficient clearance for the Silverdale Line to remain viable however it may still be possible for Madeley Chord to give access from the WCML to the Silverdale line to the east of the junction. Diversions of the A53 and A525 are avoided.	+ +	Removes all interface with the operational WCML. The Silverdale Branch line and Madeley Chord are also unaffected. Diversions of the A53 and A525 are avoided.	+ + +

Appendix B.1 Sift Supporting Proposed Scheme (May 2016)		Study Areas 9/10/11 - Whitmore Tunnel, WCML Crossing & Madeley Tunnel							
Option name and description:		Sift D - Route realignment options							
Request number(s)									
OPTIONS CONSIDERED:		D9-11.0a		D9-11.0b		D9-11.1		D9-11.3	
OPTION DESCRIPTION		Baseline (CP1 design)		Refined baseline - Sift A/B/C output		Realignment to west to avoid Whitmore Wood		Long bored tunnel	
Headings	Appraisal criteria	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
HS2 Operation Feasibility – Trains (HS2 and Network Rail)	Assess the relative flexibility and reliability of the track layout Assess the relative train maintenance and servicing arrangements	Tunnel sections designed for 360km/h running. Direct fixing of NR OHLE to HS2 bridge likely. This may make maintenance difficult and may bring very onerous movement limits for the structure.	O	Minor worsening during operation due to increased tunnel length therefore shorter length of track that could be later upgraded to 400km/h running. (No impact on scheme for opening at 360km/h running.) Minor improvement at WCML crossing through reduced likelihood of direct fixing of OHLE to HS2 structure Undulating alignment with higher gradients and longer tunnels increases traction power loading. Risk of non-compliant system/train voltages for South Crewe ATFS. Could be mitigated by relocating the ATFS southwards, but this could lead to a requirement for Hoo Green ATFS (Phase 2b) to be equipped with additional incoming/transformer circuit from National Grid 400kV.	-	Minor worsening during operation due to increased tunnel length therefore shorter length of track that could be later upgraded to 400km/h running. (No impact on scheme for opening at 360km/h running.) Minor improvement from removal of interface with NR OHLE Tunnel vertical profile follows a "U" shape, where a low point constrains the cross passage location. Significantly undulating alignment with higher gradients and longer tunnels leads to substantial increase in traction power loading. High probability of non-compliant system/train voltages for South Crewe ATFS, and traction power loading may exceed capacity of Crewe 132kV grid. Could be mitigated by relocating the ATFS southwards, but this could lead to a requirement for Hoo Green ATFS (Phase 2b) to be equipped with additional incoming/transformer circuit from National Grid 400kV.	- -	Worsening during operation due to increased tunnel length therefore shorter length of track that could be later upgraded to 400km/h running. (No impact on scheme for opening at 360km/h running.) Tunnel vertical profile follows a "U" shape, where a low point constrains the cross passage location. Thermodynamic performance for long tunnel will need to be reviewed to ensure maximum allowable temperature not exceeded. Significantly deeper alignment with higher gradients and longer tunnel leads to substantial increase in traction power loading. High probability of non-compliant system/train voltages for South Crewe ATFS, and traction power loading may exceed capacity of Crewe 132kV grid. Could be mitigated by relocating the ATFS southwards, but this could lead to a requirement for Hoo Green ATFS (Phase 2b) to be equipped with additional incoming/transformer circuit from National Grid 400kV.	- -
HS2 Operation Feasibility – Operations (Stations, Depots etc.)	Assess the effectiveness of Location and space for station control Location and space for accommodating staff, catering, transport police and other "back of house" activities Location and space for passenger facilities such as ticket office, travel information, toilets, left luggage etc. Location of ticket barriers	n/a		n/a		n/a		n/a	

Appendix B.1 Sift Supporting Proposed Scheme (May 2016)		Study Areas 9/10/11 - Whitmore Tunnel, WCML Crossing & Madeley Tunnel							
Option name and description:		**Sift D - Route realignment options**							
Request number(s)									
OPTIONS CONSIDERED:		**D9-11.0a**		**D9-11.0b**		**D9-11.1**		**D9-11.3**	
OPTION DESCRIPTION		**Baseline (CP1 design)**		**Refined baseline - Sift A/B/C output**		**Realignment to west to avoid Whitmore Wood**		**Long bored tunnel**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**
HS2 Operation Feasibility - Passengers	Assess Passenger Dispersal covering road (right of way), rail and public transport Assess the relative Passenger Connectivity at stations between high speed rail, classic rail, bus, coach, car, taxi, bicycle and pedestrians Assess the relative passenger flow characteristics during emergency evacuation and normal operation at stations Assess the relative 'Way Finding' of station layouts i.e. logical flow Assess the relative security or perception of security of station layouts	n/a		n/a		n/a		n/a	
Demand	Likely Relative Passenger Numbers Likely Journey Times Likely Demand	n/a		n/a		n/a		n/a	
Costs	Estimated whole life cycle costs to give relative assessment *(Appraisal considers operational costs as capital costs are considered separately below.)*	Whole-life costs will include operation and maintenance costs for tunnels. Deep siphon adjacent to Snape Hall Road will be a challenging asset to maintain.	O	Minor increase in maintenance costs associated with tunnels due to slight increases in length. Minor improvement in maintenance costs associated with watercourse crossings due to removal of siphon at Snape Hall Road.	O	Increase in maintenance costs associated with tunnels due to increases in length, offset to some extent by removal of WCML crossing requiring maintenance of structure over existing Network Rail line. Minor improvement in maintenance costs associated with watercourse crossings due to removal of siphon at Snape Hall Road.	O	Increase in maintenance costs associated with tunnel due to increase in length, offset to some extent by removal of WCML crossing requiring maintenance of structure over existing Network Rail line. Minor improvement in maintenance costs associated with watercourse crossings due to removal of siphon at Snape Hall Road.	-
	Estimated initial capital costs to give relative assessment (The capital costs include construction, land and compensation costs)	Total capital cost of £409m for the corridor from ch229+600 to ch244+300. Costings do not include land and property costs, WCML re-wiring costs, possession costs, costs of temporary works including temporary highway diversions, mitigation costs and costs associated with the closure of the Silverdale Branch. Culverts and siphons are costed based on a general allowance only.	O	Minor increase in capital cost for the corridor from ch229+600 to ch244+300.	-	Moderate increase in capital cost for the corridor from ch229+600 to ch244+300.	- -	Major increase in capital cost for the corridor from ch229+600 to ch244+300.	- - -
Environment	Input from ENVIRONMENTAL APPRAISAL MATRIX (refer to C861-ARP-EV-ASM-000-0000011)	For baseline impacts refer to environmental appraisal matrix (C861-ARP-EV-ASM-000-000011)	O	At Whitmore there will be reduced landscape effects. Reinstatement of Snape Hall lane and the A53 will remain in its current location; there will however be increased landtake in Whitmore wood due to the lowering of the vertical alignment. There are various benefits for moving the tunnel portal away from receptors such as dwellings alongside Bar Hill and the Ancient woodland. There would be reduced highways works, less agricultural land affected and there would be hydrological benefits, removing the need for an aqueduct at Bar Hill Wood.	+ + +	This option is required is more preferable but the least preferred of the three sifted options. The main benefits of this alignment are that it avoids Whitmore Ancient woodland and demolitions at Whitmore Heath. There are reduced impacts on houses at Whitmore Heath and Bar hill road from noise or vibration. The A53 will no longer be diverted and Snape Hall road will no longer be stopped up. Negative impacts compared with the baseline scheme include a slight increase in cultural heritage receptors potentially impacted and impact / land take in terms of agricultural holdings.	+ +	Broadly the preferred. This option greatly reduces impacts along the route due to reduced landtake and is the most preferable option. There is reduced impact on agricultural holdings. Reduced severance and greater retention of amenities. This option greatly attenuates operational noise and vibration impacts. This option removes impact on biodiversity receptors such as Whitmore Wood and reduces effects on landscape and visual receptors (including the setting of cultural heritage assets) between the tunnel portals. Minor negative impacts include increased energy use in the operational and construction phases and increased groundwater impacts associated with tunnelling.	+ + +

Appendix B.1 Sift Supporting Proposed Scheme (May 2016)		Study Areas 9/10/11 - Whitmore Tunnel, WCML Crossing & Madeley Tunnel							
Option name and description:		**Sift D - Route realignment options**							
Request number(s)									
OPTIONS CONSIDERED:		**D9-11.0a**		**D9-11.0b**		**D9-11.1**		**D9-11.3**	
OPTION DESCRIPTION		**Baseline (CP1 design)**		**Refined baseline - Sift A/B/C output**		**Realignment to west to avoid Whitmore Wood**		**Long bored tunnel**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**
Safety	Assess the relative safety during construction,	Baseline scheme includes hazards associated with tunnelling operations, highway diversion works, retaining wall and bridge construction and deep siphon construction.	O	Overall assessed as a minor improvement against the comparator scheme due to the omission of two major highway realignment schemes (A53 and A525). This is offset slightly by the increased length of the Whitmore Wood retaining wall.	+	Overall assessed as a moderate improvement against the comparator scheme due to the omission of two major highway realignment schemes (A53 and A525) and one minor (Snape Hall Road). The omission of any interface with the WCML is also a significant benefit, there is still a viaduct to be constructed over the River Lea and Silverdale branch. The Whitmore Wood retaining wall is also omitted.	+ +	Overall assessed as a major improvement against the comparator scheme due to the following: - Reducing the tunnel boring mobilisation operations from two independent twin bore tunnels to a single twin bore tunnel. - Omission of three major highway realignment schemes (A53, Manor Road and A525) and one minor (Snape Hall Road). - Omission of any interface with the WCML. - Omission if the Whitmore Wood retaining wall. - There is an offset to be noted that the two 30m diameter shafts to be constructed as new additions.	+ + +
	Assess the relative safety during Operations, maintenance and decommissioning , and Emergency access	Activities will include inspection and maintenance of tunnels, bridges and deep siphon.	O	Minor worsening of operational safety due to the increased length of tunnel to be inspected and maintained, offset by removal of the siphon which significantly reduces maintenance requirements in this location.	O	Minor worsening of operational safety due to the increased length of tunnel to be inspected and maintained, offset by removal of the siphon and the WCML crossing (maintenance of structure over existing Network Rail line).	O	Moderate worsening of operational safety due to the increased length of tunnel to be inspected and maintained and introduction of 2no. shafts. Offset to some extent by removal of the siphon and the WCML crossing (maintenance of structure over existing Network Rail line).	- -
Commitments	Previous explicit or implicit public assurances or commitments to third parties	None known	O	No change compared with baseline	O	No change compared with baseline	O	No change compared with baseline	O
Commercial Development	Does the option provide opportunities for development in particular for over station development	n/a		n/a		n/a		n/a	
		Overall Rating	**O**	**Overall Rating**	**+ +**	**Overall Rating**	**O**	**Overall Rating**	**+**
Preferred Option:		**Preferred Option**							
Reason:		The preferred option from this sift is a combination of options D9-11.0a and D9-11.0b, taking the alignment from D9-11.0a but applying the alignment lift at the WCML from D9-11.0b (as taken from option A10.1). Taking this alignment lift with option D9-11.0a addresses the risk associated with crossing the existing Network Rail infrastructure. The other changes within D9-11.0b offer significant environmental benefits, but the cost delta associated with the option needs to be better understood before a decision on whether to adopt these changes can be made. Similarly option D9-11.3 was found to have significant environmental benefits and to offer major improvements in construction complexity and safety, but at high additional cost. It is believed that the cost delta could reduce when all aspects of the work, including land costs, possession costs, mitigation costs, etc. are taken into account. Further study on tunnelling costs will be undertaken for options D9-11.0b and D9-11.3 to inform a future decision on whether to adopt one of these alternatives. Option D9-11.1 will not be taken further as it was found not to offer sufficient benefit in relation to the negative impacts of the change.					

- - -	Major worsening on the Comparator Scheme
- -	Moderate worsening on the Comparator Scheme
-	Minor worsening on Comparator Scheme
O	Neutral / no change to Comparator Scheme
+	Minor improvement on Comparator Scheme
+ +	Moderate improvement on Comparator Scheme
+ + +	Major improvement on Comparator Scheme
N/A	Not applicable

Appendix C – Proposed Scheme Engineering Features

C.1 Proposed Scheme Engineering Features

Table C.1 The Proposed Scheme Route Primary Characteristics

Element	Chainage		Length (m)	Type
	from	to		
Stableford North Embankment	230+250	230+800	550	Railway Embankment
Cutting to Bent Lane North Diversion	230+300	230+650	350	Highway Cutting
Meece Brook Viaduct	230+800	231+040	240	Railway Viaduct
Meece Brook Realignment and Flood Plain Storage	230+800	231+000	200	Flood Plain Works
Meece Embankment	231+040	231+300	260	Railway Embankment
Whitmore South Cutting	231+300	231+830	530	Railway Cutting
Whitmore Heath Tunnel Southern Porous Portal, MAP, Portal Building, EAA and Access Track	231+400	231+970	570	Tunnel Portal and Facilities
Whitmore Heath Tunnel (Cut & Cover plus Bored Tunnel)	231+830	233+060	230	Railway Tunnel
A53 Newcastle Road	231+870	-		Highway Diversion and Overbridge
Snape Hall Road	233+000	-		Highway Stopped Up
Snape Hall Road Drop Inlet Culvert	233+030	-		Drainage Feature
Whitmore Wood Retained Cutting	233+060	233+660	600	Retained Cutting
Dab Green Drop Inlet Culvert	233+440	-		Drainage Feature
Whitmore Wood Overbridge	233+560	-		Accommodation Bridge
Lea South Embankment	233+660	234+500	840	Railway Embankment
Whitmore Wood Culvert	233+680	-		Drainage Feature
Whitmore Heath Tunnel Northern Porous Portal, Portal Building, Pumping Station, Balancing Pond and Access Track to Snape Hall Road	233+900	234+150	250	Tunnel Portal and Facilities
Whitmore North ATS and south of HS2 and east of WCML	234+000	-		Traction Power Systems
Madeley Park Culvert	234+070	-		Drainage Feature
River Lea Viaduct	234+505	234+290	785	Railway Viaduct
River Lea Flood Relief Culvert and Channels	235+000	235+520	520	Flood Plain Works
Lea North Embankment	235+290	236+150	860	Railway Embankment

Element	Chainage		Length (m)	Type
	from	to		
Manor Road Realignment	235+550	236+300	750	Highway Diversion and Overbridge
Madeley Cutting	236+150	237+170	1020	Railway Cutting
Madeley Bridleway 1 Accommodation. Green Overbridge	236+510	-		Accommodation Overbridge
Drummer Stile Inverted Siphon	236+660	-		Drainage Feature
A525 Bar Hill Road Realignment	236+840	-		Highway Diversion and Overbridge
Madeley Tunnel Southern Porous Portal, Retaining Walls, Pumping Station, Portal Building and Access Track to A525	237+000	237+300	300	Tunnel Portal and Facilities
Madeley Tunnel	237+170	238+140	970	Railway Tunnel
Bar Hill Aqueduct	237+220	-		Drainage Feature
Madeley Tunnel Northern Porous Portal, Portal Building, GSM Mast, ATS and Access Track to Bower End Lane	237+990	238+250	260	Tunnel Portal and Facilities
Checkley South Embankment	238+140	239+320	1180	Railway Embankment

Appendix D – Concept Design Plans of Single Tunnel Option

D.1 Plans of Single Tunnel 'concept design' layout

D.2. Plans of potential CT05 changes from Proposed Scheme CT05 Plans

Concept Subject To Further Development

STONE and SWYNNERTON

Extent of allgnment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

A53 Newcastle Road

BOAT 3

Bent Lane

Meece Brook

Landscape Bunds

End of tunnel

150m Porous Portal (TBC)

Min 22m track c/c spacing at first cross passage

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-020030

Access off A53

New location of Tunnel Portal

550 square metre rescue area in compound

Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design

Platform for portal building, EAP & PSTN

230-L3 Meece Brook Viaduct widened

230-L3 Meece Brook Viaduct geometry lowered to suit long tunnel alignment

Meece Brook Realigned

Bent Lane (South) Closure

Bent Lane (South) Realignment

Bent Lane (North) Diversion

Track Bed Sealing Ch 230+100 to 231+280

SP Energy Networks 132kV Overhead Line

Severn Trent Water Whitmore Borehole Facility

West Coast Main Line (WCML)

Croxton Mill Lane

For Continuation Refer to Drawing C861-ARP-CV-DPL-000-020028

FP 2

FP 5

FP 6

FP 55

MAP

EAP

MPATS

232+000

231+000

230+000

WHITMORE HEATH to MADELEY

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. For legend refer to drawing no HS2-HS2-IM-DSC-000-000001

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone

Design Stage
Preliminary Concept

Drawing Title
Whitmore Heath to Madeley Single Tunnel
Preliminary Concept General Arrangement Plan
Sheet 29

Project/Contract
P2A Civils Design & Environmental Services

Discipline/Function
Civil

Drawn	Checked	Approved
MN	TE	TE

Date	Scale	Size
13/07/2017	AS SHOWN	A1

Drawing No. C861-ARP-CV-DSK-000-020029

Rev. P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

Snape Hall Road remains open to traffic in permanent situation.

A53 Newcastle Road remains as existing

Ventilation & evacuation shaft access road

Snape Hall Road and Common Lane improved as per proposed scheme design, to provide access to shaft

Access off A53

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-011031

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-011029

233+000

232+000

FP 4

FP 5

FP 18

FP 2

BOAT 3

Snape Hall Road

A53 Newcastle Road

Common Lane

Health Road

Coney Grey Lane

Appleton Drive

West Coast Main Line (WCML)

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. For legend refer to drawing no HS2-HS2-IM-DSC-000-000001

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Preliminary Concept
Drawing Title	Whitmore Heath to Madeley Single Tunnel Preliminary Concept General Arrangement Plan Sheet 30
Project/Contract	P2A Civils Design & Environmental Services
Discipline/Function	Civil
Drawn	MN
Checked	TE
Approved	TE
Date	13/07/2017
Scale	AS SHOWN
Size	A1
Drawing No.	C861-ARP-CV-DSK-000-020030
Rev.	P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design

Maintenance Access Point

Intervention Shaft Headhouse Ch. 234+510

FP6 Diversion

Pumping Station

MAP

ATS

PSTN

Relocated Whitmore North ATS

~50m clear distance to WCML boundary

Ventilation and intervention shaft compound to include 550 square metre rescue area

Ground Treatment to reduce settlement risk WCML (TBC)

Access road design to be finalised in detail deign to ensure the ancient woodland is not affected by the proposed works. Access road alignment will be adjusted as required. The CCB boundary on the southern side of the access track accommodates for these minor changes required.

Stoke to Market Drayton Railway

West Coast Main Line (WCML)

River Lea

FP 14

FP 6

FP 18

235+000

234+000

233+009

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-020032

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-020030

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Legends/Notes:

1. For legend refer to drawing no HS2-HS2-IM-DSC-000-000001
2. For Network Rail on-network works to WCML refer to drawings C862-PBR-RT-DPL-WS09-100000 to 100009.

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Preliminary Concept
Drawing Title	Whitmore Heath to Madeley Single Tunnel Preliminary Concept General Arrangement Plan Sheet 31

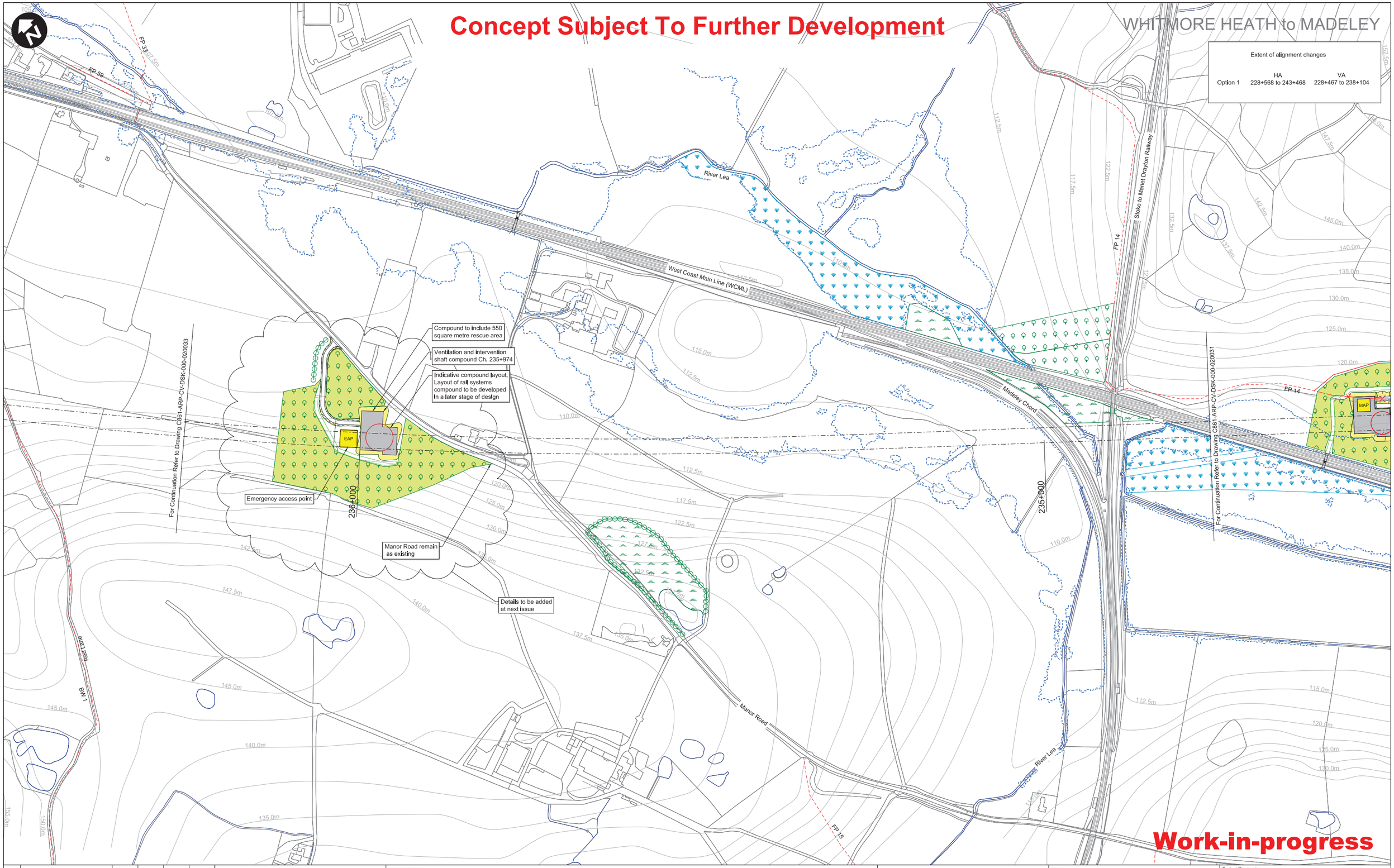
Project/Contract	P2A Civils Design & Environmental Services	
Discipline/Function	Civil	
Drawn	Checked	Approved
MN	TE	TE
Date	Scale	Size
13/07/2017	AS SHOWN	A1
Drawing No.		Rev.
C861-ARP-CV-DSK-000-020031		P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104



Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. For legend refer to drawing no HS2-HS2-IM-DSC-000-000001

METRES @ 1:2500 — 0 20 50 100 250

hs2

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone: Route Wide

Design Stage: Preliminary Concept

Drawing Title: Whitmore Heath to Madeley Single Tunnel Preliminary Concept General Arrangement Plan Sheet 32

Project/Contract: P2A Civils Design & Environmental Services

Discipline/Function: Civil

Drawn	Checked	Approved
MN	TE	TE

Date	Scale	Size
13/07/2017	AS SHOWN	A1

Drawing No.: C861-ARP-CV-DSK-000-020032

Rev.: P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

West Coast Main Line (WCML)

WCML Modifications to Accommodate HS2 Connection (See Note 2)

Madeley Footpath 26 Realignment

Madeley Footpath 24 Diversion

Madeley Bridleway 5 Realignment

Madeley Bridleway 1 remain as existing

A525 Bar Hill Road, remain as existing

Manor Road

Bower End Lane

Red Lane

A525 Bar Hill Road

FP 53

FP 26

FP 24

FP 59

FP 33

FP 6

FP 48

BW1

BW 1

238+000

237+000

236+000

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-020034

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-020032

For Continuation Refer to Drawing C861-ARP-CV-DPL-000-020133

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Legends/Notes:

1. For legend refer to drawing no HS2-HS2-IM-DSC-000-000001
2. For Network Rail on-network works to WCML refer to drawings C862-PBR-RT-DPL-WS09-100000 to 100009.

METRES @ 1:2500 0 20 50 100 250

hs2

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Preliminary Concept
Drawing Title	Whitmore Heath to Madeley Single Tunnel Preliminary Concept General Arrangement Plan Sheet 33
Project/Contract	P2A Civils Design & Environmental Services
Discipline/Function	Civil
Drawn	MN
Checked	TE
Approved	TE
Date	13/07/2017
Scale	AS SHOWN
Size	A1
Drawing No.	C861-ARP-CV-DSK-000-020033
Rev.	P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

West Coast Main Line (WCML)

WCML Modifications to Accommodate HS2 Connection (See Note 2)

River Lea

Madeley Bridleway 5 Realignment

GSM-R Telecommunications Mast

Length of Madeley Footpath 28 to be upgraded to bridleway

Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design

239-S1 Madeley Bridleway 2 Accommodation Underbridge

238-S2 Wrinehill Wood Culvert

239-S3 Madeley North Auto-transformer Station

130 Km/h Crossover

Trackside Laydown Area

Trackside Laydown Area

Rescue Area

Portal Building

550 square metre rescue area

130 Km/h Crossover

150m Porous Portal (TBC)

Min. 22m track c/c spacing at first cross passage

For Continuation Refer to Drawing C861-ARP-CV-DPL-000-020035

For Continuation Refer to Drawing C861-ARP-CV-DSK-000-020033

Watercourse Diversion

Madeley Bridleway 5 Closure

Watercourse Crossing In Shared Underbridge

Footprint widened by up to 4 metres to accommodate wider track c/c spacing through tunnel. Engineering details similar to Hybrid Bill Scheme

End of tunnel

Checkley Brook

Bower End Lane

FP 7

FP 27

FP 28

FP 48

FP 6

BW 2

BW 5

MAP

ATS

2390+000

2380+000

SOUTH CHESHIRE

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. For legend refer to drawing no HS2-HS2-IM-DSC-000-000001

METRES @ 1:2500 — 0 20 50 100 250

hs2

Registered in England Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone: Route Wide

Design Stage: Preliminary Concept

Drawing Title: Whitmore Heath to Madeley Single Tunnel

Preliminary Concept General Arrangement Plan

Sheet 34

Project/Contract: P2A Civils Design & Environmental Services

Discipline/Function: Civil

Drawn	Checked	Approved
MN	TE	TE

Date	Scale	Size
13/07/2017	AS SHOWN	A1

Drawing No.: C861-ARP-CV-DSK-000-020034

Rev.: P03

Concept Subject To Further Development

STONE and SWYNNERTON

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

A53 Newcastle Road
BOAT 3
Bent Lane
Meece Brook
Landscape Bunds
End of tunnel
150m Porous Portal (TBC)
Min 22m track c/c spacing at first cross passage
For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020030
Access off A53
New location of Tunnel Portal
550 square metre rescue area
Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design
Platform for portal building, EAP & PSTN
230-L3 Meece Brook Viaduct
Meece Brook Realigned
Bent Lane (North) Diversion
SP Energy Networks 132kV Overhead Line
Grand Union Canal
HV OHL SP
HV OHL SP
HV OHL SP
For Continuation Refer to Drawing C861-ARP-CL-DPL-000-020028
West Coast Main Line (WCML)
Bent Lane (South) Closure
Bent Lane (South) Realignment
Track Bed Sealing Ch 230+100 to 231+280
Severn Trent Water Whitmore Borehole Facility
Chapmon Mill Lane
FP 2
FP 5
FP 6
FP 55
FP 56
MAP
EAP
MPATS

WHITMORE HEATH to MADELEY

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Key added. CCB refined	DS 09/02/2018	AG 02/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. Consolidated Construction Boundary (CCB) for Published Scheme based on Drawing C861-ARP-CL-DPL-000-021029 - P05
2. CCB for Long Tunnel Concept Layout

Key:

- Land to be acquired / CCB unchanged from Published Scheme and not part of the Long Tunnel Option Study
- Land to be acquired / CCB unchanged from Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB additional to Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB contained in Published Scheme and no longer required for Long Tunnel Options (but note that access may still be required in order to monitor settlements or noise and vibration during construction)

METRES @ 1:2500 0 20 50 100 250

hs2

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

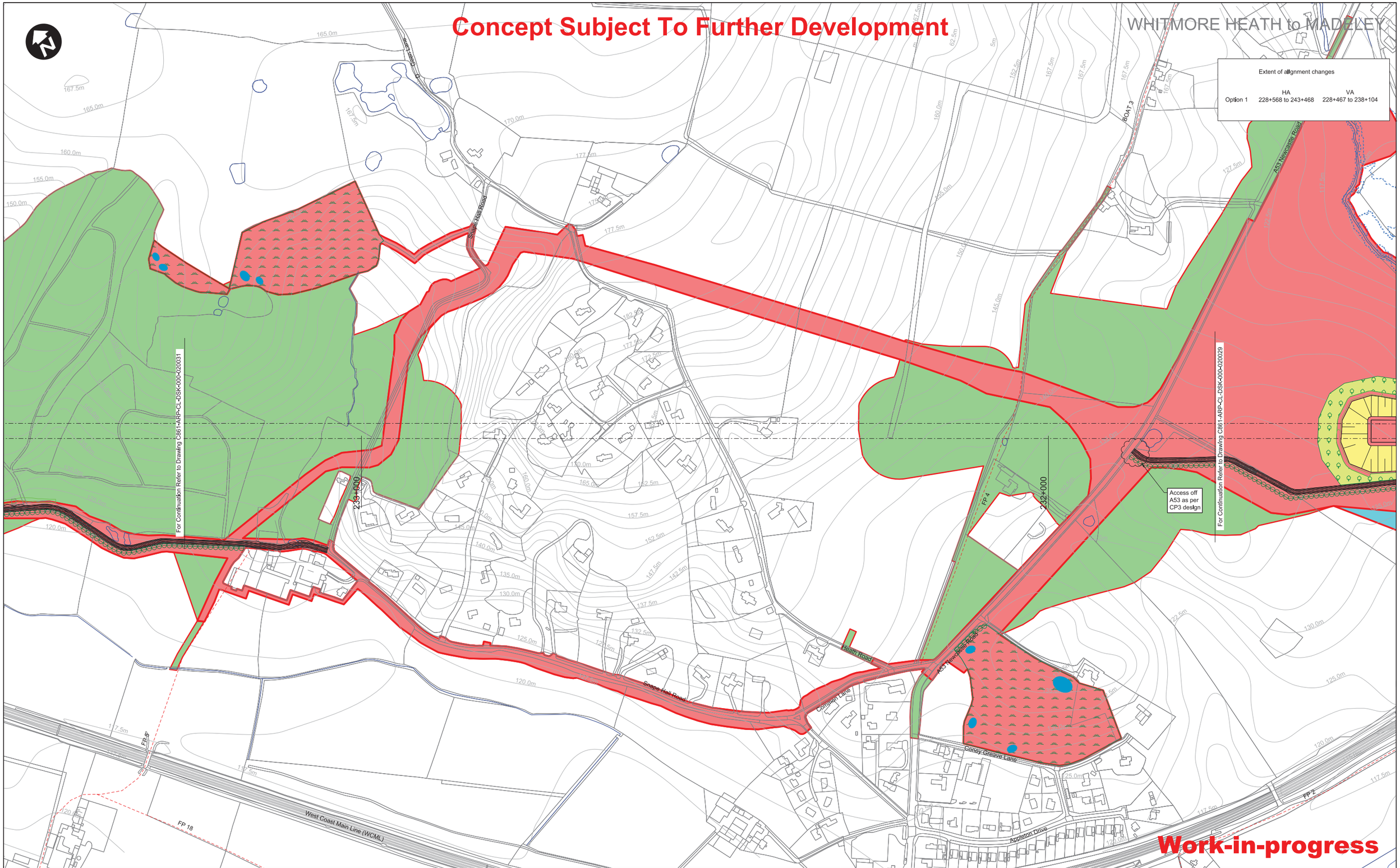
Zone	Route Wide
Design Stage	Preliminary Concept Design
Drawing Title	Whitmore Long Tunnel Options 1 Preliminary Concept Revised CCB Sheet 29
Project/Contract	P2A Civils Design & Environmental Services
Discipline/Function	Construction and Logistics
Drawn / Checked / Approved	EW / AG / TE
Date / Scale / Size	21/07/2017 / AS SHOWN / A1
Drawing No. / Rev.	C861-ARP-CL-DSK-000-020029 / P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104



Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Legends/Notes:

1. Consolidated Construction Boundary (CCB) for Published Scheme based on Drawing C861-ARP-CL-DPL-000-021030 - P05
2. CCB for Long Tunnel Concept Layout

Key:

- Land to be acquired / CCB unchanged from Published Scheme and not part of the Long Tunnel Option Study
- Land to be acquired / CCB unchanged from Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB additional to Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB contained in Published Scheme and no longer required for Long Tunnel Options (but note that access may still be required in order to monitor settlements or noise and vibration during construction)

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone: Route Wide

Design Stage: Preliminary Concept Design

Drawing Title: Whitmore Long Tunnel Options 1

Preliminary Concept Revised CCB

Sheet 30

Project/Contract: P2A Civils Design & Environmental Services

Discipline/Function: Construction and Logistics

Drawn	Checked	Approved
PN	AG	TE

Date	Scale	Size
06/09/2017	AS SHOWN	A1

Drawing No.: C861-ARP-CL-DSK-000-020030

Rev.: P03

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

Intervention Shaft Headhouse Ch. 234+510

Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design

Maintenance Access Point

FP6 Diversion

Pumping Station

Ventilation and intervention shaft compound

Ground Treatment to reduce settlement risk WCML (TBC)

Relocated Whitmore North ATS

~50m clear distance to WCML boundary

Access road design to be finalised in detail deign to ensure the ancient woodland is not affected by the proposed works. Access road alignment will be adjusted as required. The CCB boundary on the southern side of the access track accommodates for these minor changes required.

MAP

ATS

PSTN

Stoke to Market Drayton Railway

West Coast Main Line (WCML)

River Lea

FP 14

FP 6

FP 18

235+000

234+000

233+000

For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020032

For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020030

Concept Subject To Further Development

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Legends/Notes:

1. Consolidated Construction Boundary (CCB) for Published Scheme based on Drawing C861-ARP-CL-DPL-000-021031 - P05
2. CCB for Long Tunnel Concept Layout

Key:

- Land to be acquired / CCB unchanged from Published Scheme and not part of the Long Tunnel Option Study
- Land to be acquired / CCB unchanged from Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB additional to Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB contained in Published Scheme and no longer required for Long Tunnel Options (but note that access may still be required in order to monitor settlements or noise and vibration during construction)

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone: Route Wide

Design Stage: Preliminary Concept Design

Drawing Title: Whitmore Long Tunnel Options 1 & 2 Preliminary Concept Revised CCB Sheet 31

Project/Contract: P2A Civils Design & Environmental Services

Discipline/Function: Construction and Logistics

Drawn	Checked	Approved
PN	AG	TE

Date	Scale	Size
06/09/2017	AS SHOWN	A1

Drawing No.: C861-ARP-CL-DSK-000-020031

Rev.: P03

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

WCML Modifications to Accomodate HS2 Connection (See Note 1) may not be required for Long Tunnel 1 options (TBC)

Ventilation and Intervention shaft compound

Intervention shaft headhouse Ch. 235+974

Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design

CCB for Borrow Pit Extent TBC for Long Tunnel Options

River Lea

West Coast Main Line (WCML)

Madeley Chord

Stoke to Market Drayton Railway

FP 14

FP 33

FP 50

FP 15

EAP

MAP

Emergency access point

Manor Road remain as existing

Manor Road

River Lea

Road Lane

BW 1

For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020033

For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020031

236+000

235+000

Concept Subject To Further Development

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Updated post-sift selected engineering & mitigation details	DW 09/02/2018	TE 07/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. Consolidated Construction Boundary (CCB) for Published Scheme based on Drawing C861-ARP-CL-DPL-000-021032 - P05
2. CCB for Long Tunnel Preliminary Concept

Key:

- Land to be acquired / CCB unchanged from Published Scheme and not part of the Long Tunnel Option Study
- Land to be acquired / CCB unchanged from Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB additional to Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB contained in Published Scheme and no longer required for Long Tunnel Options (but note that access may still be required in order to monitor settlements or noise and vibration during construction)

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator: Ove Arup & Partners International Ltd

Zone: Route Wide

Design Stage: Preliminary Concept Design

Drawing Title: Whitmore Long Tunnel Options 1 & 2

Preliminary Concept Revised CCB

Sheet 32

Project/Contract: P2A Civils Design & Environmental Services

Discipline/Function: Construction and Logistics

Drawn	Checked	Approved
PN	AG	TE

Date	Scale	Size
05/09/2017	AS SHOWN	A1

Drawing No.: C861-ARP-CL-DSK-000-020032

Rev.: P03

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

West Coast Main Line (WCML)

WCML Modifications to Accomodate HS2 Connection (See Note 3) may not be required for Long Tunnel options (TBC)

Madeley Bridleway 5 Realignment

Temporary Roundabout to Control Vehicles at Site Road Crossing

A525 Bar Hill Road remain as existing

Manor Road

Bower End Lane

Red Lane

A525 Bar Hill Road

FP 24

FP 26

FP 53

FP 59

FP 6

FP 48

BW1

EAP

238+000

237+000

236+000

For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020034

For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020032

For Continuation Refer to Drawing C861-ARP-CL-DPL-000-020133

Concept Subject To Further Development

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P03	Minor Refinements	DS 01/03/2018	TE 01/03/2018	TE 01/03/2018	
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Key added. CCB refined	DS 09/02/2018	AG 02/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. Consolidated Construction Boundary (CCB) for Published Scheme based on Drawing C861-ARP-CL-DPL-000-021033 - P05
2. CCB for Long Tunnel Preliminary Concept

Key:

- Land to be acquired / CCB unchanged from Published Scheme and not part of the Long Tunnel Option Study
- Land to be acquired / CCB unchanged from Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB additional to Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB contained in Published Scheme and no longer required for Long Tunnel Options (but note that access may still be required in order to monitor settlements or noise and vibration during construction)

METRES @ 1:2500 0 20 50 100 250

Registered In England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Orlginator
Ove Arup & Partners International Ltd

Zone	Route Wide
Design Stage	Preliminary Concept Design
Drawing Title	Whitmore Long Tunnel Options 1 & 2 Preliminary Concept Revised CCB Sheet 33
Project/Contract	P2A Civils Design & Environmental Services
Discipline/Function	Construction and Logistics
Drawn	EW
Checked	AG
Approved	TE
Date	21/07/2017
Scale	AS SHOWN
Size	A1
Drawing No.	C861-ARP-CL-DSK-000-020033
Rev.	P03

Concept Subject To Further Development

WHITMORE HEATH to MADELEY

Extent of alignment changes

	HA	VA
Option 1	228+568 to 243+468	228+467 to 238+104

BW 2
FP 27
West Coast Main Line (WCML)
WCML Modifications to Accomodate HS2 Connection (See Note 2) may not be required for Long Tunnel options (TBC)
Length of Madeley Footpath 28 to be upgraded to bridleway
River Lea
Balancing Pond (Option 2 only)
Madeley Bridleway 5 Realignment
GSM-R Telecommunications Mast
238-S2 Wrinehill Wood Culvert
BW 5
FP 28
Indicative compound layout. Layout of rail systems compound to be developed in a later stage of design
239-S1 Madeley Bridleway 2 Accommodation Underbridge
239-S3 Madeley North Auto-transformer Station
Rescue Area
130 Km/h Crossover
Trackside Laydown Area
Trackside Laydown Area
FP 7
Checkley Brook
MAP
ATS
MAP
MAP
Portal Building
MAP
150m Porous Portal
550 square metre rescue area
239+000
238+000
End of tunnel
Min. 22m track c/c spacing at first cross passage
For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020033
For Continuation Refer to Drawing C861-ARP-CL-DSK-000-020035
River Lea
Bower End Lane
FP 6
SOUTH CHESHIRE
Watercourse Diversion
Watercourse Crossing In Shared Underbridge
BW 2
Madeley Bridleway 5 Closure
Footprint widened by up to 4 metres to accommodate wider track c/c spacing through tunnel. Engineering details similar to Hybrid Bill Scheme
FP 48
FP 7
FP 6

Work-in-progress

Rev	Description	Drawn	Checked	Con App	HS2 App
P02	Minor Refinements	DS 28/02/2018	TE 28/02/2018	TE 28/02/2018	
P01	Key added. CCB refined	DS 09/02/2018	AG 06/02/2018	TE 07/02/2018	

Scale with caution as distortion can occur.

Legends/Notes:

1. Consolidated Construction Boundary (CCB) for Published Scheme based on Drawing C861-ARP-CL-DPL-000-021034 - P05
2. CCB for Long Terminal Options proposed for Options Sift September 2017
3. For Network Rail on-network works to WCML refer to drawings C862-PBR-RT-DPL-WS09-100000 to 100009

Key:

- Land to be acquired / CCB unchanged from Published Scheme and not part of the Long Tunnel Option Study
- Land to be acquired / CCB unchanged from Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB additional to Published Scheme and required for Long Tunnel Options
- Land to be acquired / CCB contained in Published Scheme and no longer required for Long Tunnel Options (but note that access may still be required in order to monitor settlements or noise and vibration during construction)

METRES @ 1:2500 0 20 50 100 250

Registered in England
Registration No. 06791686
Registered office:
2 Snow Hill,
Queensway,
Birmingham, B4 6GA

Creator/Originator
Ove Arup & Partners International Ltd

Zone: Route Wide

Design Stage: Hybrid Bill - Draft Initial Preliminary Design

Drawing Title: Whitmore Long Tunnel Options 1 & 2

Revised CCB

Sheet 34

Project/Contract: P2A Civils Design & Environmental Services

Discipline/Function: Construction and Logistics

Drawn	Checked	Approved
EW	AG	TE

Date	Scale	Size
21/07/2017	AS SHOWN	A1

Drawing No.: C861-ARP-CL-DSK-000-020034

Rev.: P02

Appendix E – Engineering and Rail Systems Technical Requirements/Considerations for the Single Tunnel Option

E.1 Summary of Engineering Requirements for Single Tunnel Scheme

E.2 Summary of Rail Systems Requirements for Single Tunnel Scheme

Appendix E – Engineering and Rail Systems Technical Requirements/Considerations for the Single Tunnel Option

Appendix E. 1 - Summary of Engineering Requirements for Single Tunnel Scheme

Table Ea: Single Tunnel Design Criteria

Description	Criterion
Design Line speed in bored tunnel	360kph
Design Running speed in open track	400kph
Tunnel Diameter	8.8m
Minimum gradient for tunnel drainage	0.5%
Cross passage spacing	Not more than 380 metres – see para 6.4.4
Geological Conditions (based on available geological information)	The long tunnel is expected to be driven through Sherwood Sandstone (Chester and Wilmslow Formations) at its southern and northern ends. The main, central part of the tunnel will be driven through strata of interbedded mudstone and sandstone of the Warwickshire Group, specifically the Salop and Halesowen Formations, the latter including occasional thin coals (unworked) and limestone beds). The Madeley Glacial Channel lies beneath the valley of the River Lea between about Ch 234+500 to Ch 235+700 and overlies the proposed tunnel alignment. The axis of the glacial channel is estimated to be narrow and up to 20m deep and appears to be located around the line of the Madeley Fault. It is likely to be infilled with a variable mixture of water-bearing granular or non-cohesive materials. At the northern portal, the excavation will be into the Bar Hill Moraine which comprises glacial till with lenses of fluvial deposits estimated to be 15m to 20m thick.
Particular features required, subject to detail design	2014 Edition of Technical Specifications for Interoperability (TSI): Intervention/ventilation shafts required at nominally 3000m centres

Appendix E.2 – Summary of Rail Systems Requirements for Single Tunnel Scheme

Table Eb: Rail System requirements for a single tunnel option

Discipline	Requirement
Tunnel Ventilation and Fire Engineering	Tunnel ventilation system incorporating two Intervention/Ventilation shafts and fans at tunnel portals. A building adjacent to each shaft to contain mechanical and electrical equipment. A rescue area to be allocated next to this building. A portal building and rescue area at each portal. Additional tunnel cross passages will be required.
Mechanical & Electrical	Additional mechanical and electrical loads due to increased power demand of the tunnel ventilation system.
Operation Planning	Technical Headways (minimum time interval between trains that allows them to run at full speed) to be maintained below 120 seconds where possible, and never to exceed 150 seconds. This to allow a buffer to absorb minor disruption without delay to one train escalating to others.
Train Control	The tunnel will be split into three signalling sections to coincide with the tunnel entrance/exit and the shaft locations. Position of signalling equipment affected by potential requirement of crossings north of the tunnel.
Traction Power	Greater traction power loading in comparison to the short tunnel options. In order to cater for this increase in traction power loading, (potentially) significant upgrades to the traction power system arrangement in the Proposed Scheme will be required to comply with Energy Technical Specification of Interoperability (TSI). The introduction of a long tunnel will require Whitmore North ATS (AutoTransformer Station) to move adjacent to the southern shaft headhouse.
Overhead Catenary System (OCS)	Additional sectioning and switchgear will be located at each of the tunnel to comply with Safety in Railway tunnels TSI, and possibly at the midpoint of the tunnel. It can be difficult to provide sufficient space within the tunnel for the switchgear. This gear will also need low voltage power for protection and control of the OCS system. An Increased tunnel length increases the quantity of OCS supports suspended from the tunnel roof.
Maintenance	Additional maintenance access to shaft headhouses, via road. Increased complexity of safety arrangements to be put in place for working in long tunnel. Applicable procedures required to be in place.
Construction & Logistics	Additional compounds at the ATS/Vent Shaft location. Compounds at both tunnel portals. Adequate civil engineering work will need to be completed to allow a continuous track laying sequence.

Appendix F- #Ï Î ÓÔÒÕÃÔÉÏ Î 4ÒÁÆÆÉÃ ! ÐÐÒÁÉÓÁÌ

F.1 – ! ÐÐÒÁÉÓÁÌ of #Ï Î ÓÔÒÕÃÔÉÏ Î Traffic ImpacÔ between ÔÈÅ Proposed Scheme and the Single Tunnel Option

Appendix F – Construction Traffic Appraisal

F.1 – Summary of the Construction Traffic Appraisal Comparison for the Proposed Scheme and the Single Tunnel Option

Overview of Appraisal

1.1.1 Construction works associated with the Proposed Scheme (route wide) require the use of the A519 Newcastle Road, the A53 Newcastle Road, A51 London Road and the A525 Bar Hill to access the construction compounds and transfer nodes in CA4. The Environmental Statement reported significant effects on these routes due to the increase in of construction HGV traffic when compared to baseline traffic flows.

1.1.2 This appraisal is a comparison that has been undertaken for the Single Tunnel against construction traffic for the Proposed Scheme, which has been assessed on a route wide basis. This requires high level assumptions with respect to the excavated material from the tunnel and where this material is directed. In addition, in order to represent a scheme that incorporates the Single Tunnel, amendments have been made to the assumptions on export and import of material in the traffic assessment on a route wide basis.

1.1.3 The route wide traffic appraisal of the Single Tunnel, is a high-level assessment of changes to traffic flows at transfer nodes. The assessment is based on import-export material from transfer nodes. These figures have been adjusted to reflect reduction in movements for design elements of the Proposed Scheme removed (viaducts, earthworks etc.) and additional export material from the Single Tunnel added.

High level appraisal with respect to the Single Tunnel excavation material

1.1.4 The Single Tunnel will increase the total volume of surplus material to be moved via the transfer nodes. Conversely, the Single Tunnel will remove construction compounds in CA4 between the tunnel portals, which will change construction traffic flows in the area. The high level assessment with respect to direction of the excavated of material from the Single Tunnel is presented below. Total tunnel excavation for the Single Tunnel scheme is estimated at 1.28million m^3. The split of reuse/export of this material is as follows: -

Assessed direction of excavated material	Estimated volume m3	% of total volume
used in route earthworks	470,000	36%
BP235 Backfill	140,000	11%
Exported	680,000	53%
	1,280,000	total excavated (as per SEQS)

Changes to the assumptions incorporated in the Traffic Appraisal for the Single Tunnel

1.1.5 Additional export movements through the transfer nodes for the appraisal of the Single Tunnel scheme compared to the Proposed Scheme:

- +680,000m³ additional tunnel excavation material exported;
- +230,000m³ consequential exports from other earthworks features of Proposed Scheme (i.e. embankment fill for the Proposed Scheme taken from a location at the northern end of CA4);

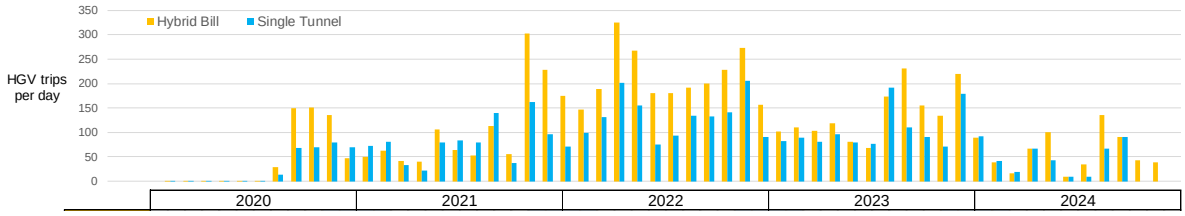
1.1.6 In addition, the following amendments to the Phase 2a Traffic Assessment imports/exports are made to take account of replacement of the Proposed Scheme with the Single Tunnel:

- +140,000m3 borrow pit backfill assessed for the Proposed Scheme, redirected as exported surplus material;
- -70,000m3 reduction in top soil export assessed for the Proposed Scheme; and
- -80,000m3 reduction in import (sub-ballast and sub-grade) assessed for the Proposed Scheme.

1.1.7 For the Single Tunnel, there is therefore a net increase of 900,000m³ export compared to the Proposed Scheme assessment of import/export on a route wide basis, when taking into account the above adjustments.

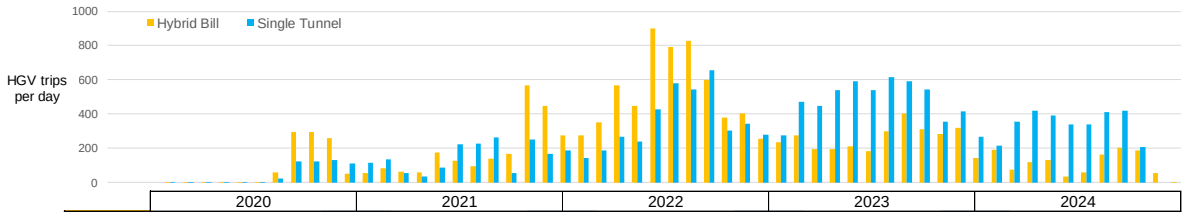
Overview from the appraisal

1.1.8 The following histograms shows a comparison of Proposed Scheme and Single Tunnel traffic associated with the transfer node on the A525 Bar Hill (Madeley Tunnel south transfer node - TN-237).



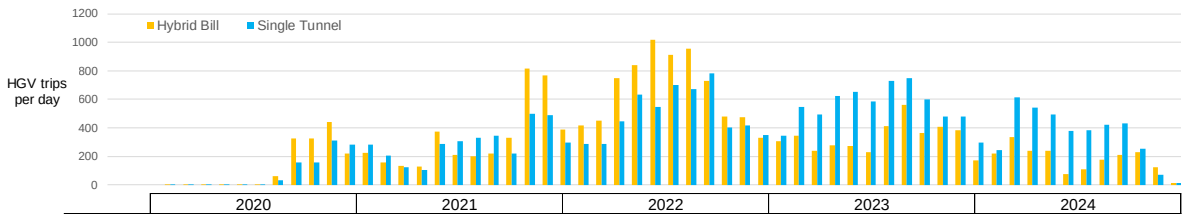
1.1.9 The histogram shows that the Single Tunnel is not expected to increase the peak level of traffic on the A525 Bar Hill, and consequently the A51 London Road, over and above that identified for the Proposed Scheme (route wide). Flows associated with the transfer node on the A525 Bar Hill are expected to reduce and this is likely to be as a consequence of the Proposed Scheme (route wide) utilising the transfer node on the A525 Bar Hill for the Madeley Tunnel works whereas the surplus material for the Single Tunnel would now be removed via the transfer node on the A53 Newcastle Road (A53 Newcastle Road transfer node - TN-232).

1.1.10 The following histogram shows a comparison of Proposed Scheme and Single Tunnel traffic associated with the transfer node on the A53 Newcastle Road (A53 Newcastle Road transfer node - TN-232) combined with the flows for the transfer node on the A525 Bar Hill (Madeley Tunnel south transfer node - TN-237). The two transfer nodes are combined to show the potential cumulative impact on the A53 Newcastle Road.



1.1.11 The histogram shows that the Single Tunnel is not expected to increase the peak level of traffic on the A53 Newcastle Road over and above that identified for the Proposed Scheme (route wide). Whilst the assessed peak month flows in the Proposed Scheme (route wide) are not expected to be exceeded, however the network is expected to stay busier for longer. Any future assessment will need to consider whether the increased 'busy' period results in a higher cumulative peak when combined with other compounds and works in the area and in the adjoining areas. However, as the transfer nodes are generally the primary generator of traffic flows, this is not expected to result in a new combined higher peak.

1.1.12 The following histograms shows a comparison of Proposed Scheme and Single Tunnel traffic associated with the transfer node on the A53 Newcastle Road (A53 Newcastle Road transfer node - TN-232) combined with the flows for the transfer node on the A525 Bar Hill (Madeley Tunnel south transfer node - TN-237) and also combined with the flows for the transfer node on the A519 Newcastle Road (Swynnerton North cutting transfer node - TN-226). The transfer nodes are combined to show the potential cumulative impact on the A519 Newcastle Road in the vicinity of M6 J15.



1.1.13 As with the A53 Newcastle Road, the histogram shows that the Single Tunnel is not expected to increase peak levels of traffic on M6 J15 over and above that identified for the Proposed Scheme (route wide), however the network is expected to stay busier for longer. As identified for the A53 Newcastle Road, any future assessment will need to consider whether the increased 'busy' period results in a higher cumulative peak when combined with other compounds and works in the area and in the adjoining areas.

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

General

1.1.1 This section of the report provides discussion regarding Whitmore to Madeley Single Tunnel Option L1 (refer to drawing C861-ARP-RT-DSK-000-252021 version P00.1), which lists the tunnel elements as 231+380 (Portal), 234+353 (Shaft), 235+975 (Shaft), 238+141 (Portal).

Tunnel Ventilation and Fire Engineering

1.1.2 For this scheme, in the event of an incident, evacuation of train passengers is proposed to be via the adjacent non-incident tunnel bore, with appropriate tunnel infrastructure and ventilation provisions to meet the *Technical specification for interoperability relating to 'safety in railway tunnels'* (TSI-SRT) 2014 regulations and safety requirements as determined necessary to provide a safe means for the emergency services to undertake their role. Key factors in this are the ability to provide intervention points for fire fighters and to limit the number of trains between ventilation shafts to one (to limit the amount of trains that might be affected by smoke in a fire emergency).

1.1.3 Regular cross passages are required to allow passengers to escape into the non-incident tunnel bore. Because the Single Tunnel is longer than the short tunnel more cross passages are required. The nature of the cross-passage doors may also add further cost.

1.1.4 The HS2 design criteria is set for ventilation and intervention shafts to be provided at regular distances (typically up to 3km) along the line of long (twin-bore) tunnels (>3 km). Each shaft shall contain a number of combined functions, namely:

- Emergency intervention access/egress points which would contain protected stairs and lifts;
- Provision of mechanical ventilation to control smoke and hot gases in a fire emergency, to control temperatures in the event of train congestion within the tunnel and to control the tunnel environment during maintenance in the tunnel;
- Provision of bypass shafts which may allow some natural ventilation of the tunnel during normal train operations; and
- Provision of rooms to house Rail Systems equipment associated with tunnel lighting, communications, drainage, low voltage power and traction power sectional isolation.

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

1.1.5 The Single Tunnel option will require a tunnel ventilation system incorporating two ventilation and intervention shafts and jet fans located within the tunnel bore near the portals. This differs from the Proposed Scheme which utilises only jet fans within the tunnel bores near the portal. The required airflow capacities at the ventilation and intervention shafts are considered likely to be similar to the proposed capacity of other similar shafts adopted for HS2.

1.1.6 A ground level shaft compound will be located at each ventilation and intervention shaft and would comprise of a shaft head house building, a hard-standing rescue area which also allow for maintenance and emergency access/egress from the tunnel, utility connections. An access road will be provided.

1.1.7 Connections to the tunnels, the depth of shafts, the requirement for hard standing rescue areas, and their internal arrangement would need further design development. Their architectural form, construction form, and constructability would need to be considered in further detail.

1.1.8 Either the ventilation and intervention shafts need to be designed with sufficient depth and ground cover to accommodate the required ventilation equipment, or the equipment must be located above ground which in turn has a greater visual impact.

1.1.9 Subject to detailed assessment and space planning, ventilation and intervention shafts less than about 25m depth would result in a difference in the size of the ground level spatial demands. This means the compound for shallow and deeper tunnel alignments could be different since for a shallow alignment, more equipment might be needed at ground level.

1.1.10 Additional Railway Systems mechanical and electrical equipment will also be necessary for passengers to be able to safely evacuate, under tenable conditions, from the train to a place of safety compared to the Proposed Scheme.

1.1.11 In addition to the ventilation and intervention shafts, firefighting points are required at the portals of the tunnels for both schemes. These portal facilities would include access to the track and a hard-standing area for maintenance and emergency access/egress from the tunnel, drainage tanks and utility connections providing firefighting and tunnel building drainage. An access road will be provided from the public highway to the firefighting point.

1.1.12 For the Proposed Scheme, a firefighting point would be required at all portals, and would still require rail systems equipment and buildings at the portals to provide power and communications to the tunnel. For the Single Tunnel, the TSI-SRT mandates a firefighting point at both portals.

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

Fan usage

1.1.13 The increase in length of tunnels theoretically increases the probability of a train stopping in the tunnel during congestion. This potentially increases the usage and wear and tear on the fans and associated equipment and also the probability of an uncomfortable event occurring if the ventilation system at any shaft were not available.

1.1.14 During maintenance activities, for longer tunnel options it is assumed that the ventilation facilities could be operated to manage the emissions from a diesel-powered rail grinding train, albeit that the final technology of the rail grinding train and other heavy maintenance vehicles remains under review. With longer tunnels, the ventilation system would need to operate more frequently in support of such rail grinding activities meaning more maintenance and cleaning of the airways.

Mechanical & Electrical Public Health

1.1.15 The Single Tunnel option will cause increased ventilation system load. Comparatively there is expected to be a moderate impact to the provision of electrical power load.

1.1.16 At the tunnel portals there is no expected change which will mitigate the requirement for any additional MEPH equipment (i.e. firefighting lifts, pressurised evacuation stairs etc, for passenger evacuation at their location).

Operations Planning

1.1.17 Operational requirement: Technical Headways to be maintained as low as possible under 120 seconds, and never to exceed 150 seconds, which is permitted only exceptionally and where there is no reasonable alternative. This allows a buffer between Technical Headway and the timetabled interval of trains to absorb minor perturbation such as differences in traction performance, slight late handover for Conventional Rail Network, Temporary Speed Restriction, without secondary impact on other trains.

1.1.18 Single tunnels have typically been found to worsen operational headways, due to spacing of ventilation shafts, combined with the "one train between shafts" rule. Typically, signal sections in open air will be about 1600m, but the spacing of vent shafts is about twice this. Headway is extended at the point where a train runs through a long section, by around 16 seconds for a speed of 360 kph in a typical case.

1.1.19 Moreover, gradients associated with tunnels will tend to be more severe than for surface routes. The falling gradient will also tend to extend headways as train braking distance will increase.

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

1.1.20 These extended headways increase the risk that minor disruption will impact upon a series of trains rather than just the one immediately affected, tending to worsen achievement of performance targets. The precise effect will depend on the circumstances of each case such as the actual speed of trains, gradients and shaft spacings.

1.1.21 The Single Tunnel option leads to increasing headways, depending on direction. This worsening is assessed as moderate. Further alignment development may reveal different headway values therefore requiring further measurement.

Train Control

1.1.22 The Single Tunnel option may result in a slight reduction in the amount of signalling equipment required; however due to the requirement of only having one train per ventilation section there may be a consequent increase in the headway figures.

Traction Power

1.1.23 The Single Tunnel option will increase the forces due to tunnel resistance and (steeper) alignment gradient encountered by the rolling stock, which will consequently result in a greater traction power loading in comparison to the short tunnel options. In order to cater for this increase in traction power loading, (potentially) significant upgrades to the proposed traction power system arrangement will be required to achieve compliance with the Energy TSI. Initial studies, based on early assumptions regarding rolling stock and grid supply characteristics indicated that this could be addressed by significantly increasing the conductor size of the express feeder cable between Newlands Lane ATFS and Yarlet EFATS, although practically likely requiring introduction of a second cable in parallel to maintain cable bending radii within limits that allow feasible implementation. Further confirmation of initial assumptions in combination with alignment development potentially leading to an undulating vertical alignment and/or a deeper tunnel could lead to further upgrades which would consist of relocating various traction power sites closer to the portal as well as increasing the size and capacity of select sites.

1.1.24 In addition, one site- Whitmore North AutoTransformer Station (ATS) - currently on an at-grade route portion, will need to be relocated to be coincident with the southernmost ventilation shaft of the Single Tunnel. It will require 25kV cable connections down the shaft to reach track level, in turn requiring additional 25kV cabling length and the associated cost.

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

Overhead Catenary System

1.1.25 For the Single Tunnel option, Overhead Catenary Systems (OCS) will require electrical sectioning and switching at each end of tunnel to comply with SRT TSI for tunnels greater than 5km length, and possibly at midpoint depending on operational safety requirements. Sectioning will need to be provided; this requires spatial provision for the switch apparatus, which is more difficult in a tunnel section. Switching will need motorization with a low voltage electrical power supply for protection and control equipment.

1.1.26 Increased tunnel length increases the quantity of OCS supports are suspended from intrados in tunnel compared to the two short tunnels option in the Proposed Scheme.

Maintenance

1.1.27 Additional maintenance access to shaft headhouses, via road, will be required to facilitate maintenance/renewal of plant/assets.

1.1.28 There is increased complexity of safety arrangements to put in place for working in long tunnels (i.e. ensuring adequate ventilation), but applicable procedures will be in place. At this point in the design it is assumed that maintenance access to assets will not require any bespoke solutions and will be similar to other HS2 tunnels.

Railway Systems Construction & Logistics

1.1.29 The railway systems installation works include primarily track, overhead line equipment, communication equipment and traction power supply.

1.1.30 The installation of the trackform in tunnels will be on concrete slab track cast in situ starting from either end of the tunnel.

1.1.31 The rest of the railway systems installation will follow a south-to-north direction with long elements such as Long Welded Rail and cables coming from the Stone Railhead.

1.1.32 The Single Tunnel option will introduce additional complexities (compared to the Proposed Scheme) within the tunnel (cross passages, longer single line installation which poses logistical problems) and new works for the ventilation shafts and the associated cabling and ATS. However, these additional works are very similar to respective works in Phase 1 and they can be undertaken following well known construction practices in the UK.

1.1.33 Before the railway systems installation can commence, adequate civil engineering work will need to be completed to allow continuous track laying sequence.

Appendix G – Rail Systems technical details for Single Tunnel option

G.1 Summary of Rail systems details for the Single Tunnel option

Construction Programme

1.1.34 In terms of Railway systems, the construction programme is affected by the additional fit out works in the tunnel and the ventilation shafts. Also, track laying is slower in the tunnel rather than the open section. This leads to a more constrained construction programme since more activities need to be completed within the same time frame. However, the overall construction programme does not get delayed due to some inherent float in the Proposed Scheme programme.

Railway Systems Risks

Tunnel Ventilation and Fire Engineering

1.1.35 The Single Tunnel length increases the likelihood of a stopped train the tunnel and potentially activate the tunnel ventilation system during normal operating hours.

Traction power

1.1.36 There is a risk that the likely requirement for the introduction of additional second express feeder cables may require additional lateral space provision at structures, resulting in the need for viaducts widening between these two sites.

Appendix H – Cost Assessment

H.1 Cost Assessment Breakdown

Cost Assessment Breakdown

The table shows the cost differences of the Single Tunnel compared to the Proposed Scheme. It should be noted that costs are likely to change following further design development.

Item	Proposed Scheme (£ million)	Single Tunnel (£ million)
Tunnels	182.02	369.38
Civil engineering (excluding earthworks)	144.52	50.55
Rail Systems	69.66	103.55
Indirect Costs	65.37	84.92
Sub-total: Construction & Indirect Costs:	461.57	608.39
Sub-total difference:		146.82
Earthworks (reduction against Proposed Scheme)		-8.82
Land & Property (reduction against Proposed Scheme)		-15.94
Efficiency Adjustment		5.38
Avoided design improvements required for Proposed Scheme		-1.20
Total Difference:		**126.24**
Contingency (40%)		50.50
Total cost difference from Proposed Scheme:		**176.74**

Notes:

1. Tunnel costs include bored tunnels, cross passages, cut & cover tunnels, portals and shafts. The tunnel advancement rate assumed is 90 metres per week.
2. Civil engineering costs include bridges, viaducts & other structures, roads and utility diversions.

3. Indirect Costs include HS2 corporate costs, project management, design development & insurances. They are calculated on a % basis.
4. Earthworks costs represent the cost saving in adopting the single tunnel. The earthworks model considers re-use of excavated material, processing requirements, mass haul, disposal etc. These costs cannot be isolated for a specific section of route.
5. The cost shown for Land & Property illustrates the saving associated with avoided purchases from adopting the Single Tunnel Scheme.
6. The Efficiency Adjustment represents expected opportunity cost savings associated with rail systems and indirect costs and the loss of efficiency opportunity associated with the reduced civil engineering cost.
7. Contingency (40%) is consistent with the Proposed Scheme and is applied to the Total Difference.
8. All costs are stated at base date 1Q 2015.

Appendix I - Comparative analysis matrix for the Single Tunnel Option (2017)

I.1 Engineering Comparative Analysis Matrix for the Single Tunnel Option

I.2 Environmental Comparative Analysis Matrix for the Single Tunnel option

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme			
Request number(s)		E			
OPTIONS CONSIDERED:		Baseline - t|2U2ăSR {0KŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION		690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)	
Headings	Appraisal criteria	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING		RATING
		Alignment The Proposed Scheme alignment is compliant with Standards. All horizontal elements at desirable values through between Whitmore and Madeley. All vertical elements at desirable values except for 1 no. Limiting radius vertical curve 38,725m and 1 no. Limiting length vertical curve, 216.4m (desirable length = 240m) The track spacing from Whitmore South Porous Portal to Madeley North Porous Portal is a constant 18m c/c		**Alignment** (=) Neutral All horizontal elements have desirable values except for 1 no. Limiting length (272.5m) horizontal element (desirable length = 310.4m) Same number of vertical elements as baseline vertical alignment All vertical elements within the extent of vertical alignment change have desirable values Up and Down lines have almost identical vertical alignment (maximum vertical difference of <0.1m). In order to extend the length of Whitmore and Madeley tunnels so that they form one continuous long tunnel, the alignment dives down and introduces a low spot in the tunnel which is not desirable. A shaft is proposed at the low spot which will house a pump to discharge any infiltration water that collects at the low spot	
		Earthworks/Geotechnics 230-L2 Stableford North Embankment is 550m long from Ch 230+250 at the northern end of Stableford South Embankment (just north of the southern boundary of Community Area 4), to the southern abutment of Meece Brook Viaduct at Ch 230+800. Track spacing on the embankment varies from 5.2m at the north end (adj. to Meece Brook Viaduct) to 5.0m elesewhere. Maximum height is 11m 231-L1 Meece Embankment is from the northern abutment of Meece Brook Viaduct at Ch 231+040 for 260m north to Whitmore South Cutting at Ch 231+300. The track spacing on the embankment varies from 14m at the northern end to 8.1m at Meece Brook Viaduct. Maximum height is 10m 231-L2 Whitmore South Cutting is from Meece Embankment at Ch 231+300 up to the south end of the Whitmore Heath Tunnel South Portal at Ch 231+829 over a distance of 529m. There are two visual mitigation landscape bunds each 2m high, one upside and one downside, where HS2 is at grade at the south end of the element. Maximum depth is 14m 233-L1 Whitmore North Cutting is a retained cutting 600m long from the northern end of the Whitmore Heath Tunnel North Portal at Ch 233+057 to the southern end of Lea South Embankment at Ch 233+660. The retained length of cutting is on the UP side only, from Ch233+057 to Ch233+660. The maximum depth of cutting on the DOWN side is 13m. The maximum height of retaining wall is 20m, with an average of 16m. The wall is assumed to be embedded at the toe, with several horizontal layers of ground anchors above and is a substantial structure 233-L2 Lea South Embankment is from the northern end of 233-L1 Whitmore North Cutting at Ch 233+660 where HS2 is at grade to the southern abutment of the River Lea Viaduct at Ch 234+505. Maximum height adjacent to the DOWN line is 14.5m and maximum height adjacent to the UP line is 11m. There are landscape earthworks with a 1v in 4h outer slope on both sides of HS2 (length differs slightly) 235-L1 Lea North Embankment is 860m long and up to 16m high, with a mean height of 9m. Mitigation earthworks alongside are graded out to blend with the landscape 236-L1 Madeley Cutting adjoins Lea North Embankment at 236+150 and extends for 1,017m to the south portal of Madeley Tunnel. There is a landscape earthworks bund along the north-east side of the cutting. Maximum depth is 18m and the average is 7m 235-S2 Manor Road Overbridge carries a re-aligned Manor Road over HS2 on a skew crossing at 235+977. The toal length of the realignment is 977m and the maximum height is 13m		**Earthworks/Geotechnics** (---) Major worsening compared to the CP3 Baseline Scheme - earthworks cut and fill quantities will reduce because the long tunnel will reduce or eliminate a number of cuttings and embankments, namely, Whitmore South Cutting, Whitmore North Cutting, Lea South Embankment, River Lea Viaduct, Lea North Embankment, Madeley Cutting. Despite the introduction of 2 vertical shafts, tunnel crossings and local widening of earthworks due to increased track width, the overall quantity of excavation in surface cuttings has been reduced by 10% and the fill requirement has been reduced by 20% compared to the baseline option However, the long tunnel alignment will run across the Madeley Channel (River Lea valley) (i.e. a 20-30m deep glacial channel infilled with variable & soft deposits) from Ch 234+900 to Ch 235+500. These glacial deposits are likely to be a variable mixture of water-bearing granular, non cohesive and soft / loose materials which will lead to challenging tunnelling conditions. Therefore, additional mitigation works will be required there Most of the TBM excavated material will be in the Warwickshire Group (i.e. mainly mudstone) which it is estimated could only be reused as landscape fill at best. It is estimated that most of the TBM excavated material will be surplus to the requirements for landscape earthworks or borrow pit backfill and will need to be disposed off-site (about 0.92 Mm^3)	

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme			
Request number(s)		E			
OPTIONS CONSIDERED:		Baseline - t|2U2ăSŘ {0KŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION		690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)	
Headings	Appraisal criteria	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING		RATING
		Structures 234-L1 River Lea Viaduct Ch234+505 to Ch235+290 is 785m long and comprises 2 parallel concrete viaducts, due to the track spacing of 18m c/c 230-L3 Meece Brook Viaduct is a 240m long tapered concrete viaduct, from Ch230+800 to Ch231+040, carrying HS2 over the realigned Meece Brook and its associated floodplain. The viaduct sits between line of route elements 230-L2 Stableford North Embankment (Ch 230+250 to 230+800) and 231-L1 Meece Embankment (Ch 231+040 to 231+300). Track spacing on the viaduct varies from 8.0m c/c at the north end to 5.2m c/c at the south end hence the deck width between parapets varies from 16.58m to 13.72m. The viaduct is substantially higher than the required 0.6m above 100-year flood level plus climate change or 4.0m above bank level that is required 231-S1 A53 Newcastle Road Overbridge is a 3-span 101.2m long overbridge which carries the A53 over the southernmost porous portal to Whitmore Tunnel 233-S3 Whitmore Wood Accommodation Overbridge facilitates a new, single track accommodation access road, approx. 250m long, crossing HS2 mainline to provide access to Whitmore Wood and pasture land to the north of the rail corridor. At this location HS2 has just exited the Whitmore tunnel and is in a small cutting. In order to cross HS2 an 8m high embankment is required on the accommodation access. The 3-span overbridge is 45.8m long and 4.7m wide between parapets, HS2 track c/c spacing at this location is 18m 235-S2 Manor Road Overbridge provides 7.15m headroom above HS2 tracks and is a 4-span structure with a total deck length of 89.20m. There is a large 50° skew angle 236-S1 Madeley BW1 Overbridge provides 7.15m headroom above HS2 tracks and is a 2-span structure with a total deck length of 38.4m and a deck width of 20m. The is a 29° skew		**Structures** All structures are in accordance with design standards and fulfill HS2 requirements Minor changes to Rowe Farm Overbridge, Dog Lane Overbridge and Swynnerton Footpath 10 Accommodation Underbridge due to new alignment (+) Minor improvement to Meece Brook Viaduct which is now 2 separate viaducts due to the increased track separation (++) Moderate Improvement as a number of structures are no longer required including: A53 Newcastle Road Overbridge, Whitmore Wood Retaining Wall, Whitmore Wood Retaining Wall, River Lea Viaduct, Manor Road Overbridge, Madeley Bridleway 1 Accommodation Overbridge, A525 Bar Hill Overbridge and Bar hill Aqueduct (-) The increased track separation increases the bridge lengths and structure depths for Madeley Bridleway 2 Accommodation Underbidge and Checkley Lane Overbridge. Checkley Brook Viaduct is already 2 separate structures so option only an increase in abutment width and not deck width	
		Highways 231-S1 A53 Newcastle Road. There are Departures from Standards for the combination of vertical alignment and stopping sight distance on each approach to the overbridge. Refer to items 46, 47, 87,88,89, 90 and 91 in the Departures Register C861-ARP-AU-REG-000-000001 Snape Hall Road is stopped up A525 Bar Hill Road - Complies with Standards for a 85kph design speed with a min crest K value of 55, sag K value of 20 and minimum horizontal radius of 650m. The existing road is realigned to the south and elevated across HS2 on an embankment up to 3.5m high, with a maximum gradient of 7.1%. The existing		**Highways** (++) Moderate Improvement. A53 Newcastle Road, Manor Road and A525 alignments are unchanged from existing and diversion is not required. In addition Snape Hall Road remains open to vehicular traffic and alignment is unchanged	
		Accommodation Works/PRoW No Public Right of Way is provided at Snape Hall Road 236-S1 Madeley BW1 (Red Lane) forms a junction with A525 Bar Hill Road to the north of the rail corridor and extends south, following the line of the existing Bridleway, crossing HS2 via an overbridge. The existing alignment of is coincident with Red Lane, which will be widened locally (including passing bays) to meet HS2 access standards for access to the Drummer Stile Inverted Siphon Maintenance Access Points (MAPs). The Bridleway realignment is coincident with HS2 Chainage 236+514 and has a length of 625m. It is designed with 8% gradient on both approaches to the HS2 overbridge, however the existing gradient along the bridleway is above this value to the south-west of HS2. The maximum embankment height is 7m		**Accommodation Works/PRoW** (--) Moderate Improvement. Snape Hall Road remains open to non-vehicular traffic. Madeley Bridleway 1/Red Lane re-alignment no longer required. Significantly smaller diversion to Whitmore FP6 is required, local to the shaft location for the Option. Accommodation Access over Whitmore Wood O/b no longer required.	

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		**'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme**			
Request number(s)		**E**			
OPTIONS CONSIDERED:		**Baseline - t|2U2ăSŘ {0KŠYŠ**		**Option L1 - Single Tunnel**	
OPTION DESCRIPTION		**690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl**		**Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**		**RATING**
Strategic Fit	Capture whether an option meets the Project Specification	**Tunnels** Whitmore Heath Tunnel is primarily a twin bored tunnel running from Ch231+829 to ch.233+057. There are 690m long 8.8m ID twin bored tunnels (Ch232+217 to Ch232+907) and a 238m long cut and cover tunnel towards the south (separated twin tunnels for up and down line individually, Ch231+979 to Ch232+217 237-L1 Madeley Tunnel comprises two bored tunnel with two porous portals at either end. It passes under a small hill directly adjacent to the town of Madeley where the mainline passes the town on the south side. The tunnel comprises 673m long 8.8m internal duiameter twin bored tunnels (Ch237+317 to 237+990) and 150m long porous portals at both end of the bored tunnel (Ch237+167 to Ch237+317 and Ch237+990 to Ch238+140) Madeley tunnel passes under the northern side of Bar hill which, from the south, rises gradually, and reduces with a steeper gradient after a brief area of flatter ground. Due to the way the mainline passes underneath the side of the hill, this means that the southernmost portal is located on a significant cross-fall as the peak of the hill is located to the south-west of the tunnel. The tunnel doesn't directly pass underneath any buildings, but it does pass underneath Bower End lane which also accommodates a footpath. Barhill wood is located to the south-west side of the tunnel. There are several farms and farm buildings scattered to the north and south of the tunnel	**O**		**Tunnels** (+) Minor Improvement. The A53 is no longer affected by the works, and no cut and cover tunnel is required, so the bored tunnel can connect directly to the southernmost porous portal. This is a moderate improvement. However cover to the A53 is still marginally less than 1D so some ground improvement to limit settlement in this area may be required. (---) Major worsening. The tunnel alignment passes directly through a buried glacial valley, known as Madeley Glacial Channel. This valley will likely contain soft, normally consolidated, water bearing material deposited in layers, including both Glaviofluvial and Glaciolacustrine deposits. These may contain perched water tables and artesian aquifers. When the TBM enters the buried glacial valley, this could result in sudden inflow of ground water, this could lead to flooding of the tunnel or collapse during construction. There are also issues with tunnelling through variable geology including soft water bearing material in the glacial valley and hard to weathered rock. These are difficult ground conditions to tunnel through, as TBM machine cutting heads tend to be designed for hard rock or soft ground. Significant additional geotechnical investigation and potentially ground improvement would be required in order to reduce risks to this option (--) Moderate worsening. The construction methodology will be significantly changed. The tunnel length is dramatically increased and requires two large ventilation and intervention shafts to be constructed. (-) Minor Worsening, a low spot is introduced within the tunnel which will require a sump pump. However the alignment does allow a shaft to be located at the low spot which can accommodate the permanent pumping equipment. The overall assessment is therefore Moderate Worsening as the tunnel is much larger, requiring two shafts, and the TBM would be required to pass through highly difficult ground. There is an opportunity to refine the design post-sift to remove one ventilation/intervention shaft	**--**
		Access Tracks			**Access Tracks** (++) Moderate Improvement. Removal of Madeley Tunnel South Portal and Whitmore Tunnel North Portal removes the need for access trackes/EAPs at these locations. Removal of 4 balancing ponds removes need for access tracks/MAP. Removal of Drummer Stile inverted siphon removes need for access/MAPs. Access tracks off Manor Road required for the northern shaft and access off Snape Hall Road required for southern shaft however this would largely be the same as that required in baseline for access to River Lea Viaduct southern abutment	
		Track Drainage Balancing ponds are provided at Ch. 231+200, 233+100 and 233+700			**Track Drainage** (++) Moderate improvement. Longitudinal surface water drainage systems are not required between the start and end of the longer tunnel. A drainage system within the tunne lis required to manage infiltration and fire water	
		Surface Water Drainage 233-S1 Snape Hall Road Drop Inlet Culvert passes beneath the porous portal and is constrained vertically - higher is not possible due to HS2 and lower is not possible due to the grading out of the long outfall ditch to the west 233-S2 Dab Green Drop Inlet Culvert 234-S4 Whitmore Wood Culvert 234-S1 Madeley Park Culvert There is an aqeduct (237-S1) across the southernmost portal to Madeley Tunnel which drains a dry river valley There is an inverted siphon at Drummer Stile (236-S2) There is a flood culvert (236-S3) beneath Lea North Embankment			**Surface Water Drainage** (++) Moderate Improvement. 4No. balancing ponds and associated vehicle access arrangements are removed (+) Minor improvement. All perimeter drainage between the start and end of the tunnel is removed (-) Minor Worsening. Groundwater (and fire water) pumping station is required at the low point in the tunnel (+++) Major Improvement because fewer surface water features are affected and River Lea significant impacts not observed/River Lea Flood Relief Culvert 253-S3 not required	

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme			
Request number(s)		E			
OPTIONS CONSIDERED:		Baseline - t|2U2ăSR {0KŠY Ŝ		Option L1 - Single Tunnel	
OPTION DESCRIPTION		690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)	
Headings	Appraisal criteria	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING		RATING
		Railway Systems - Tunnel Ventilation		**Railway Systems - Tunnel Ventilation** Require new ventilation system incorporating two ventilation shafts and potentially jet fans at the portals. C862 are able to design two ventilation shafts for this option. Expect environmental impact due to need to locate a shaft head house at ground level Confirmed with C861 (WIP sketches C861-ARP-CV-DSK-000-020029.pdf and C861-ARP-CV-DSK-000-020034.pdf) that tunnel portals remain unchanged and will not require additional Rail Systems MEPH equipment, such as fire fighting lift and pressurised evacuation staircase, for passenger evacuation	
		Railway Systems - Non-traction power		**Railway Systems - Non-traction power** (--) Moderate worsening, related to additional tunnel ventilation loads	
		Railway Systems - MEPH		**Railway Systems - MEPH** At CP3 Whitmore Tunnel has two cross passages and Madeley Tunnel has two cross passages C861 confirmed that Long Tunnel Option L1 will have 16 cross passages. Therefore 12 additional cross passages will be required for this design Electrical Load will need to increase to account for two ventilation shafts and additional 12 cross passages Therfore assessed as overall Moderate Worsening (--)	
		Railway Systems - OCS		**Railway Systems - OCS** (-) Minor worsening. Will require additional 25kV switchgear for sectioning and earthing of tunnel OCS to be housed in vent shaft and outside portals to comply with SRT TSI for tunnels greater than 5km length	
		Railway Systems - Maintenance		**Railway Systems - Maintenance** (-) Minor Worsening •introduce additional complexity of undertaking maintenance working in tunnels – although already required for separate tunnels in the vicinity the significant increase in length will increase the impact; • Increased infrastructure due to cross-passages and shaft ventilation fans; • Decreased infrastructure as assumed jet fans will no longer be required; • Assumed that suitable road access will be provided to ventilation shaft head-houses etc.; • Assumed that no additional maintenance factors introduced due to movement of other assets to accommodate the tunnel (e.g. relocation of ATS compounds does not require bespoke solutions).	
		Railway Systems - Communications		**Railway Systems - Communications** No significant change. Potential changes in technology will require the communications system to be revaluated and a revised design proposed	
		Railway Systems - Signalling		**Railway Systems - Signalling** No real change from a signalling perspective, there may be a slight reduction in the equipment required, this however may be offset by shaft location affecting headway figures	

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme			
Request number(s)		E			
OPTIONS CONSIDERED:		Baseline - t|2U2ăSR {0KŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION		690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)	
Headings	Appraisal criteria	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING		RATING
Construction Feasibility		<u>Railway Systems - Traction Power</u>		<u>Railway Systems - Traction Power</u> (--) Moderate Worsening. Appreciable increase in traction power loading due to significant length tunnel (as resistance force in tunnel is higher). Traction power modelling confirms that this results in a non-compliant (with Energy TSI) traction power system design in terms of mean useful voltages on combined Newlands Lane ATFS to Yarlet EFATS to South Crewe MPATS feeding zone - because CP3 traction power system design is operating at its capability limit. This can be addressed by increasing the conductor size of the express feeder cable between Newlands Lane ATFS and Yarlet EFATS from 630 sq mm to 1000 sq mm Copper [note: practically, due to bending radii, this may require 2x500 sq mm cables in parallel]. Requires ATS at Whitmore North to be relocated 353m north to be coincident with the southern of the two ventilation shafts (which maintains acceptable ATS spacing), however requires additional 25kV cabling length down shaft from surface level ATS to reach track level. Also minor adverse impact of increased height differential between Stableford ATS and trace level leading to possible introduction of CDM risk for accessing cable routes thus defeating benefit of ATS AP1 change (ATS level with trace)	
	Assess the relative complexity of construction		O	<u>C861</u> The construction activities within the programme will be simplified by the omissions . The mass haul will also be simplfied but the surplus 0.94 million m3 will require disposal off site or consideration of reprofiling the borrowpit reinstatment. Ground conditions under the river Lea valley are a risk to tunnelling . Any ground improvement close to the WCML could be critical. Settlement effects on the WCML could require remedial action. <u>C862</u> There is a moderate worsening since many works are required within the tunnel (14-16 cross passages, longer single line installation which poses logistical problems etc) and new works for the vent shafts and the associated cabling and ATS. Although this complexity is very similar to respective works in Phase 1 it is still worse than the baseline	-
	Assess the relative construction programme		O	<u>C861</u> Using 2No TBMs starting at Whitmore south end the programme in this area will stay within the planned overall period. The tunneling will run 24/7 for up to 2yrs with spoil exported north to the Borrowpit just north of the river Lea via haul road . Access to the shafts will also be via the same haul route. Utility diversions will be reduced but will probably still be needed for items affected by settlement. The savings on the omissions will offset the additional TBM duration to the effect that the programme will remain the same. Assumed that suitable temporary power can be provided for 2 TBMs working concurrently <u>C862</u> The construction programme is affected by the additional fit out works in the tunnel and the vent shafts. Also, the track laying is slower in the tunnel rather than the open section. This leads to a more constrained construction programme since more activities need to be completed within the same time frame. However, the overall construction programme does not get delayed due to some inherent float in the CP3 programme. Therefore, the minor worsening is due to more activities in the same time frame without this affecting the overall programme duration	-

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		**'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme**			
Request number(s)		**E**			
OPTIONS CONSIDERED:		**Baseline - t|2U2ăSR {0KŜYŜ**		**Option L1 - Single Tunnel**	
OPTION DESCRIPTION		**690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl**		**Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**		**RATING**
	Assess the relative disruption to existing infrastructure, e.g. rail, highways etc.	The A53 Newcastle Road crossing of the alignment designed to be on its existing horizontal alignment will require a temporary full road diversion running adjacent for approximately 18 months. In terms of Utilities, at 231+870 there are multiple underground BT Openreach assets. Telecommunications cables (100 copper pairs, each 0.5mm diameter) and joint boxes are under the footway on northern side of A53 Newcastle Road. BT Openreach aerial telecommunications cables (assumed copper) and poles servicing The Hill near A53 Newcastle Road at chainage 231+970. Property serviced from A53 Newcastle Road. There is a need to ensure service is maintained to property during Whitmore Heath (South) porous portal construction and A53 Newcastle Road Overbridge	**O**	**C861** (+) Minor Improvement. A53 Newcastle Road , the A525 and the existing utilities within it together with BOAT 3 and Whitmore FP4 will not be disrupted. However the temporary interface will be increased as the haul route for mass haul will have to cross the A53 under temporary traffic control or use a temporary bridge There will be less disruption to the WCML from the viaduct omission however settlement may require remedial action Mass haul of surplus of 500k m3 may be required on the existing highways **C862** No additional disruption to existing infrastructure due to Railway Systems Works	**+**
	Construction compounds, transfer node and materials laydown areas		**O**	**C861** (+) Minor Improvement. Compounds to the north of the A53 will be reduced to just a receiving area and compounds to the south will be increased but there will be an overall reduction. Similar situation at Madeley and along the route **C862** (+) Minor Improvement. This Option requires 1 less compound than the baseline. This is due to combining the Whitmore North ATS compound with the compound for the 1st Vent Shaft	**+**
	Assess amount of demolition required		**O**	**C861** 12 No outbuildings and 3 No residential buildings no longer required to be demolished **C862** (=) No change from baseline - no demolitions related to Railway Systems works	**+**
HS2 Operation Feasibility – Trains (HS2 and Network Rail)	Assess the relative flexibility and reliability of the track layout Assess the relative train maintenance and servicing arrangements		**O**	Increase in headway of about 6 to 9 seconds depending on direction	**- -**
HS2 Operation Feasibility – Operations (Stations, Depots etc.)	Assess the effectiveness of Location and space for station control Location and space for accommodating staff, catering, transport police and other “back of house” activities Location and space for passenger facilities such as ticket office, travel information, toilets, left luggage etc. Location of ticket barriers			n/a	
HS2 Operation Feasibility - Passengers	Assess Passenger Dispersal covering road (right of way), rail and public transport Assess the relative Passenger Connectivity at stations between high speed rail, classic rail, bus, coach, car, taxi, bicycle and pedestrians Assess the relative passenger flow characteristics during emergency evacuation and normal operation at stations Assess the relative ‘Way Finding’ of station layouts i.e. logical flow Assess the relative security or perception of security of station layouts			n/a	
Demand	Likely Relative Passenger Numbers	n/a		n/a	
	Likely Journey Times		**O**	Subject to modelling, we do not expect material impacts on journey time or line headway	**O**
	Likely Demand	n/a		n/a	

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:		**'Single Tunnel' between Whitmore and Madeley, compared with Proposed Scheme**			
Request number(s)		**E**			
OPTIONS CONSIDERED:		**Baseline - t|2U2ăSR {0KŠY Š**		**Option L1 - Single Tunnel**	
OPTION DESCRIPTION		**690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl**		**Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**		**RATING**
Costs	Estimated whole life cycle costs to give relative assessment *(Appraisal considers operational costs as capital costs are considered separately below)*		**O**	Overall Minor Improvement. A number of surface features are removed by this option, which reduces maintenance requirements, however there is an increase in tunnel inspections and maintenance due to the significantly increased tunnel length and the inclusion of shafts	**+**
	C861 Estimated initial capital costs to give relative assessment (The capital costs include construction, land and compensation costs)	Sub-total of construction works capital cost £278.2m plus prelims 25%, MCD 5% and OHP 8% giving a total cost estimate of £394m	**O**	Major increase in capital cost over baseline, excluding movements on land and compensation costs	**- - -**
	C862 Estimated initial capital costs to give relative assessment (The capital costs include construction, land and compensation costs)		**O**	Moderate increase in capital costs	**- -**
Environment	Input from ENVIRONMENTAL APPRAISAL MATRIX (refer to C861-ARP-EV-ASM-WS06-000075)		**O**	The overall environmental rating for option L1 is predicted to be major positive improvement on baseline. Environmental benefits derive from the removal of construction effects, the presence of the built scheme and presence of operating trains between the tunnel portals that were present in the baseline scheme. Between the portals, most landscape and visual, heritage, biodiversity and agricultural impacts along the tunnel's route would be removed. Notably there would be the retention of approximately 6.4ha of ancient woodland from Whitmore wood and other surrounding AWIS. There would be moderate surface water improvements from the removal of direct impacts on the River Lea. Air quality improvements due to the removal of many baseline construction compounds, above ground works and road realignments. Contaminated sites in the River Lea viaduct area would be avoided. The removal of surface works between the Whitmore Heath and Madeley tunnels is likely to remove the vast majority of the construction noise and vibration impacts. During operation it is likely that this option would materially reduce the groundborne noise and remove vibration levels at properties above the Whitmore tunnel. Demolition of three residential properties would be avoided The direct effects on a local business would be reduced. The avoidance of the closure of Snape Hall Road and reduced disruption on the A53 Newcastle Road, Manor Road, A525 Bar Hill Road and local PRoW would reduce impacts to community, health and wellbeing in the area. There would be a reduction to HGV movement along highways throughout the area apart from on the A53 Newcastle Road which would see an increase in peak HGV movement from the transfer nodes around the southern portal. There would be an intensification of construction activity around the tunnel portals. Construction would produce a predicted additional 1.9 million tonnes of surplus excavated material, requiring off-site disposal to landfill. This material would require increased HGV movement. There would be an increase in GHG and energy use during construction (this is balanced against the removal of embankments/viaducts to produce a minor worsening from baseline). There would be a worsening of groundwater impacts to the baseflow to the Meece Brook during construction plus the potential to impact groundwater quality at the Whitmore abstraction during operation. There would be a need to employ a greater number of pumps during operation to remove water from the tunnel and this brings possible contamination issues. On balance these negative aspects do not affect the major positive rating given to this option	**+ + +**

Appendix I.1 Engineering Sift Matrix (2017)		Community Area CA4 - Whitmore Heath to Madeley		
Option name and description:		**'Single Tunnel' between Whitmore and Madeley, compared ø1ú̊K t№2LJ2ăŠŘ {ÔKŜYŜ**		
Request number(s)		**E**		
OPTIONS CONSIDERED:		**Baseline - t№2LJ2ăŠŘ {ÔKŜYŜ**		**Option L1 - Single Tunnel**
OPTION DESCRIPTION		**690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel ó928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl**		**Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 (Arup internal use)**
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	
Safety	Assess the relative safety during construction		**O**	**C861** (+) Minor Improvement. There is a reduction in the traffic interface on the A53 and A525, simplified construction by removal of the cut and cover tunnel, and reduced works to the existing highway network. Also moderate improvements as a consequence of removal of works over the WCML and a general reduction in working at height. Working on two long tunnel bores with two TBMs is considered to be a minor improvement over working on two short tunnels/4 tunnel bores with more significant set-up/decommissioning risks. There are increased construction risks associated with sinking the shafts. Overall assessed as minor improvement **C862** (-) Minor Worsening. There are increased construction risks due to working in much longer tunnels (tight working spaces). Also working in shafts is a new construction risk in Phase 2A. However, these risks can be mitigated and managed using normal risk management practices	**+**
	Assess the relative safety during Operations, maintenance and decommissioning, and Emergency access		**O**	Increased complexity of safety arrangements to put in place for working in long tunnel (i.e. ensuring adequate ventilation), but applicable procedures will be in place. Assume maintenance access to assets will not require any bespoke solutions and will be similar to other tunnels eg Phase 1	**-**
Commitments	Previous explicit or implicit public assurances or commitments to third parties		**0**	None specific	**0**
Commercial Development	Does the option provide opportunities for development in particular for over station development	n/a		n/a	
Preferred Option:		**O**		**---**
Reason:				**An extension of Whitmore tunnel to the south provides some environmental benefits as well as a simpler engineering solution, as a result of removing the cut and cover tunnel portion and reducing the size/cost of the Whitmore Wood retaining walls. The proposed changes are estimated to deliver a modest cost saving of the order of £11m over baseline and would not require a re-design of the power system or inclusion of a neutral section at Swynnerton. Both single tunnel options deliver major environmental improvements and there are no substative differences between the benefits delivered by the two options. Both L1 and L2 come at a major cost increase to the scheme. An improvement of about £12m in route civils costs could be delivered aganst these estimates if only one intervention shaft can be provided for the long tunnel, rather than two. This would be counterbalanced to an extent by a more expensive tunnel ventilation system. There are measurable differences between the engineering aspects of Single Tunnel options L1 and L2. A shallower tunnel (L1) would avoid the need for a significant power system re-design that would introduce a neutral section at Swynnerton. However it attracts significant**

- - -	Major worsening on the Comparator Scheme
- -	Moderate worsening on the Comparator Scheme
-	Minor worsening on Comparator Scheme
O	Neutral / no change to Comparator Scheme
+	Minor improvement on Comparator Scheme
+ +	Moderate improvement on Comparator Scheme
+ + +	Major improvement on Comparator Scheme
N/A	Not applicable

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tŭ2LJ2ăŜŘ {ŭKŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tŭ2LJ2ăŜŘ {ŭKŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
Greenhouse gas emissions and climate change	Climate adaptability	Construction	CC-8	The climate change resilience assessment and the in-combination climate change impacts assessment were both undertaken at a route-wide level, with any effects and mitigation measures also identified at the route-wide level. No significant climate change resilience effects were identified in relation to tunnels as an asset type and no significant in-combination climate change effects were identified for the area around the Whitmore and Madeley Tunnels during construction or operation.	0	As the climate change resilience assessment and the in-combination climate change impacts assessment are both undertaken at a route-wide level, with any effects and mitigation measures also identified at the route-wide level, modifications to the Whitmore to Madeley Long Tunnel are not considered to affect the outcomes of either assessment.	0
		Operations	CC-8	The climate change resilience assessment and the in-combination climate change impacts assessment were both undertaken at a route-wide level, with any effects and mitigation measures also identified at the route-wide level. No significant climate change resilience effects were identified in relation to tunnels as an asset type and no significant in-combination climate change effects were identified for the area around the Whitmore and Madeley Tunnels during construction or operation.	0	As the climate change resilience assessment and the in-combination climate change impacts assessment are both undertaken at a route-wide level, with any effects and mitigation measures also identified at the route-wide level, modifications to the Whitmore to Madeley Long Tunnel are not considered to affect the outcomes of either assessment.	0
	Greenhouse gas emissions	Construction	CC-1	The ES GHG (Greenhouse gas emissions) assessment reports all tunnels and viaducts to account for approximately 8% and 24% of total embodied construction emissions, respectively. The Whitmore and Madeley tunnel sections (928m total length) account for approximately 6% (41,205,958 tCO2e) of total embodied construction emissions	0	The construction of this option represents approximately a 420% increase in tunnel length compared to baseline. It will result in substantial increases in the material required including increased excavated material as well as the potential increase in energy use associated with the construction of the long tunnel, potentially resulting in increased GHG emissions. However, the increased length of tunnel compared to baseline, results in the avoidance of construction of other design elements such as the River Lea viaduct (5% of total embodied construction emissions) and highway diversions including the A53 (0.5% of total embodied construction emissions) and A525 (0.5% of total embodied construction emissions) which together account for a large proportion of the total embodied construction emissions at baseline. Balancing both the lengthening of the tunnel and the potential GHG savings associated with the avoidance of construction of a number of design elements, this option is likely to have a minor worsening in comparison to the baseline option.	-
		Operations	CC-1	The ES GHG assessment reports on operational (non-traction) emissions at a route-wide level and includes signalling and telecommunications, and switches heating. This accounts for 7% of total operational GHG emissions across the entire Proposed Scheme. The design in this area represents just a small section of the wider infrastructure where signalling/ lighting/ switches are likely to be used and its operational emissions are expected to be minor.	0	An increase in traction energy and carbon emissions is expected as a result of additional wind resistance due to the longer tunnel section, but this increase is expected to be small and hence change between this option and the baseline option is likely to be neutral.	0
	Energy use	Construction	CC-1	Energy consumption and carbon emissions are closely linked. An increase in fuel or electricity consumption would also result in an increase in carbon emissions. Hence the conclusions presented above regarding carbon emissions stand for energy use as well.	0	Energy consumption and carbon emissions are closely linked. An increase in fuel or electricity consumption would also result in an increase in carbon emissions. Hence the conclusions presented above regarding carbon emissions stand for energy use as well.	-
		Operations	CC-1	Energy consumption and carbon emissions are closely linked. An increase in fuel or electricity consumption would also result in an increase in carbon emissions. Hence the conclusions presented above regarding carbon emissions stand for energy use as well.	0	Energy consumption and carbon emissions are closely linked. An increase in fuel or electricity consumption would also result in an increase in carbon emissions. Hence the conclusions presented above regarding carbon emissions stand for energy use as well.	0
	Landscape/ townscape	Construction	LV-1 LV-2 LV-3 LV-4 LV-5 LV-6 LV-7	There would be both moderate and major adverse landscape impacts on the broad valley landscape of the Upper Lea valley including on the well-wooded valley sides and view from properties in and around Madeley Park Wood and Whitmore Heath. There would be similar moderate and major adverse effects on the tranquil farmland along the narrow section of the River Lea valley close to the historic Wrinehill Mill and Wrinehill Hall. These impacts would include the loss of characteristic landscape elements such as woodlands (including ancient woodland), trees, hedges and agricultural land. The character of the area would also be impacted on by the presence of construction plant and compounds in a rural landscape, which would change the nature of the area and reduce overall tranquillity.	0	Construction impacts associated with the tunnel would be intensified around the tunnel entrances and portals where there would be extensive excavation works (plus night time lighting of the tunnel boring works). At the southern end of the tunnel, construction impacts would intensify those associated with the Meece Brook viaduct. Construction at the northern end of the tunnel would result in impacts of a similar nature (although larger in scale) to the baseline as the tunnel entrance and northern porous portal are in the same location as the northern portal of the Madeley tunnel. There would be fewer visual impacts as both tunnel entrances and porous portals are in an area with few visual receptors and all visual impacts along the tunnel's route would be removed resulting in an overall major improvement compared to the baseline scheme. The rural landscape between the two tunnel portals would remain intact. Visual receptors at Madeley Park Wood, Whitmore Heath would be unaffected as would most of the visual receptors dispersed throughout the farmland. There would be localised landscape and visual effects from construction of the southern vent shaft but these would be relatively small scale compared to the baseline scheme in this area (construction of the Lea South embankment and associated infrastructure). There would be localised landscape and visual effects from construction of the northern vent shaft but these would be relatively small scale compared to the baseline scheme (construction of the Madeley cutting and Manor Road diversion and overbridge).	+ + +

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tŭ2LJ2ăŜŘ {ŌḰŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tŭ2LJ2ăŜŘ {ŌḰŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
Natural and cultural resource protection	Landscape/ townscape	Operations		The presence of the Proposed Scheme including: Whitmore North cutting; Whitmore Wood retaining wall; Madeley and Whitmore tunnel porous portals; River Lea viaduct and associated embankments; the diverted section of Manor Road; and Bar Hill overbridge would lead to moderate adverse effects on the rural landscape of the Upper Lea valley and also on the tranquil farmland along a narrow section of the River Lea valley around the historic Wrinehill Mill and Wrinehill Hall. There would also be significant effects on visual receptors including on multiple residential properties along the edge of the settlements of Madeley Wood and Madeley.	0	Creation of the tunnel means that along its route, all landscape and visual impacts identified for the baseline scheme would be removed resulting in an overall major improvement. The rural landscape between the two tunnel portals would remain intact. Visual receptors at Madeley Park Wood, Whitmore Heath would be unaffected as would most of the visual receptors dispersed throughout the farmland. Landscape and visual impacts around the tunnel portals would be similar to those for the baseline option. This is because at the southern porous portal it is similar in terms of its visibility to the Whitmore South cutting (baseline option) that is in the same location and the northern porous portal is similar to the northern porous portal of the Madeley tunnel (baseline option). There are relatively few receptors in both locations. There would be localised landscape and visual effects from the presence of the southern vent shaft but these would be relatively small scale compared to the baseline option (presence of the Lea South embankment and associated infrastructure). There would be some localised landscape and visual effects from the presence of the northern vent shaft but these would be relatively small scale compared to the baseline option (presence of the Madeley cutting and Manor Road diversion and overbridge) and would not affect the wider character of the rural landscape.	+ + +
	Cultural heritage	Construction	CH-1 CH-2 CH-4 CH-5 CH-8 CH-10	The Proposed Scheme identifies both designated and non-designated assets that would be impacted during construction. Permanent major adverse effects in this location include an area of identified archaeological features (possible Roman Villa) at the Madeley Tunnel southern porous portal and the Madeley palaeolake, south west of River Lea viaduct. Other designated heritage assets which would experience moderate adverse effects whichinclude: • Milepost on the A525 Bar Hill Road; • Snape Hall Farmhouse; • Hey House; • Offley Wellhead; and • Bridge Cottage 'Ye Olde House'. Other non-designated assets which would experience moderate adverse effects which include: • Linear earthwork features at Madeley Deer Park, Hey House and between Station Road and River Lea; • Archaeological features near Manor Road; and • Ridge and earthworks east of Bar Hill Lane. There are a number of minor or negligible adverse effects on high and low value heritage assets in locations in this area of the Proposed Scheme. No impacts on historic landscape were identified.	0	The proposed changes would lead to the avoidance of a number of direct physical impacts and/or impacts on setting deriving from the construction of the scheme or its built form, including: • Hey House (Grade II listed); • Offley Wellhead (Grade II listed); • Snape Hall Farmhouse (Grade II listed); • Bridge Cottage (Grade II listed); • Old Madeley Manor; • Madeley Conservation Area; • A Grade II listed town house in Madeley ; • Offley Almshouses (Grade II listed); • Yew Tree cottage (Grade II listed); • Madeley Old Hall (Grade II listed); • Moss House (Grade II listed); • Madeley tumulus; and • medieval earthworks east of Madeley. The Milepost on the A525 Bar Hill Road would no longer be impacted physically and would be able to remain in its present location. Of primary importance is the asset currently affected by Madeley Southern Portal an area of possible Roman activity/settlement including remains of a potential villa. The south portal of Madeley Twin Bore Tunnel would no longer exist with this option, removing much of the direct physical impacts on this asset that are documented in the current baseline. There would be reduced direct physical impacts on the following, however they would still be affected by the land required for construction haul routes and vent shafts: • a possible medieval moat at Moor Hall Farm; • ridge and furrow near Whitmore Wood; • remains of the Stoke to Market Drayton Railway; • medieval earthworks in the vicinity of Madeley Great Park; • a possible mill stream leading to the former Old Madeley Manor Mill; and • ridge and earthworks east of Bar Hill Lane. The construction of the tunnel has potential to impact glaciofluvial deposits, with the potential to contain archaeological remains, associated with the palaeolake in the former area	+ + +
		Operations		Operational impacts on the current Proposed Scheme occur through visual and noise related impacts on asset setting. Notable concerns include Hey House (a Grade II listed building) and Whitmore Conservation Area which includes a grade II* and eight Grade I listed buildings. No operational effects on historic landscape were identified.	0	Impacts on above-ground surface heritage would be removed/reduced. The setting of Hey House and the minor adverse effect on Whitmore Conservation Area would be removed with this option. While relatively few operational impacts on designated and non-designated assets were identified as a result of the baseline option the overall reduction in noise and visual effects as a result of these changes would constitute a major improvement on the baseline scheme. As no significant operational impacts on historic landscape have been identified in this area by the baseline option, these changes would not lead to any change in the assessment of impacts on historic landscape.	+ + +

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tŭ2LJ2åŠŘ {ŮKŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tŭ2LJ2åŠŘ {ŮKŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
and environmental enhancement	Biodiversity	Construction	EC-1 EC-2 EC-3 EC-4 EC-5 EC-6 EC-8	The existing Whitmore North cutting and Whitmore wood retaining wall would result in the permanent loss of 6ha of ancient woodland from Whitmore wood ancient woodland and LWS. The construction of the Lea South embankment would result in the permanent loss of a small amount of ancient woodland from Hey Sprink (wood south-west of) LWS and unnamed wood south of Hey Sprink. In addition the construction of the Madeley cutting would result in the permanent loss of 0.2 ha of ancient woodland from Bar hill Wood ancient woodland. The construction of the Lea embankment also results in the loss of an area of marshy grassland south of the WCML. The Proposed Scheme in this area affects a number of protected species including bat assemblages in the area, meta populations of Great Crested Newts, Otter records on the River Lea, a pair of barn owls east of Whitmore. Breeding and wintering bird assemblages occur in this location, a low population of reptiles is assumed and the North cutting through Whitmore wood would result in the loss of a number of main badger setts. The tunnels, viaduct, Madeley 1 accommodation overbridge, along with measures to provide passage for mammals such as culverts or dry tunnel are in the Proposed Scheme, facilitate the movement of wildlife and reduce habitat severance.	0	The reduction in land required associated with the construction of the long bored tunnel would result in a reduction in habitat loss. This would include the avoidance of habitat loss within four ancient woodlands (Whitmore Wood, woodland at Hey Sprink (south-west of), unnamed wood south of Hey Sprink and Barhill Wood). This option reduces loss of marshy grassland (priority habitat) south of Hey Sprink, avoids a veteran tree located on the edge of Whitmore Wood and avoids impacts on the River Lea from the River Lea viaduct. The reduction of the above habitat loss is beneficial in relation to protected species. This option results in reduction of habitat loss associated with bat assemblages and the avoidance of confirmed bat roosts. This option would also reduce the loss of waterbodies, including waterbodies associated with Great Crested Newt meta populations in the area. Badger setts located within Whitmore Wood would also be avoided. The removal/reduction of these impacts from construction and removal of barriers to wildlife movement between the tunnel portals of this long tunnel option represents a major improvement on the baseline option.	+ + +
		Operations		Features such as the existing tunnel under Whitmore Heath, and Madeley, Madeley 1 accommodation overbridge, and measures to provide passage for mammals such as culverts or dry tunnel are adopted to reduce operational effects of the scheme in this area. Existing operational impacts associated with the Proposed Scheme in this area are associated with collision risks from Bats and birds such as Barn Owl which are known to be present in the area.	0	The option would reduce the risk of wildlife collision with passing trains, and reduce potential impacts resulting from noise and turbulence. Operational impacts on bats, barn owls and other wildlife would therefore be reduced.	+ + +
	Water and flood risk	Construction	WR-1 WR-2 WR-3 WR-4 WR-5 WR-6 WR-7 WR-8 WR-9 WR-10	Groundwater In the Proposed Scheme Whitmore tunnel and porous portals are located within the Source Protection Zone (SPZ)3 of the public water supply (PWS) groundwater abstraction near Whitmore. However, as the Whitmore tunnel is above the saturated zone it would not provide a barrier to groundwater flow in the aquifer or reduce yield to the abstraction in the temporary or permanent case. The current alignment has potential to impact baseflow to minor tributary of the River Lea which crosses the alignment at Snape Hall Road drop inlet culvert and is a low value receptor. Detailed drainage design (following ground investigation and monitoring in this area) would ensure no significant impact. The alignment would impact on the private groundwater abstraction at Hey House Lodge as this is in the direct path of the route, and this borehole would need to be decommissioned. Madeley tunnel has potential to impact the private groundwater abstraction at Bower End Farm. This would be mitigated by agreeing an alternative water supply solution with the owner. The Madeley tunnel structure may provide a barrier for groundwater flow, but in the context of the aquifer this has been assessed has a negligible impact. Surface water and flood risk Surface water features in the vicinity of the study area from Whitmore Tunnel to Madeley Tunnel are: • Meece Brook; • a small fragmented surface water flow path south of Heath Road; • a spring fed channel at Snape Hall Drop inlet culvert; • an overland flow at Dab Green drop inlet culvert and Whitmore wood culvert; • River Lea and associated viaduct channel works to mitigate flood risk caused by embankment in floodplain; and • Overland flow path/dry valley at Drummer stile, Bar Hill aqueduct, along Bower end Lane and either side and away from northern portal towards the Checkley Brook. Along this alignment the main surface water impact of the scheme is on the River Lea. The location of embankments severe the River Lea floodplain resulting in a significant change in flood water levels up and downstream of the viaduct.	0	An appraisal of groundwater, surface water and flood risk, and WFD compliance has been undertaken. The scoring for these three subtopics topics is '- - ', '++' and '0' respectively, resulting in an overall scoring of '0'. Details are set out below. Groundwater The relative tunnel depth, southern porous portal and associated cutting increases could have increased impacts on the quality and quantity of water at Whitmore PWS, resulting in a moderate worsening in comparison to the baseline option. The southern porous portal is further to the south and deeper in comparison to the baseline option. This brings it closer towards Meece Brook and baseflow to the brook could be impacted causing a moderate worsening in comparison to the baseline option. There would be no potential to impact on the tributary of the River Lea which crosses the alignment at Snape Hall Road drop inlet culvert. This is a minor positive in comparison to the baseline option. The tunnel would cross the Madeley glacial channel and could impact baseflow to the River Lea. Further investigation and mitigation may be required which would result in a moderate worsening in comparison to the baseline option. Similarly to the baseline, the tunnel has potential to impact the private groundwater abstraction at Bower End Farm. The southern vent shaft is within a Secondary A aquifer and is hence likely to require dewatering. There is potential to impact on baseflow to the River Lea. Further investigation would be required. This would result in a minor worsening in comparison to the baseline option. The northern shaft is located within a Secondary A aquifer and is hence likely to require dewatering. This could impact on the nearby private groundwater abstraction at Hey House Lodge. The impact is similar to the baseline, but with a different cause. Surface water and flood risk By tunnelling under this area this removes the main impacts on the existing surface water environment. A moderate benefit in comparison to the baseline option.	0

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tŭ2LJ2ăŠŘ {ŮKŠYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tŭ2LJ2ăŠŘ {ŮKŠYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
	Water and flood risk	Operations		Groundwater Due to the sensitivity of the Whitmore PWS mitigation is required to ensure long term protection of the aquifer quality during operation. Potential impacts are thought to be of low likelihood, but the current agreements with Severn Trent Water are that track bed sealing within the SPZ2 and monitoring would be provided. Surface water and flood risk No impacts or effects were identified at the operational stage in association with surface waters at this location. WFD compliance No impacts or effects were identified at the operational stage in association with WFD at this location.	0	Groundwater Due to the position of the below ground elements within the SPZ2 and SPZ3, there is potential to impact groundwater quality at the Whitmore abstraction. This would need to be carefully mitigated to ensure no impact on the Whitmore PWS in close consultation with Severn Trent Water. Track bed sealing and further detailed drainage design may be required to mitigate impact risks. This is a minor worsening in comparison to the baseline option as the below ground elements are deeper in proximity to the abstraction, and possibly within the saturated zone of the aquifer. Surface water and flood risk This option would not change the assessment of the operational impacts or effects on surface water environment. However, it would increase the operational and maintenance required in association with the local water management system due to the need to employ a greater number of pumps to remove water from the tunnel. A minor worsening from the baseline option. WFD compliance: The construction of a tunnel would not change the assessment of the operational impacts or effects on WFD impacts.	-
	Air quality	Construction	AQ-1 AQ-2 AQ-4	The Proposed Scheme would result in emissions to air from construction dust and vehicle movements related to the removal of excavated material. There would be a medium risk of dust soiling from earthworks and construction and a medium to high risk of dust soiling from trackout is predicted at properties around A53 Newcastle Road and Whitmore Heath; Whitmore Wood; Manor Cottages and Hey House area; the A525 Bar Hill Road; Bowerend Farm, Beechfields; and Wrinehill Hall. Four ecological receptors (Whitmore Wood Ancient Woodland, Barhill Wood Ancient Woodland and two additional ecological receptors (Ancient woodland at Hey Sprink (south-west of) and (Ancient woodland at an unnamed wood south of Hey Sprink) are also predicted to be adversely affected by dust emissions. In relation to potential impacts from road-related emissions, no significant effects are anticipated at any receptor within the comparison area in relation to annual mean NO2, PM10 and PM2.5 concentrations.	0	The construction of this option would result in an overall reduction in HGV movements of approximately 3%, compared to the baseline option, due to the removal of many baseline construction compounds, above ground works and road realignments. Whilst there may be localised increases in vehicle movements at the southern and northern tunnel portals, and construction vehicles would continue to utilise the haul route following the route alignment, the impact from dust emissions on the sensitive residential properties and ecological receptors identified in the baseline text would be greatly reduced. Whilst there may be localised adverse impacts to air quality through dust generation and vehicle movements in relation to excavation and construction of the vent shafts at the potential adverse impacts would be less than those predicted in the baseline option at these locations. Overall this option is considered to be a moderate improvement compared to the baseline option.	+ +
		Operations		No air quality impacts are expected to occur during the operational phase.	0	No air quality impacts are expected to occur during the operational phase.	0
	Sound and vibration	Construction	SV-1 SV-2 SV-4	Direct construction noise and/or vibration impacts have been identified at nearby receptors, as follows: • Construction vibration: Approximately 47 dwellings between Whitmore Heath and Madeley, as a result of short duration surface construction activities. No significant construction vibration effects were identified primarily due to the short duration of the works (less than 1 month); and • Construction noise: Approximately 50 dwellings between Whitmore Heath and Madeley due to the construction noise associated with earthworks, tunnelling and tunnelling support works. A likely significant construction noise effects were identified at Bar Hill and Whitmore Heath. Indirect construction noise impacts have been identified at following receptors: • Minor impacts on approximately 90 dwellings on Manor Road and Bar Hill; • Moderate impacts on dwellings on approximately 10 dwellings on Bent Lane; and • Major impacts on dwellings on approximately 25 dwellings on Snape Hall Road. Impacts have also been identified at Hey House (Edland Kennels / Cattery).	0	The removal of surface works between the Whitmore Heath and Madeley tunnels is likely to remove the vast majority of the construction noise and vibration impacts. It is estimated that construction noise impacts (approx. five) would remain close to the southern portal of the Whitmore tunnel and the northern portal of the Madeley Tunnel. The likely significant construction noise effects at the communities of Bar Hill and Whitmore Heath, and at Edland Kennels / Cattery would be removed. The indirect construction noise effects on Manor Road, Bar Hill Road, Bent Lane and Snape Hall Road would likely be removed as a result of this option. The highest traffic flow on the A53 Newcastle Road marginally increased from the baseline option, although the construction duration is extended so no construction noise impact is likely on this route given the existing flows.	+ + +

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with t‖2LJ2åŠŘ {ŮKŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - t‖2LJ2åŠŘ {ŮKŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
	Sound and vibration	Operations		The direct operational ground-borne noise and vibration impacts have been identified at following locations: • High, medium and low ground-borne noise impacts on eight properties above the tunnel at Whitmore Heath. Three out of these eight properties are predicted to experience levels greater than the significant observed adverse effect level (SOAEL) due to groundborne noise. A community significant effect is also identified; and • Minor groundborne vibration impacts at six properties above the tunnel at Whitmore Heath. The direct operational noise impacts have been identified at following locations: • A minor impacts on approximately five dwellings in Whitmore and Madeley; • A moderate impact on approximately 11 dwellings in Madeley; • A major impact on approximately 10 dwellings on Snape Hall Road in Whitmore Heath, Hey House and Bar Hill in Madeley; • Impacts at non-residential receptors: Hey House (Edland Kennels/Cattery) and Madeley Cemetery; • Likely significant operational noise effects are identified at the communities at Whitmore Heath and Bar Hill.	0	The vertical alignment of this option is deeper (>10m) under Whitmore Heath, and it is likely (subject to analysis), that this option would materially reduce the groundborne noise and vibration levels at properties above the tunnel. It is likely that the properties where the predicted groundborne noise levels in the baseline option are greater than SOAEL would be reduced below SOAEL and potentially the community significant effect removed. It is likely that the minor groundborne vibration effects would be removed. Significant operational noise impacts at properties in Whitmore and Bar Hill, Madeley would be removed. Similarly, significant operational noise impacts at Hey House (Edland Kennels/Cattery) and Madeley Cemetery. No operation impacts are anticipated as a result of the operation of the vent shafts.	+ + +
	Community integrity	Construction	CO-1 CO-2 CO-3 CO-4 CO-6 CO-8 CO-9 CO-12	Construction works to the A53 Newcastle Road (associated with construction of the Whitmore Heath tunnel) would temporarily require land within four residential properties on the A53 Newcastle Road. Moderate adverse significant in-combination effects to 29 residential properties due to their proximity to construction works associated with Whitmore Heath Tunnel and works to the A53 Newcastle Road; Construction works to Snape Hall Road would require land within 4 residential properties. 20 residential properties on Manor Road in Madeley Park Wood and Madeley would experience major adverse in-combination effects (noise, HGV and visual) as a result of construction activities associated with construction between Whitmore Heath tunnel northern porous portal and Manor Road overbridge. Construction works to Manor Road (realignment and overbridge) would permanently require a small area of land at Manor Farm Cottage and the Unreal Paintball community facility. Construction of the Manor Road diversion and Manor Road overbridge would have major adverse significant in-combination effects on Madeley Cemetery. Construction would require demolition of a residential property at Hey House Lodge and two residential properties on the A525 Bar Hill Road. Construction would temporarily require small amounts of land from Hey House and from a property on the A525 Bar Hill Road. The Proposed Scheme would permanently require a small area of land from another property on the A525 Bar Hill Road and from four residential properties at Moor Hall Farm (this resulting in minor adverse community effects). Construction works associated with the Madeley Tunnel (including the Madeley south tunnel portal and the associated facilities), Madeley cutting and works to the A525 would have major adverse in-combination effects on 43 residential properties on the A525 Bar Hill road (4 of which are on Mallard Close). The properties would also experience adverse visual effects as a result of construction of the Madeley bridleway 1 green overbridge and the Bar Hill aqueduct.	0	The relocation of Whitmore south tunnel portal to the south of the A53 Newcastle Road and the removal of design features between the tunnel portals removes adverse impacts to the residential properties between these features (land take and in-combination impacts), with the exception of the residential properties (approx. 5) close to the southern portal of the Whitmore tunnel and near the northern portal of the Madeley tunnel. Snape Hall Road would remain open to traffic with this option, reducing impacts from transport severance and maintaining existing recreational use for walking in the area. Manor Road diversion and Manor Road overbridge are removed, removing land take impacts associated with these features (Manor Farm Cottage and Unreal Paintball). Construction impacts are likely to remain on Madeley Cemetery, and may remain at Hey House and Hey Lodge House due to its close proximity to the area required for construction of the north vent shaft, however they are likely to be reduced compared to the baseline. This option removes three residential demolitions between the tunnel portals.	+ +
		Operations		The operation of the Whitmore Heath tunnel (including the Whitmore north tunnel portal) would have major adverse in-combination effects (visual and noise) on seven residential properties on Snape Hall Road in Whitmore Heath. The operation of the Lea North embankment, Manor Road realignment and the Madeley cutting would have permanent major adverse in-combination effects (noise and visual) on Madeley cemetery. 14 residential; properties on the A525 Bar Hill Road, would experience permanent major adverse in-combination (noise and visual) effects due to operation of Madeley cutting, A525 Bar Hill Road realignment, Madeley Tunnel including the Madeley tunnel north and south portal.	0	Removal of above ground works removes operation in-combination impacts (noise and visual) on residential properties on Snape Hall Road in Whitmore Heath and on properties on the A525 Bar Hill Road. .Operation impacts on Madeley Cemetery would also be removed, The removal of the Whitmore northern portal would remove the major adverse in-combination effects (noise and visual) on seven residential properties on Snape Hall Road in Whitmore Heath. The removal of the Madeley cutting, A525 Bar Hill Road realignment, Madeley south tunnel portal removes major adverse in-combination effects to the 14 residential; properties on the A525 Bar Hill Road.	+ + +

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tŭ2LJ2ăŜŘ {ŮKŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tŭ2LJ2ăŜŘ {ŮKŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
Creating sustainable communities	Transport accessibility / severance	Construction	TT-3 TT-4 TT-9	The Proposed Scheme required the following temporary impacts at Whitmore Footpath 4 diversion, Whitmore Footpath 6 diversion, Madeley Bridleway 1 diversion and Madeley Bridleway 5 diversion. The main ES reported major adverse effects on both the A53 and the A525 due to increases in traffic. Peak construction traffic on the A53 Newcastle Road (between Madeley Road and Holly Bush Lane) 508 HGV's and 618 all vehicles two-way. The A525 Bar Hill Road 522 HGV's and 594 all vehicles two-way. Peak import/export construction traffic from the transfer node located on the A53 of 568 HGV's and the transfer node on the A525 of 174.	O	This option removes a number of construction compounds between the tunnel portals which would reduce peak construction traffic in the area. The transfer node located on the A53 (A53 Newcastle Road transfer node - TN-232) would reduce the peak HGV movements by approximately 35% and the transfer node located on the A525 (Madeley Tunnel south transfer node - TN-237) by 30%. The total HGV construction vehicles at the transfer node located on the A53 Newcastle Road increases by 16% and reduces at the transfer node located on the A525 Bar Hill Road by 30%. It is likely that the reported major significant effects for both the A53 and A525 would remain. .Whist the proposed amendment reduces the peak construction traffic the residual peak construction traffic would still exceed the threshold for a significant effect when compared to baseline. Due to the construction area being reduced but still following the line of the tunnel the diversions of the footpaths would still likely be required, but the lengths may be reduced.	+
		Operations		The Proposed Scheme required the diversion/realignment of the A53 Newcastle Road, Whitmore Footpath 6, Manor Road, Madeley Bridleway 1, A525 Bar Hill Road, Madeley Footpath 24 d and the Madeley Bridleway 5. Snape Hall Road closure.	O	The following diversions are not required producing a major improvement from the baseline option in this area: • A53 Newcastle Road; • Snape Hall Road closure • Manor Road; • A525 Bar Hill Road; and • Madeley Bridleway 1 Only Madeley bridleway 5 diversion remains unchanged to the north of the A525 Bar Hill Road which is impacted by the Checkley North embankment.	+ + +
	Health, wellbeing &	Construction	N/A	Neighbourhood quality The construction of the Whitmore Heath tunnel north portal and the satellite compound and logistics area would temporarily impact neighbourhood quality on the north side of Whitmore Heath. Construction activities would be visible from Snape Hall Road and some properties, and construction noise would be noticeable across the village. HGVs would be present on Common Lane, Snape Hall Road and Heath Road. Snape Hall Road would also be affected by widening works. The closure of Snape Hall Road on the north side of Whitmore Heath and the widening of Snape Hall Road on the west side of the village would permanently change the layout and visual appearance of the area. Outside space from three properties would be permanently required for the widening of this road. The temporary and permanent impacts of construction would adversely affect wellbeing through changes to the rural character and tranquillity of Whitmore Heath. Temporary road diversions, haul roads, road widening and utilities work would directly impact outside space at properties in Whitmore and Whitmore Heath (three properties in Whitmore Heath, three on the A53 Newcastle Road, two on Three Mile Lane in Whitmore and one on Common Lane). Residents are likely to experience reduced levels of satisfaction with their living environment. In Baldwin's Gate and Whitmore, HGVs would be present on the A53 Newcastle Road. Residents are likely to experience reduced levels of satisfaction with their living environment. The construction of the Lea South embankment would be visible from properties on the east side of Madeley Park Wood and construction noise would be noticeable in this area. HGVs would pass along Manor Road on the west side of Madeley Park Wood. Residents are likely to experience reduced levels of satisfaction with their living environment and concerns about road safety. To the south of Madeley, construction of the Madeley cutting, Madeley tunnel and the A525 Bar Hill Road realignment would take place in proximity to 9 residential properties on Bar Hill, as well as Moor Hall Farm and Bower End Farm, and the allotments on Manor Road. The works would be highly visible from these areas and construction noise would be noticeable. HGVs would be present on Manor Road and Bar Hill. Residents on Bar Hill and the south side of Madeley are likely to experience reduced levels of satisfaction with their living environment and concerns about road safety during construction. Madeley cutting, Madeley tunnel portals and the A525 Bar Hill realignment would be in proximity to properties on Bar Hill, permanently impacting on neighbourhood quality in this area. Residents are likely to experience reduced levels of satisfaction with their living environment.	0	The relocation of Whitmore south tunnel portal to the south of the A53 Newcastle Road, and the removal of design features in the baseline design between the tunnel portals would result in the removal of the following health effects: • Removal of the majority of temporary and permanent neighbourhood quality impacts at Whitmore Heath. The upgrade and widening of Snape Hall Road would remain but the scale and duration of these works would not give rise to any adverse wellbeing effects associated with neighbourhood quality; • Removal of adverse effects on wellbeing resulting from direct impacts on outside space at residential properties on the A53 Newcastle Road, Three Mile Lane in Whitmore and Common Lane; • Removal of all temporary and permanent neighbourhood quality impacts, and associated adverse effects on wellbeing, at Madeley Park Wood; • Removal of the majority of temporary neighbourhood quality impacts along Bar Hill and the south side of Madeley. Impacts from HGVs on the A525 Bar Hill and haul road would remain. Overall adverse effect on wellbeing associated with neighbourhood quality impacts would be reduced / removed; and • Removal of all permanent neighbourhood quality impacts, and associated adverse effects on wellbeing, along Bar Hill and the south side of Madeley. There would be no change to impacts on social capital and associated effects on wellbeing. The proposed option would not result in any new health and wellbeing effects.	+

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tŭ2LJ2ăŜŘ {ŷKŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tŭ2LJ2ăŜŘ {ŷKŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
	equality	Operations		The noise and visual impacts of passing trains would be noticeable in the northern parts of Whitmore Heath and Snape Hall Road, properties on the east side of Madeley Park Wood, and properties on Bar Hill and Red Lane on the south side Madeley. These impacts would reduce the sense of rural character and tranquillity. Residents are likely to experience reduced levels of satisfaction with their living environment. Health burden of noise is assessed across the Proposed Scheme as a whole. Impacts for individual Community Areas are not presented in the ES.	0	The relocation of Whitmore south tunnel portal to the south of the A53 Newcastle Road and the removal of the above ground rail alignment up to and including the Madeley south tunnel portal would result in the removal of the following health effects: • Removal of neighbourhood quality impacts resulting from the noise and visual impacts of passing trains at Whitmore Heath, Madeley Park Wood and Bar Hill / Red Lane on the south side of Madeley; and • Removal of receptors in Whitmore Heath, Madeley Park Wood and Bar Hill, as well as individual rural properties, from the route-wide assessment of the health burden of noise from operational trains. This would reduce the overall of train noise on the health of the population at route-wide level.	+
	Socio-economic factors	Construction	SE-1 SE-2	Direct effect (although not significant) on the Unreal Paintball business as a result of the alignment and associated works to the east of Manor Road; however the nature of the use makes it unlikely that the business activity would be disrupted sufficiently to require the relocation of the activity.	0	With this option the direct impact on the Unreal Paintball business would be reduced (as a result of reduced land take). There may be worsened indirect impacts around the southern portal as the revised construction method results in an increase in HGV movement along A53 Newcastle Road as there is a sensitive receptor (The Mainwaring Arms -pub) located on this road. There are few receptors in the location of the northern portal and therefore no additional impacts identified. There is a sensitive business (committed development for two holiday lets) within proximity to the works. However, the works are relatively small scale compared to the baseline option and therefore no additional indirect effects are foreseen.	+
		Operations		No socio economic impacts are expected to occur during the operational phase.	0	No socio economic impacts are expected to occur during the operational phase.	0

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with tll2LJ2âŠR {ÔKŠYŠ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - tll2LJ2âŠR {ÔKŠYŠ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
	Planning Policy	Construction	N/A	The Proposed Scheme does not interact with any committed developments. The land required is close to 10/00108/FUL an application conversion of redundant barn to single dwelling and two holiday lets.	0	The land required is moved further away from 10/00108/FUL, however development is deemed viable for the baseline option. Therefore this option is considered neutral to baseline.	0
		Operations					
	Committed Developments	Construction	N/A	Within an area of landscape restoration, landscape maintenance and greenbelt.	0	Within an area of landscape restoration, landscape maintenance and greenbelt, therefore considered neutral to baseline.	0
		Operations					
	Agriculture, soil & land use	Construction	AS-1 AS-2 AS-3	Between the southern portal of the Whitmore Heath Tunnel, and the northern portal of the Madeley tunnel, the Proposed Scheme would affect 18 farm holdings. Of these, four holdings would experience major adverse temporary effects during construction and a further two experiencing major/moderate adverse temporary effects during construction. Of these, it is unlikely that Baa Hill Farm would be able maintain its viability of the farm shop through this construction period. In terms of permanent construction effects, eight farm holdings would experience significant adverse permanent effects. Of these, Snape Hall Farm would continue to experience a major adverse effect, with three others experiencing major/moderate adverse effects. The Proposed Scheme would temporarily require approximately 134ha of best and most versatile agricultural land in Grades 2 and 3a, which has been assessed as a minor adverse effect within the context of agricultural land quality in the area, which is not significant. The Proposed Scheme would permanently require approximately 63ha of best and most versatile agricultural land in Grade 2 and 3a. This is also assessed as a minor adverse effect, not significant. The Proposed Scheme would require approximately 24ha of woodland, of which 6ha is from the ancient woodland at Whitmore Wood, which is commercially managed.	0	This option would affect 14 farm holdings temporarily during construction, of which five holdings would be likely to experience significant adverse effects. These are Whitmore Hall Farm and Bower End Farm at the southern and northern portals respectively, which would experience increased adverse effects from intensification of construction work in these areas, Netherset Hey Farm which continues to be affected by the proposed borrow pit, and Snape Hall Farm and Manor Farm which are high sensitivity dairy units affected by land required and severance. In terms of permanent construction effects, this option would affect eight holdings (although this is greatly reduced compared to the baseline option): two at each tunnel portal, two affected by the vent shafts, and four which are affected by widened access roads, balancing pond etc. Of these holdings, Whitmore Hall Farm and Bower End Farm at the tunnel portals would continue to experience adverse effects. The area of best and most versatile land temporarily required by this option would be less, however still substantial due to the large areas required at both tunnel portals, construction compounds and at the vent shafts. Given that the baseline option, which has a larger agricultural land requirement with similar proportions of best and most versatile land, does not give rise to a significant adverse effect, it is assumed that this option would also not have a significant adverse effect, either temporarily or permanently. This option would substantially reduce the area of woodland required; in particular it would not affect Whitmore Wood.	+ + +
		Operations		No agricultural impacts are expected to occur during the operational phase.	0	No agricultural impacts are expected to occur during the operational phase.	0
Sustainable consumption and production	Land quality	Construction	LQ-1 LQ-6	The Whitmore Heath Tunnel traverses below a gravel pit of unknown depth at Whitmore Heath (site 4-5) and a secondary gravel pit is located 50m south-west of the tunnel (site 4-4). The materials placed back into the former pits are likely to be variable, poorly compacted and are unlikely to be documented. No formal landfill is recorded with the exception of site 4-62 detailed below. Remediation may be required if significant contamination is encountered in this area. A historical landfill (site 4-62) is located 170m south-west of the tunnel in the area of Whitmore Heath. The landfill presents a potential risk to sensitive receptors during the construction phase, due to the potential for the migration of contaminated groundwater or gases. The risks presented may extend beyond the boundaries of the landfill site. The WCML is traversed by the River Lea viaduct. Contaminants associated with railway land are potentially present and could be disturbed by the foundation excavations for the viaduct and migrate laterally to adjoining land. A former garage (site 4-72) is located 40m south-west of the tunnel Madeley Tunnel, where the route goes into cutting. Some residual hydrocarbon contamination may be present. A prehistoric burial ground (site 4-63) is 50m south-west of the tunnel. The tunnel traverses below an infilled pond (site 4-56). Several infilled ponds and a former pit are also in the vicinity. The materials used to backfill ponds are likely to be variable, poorly compacted and are unlikely to be documented In the vicinity of the Madeley northern tunnel portal, there are two historical landfills located at Beechfields Farm (site 4-65) and Bowerend Farm (site 4-66), which are located at the edge of the land required for the Proposed Scheme. The landfill presents a potential risk to sensitive receptors during the construction phase, due to the potential for the migration of contaminated groundwater or gases. The risks presented may extend beyond the boundaries of the landfill site. A section of the Proposed Scheme in this area is within Mineral Safeguarding Areas (MSA) for sand and gravel. No significant effects are predicted.	0	No potential contaminative sites have been identified directly at the southern or northern porous tunnel portals. However there are two historical landfills located either side of the routeat Beechfield Farm Landfill (site 4-65) and Bowerend Farm Landfill (site 4-66), 200m south and 430m south-west, respectively, of the northern portal and one historical landfill Whitmore Heath Landfill (site 4-4) 1.2km north-west of the southern portal. Along the length of the tunnel, the tunnel works would be deeper than the baseline option, particularly in the River Lea central section where cuttings, viaduct and embankment are proposed. Increasing the depth of cover to the tunnel reduces the risk of contamination migration. The two shafts do not intersect with any potentially contaminative sites. Dewatering for the tunnel at its northern end has the potential to intercept contaminated groundwater and gases associated with the two historical landfills located at Beechfields and Bowerend Farms. Similarly dewatering at the southern end may intercept contaminated groundwater and gases from the historical landfill at Whitmore Heath. No sites directly in the area of the southern vent shaft however the WCML lies 90m west (site 4-39). No sites directly in the area of the northern vent shaft. Manor Road Cemetery is 100m north-east (site 4-18). A former pit is 350m south (site 4-2). Kennel buildings lie 350m southeast (site 4-17) at Hey House. The northern vent shaft is located in an MSA for sand and gravel. Therefore construction could result in the extraction of minerals, which entails a very minor additional impact on the MSA.	+
		Operations		The tunnels beneath Whitmore Heath and Madeley have the potential to act as a sink, which could potentially draw groundwater that might be contaminated into the tunnels. Gases from contaminated sites may also potentially collect in the tunnels.	0	The tunnel has the potential to act as a sink, which could potentially draw groundwater that might be contaminated into the tunnel. Gases from contaminated sites may also potentially collect in the tunnel. The water pumped from the sump, at the lowest point of the tunnel may require treatment. The water pumped from the pumping station, at the lowest point of the tunnel may require treatment if there is ingress of contamination.	-

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared t|2LJ2âŠŘ {ÔKŜYŜ			
Request number(s)							
OPTIONS CONSIDERED:				Baseline - t|2LJ2âŠŘ {ÔKŜYŜ		Option L1 - Single Tunnel	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING
	Waste & material resources	Construction	WM1 and WM2 apply. WM3, WM4 and WM5 would apply once construction work commences. Whilst attaching the WM1 and WM2 EDAs to the sift (as these cover design work) these EDAs were drafted on the basis of waste being managed route-wide and at the level of individual design elements may be less applicable.	Construction of the tunnels and connecting viaduct would produce excavated material and construction waste such as concrete, steel and packaging materials. Excavated material and construction waste would be managed in accordance with designing out waste principles and the waste hierarchy to minimise waste requiring off-site disposal to landfill.	0	The construction of this option would produce excavated material and construction waste such as concrete, steel and packaging materials. Its construction would avoid the need to construct other design elements such as the River Lea viaduct. The construction of this option would also avoid the need for highway diversion for the A53 and A525. The construction of this option also changes the vertical alignment, lowering a number of cuttings and shortening the Meece embankment. Any loss of embankment impacts on the reuse opportunities for excavated material. The construction of this option would produce approximately an additional 1.9 million tonnes of surplus excavated material, requiring off-site disposal to landfill, compared to the baseline option. The increased tunnel length may also lead to additional quantities of construction waste compared to the baseline option, depending on the extent of the 'off-set' afforded by avoiding construction of viaducts and highway diversions. In terms of overall assessment, there is an additional requirement for off-site disposal to landfill but that requirement is unlikely to have a significant effect on the baseline assessment. On this basis, the overall assessment for construction wastes is moderate worsening.	- -
		Operations	WM6	The tunnels would carry track and house ancillary infrastructure both of which would produce maintenance waste during the operation of the railway. Operational waste would be managed in accordance with the Waste Hierarchy to minimise waste requiring off-site disposal to landfill.	0	This option replaces a number of design elements but does not extend the length of track that would require maintenance. Therefore, the quantity of track maintenance waste produced is comparable to the baseline option. Similarly, for ancillary infrastructure and its associated maintenance waste. Operational waste would be managed in accordance with the Waste Hierarchy to minimise waste requiring off-site disposal to landfill. On this basis, the overall assessment for operational wastes is no change.	0
Safeguarding the environment	Major accidents and natural disasters	Construction	MAND-1	The assessment for major accidents and disasters was undertaken on a route wide basis. The following grouped risks scoped into the main ES are considered applicable to the construction and presence of the engineering elements at this location: o Train derailment or collision on West Coast Main Line (WCML); o Major road traffic accident; o Fire and/or explosion or release of harmful gas; o Flood event leads to release of stored construction related material; and o Collapse of or damage to existing structures. These risks were all shown to be managed to be ALARP (As Low As Reasonably Practicable) with embedded mitigation in place, and as such no significant adverse impact was identified.	0	Major accidents and disasters assessment is undertaken on a route wide basis and therefore no individual consideration of tunnel, southern vent shaft and northern vent shaft has been made. Discussions with other environmental topics covered within this sift suggest no new risks or receptors not already covered by the grouped risks of the main ES assessment have arisen as a result of this design change. Consideration of the Phase One design, where 'long tunnels' do exist, has determined that the construction and presence of elements risk is demonstrated to be managed ALARP via the projects risk management process, ensuring HS2 Ltd. achieve the authority to place HS2 into service. The HS2 development agreement between the government and HS2 Ltd. includes a commitment that "HS2 Ltd will design, build and operate the Railway to meet or better the performance standard of HS1, to reduce safety risks as low as reasonably practicable and in line with best current international practice". As such it can be determined that any specific 'long tunnel' risk generated by the Madeley to Whitmore long tunnel would be managed as per this agreement.	0
		Operations	MAND-1	The assessment for major accidents and disasters was undertaken on a route wide basis. The following grouped risks scoped into the main ES are considered applicable to the operation of HS2 at this location: o Train derailment or collision (both HS2 trains and Network Rail trains); o Major road traffic accident; o Collapse or significant movement of structures; o Fire and/or explosion; o Alteration of flood patterns during an extreme weather (flood) event; o Accidental drowning due to presence of balancing ponds; o Non-motorist falling from bridges, viaducts, cuttings etc., including potential electric shock due to contact with overhead line equipment; o Vehicle falling from overbridge or adjacent road; o Traffic incident involving non-motorists; o Emergency response activities impacts on environmental receptors; and o Electric shock due to exposure to live conductor/arcing etc. These risks were all shown to be managed to be ALARP with embedded mitigation in place, and as such no significant adverse impact was identified.	0	Major accidents and disasters assessment is undertaken on a route wide basis and therefore no individual consideration of tunnel, southern vent shaft and northern vent shaft has been made. Discussions with other environmental topics covered within this sift suggest no new risks or receptors not already covered by the grouped risks of the main ES assessment have arisen as a result of this design change. Consideration of the Phase One design, where 'long tunnels' do exist, has determined that the operation of the scheme and the risks caused by the presence of these elements is demonstrated to be managed ALARP via the projects risk management process, ensuring HS2 Ltd. achieve the authority to place HS2 into service. The HS2 development agreement between the government and HS2 Ltd. includes a commitment that "HS2 Ltd will design, build and operate the Railway to meet or better the performance standard of HS1, to reduce safety risks as low as reasonably practicable and in line with best current international practice". As such it can be determined that any specific operational 'long tunnel' risk generated by the Madeley to Whitmore long tunnel would be managed as per this agreement.	0

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				**Community Area CA4 - Whitmore Heath to Madeley**			
Option name and description:				**'Single Tunnel' between Whitmore and Madeley, compared t|2U2âŠŘ {ÔKŜYŜ**			
Request number(s)							
OPTIONS CONSIDERED:				**Baseline - t|2U2âŠŘ {ÔKŜYŜ**		**Option L1 - Single Tunnel**	
OPTION DESCRIPTION				**690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl**		**Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128**	
Key Sustainability Issue	**Topic**	**STAGE: Construction or Operation**	**Environmental Design Aim considered (incl. Topic and Ref no.) Comment**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**
				Overall Rating	**0**		**+++**
Reason for overall rating:						The overall environmental rating for option L1 is predicted to be major positive improvement on baseline. Environmental benefits derive from the removal of construction effects, the presence of the built scheme and presence of operating trains between the tunnel portals that were present in the baseline scheme. Between the portals, most landscape and visual, heritage, biodiversity and agricultural impacts along the tunnel's route would be removed. Notably there would be the retention of approximately 6.4ha of ancient woodland from Whitmore wood and other surrounding AWIS. There would be moderate surface water improvements from the removal of direct impacts on the River Lea. Air quality improvements due to the removal of many baseline construction compounds, above ground works and road realignments. Contaminated sites in the River Lea viaduct area would be avoided. The removal of surface works between the Whitmore Heath and Madeley tunnels is likely to remove the vast majority of the construction noise and vibration impacts. During operation it is likely that this option would materially reduce the groundborne noise and remove vibration levels at properties above the Whitmore tunnel. Demolition of three residential properties would be avoided The direct effects on a local business would be reduced. The avoidance of the closure of Snape Hall Road and reduced disruption on the A53 Newcastle Road, Manor Road, A525 Bar Hill Road and local PRoW would reduce impacts to community, health and wellbeing in the area. There would be a reduction to HGV movement along highways throughout the area apart from on the A53 Newcastle Road which would see an increase in peak HGV movement from the transfer nodes around the southern portal. There would be an intensification of construction activity around the tunnel portals. Construction would produce a predicted additional 1.9 million tonnes of surplus excavated material, requiring off-site disposal to landfill. This material would require increased HGV movement. There would be an increase in GHG and energy use during construction (this is balanced against the removal of embankments/viaducts to produce a minor worsening from baseline). There would be a worsening of groundwater impacts to the baseflow to the Meece Brook during construction plus the potential to impact groundwater quality at the Whitmore abstraction during operation. There would be a need to employ a greater number of pumps during operation to remove water from the tunnel and this brings possible contamination issues. On balance these negative aspects do not affect the major positive rating given to this option.	

Appendix I.2 Environmental Sift Matrix for the Single Tunnel				Community Area CA4 - Whitmore Heath to Madeley			
Option name and description:				'Single Tunnel' between Whitmore and Madeley, compared with CP3 as Baseline			
Request number(s)				EI-xx			
OPTIONS CONSIDERED:				Baseline - CP3 Design		Option L1 - Single Tunnel Shallow Under WCML	
OPTION DESCRIPTION				690m long Whitmore Bored Tunnel plus 238m long Cut and Cover Tunnel at CP3 (928m total length between tunnel eyes), then overground with viaduct across River Lea/WCML and 670m long Madeley Bored Tunnel. Track c/c spacing widens to 18m through each tunnel and is maintained at 18m c/c between the tunnels Drawings C861-ARP-CV-DPL-000-020029 to -020035 incl		Track vertical alignment lowered such that the south tunnel portal can be moved south of the A53. Northern portal in same position as for CP3 Madeley North Tunnel Portal. Track c/c spacing widened to 22m in tunnel. Porous portals 150m long. Tunnel depth is minimum safe cover under WCML. 2 shafts are required, one to the north of Whitmore Wood/south of the WCML and one near to Manor Road. Tunnel length between eyes 6700m. Plan:Profile sketch C861-ARP-RT-DSK-000-252021 Lift:Slew Report against 'Gecko' C861-ARP-RT-WKG-000-001003 List of surface features affected by Option: C861-ARP-HW-WKG-000-000128	
Key Sustainability Issue	Topic	STAGE: Construction or Operation	Environmental Design Aim considered (incl. Topic and Ref no.) Comment	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING	QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT	RATING

- - -	Major worsening on the Comparator Scheme
- -	Moderate worsening on the Comparator Scheme
-	Minor worsening on Comparator Scheme
O	Neutral / no change to Comparator Scheme
+	Minor improvement on Comparator Scheme
+ +	Moderate improvement on Comparator Scheme
+ + +	Major improvement on Comparator Scheme

Assumptions

General

- Changes in track alignment for the options in other CA's (3 and 5) have been considered but remain very small and the scope of this sift is largely confined to CA4 only.
- Power for driving TBMs is sufficient in current design and no extra power connections are needed for both options and therefore no changes to routewide power supply demands.
- Vent shafts are standard "worst case" design and would remain the same size and shape during operation.
- Tunnelling construction/operational lighting is the same as in Hybrid Bill design.
- Operational hours are as Hybrid Bill for tunnelling compounds.
- Routewide borrow pits locations remain as per Hybrid Bill.
- Worker numbers would remain the same as the baseline design.

Topic – Major accidents and disasters

- Assumptions and limitations as outlined in the main ES are still applicable.
- A review of the CDM register in relation to MA&D has not been possible at this stage of the sift. This should be undertaken following the option selection to ensure any new risks in the scope of MA&D are included in the original grouping of risks, and if not assessment is undertaken to demonstrate they are mitigated to be ALARP.
- Assumed that risks of a major accident and disaster caused explicitly by the presence of a long tunnel, not previously included within the assessment, would be managed via HS2 development agreement to be ALARP and in line with best practice.
- In the absence of detailed traffic modelling related to the sift (due at AP2), new risks associated with traffic are not expected to cause a new significant effect.

Cultural Heritage

- Construction work would physically impact all areas within the CCB.
- that ground settlement due to tunnelling (construction) and train activity (operational) are negligible over 300m from tunnel).
- Portal design (aesthetics) would not differ from current design.

Ecology

- The southern boundary of Whitmore Wood would not be encroached from the CCB/Haul Road and subsequent access road.

Water

- A viaduct would still be retained at Meece Brook so there would not be any change to channel morphology except for any localised channel realignment

Limitations:

General

- Changes needed to design to accommodate increased power supply for option L2 are out of scope of the environmental appraisal. This includes changes to ATS/ATFS and Viaduct widths further down the route.

Cultural Heritage

- Exact extent and depth of Palaolake (WHM083). Limitations include a low number of data points acquired to date. Therefore current understanding of palaeolake depths should only be taken as indicative.
- Understanding of full extent of vibration impact, due to a) level of ground settlement to occur and b) unknown condition of impacted heritage asset foundations. Therefore Scale of impact undeterminable.

Traffic and transport

- At present the level of detail doesn't allow the effect on construction traffic to be separated between the long tunnel options and vent shaft to be done.

GHG/energy use

- Traction emissions are reported at a route wide level and do not have the granularity to assess the operational impacts at specific locations along the Proposed Scheme.