Proposal for Northern Extension of Northolt Tunnel SIFT Report

Revision	Date	Issued for/Revision details	Revised by
P01	13.06.2014	Issued for review	HSF
P02	30.01.2015	Review and update to include HS2 comments	SS
P03	24.02.2015	Updated to include comments and Rail Systems info	AR
P04	26.02.2015	Updated following review	AR
P05	27.02.2015	Updated for final review	AR
P06	02.03.2015	Final	AR

Name	Data
FOI / EIR	None
Document type	Report
Directorate	London West Midlands
WBS	B320 & PE.06.57
Keywords	Colne Valley Viaduct, Northolt Tunnel, River Colne
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Employer's Lead Reviewer	Neil Cowie
Authorised for use	

London West Midlands

Northolt Tunnel Extension - SIFT Report

Contents

Page number

List of figures

List of tables

List of acronyms

DP	Delivery Partner
EIR	Environmental Information Request
FOI	Freedom of Information
PSC	Professional Services Consultant
PSF	Professional Service Framework

References

Title	Reference
HS2 Project dictionary	HS2-HS2-PM-GDE-000-000001
Style guide	HS2-HS2-CO-GDE-000-000001
HS2 – Route Development Appraisal Template	HS2-HS2-SA-TEM-000-000004 rev. P02
HS2 Route Development Procedure	HS2-HS2-SA-PRO-000-000007 rev. P04

1 Executive Summary

1.1.1 The options for extending the Northolt Tunnel reviewed in this report are similar to the options proposed on behalf of London Borough of Hillingdon (LBH) and described in their report titled '*HS2 Tunnel Extension: Reducing the Environmental, Social and Economic Burden in Hillingdon'* published in December 2014. An engineering review has been undertaken of the LBH options and are reported in a separate report.

1.1.2 This document presents an engineering review of an alternative proposal by the Colne Valley Community Forum to that outlined in the Hybrid Bill, which would replace the Colne Valley viaduct and its approaches between Ruislip and the M25 Motorway with a tunnel. This was requested in order to achieve a route that would cause minimal impact to the surface, recognising that the area included much rural amenity including the presence of a Site of Special Scientific Interest (SSSI), the Grand Union Canal and the associated mooring basin, the River Pinn and the River Colne itself. The construction and operational railway noise and the visual impact would expected to be reduced.

1.1.3 The proposal has been translated into an alignment option compliant with general high speed rail, fire and safety requirements and the HS2 Project standards. The review has shown that in order to provide adequate depth to the tunnel construction across the Colne Valley this length of tunnel would become co-incident with the adjacent Northolt and Chiltern tunnels. This would give an overall tunnelled length of some 34km extending from the southern portal of the Northolt tunnel to the northern portal of the Chiltern Tunnel at Mantle's Wood. The alternative option is illustrated on drawings that show the alignments and impact of the proposed works to the ground surface.

1.1.4 This report describes the process for the development of the alternative option and the associated SIFT exercise for the replacement of the Colne Valley Viaduct with a tunnel. The fundamental change comprises extending the Northolt tunnel beneath the Colne Valley, such that it connects with the Chiltern Tunnel at some point, not necessarily at the current south portal position just (inside) the M25. In doing so, the tunnel would pass beneath the lakes in the Colne Valley, the River Colne and the Grand Union canal, and depending upon the relative vertical positions, would impact upon them in varying degrees (discussed in this report).

1.1.5 It has been assumed that the 8800mm ID tunnels would be constructed using tunnel boring machines (as described in HS2 Information Paper D7: Tunnel Construction and Methodology). Inclusion of passive provision for the Heathrow spurs means allowance has to be made for the inclusion of turnouts. The turnouts would be included within caverns each capable of containing two divergent tracks, and the excavations required would therefore be of a significant size.

1.1.6 The following options have been assessed and compared against the Proposed Scheme as set out in the Hybrid Bill (an alignment requiring a viaduct over the Colne Valley):-

- Option B – a subsurface alignment to include a 700m long "Intervention Gap" (including space required for the portal hoods) which provides compliance with the European Technical Specification of Interoperability (TSI) 2014, including passive provision for the Heathrow spurs.
- Option C – as above, but without provision for Heathrow spurs.

1.1.7 The extension of the Northolt Tunnel under the Colne Valley would create around 4.3 million m^3 of earthwork in total. This material wold principally comprise Chiltern tunnel excavated material (no longer required for mitigation earthworks in this area) and the excavation material from the Intervention Gap as well as the new tunnel under the Colne Valley. Approximately 4.2 million m^3 of this would require disposal by road via the M25 from the construction compound adjacent to the Chiltern Tunnel south portal with the potential of additional environmental impacts depending on disposal locations.

1.1.8 Although the Environmental assessment concludes that Options B and C would avoid the majority of the above ground impacts identified in Option A during construction and operation, it is concluded that the Proposed Scheme as set out in the hybrid Bill is preferred, on the grounds of cost, programme implications, construction safety and traffic effects as a result of removal of tunnel excavated material.

2 Introduction

2.1.1 The London Borough of Hillingdon, HOAC and the Colne Valley Community Forum amongst other petitioners have asked HS2 Ltd. to consider an alternative proposal for a section of the London - West Midlands route at Colne Valley which would comprise a tunnel to pass beneath the River Colne and the Colne Valley lakes between Ruislip and the M25. This would be considered preferable by the community because it would address concerns for above ground disturbance from construction and would remove visual and noise impacts during construction and operation. In addition, it is recognised that the area includes much rural amenity including the presence of a Site of Special Scientific Interest (SSSI), the Grand Union Canal and its associated mooring basin, as well as the River Colne itself.

2.1.2 The hybrid Bill proposal for crossing the Colne Valley in Community Forum Area (CFA) 7 comprises a viaduct, 3.4km in length, located between chainages 26+000m and 29+400m (the Proposed Scheme). This proposed structure is positioned inside the M25 Orbital Motorway near the towns of Denham and South Harefield and passes through the southern sections of the Colne Valley Site of Special Scientific Interest (SSSI), as shown in Figure 5.1. The SSSI includes a number of disused gravel pits, which now form lakes, the Grand Union Canal, and the River Colne. The Viaduct connects the line of HS2 close to where it emerges from the Northolt tunnel, west of West Ruislip station, to the Chiltern tunnel portal south of the M25. The interface between the C222 Contract and the C221 Contract is at chainage 25+800m at the eastern end of the viaduct approach embankment, Structure 025-L1.

2.1.3 In the development of the railway alignment for the Proposed Scheme, passive provision has been made for a spur line serving Heathrow Airport, the alignment of which is shown in Figure 2.1.

2.1.4 The purpose of this report is to evaluate replacing the Colne Valley viaduct with a bored tunnel. The outcome of this review is that the only way to provide this additional bored tunnel is by making it co-incident with the adjacent Chiltern tunnel and Northolt Tunnel, due to limiting gradients on the railway alignment. Given that this would then create an effective 34km long tunnel the requirements of the 2014 European Technical Specification for Interoperability (TSI) have been considered in the development of the options. Drawings showing the assumed vertical alignment of an extended Northolt Tunnel under the Colne Valley and which form the basis of this assessment are included in Appendix A.

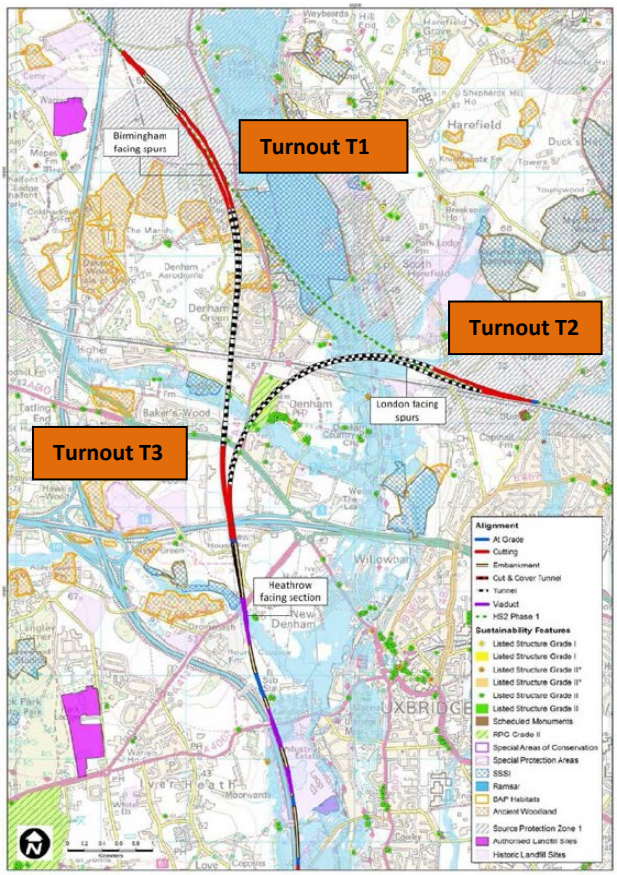

Figure 2.1 Provision for the Heathrow Spur

2.1.5 The Proposed Scheme position of the portal to the Northolt Tunnel at West Ruislip is located at chainage 23+480m as indicated on Map No. CT-06-018 from the ES Volume 2 mapbooks, CFA 6 South Ruslip to Ickenham. For Options B and C the inclusion of a tunnel to pass beneath the River Colne, and the associated vertical alignment requirements would remove the need for this.

2.1.6 The principal features of the alternative options are included in Drawing Nos C222-ATK-RT-DSK-020-011303 and C222-ATK-RT-DSK-020-011304.

2.1.7 Similarly, an environmental assessment of the northern extension of the Northolt Tunnel has been undertaken and is reported in C252-ETM-EV-REP-020-000116.

2.1.8 The evaluation has been undertaken in accordance with HS2 Route Development Procedure (HS2-HS2-SA-PRO-000-000007 rev. P07) and utilising HS2 – Route Development Appraisal Template document (HS2-HS2-SA-TEM-000-000004 rev. P03).

3 Scope of the Sift

3.1.1 The assessment of the possible alternative options (Options B & C) will comprise a comparison with different elements of the Proposed Scheme (Option A) in terms of engineering feasibility, environmental impact and cost.

3.1.2 The comparison scheme for the sift tables, drawings and costing is the Proposed Scheme as presented in the Environmental Statement and Hybrid Bill submission, and this comparison has taken into account the HS2 design requirements (civil and rail systems) and the geological conditions along the line of the proposed tunnel.

3.1.3 The Proposed Scheme for the Northolt tunnel, has an overall length of 13.4km. The baseline position of the west portal to the Northolt tunnel is at Ch 23+480m, from which point, continuing westwards, it enters a section of cutting and embankment at about Ch 25+900m and the commencement of the Colne Valley viaduct structure at Ch 26+000m. North-west of the viaduct, the alignment enters a further section of tunnel, the 13.3km long Chiltern tunnel, with its southern portal at Ch 31+363m.

4 Assumptions

4.1 General

4.1.1 It has been assumed that the Proposed Scheme horizontal (plan) rail alignment would remain applicable to the alternative options. The vertical alignment of the HS2 mainline is included as Drawing Nos. C222-ATK-RT-DSK-020-011301 and C222-ATK-RT-DSK-020-011302.

4.1.2 For Option B it is assumed that adequate passive provision for the Heathrow Spurs has been made through initial design of turnout caverns, however the alignment of the spurs themselves need not be designed at this stage. The horizontal and vertical alignments of the Heathrow spur connections to the mainline recognise the particular requirements of high speed turnouts and the need for the spur lines to pass either over or beneath the mainline tunnels. Note that the two profiles shown in red and blue (drawings 011301 and 011302) relate to whether the Heathrow spur tunnels indicatively run above or below the mainline (at this stage no preference need be expressed since passive provision only is required).

4.1.3 For Option B it is assumed that the spur tunnels would pass over or beneath the main running tunnels with a minimum clear separation of one tunnel diameter. Similarly minimum ground cover over the tunnel crown should be one tunnel diameter except beneath the lakes where this requirement would increase to a minimum of two tunnel diameters at this stage of design. Indicative vertical alignments are included as Drawing Nos C222-ATK-RT-DSK-020-011303 and C222-ATK-RT-DSK-020-011304.

4.1.4 It is assumed that the Option C rail alignment would be the same as that for Option B mainline, but that there would be no requirement for turnouts to form the Heathrow spur.

4.1.5 Options B and C would require ventilation-intervention shafts for the additional tunnelled length. Due to constraints on the locations of the shafts across the Colne Valley, the maximum distance between shafts would need to be in excess of the general requirement of 3000m, up to a maximum of 3200m. It is assumed that this is acceptable for this study, however this would need to be confirmed at detailed design stage. A key requirement would be the need for a shaft adjacent to Ickenham Auto Transformer Feeder Station (ATFS) to facilitate power supply to the railway.

4.1.6 It is assumed that a temporary connection to the railhead near Harvil Road would be designed for low speed and a maximum gradient of 3.5%, as is permissible within current HS2 design standards

4.1.7 It is assumed that access from the railhead to HS2 would be required in both directions.

4.1.8 It is assumed permissible to operate diesel locomotive hauled trains onto and along HS2 during construction and that suitable ventilation provision can be made within the tunnels. It is assumed that overhead line electrification equipment would not be required on the railhead connection, and it could be constructed to reduced clearances given it would be used by UK loading gauge rail vehicles (having accessed the line from Network Rail). A reduced rail to soffit height of 4500mm has been assumed, which is

representative of the maximum typical height of UK Loading Gauge rail vehicles on a non-electrified line.

4.1.9 It is assumed that the current Ruislip railhead connection would be temporary during construction and used for fit out of HS2 only; upon completion of the works the junction structure can be decommissioned and the connection removed. It is therefore assumed a permanent maintenance siding would not be provided for HS2 at this location.

4.1.10 It is assumed that an appropriate design can be provided for a traction power connection from Ickenham Auto Transformer Feeder Station (ATFS) to HS2 at rail level via the nearest ventilation –intervention shaft.

4.1.11 For a list of environmental assumptions please refer to C252-ETM-REP=020-000116.

4.1.12 It is assumed that cross passage spacing of 380m used in the Proposed Scheme for passengers to move from the incident tunnel to a place of safety and intervention shafts where rescue services can access the tunnels are at approximately 3000m centres satisfies the fire life and safety requirements for the additional tunnel options considered.

4.1.13 The key design criteria, included as Table 4.1, include particular requirements for the options.

Table 4.1 Key design criteria

Description	Criterion
Line speed in Chiltern and Northolt Tunnels	320kph
Line speed in Heathrow Spur Tunnel	230kph
Free cross-sectional area in bored tunnel	56m² per bore
Minimum gradient for tunnel drainage	0.5%
Geological Conditions Drawing No C222-ATK-GT-DPP-020-000031	The Northolt Tunnel Extension is expected to be driven through the Seaford and Newhaven Chalk Formations (LESE) largely and, possibly, in the deeper stretches the Lewes Nodular Chalk (LECH).
Particular features required, subject to detailed design	<u>For the 2014 Edition of TSI:</u> Additional intervention / ventilation shafts required at nominally 3000m centres. For compatibility with the Fire Safety strategy of the Proposed Scheme (which does not require a Special Safety Investigation for tunnels over 20km) 700m long open sections [500m plus 2No 100m long perforated portal hoods], to limit the maximum length of any tunnel to 20km.

4.2 Applicable Safety Standards

4.2.1 The planning for safety in tunnels has followed the recommendations of the Technical Specification for Interoperability relating to 'safety in railway tunnels' in the trans-European conventional and high-speed rail system. During the assessment period this

document has been re-drafted and some of the fundamental requirements have been updated/clarified.

4.2.2 The 2014 edition requires that a tunnel should have a firefighting point for a minimum of every 20 km and within the firefighting point there should be passenger access to a place of safety.

5 Constraints and Issues

5.1 Study Area

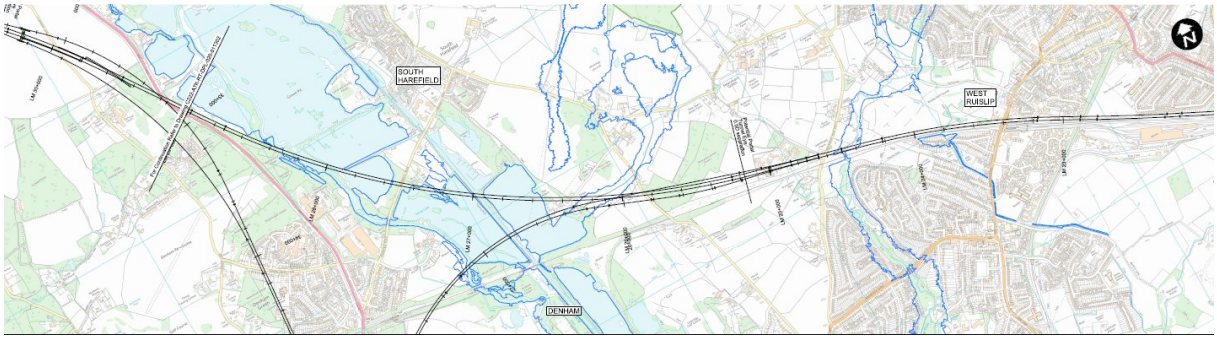

Figure 5.1 Location Plan – Extract of Drawing No C222-ATK-RT-DSK-020-011301

5.1.2 The study area extends from approximately Ch 22+800m at which point the vertical alignment of the proposed tunnel connection meets the Northolt tunnel to Ch 34+200m where it meets the Chiltern tunnel.

5.2 Site Constraints

5.2.1 The route of the scheme is intersected by or adjacent to the following physical elements which, depending on the option selected, may represent a constraint to development, although the "threat" differs between baseline surface and tunnelling options:-

- Lakes formed in the abandoned gravel pits (Ch27+000m to Ch29+000m), the depths of which are not known, but geological long sections suggest the base of the gravels, excluding any chalk solution or erosional features, are at approximately 30mOD;
- The Grand Union Canal (Ch27+000m), the construction of which may be critical, particularly where it runs immediately adjacent to / through the lake, and especially the canal lining type (whether puddle clay, concrete or other) and condition. The Canal and River Trust would be expected to advise on this, using archive drawings and local knowledge should a tunnel be introduced into this area;
- Moorhall Road (Ch27+500m);
- A footpath that follows the edge of the lakes;
- Sites of Special Scientific Interest (SSSI);
- The River Pinn.

5.3 Environmental Constraints

5.3.1 The proposed viaduct would cross through the Colne Valley, including the Colne Valley Regional Park, over the Grand Union Canal, the Mid Colne Valley SSSI, the River Colne and a number of lakes whereas the proposed tunnel alternatives would pass under all these areas.

5.3.2 The landscape in the Colne Valley is defined by the floodplain of the river and is largely agricultural, but the overwhelming influences are the lakes left from mineral workings. Further development has since occurred, and as a result there are some new structures and buildings in the area, particularly in the area around the possible tunnel Shaft F.

5.3.3 There is one Ancient Woodland within 50m of the HS2 centreline. There is one BAP Habitat within 50m of the centreline. The site is located within an SSSI and a further three SSSIs are within 2km of the centreline. The Colne Valley viaduct is partially within Source Protection Zones (SPZ) 1 and 2 and the proposed tunnel options would similarly pass through the same extent of the SPZ.

5.3.4 For further environmental details refer to Section 9.

5.4 Land and Property Constraints

5.4.1 Options B and C would require substantially different limits of land to the hybrid Bill limits. At this stage there are no known constraints that would prevent land acquisition and use under each of the options. Overall, a tunnel under the Colne Valley is likely to require less land-take, both temporary and permanent, than a viaduct solution. In particular, the Hillingdon Outdoor Activities Centre (HOAC) would not be affected.

5.5 Engineering Construction

5.5.1 In the broadest sense, the alternative proposal would entail the linkage of the two currently separate 8.8m internal diameter tunnels (the Chiltern and Northolt tunnels) to create a single tunnel, the overall length of which would be some 34km (excluding the requirements for the Heathrow spur). It should be noted that apart from the Channel Tunnel which is about 50km in length, such a length of tunnel would be unprecedented in the UK mainland for a transport facility and would be about the 7th longest rail tunnel in the world by the time it is constructed.

5.5.2 In order to accommodate the turnouts for the Heathrow spur, the form of tunnel construction would necessarily include for large span (>20m) cavern structures and a deep 700m long “gap” structure. Assuming that the ground around the caverns can be dewatered, they would reasonably be expected to be mined with a sprayed concrete temporary and permanent lining and with a waterproof membrane. The remaining length of the spur tunnels from the turnout would also be expected to be mined, in part at least, depending upon its overall alignment, length and the overall construction logistics for the whole tunnel and be waterproofed.

5.5.3 The inclusion of a 700m long trough structure, located in the area currently identified as the southern works area serving the Chiltern tunnel would aid tunnel construction. It would allow a point from which pairs of tunnel boring machines could be launched to both east and west, segments could be supplied, spoil managed and the system

serviced. Such a gap would also reduce the length of continuous tunnels to less than 20km as recommended by the TSI regulations, and thus keep similar fire and safety requirements as for the Proposed Scheme.

5.6 Rail Systems Construction

5.6.1 An extension of the Northolt Tunnel would create a tunnel of 34.6km in length. A tunnel of this length would create a number of rail systems issues that would need further investigation for resolution should either Option B or C be adopted.

5.6.2 The areas of the rail system that would be impacted by the extension of the tunnel would be:

- Tunnel Ventilation and Smoke Control.
- Traction Power requirements
- Journey Time
- Aerodynamics
- Rail safety
- Vent Shaft Spacing
- Maintenance

5.6.3 These areas and the issues are discussed in more detail in Section 6.6 of this report.

6 Option Description

6.1 General

6.1.1 This report considers the following design options:

- Option A – the Proposed Scheme as set out in the hybrid Bill and Environmental Statement;
- Option B – a subsurface alignment, including passive provision for the Heathrow spurs; and
- Option C - a subsurface alignment, without provision for Heathrow spurs.

6.1.2 The qualitative assessment against the SIFT criteria is contained in Section 7.

6.1.3 The options have been developed to address the following requirements:-

- Limiting the length of any section of the tunnel to 20km by inclusion of an Intervention Gap/Firefighting point structure;
- Including intervention / ventilation shafts at nominally 3km spacing and vertical re-alignment to minimise shaft and Intervention Gap/Firefighting points;
- Identifying the means of providing the turnouts for the Heathrow spur (Option B);
- Routing the Heathrow spur tunnels either over or below the mainline tunnels as necessary (Option B); and
- Temporary connection to the Chiltern Main Line railway for construction logistics.

6.1.4 The options identified have also been assessed to establish how they relate to the efficiency of construction planning, for example, from where to launch / retrieve the tunnel boring machines and service their activities.

6.1.5 An initial alignment for the option of tunnelling under the Colne Valley has been developed using minimum line gradients as shown on Drawing Nos C222-ATK-RT-DSK-020-011303 and C222-ATK-RT-DSK-020-011304, which indicate that a suitable configuration is feasible although it does require the linking of the Chiltern and Northolt tunnels. The alignment has been considered against the TSI recommendations, the influence of high speed turnouts, the limiting ground cover, the line speed variation between the mainline and the spur, the optimisation of shaft depths, and the alignment of the spur connection (where required). However, the implication of such requirements will be discussed in the following sections.

6.2 Intervention Gap Development

6.2.1 Given that the option of tunnelling under the Colne Valley would join up the Northolt tunnel and the Chiltern tunnel, the commencement of the alternative option tunnel would thus be in the east, at Ch 10+060m. The termination would be at the north end of

the Chiltern tunnel at Ch 44+635m, a total length in excess of 34km. Thus to limit individual elements of the tunnel to a length of 20km, the permissible envelope for the open excavation shall be within the section from Ch 24+635m to Ch 30+063m. Unfortunately, the section of the route through which the River Colne flows is from Ch 26+000m to Ch 29+400m which limits the possibilities for the open structure to two sections of length 1365m in the east and 663m in the west, located either side of the river, SSSI, canal and lakes. In addition, both of these positions appear to be coincident with high parts of the topography which means that the depth of the gap excavation would be in excess of 50m as shown at Section 30+400m on Drawing No C222-ATK-RT-DSK-020-011306, and would represent a considerable design and construction challenge.

6.2.2 It should be noted that the 20 km limitation is subject to a location of firefighting points according to the 2014 edition of the TSI, and it is possible that detailed design of tunnel safety systems could lead to a tunnel solution without a gap. In addition, it may be possible to limit the depth of excavation by lifting the alignment, although this would impact on the minimum required ground cover beneath the lakes, and thus increase the risk of adverse ground conditions affecting the tunnel drives.

6.2.3 A better solution, and that which has been adopted for the proposed alternative tunnel options, would be to use the Chiltern Tunnel Main Compound. This means that the extended Northolt Tunnel under the Colne Valley will slightly exceed the 20km length, and detailed appraisal would be required to validate this assumption. The position of the gap can be located in the flatter ground of the proposed southern works area, outside the SSSI, with the depth of most excavation limited to approximately 20m.

6.2.4 The provision of the Intervention Gap structure at the Proposed Scheme southern works area would also support the option for removing excavated material from both the Chiltern tunnel and the proposed alternative options, rather than creating an alternative enlarged ventilation shaft. The location of the gap structure allows room for temporary storage of excavated material within the Hybrid Bill limits.

6.2.5 This proposal has the additional benefit of being in a position which would allow access to public roads for construction and operational purposes, allow routes to track level to be developed without impinging on the Hybrid Bill limits, provide an option for launching the Tunnel Boring Machines (TBM) in both directions, and provide a route for servicing both the mined and bored tunnelling operations.

6.2.6 A consequence of Options B and C is that the Chiltern tunnel south portal would not be immediately adjacent to the M25 (as opposed to Option A) and the tunnel would be lower under the M25, reducing settlement risks.

6.2.7 Given the need for provision for the Heathrow spur (Option B) it is assumed that the “gap” would include turnouts T1, but in order to provide appropriate separation between the tunnel bores, the structure would need to be a tapered structure with a maximum of width of 70m, as shown in Drawing No. C222-ATK-RT-DSK-020-011306. However, it is anticipated that this could be reduced slightly with further development of the vertical and horizontal alignments and assessment of engineering impact. It should also be noted that for Option C (without provision for Heathrow Spur), the “gap” structure width would be reduced as the additional space for the turn outs would not be required. In the case where passive provision for the Heathrow spurs is not required, there is scope to raise the vertical alignment allowing a shallower gap structure, however this is beyond the scope of this report.

6.2.8 The design of the "gap" structure would require the inclusion of an access road from rail level to the surface rescue area. Given the depth of excavation, and the need to provide access from both portal structures, it would be anticipated that such a route would emerge from it centrally and approximately normal to the mainlines.

6.2.9 The form of the excavation would require either a retained cutting, an open cut with engineered side slopes through the chalk and groundwater control, or a combination of the two. For a retained cutting, the width of the excavation would preclude conventional propping and it is expected that ground anchorages would need to be utilised. It should be noted that the groundwater levels are currently assumed to be at a depth of about 5m below existing ground level, so the influence of water during construction and operation could be a significant constraint depending upon ground and flow characteristics. Permanent de-watering may be required.

6.2.10 Consideration should also be given to the probable negative impact of a major excavation on the principal chalk aquifer which is designated as Source Protection Zones (SPZ) 1 and 2 by the Environment Agency.

6.3 Provision for Heathrow Spurs - General

6.3.1 In respect to making an allowance for the Heathrow spurs there are three locations where the tunnel would need to include turnouts in order to access Heathrow Airport as shown on the plan in Figure 2.1, namely:-

- Turnout 1 (a and b) - on the mainline immediately east of the existing Chiltern tunnel,
- Turnout 2 (a and b) - on the mainline immediately west of the Northolt tunnel, and
- Turnout 3 - where the foregoing lines meet in turnout and crossover to continue towards Heathrow Airport. Note that Turnout T3 is not designed or costed for this report.

6.3.2 Section 6.2 identifies the connection details which are related to the requirements for a gap structure that would be located at Turnout T1.

6.3.3 The principal requirement for the turnouts is that they are included on straight sections of track. As such they dictate the horizontal and vertical alignment of the spur lines (from Birmingham at Turnout T1 and to London at Turnout T2) and whether they pass below or over the HS2 mainline. In both cases, the required vertical separation between the main and spur tunnels is assumed to be equivalent to one tunnel diameter. In the approach to the Turnout 3 the four lines are required to merge to form a twin track railway, by the inclusion of both turnouts and crossover.

6.3.4 It has to be recognised that high speed trains require matching high speed turnouts, and for these high speed turnouts the rate of divergent separation of the tracks is required to be at a ratio of 1:49, and the vertical alignment through the turnout is required to be flat. Generally, to operate the very long and heavy switch blade there would need to be multi-point motors and these would probably need to be accommodated within niches in the tunnel / cavern, and heaters would be required.

6.3.5 When these requirements are combined with the need for the alignment of the spur to fall / rise and arc beneath / above the mainline, a large span space may be required to accommodate the overall configuration. This space would be provided by a cavern excavated within the chalk, the dimensions of which may be significant with design and construction influenced significantly by the presence of groundwater.

6.3.6 For a fully tunnelled option (Option B) Turnout T2 would be located in a cavern at significant depth to suit the mainline rail alignment. It is expected that this cavern would be mechanically excavated and lined with a sprayed concrete lining. Two options are generally possible for the size and shape of this cavern:-

- To have one very large cavern, which would accommodate:
    - Entry of the two 8.8m ID bored tunnels;
    - Turnouts which diverge to both directions; and
    - Exit points for four 8.8m ID bored tunnels with a specified minimum separation.
- To have two smaller parallel caverns which, noting the 21m separation of the mainline tracks, should be achievable with a chalk rib of some 10m width between them. The rib condition and size would need to be assessed in detail to ensure that conditions of stability can be created, noting that the cavern would not be excavated by the tunnel boring machine but by “normal” excavators in a staged sequence.

6.3.7 The principal construction issue would probably be related to groundwater which is currently identified to be at a level of about +40mOD consistent with the surface level of the lakes. Construction of this cavern would be significantly at risk of any poor ground conditions at this location.

6.3.8 A further key concern with the cavern construction is that although relatively deep (40-50m to rail level) the cavern works would be in close proximity / underneath the pharmaceutical research facility with particular concerns over vibration impacts.

6.3.9 In order to minimise dimensions for the single cavern option, it would be required to optimise alignments by bringing the mainline tracks closer together. Even with this adjustment, such an option is unlikely to be feasible as for a minimum separation of 0.5xDiameter between tunnels, the cavern width would be in excess of 50m at the wider end.

6.3.10 For the twin parallel cavern option, T2 would require to include cavern structures of a height of 14m, a span of greater than 20m and a length of some 300m to accommodate the turnout. After this point the tunnels are separated by at least one tunnel diameter vertically as the alignment climbs over the mainlines as illustrated by the sections included as Drawing No. C222-ATK-RT-DSK-020-011305.

6.3.11 In the case of Turnout T1 the Option B issues are discussed in Section 6.2.

6.3.12 The line speed for the Turnouts T1 and T2 is currently 230kph but given the tight horizontal radius of curvature required it may be necessary to restrict the speed to 180kph which would impact upon journey time.

6.4 Development of Railhead Location - General

6.4.1 Close proximity of HS2 to the Network Rail Chiltern Main Line allows temporary railhead sidings to be constructed near to Harvil Road. This would give rail access to be utilised in construction of the mainline, enabling loading and unloading from trains delivering material to the site, and excavated material to be removed. The use of railheads is encouraged where practicable, as it provides a more environmentally friendly route for servicing the tunnelling operations in comparison to use of public roads, subject to sufficient train paths being available.

6.4.2 The connection to the Chiltern Main Line would be formed by linking to the northern end of the railhead. The sidings require flat gradient for 440m long sidings to accommodate 400m long trains, and therefore the point at which the railhead can start to descend into tunnel is constrained.

6.4.3 The connection from the railhead to HS2 would be in both directions. This would be feasible given that the chamber for the turnout connection is thought to be shallow enough to be constructed as an open cut until tunnelling is complete, at which point it would be covered and filled. If the chamber width is to be minimised by connecting the railhead in one direction only (provided in a southerly direction), engineering or construction trains accessing HS2 to the north of the turnout would be required to reverse direction of travel for some 5km, before reaching the “gap” structure where a crossover point is provided.

6.4.4 The location of the railhead would be governed mostly by the difference in level that is needed between the railhead sidings and HS2 rails. Two options were considered for locating the railhead, depending on where the turnouts were to be located.

6.4.5 Option 1 would locate the railhead sidings west of and under Harvil Road, at Ch26+100 (Figure 6.1). This would require a diversion of the road onto a new viaduct. The railhead would immediately descend at 3.5% (assumed maximum gradient for engineering trains) in a retained open cut adjacent to the Schering Plough Research Centre (MSD Animal Health Pharmaceutical Products Manufacturers), and then descend into tunnel underneath Breakspear Road and the River Pinn. Roughly 1 Diameter clearance can be provided above the tunnel under Breakspear Road, however the gradient would be at a maximum and it may be desirable to reduce this to create a shallower retained cut.

6.4.6 If the gradient is reduced, the clearance over the railhead would not be sufficient to begin tunnelling before reaching Breakspear Road. In this case, it would be possible to replace Breakspear Road deck with a slab (built incrementally, necessitating some degree of traffic management). The railhead can sit in a box structure underneath the road, with enough clearance from the rails to the soffit. This would therefore allow the retained cut section to be shallower, as the reduction in gradient raises the vertical alignment of the railhead.

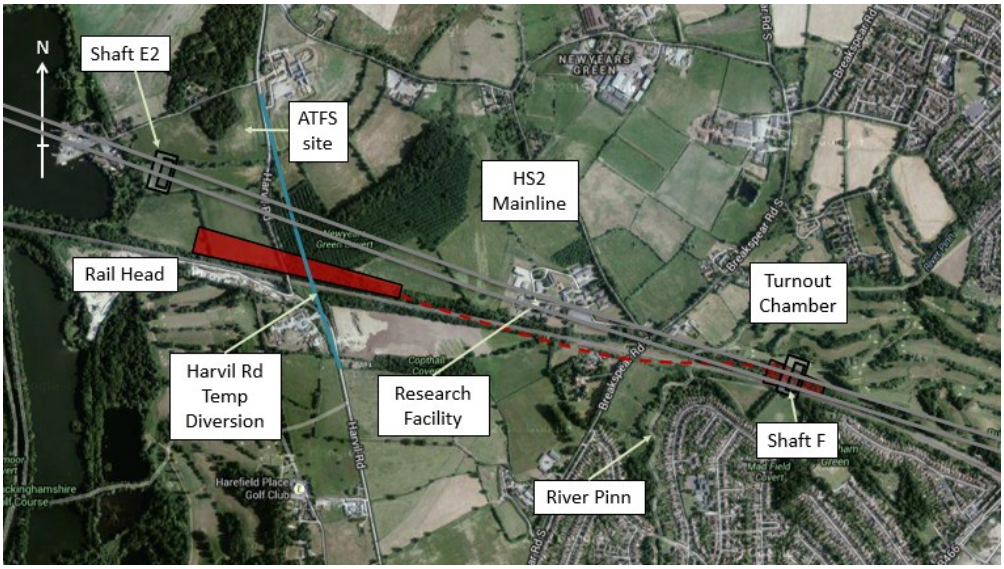

Figure 6.1 – Railhead Location West of Harvil Road

6.4.7 The turnout would be positioned at Shaft F (chainage 24+300m), which would require the construction of a chamber or box to accommodate it. The minimum clear spacing between tunnels at the entrance would be 0.5xDiameter (4.8m); this would give a total width at the wider end of the chamber of 35.6m (24m width at the narrower end). At approximately 20m below ground level, the chamber would more likely be constructed as open cut, and covered and filled on completion of the tunnels. This site would allow the construction of Shaft F to be combined with the turnout chamber, condensing the work sites to one location for both. However an additional chamber would be required for connection to the Heathrow spur should passive provision be included – this would be located just 1km to the west.

6.4.8 Locating the railhead sidings to the west of Harvil Road would encroach on land already reserved for the site of Ickenham Auto-Transformer Feeder Station (ATFS) (see Rail Systems Construction 5.6.1). This proposal would thus necessitate the relocation of the ATFS site to an open area adjacent to Shaft E2. This new site would be combined with that of Shaft E2, and would be likely to reduce the length of cables between the National Grid substation and ATFS in comparison to its current proposed position. Access to this site can be provided from Harvil Road directly.

6.4.9 Alternatively, the possibility of placing the railhead east of Harvil Road at Ch 25+200m was considered. This would require the sidings to continue at grade over Breakspear Road, over the River Pinn, and only then begin to incline at 3.5% maximum gradient into a tunnel which would connect to the mainline at West Ruislip, Ch 23+800m. This would involve construction of extensive temporary works such as bridges over the River Pinn and Breakspear Road, and the turnout would be adjacent to a large residential area close to West Ruislip station, which limits the availability of land to the south. It is considered that the tight spatial constraints mean that the maximum gradient of 3.5% cannot be achieved in the space available.

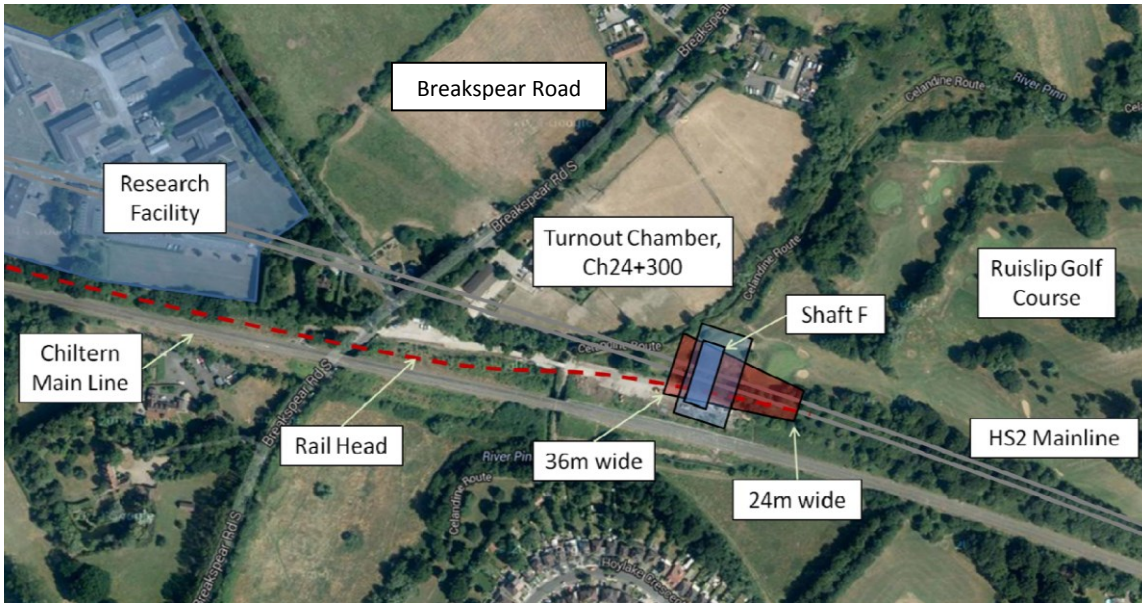

Figure 6.2 – Turnout Chamber

6.4.10 The availability of open space at Shaft F (Ch 24+300m) and the location of the railhead sidings to the west of Harvil Road indicate that this option would be the least intrusive and more easily constructed.

6.5 Development of Intervention Shaft Locations - General

6.5.1 For tunnelled railway, shafts shall be located at nominally 3km intervals to comply with the project requirements, although the particular influence of caverns would not be included at this stage. For this option, it is assumed that the following shafts currently included within the Proposed Scheme areas shall be fixed i.e.:-

- Chalfont St Peter Shaft, S1, at Ch 34+050m which serves the Chiltern Tunnel; and
- South Ruislip Shaft at Ch 20+740m which serves the Northolt Tunnel.

Ref	Chainage	Separation (m)	Location
CSP	34+050	-	Chalfont St Peter
GAP N	31+100	2950	700m "gap" structure
GAP S	30+400	-	
E	27+500	2900	On perimeter of SSSI, adjacent to Moorhall Road
F	24+200	3300	200m East of River Pinn
SR	20+740	3440	South Ruislip

Table 6.1: Initial Proposed Shaft Locations (Options B and C)

6.5.2 Located on a bench of land in between SSSI protected gravel pits, the initially proposed Shaft E would have been adjacent to a groundwater abstraction point. This is an extremely sensitive location as contamination to the abstraction point would be likely to occur during construction. The shaft would also fall within a SPZ1 site (Groundwater Source Protection Zone 1), which indicates that the groundwater source within this area is susceptible to contamination as it is within 50 metres of the water table. Contamination of the source could lead to unpotable water and may take a long period of time to remediate. Alternative shaft sites were therefore proposed.

6.5.3 To keep the spacing between shafts as close to 3000m as possible, two alternative shafts would be needed: E1 and E2 (Figure 6.3).

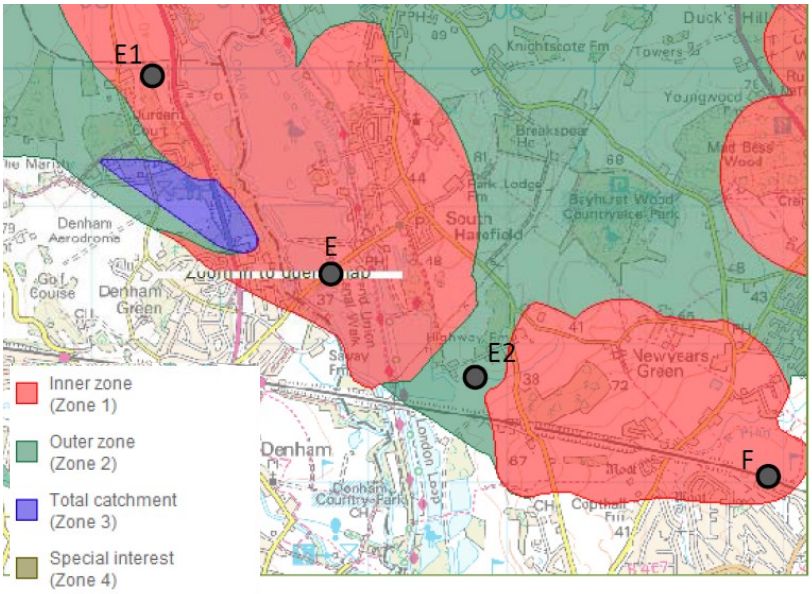

Figure 6.3 – Shaft Locations

6.5.4 Shaft E1, located at Ch 29+400m, would be situated in a field which is classed as 'woodland' according to the Environmental Baseline drawing for Colne Valley CFA07 (ref CFA7 map book, map CT-10-012), however it does not have SSSI protected status. The location of Shaft E1 would be constrained by the Heathrow spurs to the south (Figure 6.4). Shifting the shaft further east would either impinge on the A412 road or Ancient Woodland (Battlesford Wood), which also lies within a SSSI area. All possible locations for Shaft E1 are situated within a Source Protection Zone 1 (SPZ1), in a location likely to give concerns for the Environment Agency and licensed abstractors, Affinity.

Figure 6.4 – Shaft E1

6.5.5 Shaft E2 would be bounded by the Hillingdon Outdoor Activity Centre (HOAC) to the north (Ch 26+250m), and the East Heathrow spur (to the west). To limit the spacing between shafts, Shaft E2 would be placed as far north as possible without impacting on the HOAC. This location would also fall within a SPZ2 (Groundwater Source Protection Zone 2) site, which is more desirable than nearby alternatives within SPZ1. The shaft would also lie within a floodplain and may require flood defences. Under Options B and C, Ickenham Feeder Station could also be located at this site, which would give extra benefit to locating the shaft here.

6.5.6 The locations of the shafts, particularly when adjacent to or within the influence of bodies of water would need to be carefully selected. Depending upon the outcome, the connections to the tunnels, the depth of shafts, the requirement for 500m2 rescue areas, and their internal arrangement would need to be re-assessed for compliance at detailed design stage. In addition their architectural form, construction form, and constructability would be considered in further detail.

6.5.7 However, with the introduction of caverns necessary to accommodate the turnouts there would be a requirement to re-assess the overall fire life safety and ventilation strategy for this revised system of tunnels given the presence of two lines converging, i.e. there is a possibility of smoke being blown down both the incident bore and the bore forming the place of relative safety without some form of mitigation being in place.

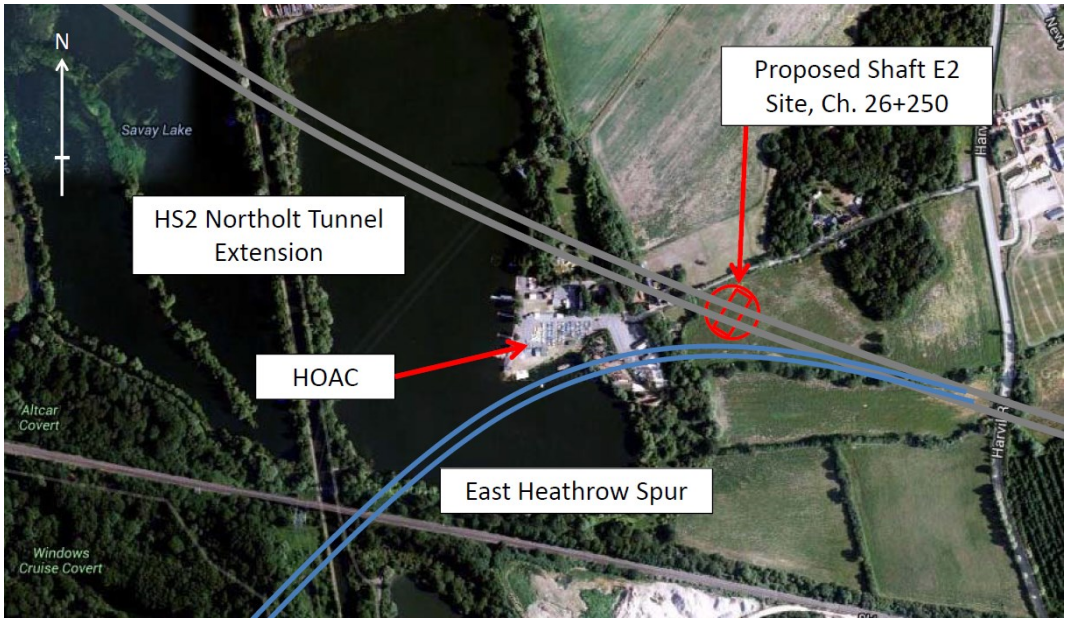

Figure 6.5 – Shaft E2

6.5.8 Shaft F, required for Options B and C, would be located near to the current proposed tunnel portal for the Northolt tunnel. It is proposed the shaft structure be combined with the turnout chamber required for the temporary railhead connection. This shaft would be the principal point from which the Northolt tunnel would be constructed.

6.6 Impact on Rail Systems

6.6.1 Tunnel Ventilation and Smoke Control

6.6.1.1 The rolling stock TSIs require a capability to operate for 15 minutes at 80 km/h, which implies a range of 20km. Consistent with this, rescue stations at a maximum spacing of 20 km would normally be considered. The rescue station would have the capability to provide a tenable environment for passengers in the event of a fire. This could be a subterranean facility, with local tunnel ventilation exhaust and supply, or an open facility. The proposal for an open rescue location is considered reasonable considering the shallow depth and lower complexity of a natural ventilation system.

6.6.1.2 The remainder of the tunnel ventilation system would be consistent with other HS2 tunnels and adopt longitudinal tunnel ventilation shafts at 2 to 3km spacing. The signalling system would allow one train to enter each tunnel bore between the ventilation shafts. The proposed shaft spacing of up to 3.2km is considered reasonable from a tunnel ventilation perspective, albeit the shaft spacing is irregular which may make airflow balances more challenging to achieve and may have an impact on signalling and ability to meet the train technical headway. Further detailed study would be required.

6.6.1.3 Tunnel heating is a key consideration for longer tunnels at these speeds. The aerodynamic resistance of long tunnels generates heat which is mitigated for by the cool air drawn in at the portal. Based on the prior analysis of 13.4km long Chilterns tunnel, it is considered likely that tunnels longer than 13km would cause temperatures to rise in excess of HS2's 35°C summertime criterion. Warmer tunnels may be acceptable depending on the degree, but could begin to have implications for maintenance workers and for the sizing of the rolling stock air conditioning. They could also affect the ability to control temperatures during train congestion and if too warm may affect tenability during any in-tunnel evacuation. The life of tunnel based equipment is also negatively affected by warm conditions. It is therefore likely that cooling would be required. Cooling could be by either relief air shafts integrated into the ventilation shafts, or by mechanical means, most likely from cooling pipes in tunnels. The use of relief air shafts may be possible, but the sizes required might cause micro pressure wave issues as the trains pass. Further detailed study would be required to understand whether a reasonable design could be developed to balance the needs of achieving cooling but minimising pressure waves. The shaft designs would need to change and potentially be larger to accommodate the optimised relief air paths. Without this analysis it is recommended to account for the need for cooling pipes near the portals, as adopted on the Channel Tunnel. Pipe loops, concentrated near the portals, would pass up and down the tunnels served by cooling plants served by air cooled chillers potentially located at the end most ventilation shafts.

6.6.1.4 The open firefighting point potentially allows for cool air to enter the second downstream tunnel, but careful design would be required to ensure that hot air from one portal can dissipate and cool air can be drawn into the second tunnel. If this cannot be achieved there may need to be localised extraction of the hot air at the rescue station. Regardless of the provision of ventilation, passive measures such as dividing walls extending some distance from each portal are likely to be required to prevent transfer of hot or smokey air from one bore to the other. Considering the overall length

of the tunnel, the fire authorities may request a special purpose vehicle at this location for more rapid tunnel access. Further consultation would be required on this matter.

6.6.1.5 The proposed caverns and turn-outs present significant challenges for the tunnel ventilation system. The spur tunnels are likely to require jet fans within them to both control smoke in the event of a fire in these tunnels, and also to manage the air leakage to and from these tunnels in the event of a fire in another part of the tunnel complex. There may also need to be jet fans at the turn-out cavern location. If at high level these would be a unique configuration and potentially challenging to maintain. The large cross sectional area of the turnout may make it impracticable to control smoke at this location. It may need to be accepted that smoke control can only be achieved in the connected tunnel bores and not the turnout. If this cannot be accepted options might include a ventilation tunnel constructed to connect to shaft E2 or F to provide location specific smoke extraction at this point. Sufficient time would be required to analyse the ventilation in detail and develop a working configuration. The design of the evacuation walkway would also need careful design with track crossings suitable for persons of reduced mobility a potential requirement.

6.6.1.6 The longer tunnels may affect air quality in the rolling stock. It may be necessary to shut off the outside (fresh) air to the rolling stock when in tunnels to prevent pressure waves affecting the pressure comfort of passengers. This loss of ventilation would cause carbon dioxide (CO2) levels to rise. Whilst the TSIs require a long-term safety exposure limit of 5,000 ppm, there are uncertainties in relation to general air quality at levels above 2,000ppm. Operational practice in aircraft usually results in 1,500ppm of CO2. Levels of around 2,000 ppm might be acceptable in rolling stock based on anecdotal evidence from other long tunnels. Levels between 2,000 and 5,000ppm present a risk in terms of general air quality. If the CO2 level could be controlled to 500 to 600ppm when leaving the stations (outside air is about 400 ppm), the in-car CO2 content may rise to around 2,000ppm at the end of the proposed longer tunnel for the case of 50 people per car. For a crowded car this would increase further and for slower train operations this could increase again. To achieve even 2,000ppm at the end of the tunnel potentially a supplementary rolling stock ventilation system would be required at the stations to provide a high capacity purge of the carbon dioxide down to a lower starting condition before the journey into the tunnels. It is known that some countries are considering actively controlled pressure ventilation for rolling stock that may allow some ventilation in tunnel when pressure waves were not near the train. Other countries are understood to have developed a specialised air supply system, possibly from a pressurised reservoir.

6.6.1.7 Further work would be required to develop mitigation for HS2, but at this time it is recommended to assume that some form of special measure would be required for the rolling stock. Such a special measure might only be achievable on the captive rolling stock, potentially affecting the ability for other rolling stock, including classic compatible rolling stock to operate in the longer tunnel without risks associated with pressure discomfort or poor air quality.

6.6.2 Operations

6.6.2.1 An assessment has been undertaken to determine the implications of journey time between the Hybrid Bill and the alternative proposal. The results are shown below and identify that there is a material difference, due entirely to tunnel resistance increases (*) due to a significant increase in air mass movement for the combined tunnel. Note also

that based on a review of available plots of train performance, this indicates that in the Down direction to Birmingham the train may not be able to reach the tunnel 320km/h speed limit. However, the tunnel resistance used for the modelling is considered worst case and potentially the journey time for the alternative proposal may be closer to the Hybrid Bill option. Further analysis would be required to fully understand the tunnel resistance so that the journey time can be accurately modelled.

(*) Tunnel resistance increases have been estimated on the basis of drag co-efficient increase due to the combined tunnel length increasing. Detailed analysis of this tunnel would be required to determine the exact effects.

	Time (hr:min:sec)		
Journey	**Hybrid Bill**	**Alternative Proposal(1)**	**Increase in Journey Time of the Alternative Proposal**
Old Oak Common to Birmingham Interchange	00:28:44	00:29:12	00:00:28
Birmingham Interchange to Old Oak Common	00:28:59	00:29:02	00:00:03

(1) Based on an assumed worst case tunnel resistance

Table 6.2 – Journey Time Assessment Results

6.6.2.2 There may be a potential requirement for a speed limit due to pressure waves generated when trains pass through the Heathrow spur cavern with likely impact to the signalling headway.

6.6.2.3 The impact on the operation timetable of this increase in journey time has not been assessed. The timetable may be able to cope with the increase in journey time from an emergency recovery perspective, but it is supposed to have this margin for only such purposes so any increase in journey time would impact the timetable robustness.

6.6.2.4 With the HS2 requirement for one train per vent shaft section, signalling headway was modelled for the alternative proposal to determine potential timetable constraints. The results concluded that there was no difference in the signalling headway compared to the Proposed Scheme.

6.6.3 Traction Power and Overhead Contact System

6.6.3.1 There will be an appreciable increase in traction power requirements due to the additional 8km of tunnel running and the effective increase in both Northolt and Chiltern tunnel lengths which result in increased train resistance forces. The adequacy of the currently proposed traction power system design in being able to support this increase in loading has yet to be assessed and presents an appreciable risk.

6.6.3.2 A particular issue would be that the current scheme has Ickenham ATFS (Auto Transformer Feeder Station) located adjacent to the open route portion. This has numerous high voltage cable connections between the ATFS and the overhead contact system for each of the two tracks. For the tunnelled alternative there would need to be cable shafts provided between the ATFS at surface and the tunnels or a surface cable route for c. 400m to shaft E2 and the shaft size increased to allow for the additional traction power cables.

6.6.3.3 There are factors related to the neutral sections in the overhead contact system in the area of Ickenham ATFS which would need further consideration. A neutral section is the arrangement of the overhead contact system where the source of power changes from one feeder station to another. Additional space is required at a neutral section which may be problematic to achieve and may require additional tunnel adits.

6.6.3.4 The associated relocation of Ickenham ATFS to the east side of the railway is dependent on sufficient land availability to accommodate the required feeder station and equipment layout which is not yet confirmed. In addition, as it moves the ATFS closer to the National Grid substation it potentially introduces the risk of hazardous voltage from electrical faults at the 275kV substation being transferred to the ATFS and railway, which is a risk that was not present for this site previously; this would be subject to further detailed evaluation.

6.6.3.5 The 700m long 'gap structure' would likely impact on the layout for the West Hyde ATS (Auto Transformer Station) location at 31.0km and may require additional lateral land-take.

6.6.4 Train Control and Telecoms

6.6.4.1 The high level review has not identified any significant technical issues with the alternative proposal with respect to train control or telecoms.

6.6.5 Tunnel Aerodynamics

6.6.5.1 The greater length of tunnels proposed under options B and C would require increased mitigation of micro-pressure waves ("sonic boom") and in the case of Option B, due to pressure waves generated when trains pass through the Heathrow spur cavern. Mitigation could be achieved by either of two solutions:

- Either: Increased length of perforated hoods at both ends of the 500m open section and at the northern end of Chiltern tunnel. Further work is required to define the length, which as a first estimate could be in the range 200-300m. The trough structure at the open section would then be 900-1100m in length. For Option B, train speeds through the cavern would have to be restricted (this applies to the main line in addition to the spur). Further work is required to define the maximum acceptable

speed; as a first estimate, this could be less than 200km/h. Journey times would be adversely affected.

Or

- Development of new in-tunnel mitigation measures that reduce the gradient of the pressure wave during propagation, such as air spaces engineered under walkways. A substantial research and development exercise would be required in order to validate the effectiveness and develop design details. This solution would enable the open section excavation to be as stated elsewhere in this report (700m long included 100m long hoods at either end), and would also reduce the length of the perforated hood at the northern end of Chiltern tunnel from the currently envisaged 200m. The risks are (i) the research might find that the solution does not work as planned; (ii) it is possible that the 8.8m internal diameter might need to be enlarged; (iii) it is not certain whether this solution would still require a speed reduction through the Heathrow spur cavern.

6.6.6 Construction

6.6.6.1 The key construction issue with the alternative proposal is the restrictive access to the trace increasing the logistical constraints compared to the Hybrid Bill option. This will increase risk to the overall rail systems installation. Hence complex logistics planning and access are key to the delivery and would require risk mitigation to ensure delivery

6.6.6.2 The Proposed Scheme is for the tunnel fit out to be undertaken from the Chiltern tunnel south portal. This alternative proposal will require the use of the gap structure which will increase the safety and logistical complexity as well as add time to the construction programme. This will become a key rail systems worksite resulting in a construction and logistics constraint with the civil engineering works being required to be completed prior to rail systems work completed. The gap will need to be designed to provide adequate access to crane equipment and material to track level. Short rails (60ft / 18m) would have to be lowered through the gap for track installation using the temporary rails, with re-railing with and the S&C fit-out undertaken from the temporary railhead once the track is completed. The use of the gap for tunnel fit out is further complicated by the 1.25% track gradient. Works train loading is normally undertaken on a 0.2% gradient (NR Standard) and thus this will need to be carefully reviewed to provide sufficient safety measures, which adds risks to the programme.

6.6.6.3 The revised access from the temporary railhead at Ruislip to the HS2 trace also adds issues to the construction and logistics. The c. 800m long tunnelled railhead connection would require longer to install. In addition a review is required to ensure sufficient gauge to ensure delivery of the high speed S&C. The alternative proposal also only allows a single connection to the HS2 trace. Thus track/temporary track would be required to be installed at least 300m in either direction before train moves in either direction could be accommodated which provides a further constraint to the programme.

6.6.6.4 The implications of the above to the programme, compared to the Hybrid Bill, are as follows (the following are approximate durations and further work is required to fully understand the programme implications):-

- 1 month due to the logistics constraints reducing the number of overlapping activities
- 1 month (worst case) to fit out of the crossover cavern and gap structure
- 1 month to install / remove temporary railhead connection
- 1 month for the logistical and additional installation complexity
- 1 month for the additional tunnel systems installations between 24 to 31km (this is a slower operation than for open route)

6.6.6.5 Subsequently, the overall construction programme is likely to extend by a minimum of 5 to 6 months for the alternative proposal compared to the Hybrid Bill option.

6.7 Northolt Tunnel Construction and Logistics - General

6.7.1 Under Option A, the Proposed Scheme, the Northolt tunnel is to be constructed from a tunnel portal site at West Ruislip. A temporary rail connection is to be made to the Chiltern Main Line for construction logistics subject to sufficient train paths being available. Under Options B and C, the HS2 rail alignment would be moved underground, requiring the Northolt tunnel TBMs to be launched from Shaft F. This would significantly influence the construction of the Northolt tunnel, as discussed below.

6.7.2 The railhead turnout chamber at Shaft F is suitable for the assembly and launching of Northolt tunnel TBMs in “semi-short” mode. A work site supplying the machines with tunnel lining segments and the handling of bulk excavated material would be located adjacent to Harvil Road site as per Option A. The shaft is envisaged to be constructed as a large D-wall shaft with ‘HAC’ vertical conveyor and segments installed by gantry. Fore and back shafts in sprayed concrete lining (SCL) are envisaged to start tunnelling. However, rail systems installation would need to be done from the temporary rail connection.

6.7.3 It is assumed the major components of the Northolt tunnel TBMs would be delivered in sections to the adjacent site by way of a temporary construction access to the north of the turnout chamber. Significant craneage would be required to lower the assembled TBMs into the open cut at Shaft F. The TBM support gantries would then be delivered into the cut and assembled behind the TBM cutter head and segment erector.

6.7.4 The excavated material from Northolt tunnel construction works would discharge directly onto rail wagons for onward movement via the railhead. A stockpile area for excavated material has been proposed within the main compound area to take any overspill from the railhead loading area if tunnel production exceeds capacity on the rail network.

6.7.5 The railhead connection to Shaft F would need to be in place prior to start of tunnelling works in order to facilitate tunnelling operations. This is likely to be a critical path activity to ensure that the Northolt tunnel construction can be commenced.

6.7.6 Alternatively, TBMs could be launched from the Turnout T2 cavern at Ch 25+000m. This would only be applicable to Option B, as the provision of a cavern is based on the requirement for Heathrow spur turnouts. This would provide easier access for TBMs to the site, by way of Harvil Road or Breakspear Road. However, the railhead connection would be further away from the tunnel bores, creating a logistical challenge until tunnelling reaches the railhead chamber at which point the TBMs can be serviced via the railhead. This would also increase the length of the Northolt tunnel in comparison to the previous option, which would impact on the programme.

6.7.7 For the 6.2km Northolt tunnel extension through the Colne Valley, it is proposed to launch twin TBMs south from the gap structure at the Chiltern tunnel south portal. This would provide a more convenient site for servicing the tunnel drives, with more space available at the adjacent sites for plant and materials. Four TBMs, two driving north constructing the Chiltern Tunnel, and two driving south constructing the tunnel through the Colne Valley, would therefore need to be serviced via the gap structure. SSE Energy Supply Ltd have confirmed that there would be capacity for a new 43MVA power supply as required for servicing the tunnelling operations, subject to detailed design. However the risk that other resources may require power supply in the region could have an impact on future capacity, and as a result more expensive works may be required to provide the power supply for the tunnel drives.

6.7.8 Tunnel logistics would be via public roads for both tunnels, until the tunnel under Colne Valley reaches a point past Ch 24+200m (Shaft F) where it could be serviced by the railhead. It is also noted that the tunnel extension of 6.2km could have a detrimental impact on programme time.

6.7.9 As an alternative, a single TBM could be launched from the Chiltern tunnel south portal and turned round within the turnout chamber at Shaft F to give some relief to the worksite at the Chiltern tunnel south portal, before boring back to the gap structure. For the return drive, logistics could be via the railhead connection. This would increase the programme time for the 6.2km Northolt tunnel extension, which could impede its viability.

6.7.10 As a further alternative, the tunnel under Colne Valley could be driven north from the more space-constrained open cut site at Shaft F. However, co-ordination of the tunnelling works with that of Northolt tunnel (driving south) could be a challenge, as both tunnels would require use of the railhead connection to service tunnelling operations subject to sufficient train paths being available. Removal of excavated material from the two tunnels would therefore present a number of challenges as described in Section 7.3 of the report.

6.7.11 For the purpose of this assessment, it is therefore proposed to drive the Northolt tunnel south from Shaft F, which agrees with current methodology for the Proposed Scheme. This would require TBMs to be launched in 'semi-short' mode from the 80m x 30m open cut. The length of the Northolt tunnel would be slightly increased in comparison to the Proposed Scheme (in which the TBMs are launched from West Ruislip portal at Ch 23+480m). Although the TBMs for the Northolt tunnel would be launched from the chamber containing the railhead turnout at Ch 24+200m, most of the construction support system logistics would be centred at the main compound between Harvil Road and Breakspear Road. Temporary infrastructure and facility provision requirements would include:-

- Precast segment storage areas;
- General storage areas (pipes/rail sleepers etc.);
- Grout batching plants;
- Excavated material storage/handling/buffer areas;
- Workshops and fabrication areas; and
- Office space for staff/Project offices if appropriate.

6.7.12 It is proposed to construct the 6.2km Northolt Tunnel extension under the Colne Valley from the location of the Proposed Scheme Chiltern Tunnel south portal, and service the tunnelling operations via the gap structure until the TBMs reach a point past Ch 24+200m where the tunnelling would be serviced via the railhead.

6.8 Impact on Northolt Tunnel Construction - General

6.8.1 Combining the Northolt Tunnel with the Northolt tunnel Extension in the Colne Valley would create several issues in terms of construction of the tunnel works. Current plans for the Northolt tunnel construction site compounds would be affected by the possibility of extension of the tunnel.

6.8.2 Moving the turnout from the West Ruislip portal (Ch 23+480m), further west towards Breakspear Road (Ch 24+300m), would create an extension of Northolt tunnel works of approximately 500m. The construction and logistics methodology for the Northolt tunnel would need to be reviewed.

6.8.3 The possibility of two contracts sharing a site at Ch 24+300m (Northolt tunnel driving south, Northolt tunnel Extension driving north) could complicate matters further.

6.8.4 Moving the railway into tunnel throughout the Colne Valley would require that the vertical gradient is no less than 0.5% for drainage purposes, whereas the current alignment is as low as 0.3% at the Northolt tunnel West Ruislip Portal. Therefore the vertical alignment through this area must be modified to meet required HS2 standards, impacting on the alignment further south.

6.8.5 If the decision is taken to include passive provision for Heathrow spurs, and to combine the cavern at Ch 24+300m (see 6.9.6 Option B), then the horizontal alignment would need to be adjusted to allow for a straight section of track to accommodate the turnout. This could have significant effects on the alignment many hundreds of metres away from the turnout, not least of which are the impacts on neighbouring residential properties within the town of Ickenham. At present, this particular aspect of the tunnel option has not been assessed.

6.9 Option A (Proposed Scheme) – Hybrid Bill

6.9.1 The baseline case is the Proposed Scheme as presented in the Environmental Statement and shown on Hybrid Bill drawings.

6.9.2 The viaduct crosses the Colne Valley, including the River Colne, the Grand Union Canal and number of lakes, between Ch 26+000m to Ch 29+400m and its height is generally between 11m and 15m above the ground/standing water level.

6.9.3 In summary the viaduct:-

- Crosses a stream at Ch 26+200m and Flood area Ch. 26+150m to 26+250m;
- Crosses above Dews Farm locally listed building at 26+350m;
- Passes over the Hillingdon Outdoor Activities Centre Ch 26+400m to Ch. 26+500m;
- Passes under the Overhead line at Ch. 26+600m approx.;
- Crosses access track at Ch. 26+950m approx.;
- Crosses Grand Union Canal and towpath/walkway Ch. 26+970m;
- Crosses Moorhall Road at Ch. 27+500m;
- Crosses access track to Moorhall Road at Ch. 27+900m;
- Crosses the Colne River Ch 27+950m approx. to Ch. 28+180m approx.;
- Crosses an access path to a building at Ch. 28+975m;
- Passes under the fight path of Denham airport, and
- Crosses the North Orbital Road (A412) on a high skew angle at Ch 29+200m.

6.9.4 The constraints to the proposed Colne Valley viaduct are:-

- The Viaduct location in an environmentally sensitive area which is recovering from past gravel quarrying activities;
- The Viaduct bridges over the mid Colne Valley (SSSI) landscape and a number of other features, from Durden Court to Dew's dell;
- Construction and maintenance access would not be straightforward due to the topography of the site;

- The overhead power lines at Ch 26+600m would provide constraints for any craneage and construction plant required to work beneath until they are diverted. It is crucial that this line is diverted early to enable the trestleway jetty to be fully constructed;

- The location of the pier south of the A412 which is constrained by the presence of a high pressure gas main; and

- The viaduct is partly constructed in a groundwater Source Protection Zone (SPZ) 1 and piling works would need to take appropriate measures to avoid groundwater contamination.

6.10 Option B – Tunnelled Option with Passive Heathrow Spur Provision

6.10.1 As stated in Section 6.2, the positions available at which the 700m long excavation for a "gap" structure and portal hoods can be located are limited, and as such it is proposed that the existing southern works area be used. This means that the southern limb of the tunnel would slightly exceed the 20km length, and detailed appraisal would be required to validate this assumption. The position of the gap can be located in the flatter ground of the proposed southern works area, outside the SSSI, with the depth of excavation limited to approximately 20m.

6.10.2 This proposal has the additional benefit of being in a position which would allow access to public roads for construction and operational purposes, allow routes to track level to be developed without impinging on the currently designated hybrid Bill limits, provide an option for launching the TBMs in both directions, and provide a route for servicing both the mined and bored tunnelling operations.

6.10.3 For Options B and C, the Chiltern tunnel south portal would be further away from the M25 (as opposed to Option A). Hence there would be a lower risk of excess settlement of the motorway due to "learning curve" difficulties at the start of the Chiltern tunnel TBM drive.

6.10.4 The Heathrow spur Turnout T1 would be accommodated within a tapered "gap" structure, the dimensions of which would be defined by the track spacing. As indicated in Section 6.2 the maximum width of the excavation could be some 70m accommodating the two mainline tunnels and the two spur tunnels and the access to the rescue area at existing ground level. However, it is expected that the separation could possibly be reduced slightly and the overall structural headwall width reduced accordingly.

6.10.5 The depth of excavation would depend in part upon whether the spur passes over or under the mainline, being locally shallower by some 5m if the spur passes below as shown in Drawing No C222-ATK-RT-DSK-020-011306. It may be possible to optimise the mainline alignment further, however such re-alignment may impact the low point, and thus the position of the tunnel sump and the distance that accumulated water would need to be pumped to the nearest shaft or gap.

6.10.6 The Heathrow spur Turnout T2 would be located at Ch 25+000m, significantly deeper than the railhead turnout at Ch 24+300m. It is therefore likely that the turnout would be

constructed as a mined cavern either one large cavern or alternatively two narrower parallel caverns (see Section 6.3).

6.10.7 Alternatively, the Heathrow spur Turnout T2 could be optimised and combined with the railhead turnout at Ch 24+300m by extending the Heathrow spurs parallel with the mainline for approximately 1km to the east. This would eliminate the need for two chambers within 1km distance, which would significantly reduce the construction cost and reduce programme time. The site at which the railhead turnout is located is large enough to accommodate the extra chamber width (approximately 50m); however the mainline would require horizontal realignment as high speed turnouts must be on a straight section of tracks (Paragraph 5.5.1). This could affect the horizontal alignment several hundred metres away in each direction from the chamber and in particular could have significant impacts on the residential area at West Ruislip to the south of the mainline (Ch 23+800m). As noted earlier, this variant has not been considered further.

6.11 Option C – Tunnelled Option without Passive Heathrow Spur Provision

6.11.1 Option C considers the scheme if no passive provision for Heathrow spurs is made – that is, that the scheme would not allow for construction of Heathrow spurs in the future.

6.11.2 Option C in general is identical to Option B: Locations of ventilation shafts, the railhead, and the “gap” structure remain the same.

6.11.3 Without Heathrow spurs present, there is no need to provide Turnouts. Therefore, T2 would be eliminated completely, and there would be the possibility to reduce the dimensions of the “gap” structure as the width would not need to account for four tunnel bores. This could significantly reduce the cutting in the area of the “gap”, as the width could be reduced by as much as 40m at the base.

6.11.4 If no passive allowance for Heathrow spurs is made, the alignment may be raised locally to the T2 area, allowing easier connection to the railhead at Harvil Road, and the possibility of optimising the tunnel vertical alignment towards Ruislip

7 Comparison of Options

7.1 Construction Costs

7.1.1 The additional construction costs of Options B and C compared to the Proposed Scheme have been estimated as follows:-

- Option B additional cost: £215.0 million
- Option C additional cost: £185.1 million

Item	Option A Proposed Scheme (inc H'row spur passive provision) £m	Option B (Tunnel inc H'row Spur Passive Provison) £m		Option A (exc cost of H'row spur passive provision) £m	Option C (Tunnel exc H'row spur Passive Provision) £m
Tunnels	£63.6	£523.3		£63.6	£487.9
Civil Engineering	£413.1	£103.7		£388.1	£88.8
Railway Systems	£111.1	£159.7		£111.1	£157.0
Sub Total: Construction	£587.8	£786.7		£562.8	£733.7
Difference		£198.9			£170.9
Time related costs; indirect costs; VE and efficiency savings		£16.1			£14.2
Total cost difference with Proposed Scheme		£215.0			£185.1

Note: Costs are inclusive of all works required between the Proposed Scheme West Ruislip portal and the Chiltern Tunnel south portal.

Table 7.1: Colne Valley Tunnel Costs

7.1.2 In addition to the tunnel works, these estimates include all associated works required for construction, including tunnel portals, highway diversions, retaining walls, temporary railhead connection, and ventilation-intervention shafts. The costs include extended time costs, indirect costs, and efficiency and value engineering savings.

7.1.3 The Option C cost estimate is based on the assumption that there would no longer be a requirement for a cavern at Ch 25+000m which provides passive provision for possible future construction of the Heathrow spur.

7.1.4 These costs do not include estimates for possible new utility diversions associated with the extra tunnel lengths. These costs do include reduction for diversions that are required for Option A but not for Options B and C (see section 7.4).

7.2 Programme Impacts

7.2.1 Additional tunnel drive lengths associated with Options B and C are as follows:-

- Northolt tunnel - (extended from Ch 23+480m to Ch 24+200m) +0.72km;
- Chiltern tunnel - (extended from Ch 31+363m to Ch 31+100m) +0.26km; and
- Northolt tunnel Colne Valley extension - (Ch 30+400m to Ch 24+200m) +6.2km.

7.2.2 An average tunnel advance rate of 80m/week has been assumed to calculate the additional duration of construction.

7.2.3 It is proposed to construct the Northolt tunnel extension through the Colne Valley with two TBMs, each driving one bore of the additional 6.2km tunnel length. If a single TBM were to be used, the TBM would need to be turned around before continuing to drive the bore in the opposite direction. The time taken to complete both bores would therefore be doubled in comparison to use of twin TBMs, plus further time allowed to turn the TBM.

7.2.4 Therefore, the tunnel construction period for the Northolt tunnel extension associated with Options B and C is 18 months assuming 2 No. TBMs. To this should be added the programme time for trackbed and services. This construction period is assumed to run in parallel with construction of the Northolt tunnel and the Chiltern tunnel.

7.2.5 The construction period for the viaduct Option A in the Colne Valley area is approximately 66 months, which includes the period for diverting the National Grid 275kV overhead cables.

7.2.6 The additional construction periods associated with lengthening of the Northolt tunnel (0.72 km) and the Chiltern tunnel (0.26 km) with drive rate of 80 m / week, under Options B and C are estimated as follows:-

- Northolt Tunnel +2 months
- Chiltern Tunnel +1 months

These periods are additional to the programme time for these works under the Proposed Scheme.

7.2.7 The overall rail system installation could thus be expected to extend by approximately 5 to 6 months as described in paragraph 6.6.6.4, when compared to the Proposed Scheme.

7.3 Excavated Material

7.3.1 The total excavated material that would be generated for the Northolt tunnel extension under Options B and C amounts to approximately 4.3million m3. This includes material generated from the construction of the 'gap' structure but excludes the excavated material generated from the construction of additional ventilation-intervention shafts. Material generated from the construction of the Proposed Scheme Chiltern tunnel which equates to approx. 2million m3 is also included in this sum as nearly all this material would need to be disposed off-site. Breakdown of the material generated as a result of the Northolt tunnel extension is shown in table 7.2.

7.3.2 Majority of this material (approximately 4.2million m3) would be generated from the construction compound by the M25. It is currently anticipated that this material would be removed from site via public roads (M25), equating to approximately 990,000 two-way lorry trips during the construction period.

7.3.3 For the additional 720m length of the Northolt tunnel extension up to Shaft F, under Options B and C, the excavated material amounts to approximately 107,000m3 which would be serviced via the railhead connection. The quantity of excavated material being generated each week would require approximately 20 trains to move the material by rail. This is in addition to the remainder of the 14km long Northolt tunnel, which would generate an approximate volume of 2,000,000m3 excavated material from tunnelling operations which is to be serviced via the railhead connection (as set out in Option A). A stockpile area for excavated material has been proposed within the main compound area adjacent to Harvil Road (as above) to take any overspill from the railhead loading area if tunnel production exceeded capacity on the rail network.

7.3.3 Summary of the excavated material generated from the tunnel under Colne Valley is presented in Table 7.2.

Description	From (Ch.)	To (Ch.)	Approx. Spoil Generated (m^3)	Approx. 2-way Lorry Trips
Proposed Scheme location of Northolt Tunnel north portal to Shaft F	23+480	24+200	107,000 (Removed from Shaft F)	- (Removed via railhead at Ruislip)
Shaft F to Gap Structure	24+200	30+400	920,000 (Removed from the compound by M25)	216,000
Gap Structure	30+400	31+100	1,260,000 (Removed from the compound by M25)	300,000
Gap Structure to south portal of Chiltern Tunnel	31+100	31+363	40,000 (Removed from the compound by M25)	9,200
Proposed Scheme Chiltern Tunnel	31+363	44+635	2,000,000 (Removed from the compound by M25)	465,000

Note: Bulking of spoil is not included in calculated spoil volumes.

Table 7.2: Excavated Materials

7.4 Utility Diversions

7.4.1 There is a relatively dense network of major utility infrastructure in proximity to the works for the Proposed Scheme (Option A). This includes high pressure gas mains, large diameter water mains, large diameter sewers, and high and low voltage electricity lines. In comparison, Options B and C would not require diversion of many of these utilities as the tunnelled HS2 mainline would pass under utilities for the majority of the alignment.

7.4.2 At Ch 26+600m, a National Grid Electricity 275kV overhead line meets the proposed viaduct (Option A). Studies undertaken by National Grid conclude there is no option to increase the height of the overhead lines enough to achieve required HS2 clearances and the line is redesigned in the Proposed Scheme. Options B and C would not require this diversion, and therefore would provide a significant cost saving.

7.4.3 There are two high pressure gas mains running north to south between Harvil Road and Breakspear Road. The larger of the two (48'' steel gas transmission pipe) runs between Harefield and Southall, and the slightly smaller (18'' steel gas transmission pipe) runs

north to south between Fulmer and Haste Hill. Implementing Option A requires a diversion which would require extensive planning to temporarily divert the routes. These diversions would not be required for Options B and C.

7.4.4 The Proposed Scheme requires diversion of a 600mm ductile iron water main which also lies to the west of Breakspear Road.

7.4.5 A Scottish and Southern Energy high voltage overhead line alongside the M25, adjacent to the Proposed Scheme Chiltern Tunnel south portal, would also require diversion if Option A is to be adopted. This diversion would not be required for Options B and C.

7.4.6 There are 18 other smaller scale utility diversions or protective measures required for construction of the Proposed Scheme, such as BT overhead cables, water mains, overhead high voltage power lines, and overhead low voltage wires.

7.4.7 Relative costs of utility diversion and protective works are included in the option costs presented in Table 7.1

7.5 Environmental Impacts

7.5.1 The proposed tunnel routes A & B pass close to two of the largest source protection zone (SPZ) 1 (TH177 and TH027) in the area; Route A passes within 50m of TH177 and within 350m of TH027; and Route B passes within 350m of TH177 and within 100m of TH027. Both tunnel options are within the SPZ 1 of these two sources. The ES HB scheme passes at similar distances to these abstractions (less than 50m and 330m). Both PWS abstractions are thought to be fed by large fissures in the Chalk, which supply most of the water for these supplies.

7.5.2 Construction of the tunnel (along either route) has the potential to contaminate groundwater through the production of turbidity (particulate) or the release of other contaminants and affect surface water features and both SPZ1s (TH177 and TH027). As stated within the ES, with the implementation of measures required by the draft CoCP, contaminants will be controlled at source. However, these measures cannot eliminate turbidity and it is likely that Affinity Water would have to temporarily close their sources to avoid impact on Public Water Supply (PWS). This impact is also identified in the Proposed Scheme due to piling for the Colne Valley viaduct and is mitigated in the ES by the production of a Management Strategy. The effect magnitude and duration on groundwater sources is considered similar under the Proposed Scheme and the two tunnel options (A & B).

7.5.3 Vent shafts and cross passages would be required for the tunnelling options, which would require groundwater dewatering. In the Colne Valley groundwater is thought to support local surface water features, such as the River Colne and lake SSSIs. Therefore, groundwater dewatering may have a temporary impact on water levels in the local surface water bodies. Where possible, water could be recharged back to ground in the vicinity of the abstraction in attempt to minimise any impact.

7.5.4 This groundwater dewatering activity could also have a short term temporary impact on the PWS and private abstractions, where these are located close to the route.

7.5.6 Figure 6.3 indicates that a high proportion of the mainline falls within this area, and with the proposed alignment highly constrained, there is little scope to reduce impacts further.

7.5.7 Tunnelling has previously been undertaken in a SPZ1 area (National Grid Croydon Cable Tunnel, London), where contamination was carefully avoided through an extensive pre-construction groundwater monitoring, sampling and testing programme which was developed through consultation with the Environment Agency.

7.5.8 The relocation of the HOAC (Hillingdon Outdoor Activity Centre) site would not be required under Options B and C.

8 Evaluation against Assessment Criteria

Table 8.1 Northern Extension of Northolt Tunnel Engineering Appraisal SIFT Assessment Table

Location:		**Colne Valley**					
Option name and description:		**Community Forum Request for Northolt Tunnel Extension**					
OPTIONS CONSIDERED:		**A**		**B**		**C**	
OPTION DESCRIPTION		**Proposed Scheme**		**Tunnel with Heathrow Spur Provision**		**Tunnel without Heathrow Spur Provision**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT ASSESSMENT and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT ASSESSMENT and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT ASSESSMENT and/or QUANTITIVE ASSESSMENT**	**RATING**
Strategic Fit	Capture whether an option meets the Project Specification	The solution is in accordance with the project specification and technical requirements.	0	The solution is in accordance with the project specification and technical requirements.	0	The solution is in accordance with the project specification and technical requirements.	0
Construction Feasibility	Assess the relative complexity of construction Assess the relative construction programme	Viaduct construction is standard, aligns with rest of adjacent sections of viaduct construction and allows repeated use of formwork and temporary works. There is a localised diversion of the River Colne to ensure that none of the viaduct piers are located within the river. This may require temporary works in order to construct the piers adjacent to the river bank.	0	The 8.8m internal diameter main tunnels will be constructed by TBM as previously proposed for the Northolt and Chiltern tunnels. The passive provision for the Heathrow spur requires that significant sized caverns are constructed of spans in excess of 20m. A tapered gap structure with maximum width of 70m, depth of 20m and 700m long box structure will be required with connecting access tracks which will allow passenger evacuation. Three additional intervention and ventilation shafts will be required at nominally 3000m intervals. Requires relocation of ATFS compared to Option A. Construction period for the Northolt tunnel extension associated with Options B and C is 19 months assuming 2 No. TBMs which would run in parallel with Chiltern and Northolt tunnel constructions. Extension of construction time for Chiltern tunnel (1 month), Northolt tunnel (2 months) or Rail Systems (3 Months) may affect overall programme time.	-	The 8.8m internal diameter main tunnels will be constructed by TBM as previously proposed for the Northolt and Chiltern tunnels. A tapered gap structure with maximum width of 70m, depth of 20m and 700m long box structure will be required with connecting access tracks which will allow passenger evacuation. Three additional intervention and ventilation shafts will be required at nominally 3000m intervals. Requires relocation of ATFS compared to Option A. Construction period for the Northolt tunnel extension associated with Options B and C is 19 months assuming 2 No. TBMs which would run in parallel with Chiltern and Northolt tunnel constructions. Extension of construction time for Chiltern tunnel (1 month), Northolt tunnel (2 months) or Rail Systems (3 Months) may affect overall programme time.	-
	Assess the relative disruption to existing infrastructure, e.g. rail, highways etc.	N/A	0	Additional burden on public roads for servicing tunnel construction. Removal of excavated material from the construction compound by the M25 would significantly increase the lorry movements within the M25 and local roads. Diversion of Harvil Road.	- -	Additional burden on public roads for servicing tunnel construction. Removal of excavated material from the construction compound by the M25 would significantly increase the lorry movements within the M25 and local roads. Diversion of Harvil Road.	- -
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	Maintenance required on viaduct.	0	Maintenance required through tunnel.	0	Maintenance required through tunnel	0
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	N/A	0	Required to assess the fire life safety strategy for the cases where caverns present, especially at turnout T2.	0	Required to assess the fire life safety strategy for the cases where caverns present.	0

Location:	**Colne Valley**
Option name and description:	**Community Forum Request for Northolt Tunnel Extension**

OPTIONS CONSIDERED:		**A**		**B**		**C**	
OPTION DESCRIPTION		**Proposed Scheme**		**Tunnel with Heathrow Spur Provision**		**Tunnel without Heathrow Spur Provision**	
Headings	**Appraisal criteria**	**QUALITATIVE IMPACT ASSESSMENT and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT ASSESSMENT and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT ASSESSMENT and/or QUANTITIVE ASSESSMENT**	**RATING**
HS2 Operation Feasibility - Passengers	Assess Passenger Dispersal covering road (right of way), rail and public transport	N/A	0	N/A	0	N/A	0
Demand	Likely Relative Passenger Numbers Likely Journey Times Likely Demand	N/A	0	Slightly increased journey times due to tunnelled alignment and Heathrow spur turnouts.	-	Slightly increased journey times due to tunnelled alignment.	-
Costs	Estimated whole life cycle costs to give relative assessment	N/A	0	Excavated material management, operation and maintenance, all likely to be significantly higher cost.	---	Excavated material management, operation and maintenance, all likely to be significantly higher cost.	---
	Estimated initial capital costs to give relative assessment (The capital costs include construction, land and compensation costs)	N/A	0	Excavated material management, operation and maintenance, all likely to be significantly higher cost. Procurement of TBMs will incur a high cost. Cost estimate: additional £215.0 million.	---	Excavated material management, operation and maintenance, all likely to be significantly higher cost. Procurement of TBMs will incur a high cost. Cost estimate: additional £185.1million.	---
Environment	Input from ENVIRONMENTAL APPRAISAL MATRIX	See separate environmental assessment	0	See separate environmental assessment.	+++	See separate environmental assessment	+++
Safety	Assess the relative safety during construction,	Safety risks associated with viaduct – working at height and over water.	0	Safety risks associated with bored tunnels - working in confined space	-	Safety risks associated with bored tunnels - working in confined space	-
	Assess the relative safety during Operations, maintenance and decommissioning , and Emergency access		0	Safety risks associated with bored tunnels- operation and maintenance in confined space	-	Safety risks associated with bored tunnels- operation and maintenance in confined space	-
Commitments	Previous explicit or implicit public assurances or commitments to third parties	N/A	0	Possibility of increased programme duration - this would impact on commitment to open HS2 in 2026. However avoids the need for utilities diversions and relocation of businesses during construction (HOAC)	0	Possibility of increased programme duration - this would impact on commitment to open HS2 in 2026. However avoids the need for utilities diversions and relocation of businesses during construction (HOAC)	0
Commercial Development	Does the option provide opportunities for development in particular for over station development	N/A	0	N/A	0	N/A	0
		Overall Rating	0	**Overall Rating**	---	**Overall Rating**	---

Preferred Option:
Option A

Reason:
Cost, programme implications, construction safety, major traffic movements for the removal of tunnel excavated material.

9 Environmental Appraisal Template

Table 9.1 Northern Extension of Northolt Tunnel Environmental Appraisal SIFT Assessment Table

Location:				**Colne Valley**					
OPTIONS CONSIDERED:				**Option A** **The Proposed Scheme as submitted in the hybrid Bill (Northolt Tunnel to West Ruislip/ Viaduct across the Colne Valley/ Chiltern tunnel east of M25 between jnc 16 and 17)**		**Option B** **Above ground section between Northolt and Chiltern tunnels placed underground in bored tunnels with provision for connection spurs to Heathrow**		**Option C** **As per option B but with no passive provision for a connection to Heathrow**	
OPTION DESCRIPTION									
Key Sustainability Issue	**Topic**	**STAGE: Construction or Operation**	**EDA Considered (incl. Topic and Ref no.) Comment**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**
Greenhouse gas emissions and climate change	Climate adaptability	Const		Not assessed	N/A	Not assessed	N/A	Not assessed	N/A
		Op		Not assessed	N/A	Not assessed	N/A	Not assessed	N/A
	Greenhouse gas emissions	Const		Not assessed	N/A	Not assessed	N/A	Not assessed	N/A
		Op		Not assessed	N/A	Not assessed	N/A	Not assessed	N/A
	Energy use	Const		Not assessed	N/A	Not assessed	N/A	Not assessed	N/A
		Op		Not assessed	N/A	Not assessed	N/A	Not assessed	N/A
Natural and cultural resource protection and environmental enhancement	Landscape/ townscape	Const	LV3 and LV6	The viaduct and associated embankments, cuttings and tunnel portals are not within any listed landscape areas; however the intricate mosaic of water features and woodland blocks of the Colne Valley gives the area a distinctive landscape characteristic and make up the bulk of the Colne Valley Regional Park. There are a large number of residential, recreational and commercial receptors that may suffer visual impact due to the viaduct construction, these include (but are not limited to) residents of Denham, Denham Green and South Harefield. Recreational users of the Colne Valley lakes, local footpaths, the River Colne and Grand Union Canal with associated marina. Users and employees of the Hillingdon Outdoor Activity Centre, local golf courses, Denham Aerodrome, Denham Grove (De Vere Hotel) and rail/road users. 1.1.1 There are two ancient woodlands (Ranston Covert and Battlesford Wood) which will be directly impacted by the	o	Considerably reduced landscape and visual impact during construction over the base case as the majority of this option would be in tunnel. Construction of the additional three vent shafts would have a local impact on the landscape and visual character of these areas. The 700m long 'gap' structure, located close to the Chiltern tunnel south portal and cutting of the base case, would have a broadly similar direct impacts, although considerably more excavated material would be handled at this location as a consequence of the extension of the Chiltern tunnel. There may be localised adverse visual impacts caused by the T3 vent shaft during construction. 1.1.2 There would be reduced adverse impact from there not being a requirement for construction activity relating to the National Grid pylon diversion.	+++	As Option B. With the lack of the Heathrow Spur there may be reduced impact from a lessor quantity of excavated material being stockpiled within the main compound.	+++

Location:				Colne Valley					
OPTIONS CONSIDERED:				**Option A** **The Proposed Scheme as submitted in the hybrid Bill (Northolt Tunnel to West Ruislip/ Viaduct across the Colne Valley/ Chiltern tunnel east of M25 between jnc 16 and 17)**		**Option B** **Above ground section between Northolt and Chiltern tunnels placed underground in bored tunnels with provision for connection spurs to Heathrow**		**Option C** **As per option B but with no passive provision for a connection to Heathrow**	
OPTION DESCRIPTION									
Key Sustainability Issue	**Topic**	**STAGE: Construction or Operation**	**EDA Considered (incl. Topic and Ref no.) Comment**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**
				Proposed Scheme during construction. There will be adverse landscape impacts upon all Landscape Character Areas and visual impacts on receptors located within the vicinity of the site during the construction phase. Due to the magnitude of change and the sensitivity of these areas there will be a moderate or major adverse effect on the aforementioned LCAs.					
		Op		There will be adverse impacts on the following LCA during operation, Harefield Farmland LCA, Colne River Valley LCA, Colne Valley LCA, Maple Cross Slopes LCA and Chalfont St Peter LCA. The operational impacts will arise from newly engineered landforms and structures cutting across the existing landscape including a new viaduct with associated infrastructure. This will result in effects ranging from major to moderate at year 1. By year 15 and 60 all effects experienced by the LCAs are deemed to be non-significant except for those in Harefield Farmland LCA (which only become non-significant by year 60) and Colne River Valley LCA (which remains significantly affected in year 60). There will be adverse visual impacts experienced by the following (but are not limited to) residents of South Harefield, Harefield, Denham Green, recreational users of the Colne Valley lakes and local footpaths. There will also be permanent land severance, the introduction of noise fence barriers, of highway infrastructure into the semi-rural environment including road bridges, of overhead power lines and the introduction of regular high speed trains. This will result in adverse visual impacts and significant effects.	o	With careful mitigation design of the landform surrounding the open gap section it would be possible to mitigate this feature within the local landscape and screen key viewpoints. Vent shafts can be designed to mirror the local vernacular and screened with planting and/or landform to minimise their long term impact. Within the base case the National Grid pylons were diverted away from the Colne Valley Lakes which was a beneficial with this option this would no longer occur.	+++	As Option B.	+++

Location:				Colne Valley					
OPTIONS CONSIDERED:				**Option A** **The Proposed Scheme as submitted in the hybrid Bill (Northolt Tunnel to West Ruislip/ Viaduct across the Colne Valley/ Chiltern tunnel east of M25 between jnc 16 and 17)**		**Option B** **Above ground section between Northolt and Chiltern tunnels placed underground in bored tunnels with provision for connection spurs to Heathrow**		**Option C** **As per option B but with no passive provision for a connection to Heathrow**	
OPTION DESCRIPTION									
Key Sustainability Issue	**Topic**	**STAGE: Construction or Operation**	**EDA Considered (incl. Topic and Ref no.) Comment**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**	**QUALITATIVE IMPACT DESCRIPTION and/or QUANTITIVE ASSESSMENT**	**RATING**
				At a number of locations, views of the Proposed Scheme will be filtered or screened by intervening lakeside vegetation. The retention of intervening hedgerows, trees and the reestablishment of lakeside vegetation will further reduce adverse impacts over time. The proposed planting of the approach embankments will help further screen the proposed viaduct. However, in certain locations it is not possible to screen or filter views of the viaduct because of the open nature of the view as it spans the Colne Valley Lakes. In such instances significant effects will continue even by year 60 of operation.					
	Cultural heritage	Const	CH1, CH4, CH5	Savay Farm (an asset grouping of high value), a scheduled monument located south of Savay Farm, Pynchester Farm, the Grade II listed Highway Farmhouse, St Leonards Farmhouse and Brackenbury Farm will be temporarily impacted by the high visibility of construction activities and associated disturbance will impact the setting of these assets. The following archaeological assets will be directly impacted by construction: • buried archaeological remains associated with the Mesolithic activity at Dew's Farm (major adverse effect); • Palaeolithic artefacts and deposits within the Thames Terrace deposits (moderate adverse effect); • prehistoric to Roman archaeological remains at Denham Park Farm and Chenies (major adverse effect); • buried archaeological remains of the former post-medieval garden at The Fisheries (moderate adverse effect); • approximately 1ha of ancient woodland at Battlesford Wood(moderate adverse effect); • archaeological remains of the former 19th	o	There is a potential to remove significant archaeological remains during groundworks associated with the 700m gap to the south of the Chiltern tunnel southern portal and the Rail Head and ventilation shafts. The sustainable placement would impact the setting of the scheduled monument Brackenbury Farm moated site. It would also affect the listed buildings St Leonards Farmhouse and Copthall Farmhouse. The sustainable placement would also have a permanent impact to the site of a Romano British settlement. Overall the construction impact of this option is significantly reduced compared to Option A.	+++	As Option B.	+++

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				century garden at Denham Grove (De Vere Hotel) (moderate adverse effect); • Buried archaeological remains of potential prehistoric date and of low value off Tilehouse Lane (moderate adverse effect); and • Buried remains of a World War II searchlight battery at Corner Hall (moderate adverse effect)					
		Op		Operational impacts have been identified for Savay Farm (an asset grouping of high value) and a scheduled monument located south of Savay Farm as a consequence of a change in setting related to operational noise. This will constitute a medium adverse impact resulting in a major adverse effect.	o	There are no impacts associated with the operation of Option B.	+	As Option B.	+ 1.1.3
	Biodiversity	Const	EC1, EC2,EC4, EC5, EC7,	The viaduct passes through the Mid Colne Valley Site of Special Scientific Interest (SSSI) resulting in the loss of ancient woodland and wetland, which are designating features of the site; effects that are assessed as significant at the national level. The combined effect of woodland, wetland and grassland loss and disturbance of the breeding bird assemblage will result in a permanent adverse effect on the integrity of the Mid Colne Valley Site of Metropolitan Importance that will be significant at the county/metropolitan level. Land required for construction within the Tilehouse Gravel Pits Biological Notification Site (BNS) will result in disturbance to birds having a permanent effect on the integrity of the site that is significant at the county/metropolitan level. 1.1.4 About 0.9ha (19%) of the River Colne east of Denham BNS is within land required for construction of the Proposed Scheme where National Grid overhead power lines will be realigned. This will	o	The tunnel section passes under the majority of the features listed in Option A (except at the vent shaft locations, see below) and has no direct impact on them. Depending on tunnel depth and construction, there are potential risks to groundwater sensitive features, such as the River Colne and the lakes themselves. The proposed vent shafts located at c29+400 and c26+400 are not located within any designated site. The construction of the vent shafts may lead to the loss of broadleaved plantation woodland, hedgerows and arable. Overall the construction impact of this option is significantly reduced compared to Option A.	+++	As Option B.	+++

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				result in a permanent adverse effect on the integrity of site that is significant at the county/metropolitan level. Denham Country Park LNR will also be affected during construction. Approximately 10ha (52%) of this site is within land required for construction of the Proposed Scheme where National Grid overhead power lines will be realigned. This extent of habitat loss is a high proportion of the LNR and it will result in a permanent adverse effect on site integrity that is significant at the district/borough level. In the Fray's Valley Local Nature Reserve, approximately 4.2ha (6% of the LNR) of woodland and grassland will be removed where National Grid power lines will be realigned. The extent of habitat loss is relatively small in relation to the site's size, however, as part of the precautionary assessment, it is assumed that the woodland and grassland lost is a habitat of principal importance. Vegetation clearance could therefore result in an adverse effect on site integrity that is significant at the district/borough level. 1.1.5 Dew's Dell Site of Biological Importance lies partly within land required for the construction of the Proposed Scheme. Construction will result in the loss of approximately 1ha (11%) of the site, which will result in a permanent adverse effect on the integrity of site that is significant at the district/borough level. The Scheme will disturb two locations where coralroot (Nationally Scare) has been recorded; effects that are assessed as significant at the county/ metropolitan level. The Scheme will disturb two locations used by					

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				pochard for breeding, and habitat used by corn bunting and coral root; effects that are assessed as significant at the county/ metropolitan level. 1.1.6 Construction The Scheme through will pass through habitats used by otter, watervole, bats, breeding and wintering birds, reptiles and great crested newts, which could result in significant adverse effects at the county/ metropolitan level.					
		Op		No significant effects have been identified for the operational phase.	o	The tunnel section passes under the majority of the features listed in the base case and has no impact on them. Overall the operational impact of this option is significantly reduced compared to Option A.	+++	As Option B.	+++
	Water and flood risk	Const	WR2, WR3, WR4, WR6	Construction within the lakes has the potential to generate impacts on water quality which could lead to a risk of a significant adverse effect. 1.1.7 If ground fissures connect the working area of the Proposed Scheme directly to very high value groundwater receptors such as Public Water Supply, the impact of even low levels of turbidity could cause the closure of a source due to the high quality required to be met for Public use. This risk is especially the case where the Colne Valley viaduct piers are sited within the areas designated SPZ1 TH177 and SPZ1 TH174 and where the SPZ1 TH027 will be intercepted by the retaining walls for the Tilehouse Lane cutting. If a PWS was forced to shut down this would be a major impact and will	o	The tunnel section passes under the majority of the surface water features listed in the base case and has no impact on them. The majority of the tunnel from Ch 023+750 northwards passes through SPZ1, with two small sections in SPZ2. These are at Wyatt's Covert Caravan Site and a section from the Hillingdon Outdoor Activity Centre to the Harvil Road. Construction of the tunnel and cavern to accommodate the Heathrow spur turnouts below the water table and in SPZ1/2 has the potential to alter the risks to groundwater flows and licensed abstractions providing key potable water supplies. Although the programme of works in SPZ1 is longer than Option A, the work would be focussed in one or two areas at a time and the risks in those areas	--	As Option B. However, avoidance of large caverns for the turnouts reduces potential impacts upon groundwater compared to Option B.	--

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				therefore result in a significant adverse effect. 1.1.8 The jetty used during the viaduct construction has the potential to obstruct some flood flows temporarily during the construction works resulting in moderate impacts on flood risk to very high value receptors with a resulting large and significant adverse effect.		better defined and this may reduce the need for simultaneous closure of groundwater sources. The tunnels' vertical alignment would avoid the need for multiple holes penetrating through the shallow aquifer into the deep aquifer. A deeper alignment may be preferred if it avoids the main intake sections of the water supply boreholes, though any change would be limited due to rail gradient requirements. Groundwater mitigation measures would still be required although the maximum flow requirement may be reduced. Groundwater quality in the vicinity of Shaft "E2" may be affected by contamination from New Years Green Landfill although the draft CoCP measures would address this. The tunnel would occlude more of the effective aquifer than the proposed, Option A pile groups. Potential extra drawdown and loss of peak output of up to 40% could occur at Potable Water Supply source. A new water supply borehole immediately south west of the tunnels could be a suitable mitigation measure. A deeper alignment may be preferred if it then avoids the main fissures and intake sections of the water supply boreholes. The flood risk to temporary works would be less than Option A since there are fewer above ground works in the flood plain			
		Op		With careful management of viaduct drainage into the surface water bodies, no operational impacts have been identified.	o	The need for viaduct drainage passing directly into surface water bodies would avoided. No operational impacts have been identified.	o	No operational impacts have been identified.	o
Creating sustainable communities	Air quality	Const		There will be substantial adverse impacts along Swakeleys Road, between Harvil Road and the A40, at a number of receptors assessed for NO2 as a consequence of construction traffic which are significant.	o	Air quality as a consequence of an increase in highway construction traffic associated with the removal of surplus excavated material from site could be severely affected. A detailed assessment would need to be undertaken in order to fully assess the implications of the additional construction traffic on air quality.	--	As Option B.	--

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				Negligible impacts related to dust emissions have been identified.					
		Op		No operational impacts	o	No operational impacts	o	As Option B.	o
	Sound and vibration	Const	SV1	Construction noise impacts which generate significant effects have been identified at Denham Grove (De Vere Hotel), HOAC and Denham Waterski Club. Construction traffic on Harvil Road and B467 Swakeleys Road is likely to cause noise impacts on adjacent residential and non-residential receptors, which is deemed to be significant.	o	The construction of the tunnel would significantly reduce direct noise impacts on dwellings compared to the Option A. Although there would still be some localised and short term sound and vibration issues for property directly over the alignment of the tunnel during construction and close to the vent shaft sites and the 700m 'gap'. However, identified noise impacts as a consequence of construction traffic for Option A would remain as construction traffic is not predicted to decline in numbers as a consequence of this option. Construction noise impacts from the tunnel portals are not likely to change in magnitude but are likely to occur over an extended time period.	+	As Option B.	+
		Op		Significant noise effects identified at South Ruislip (inc. 55 minor & 140 moderate impacts), Savay Lane (6 minor and 7 moderate impacts), Wyatts Covert (66 minor and 16 moderate impacts)and Denham grove (3 minor and 2 moderate impacts) – also the De Vere Hotel.	o	Operation of the route in tunnel would remove all impacts identified for Option A.	+++	As Option B.	+++
	Community integrity	Const	CO1, CO3, CO4, CO10, CO11	Three buildings associated with the Hillingdon Outdoor Activity Centre (commercial properties) will be demolished. The lake used by the centre will be closed during construction works (a period of five years). This considered to be a major adverse effect and is therefore significant. Users of Denham Waterski Club would be impacted during construction as a result of in-combination impacts upon amenity including noise and visual impacts for a period of approximately one and a half years. The combination of these effects is considered to result in a moderate adverse effect and is therefore significant. In combination impacts from traffic, air quality and noise would be experienced by properties on the B467 Swakeleys Road. The combination of these	o	There would be no demolition of buildings associated with community resources or residential properties identified in the base case. HOAC and Denham Water Ski club would remain operational through the construction period. 1.1.9 Potential for in-combination impacts on properties on B467 Swakeleys Lane to remain, depending on routes for spoil removal.	+++	As Option B.	+++

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				effects will result in a major adverse effect on the amenity of residents along this route, which is significant.					
		Op		In combination noise and visual impacts for 5 properties next to Denham Grove (De Vere Hotel). 1.1.10 Should HOAC remain post-construction the use of the lake would be restricted and noise and visual impacts would affect the amenity for users of the facility.	o	There would be no impact on any of the community facilities or residential properties identified in the base case.	+++	As Option B.	+++
	Transport accessibility / severance	Const	TT1, TT3, TT4, TT7, TT9	Construction of the Proposed Scheme is forecast to result in changes to daily traffic flows due to construction traffic, road closures and diversions. Delays to vehicle users and congestion is predicted for the following junctions: • A412 North Orbital Road with Denham Green Lane (major adverse effect); • B467 Swakeleys Road with Harvil Road (moderate adverse effect); and • A40 Western Avenue with B467 Swakeleys Road (moderate adverse effect). Temporary closures of Chalfont Lane and Tilehouse Road would have an adverse impact on vehicle occupants due to the increased travel time associated with the length of the diversions, resulting in a major adverse effect on vehicle occupants. Construction of the Proposed Scheme will result in substantial increases in traffic flows (i.e. more than 30% for HGV or for all vehicles) and these will cause an increase in traffic related severance for non-motorised users at a number of locations generating moderate and major adverse effects. There will be moderate adverse effects on non-motorised users due to length of temporary PROW	o	There would be no significant impacts on the cycle routes or bridleways identified in the base case. Rickmansworth bridleway 004 would be diverted permanently as it currently lies across the proposed open gap at Ch 30+500, giving a minor adverse impact The provision of a 'gap' structure in the vicinity of the M25 allows the Chiltern and the extended Northolt tunnel to be bored from the main works compounds, enabling works and processing area for excavated materials to take place at the same location as the 'base case' option. However, with the bulk of the Proposed Scheme now in tunnel, the volume of excavated materials generated would be substantially higher; conversely the requirement for engineering fill and mitigation earthworks is far lower. As a consequence, the bulk of the excavated tunnel material from the Chiltern tunnels, the 'gap' structure and the new section of tunnel is likely to be treated as surplus to project requirements. Material from the extended Chiltern tunnel,700m gap structure and the extended Northolt Tunnel from Shaft F will be removed from site via M25 and then onwards to the ultimate destination for disposal. The volume of surplus excavated material needing to be taken off-site for third party disposal, or beneficial re-use would increase to 4.22million m3 as a consequence of Option B when compared to Option A. This would result in an additional	---	As Option B, although the slight reduction in spoil removal would have a consequential reduction in HGV traffic. However, the additional traffic generation would be significantly greater than Option A.	---

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				diversions for CSP/44 and Shire Lane bridleway (CSP/43/2).		990,200 2-way lorry trips. A detailed assessment would need to be undertaken in order to understand the implications these additional vehicle movements would have on the highway network.			
		Op		No impacts.	o	No impacts.	o	No impacts.	o
	Health & wellbeing	Const		Not assessed at this stage	N/A	Not assessed at this stage	N/A	Not assessed at this stage	N/A
		Op		Not assessed at this stage	N/A	Not assessed at this stage	N/A	Not assessed at this stage	N/A
	Socio-economic factors	Const		In-combination noise and visual impacts on the De Vere Hotel. These in-combination impacts will occur over a period of 15 months and are likely to have a significant amenity effect on this business.	o	The Denham Grove (De Vere Hotel) is likely to be impacted by noise and loss of visual amenity as a consequence of the construction of shaft E1 and possibly to a lesser extent the 'gap' structure. It is likely that the impacts would not be as great as those experienced under Option A.	+	As Option B.	+
		Op		Operational noise and visual amenity impacts on the De Vere Hotel. Given these in combination effects and the high level of sensitivity, the Proposed Scheme is assessed to have a significant amenity effect on this business.	o	No impacts.	+	As Option B.	+
Sustainable consumption and production	Agriculture, soil & land use	Const		The construction phase will result in the temporary disturbance of approximately 144.1ha of land of Best and Most Versatile (BMV) quality and of that 84.4ha would be lost permanently. Permanent BMV land loss is a consequence of areas of permanent infrastructure as well as land that will revert to landscape and ecological mitigation areas. As BMV land in this area is a receptor of medium sensitivity the effect is assessed as a moderate adverse effect of the Proposed Scheme, which is significant. Three holdings would be impacted during construction (Park Lodge Farm, Home Farm and Denham Park Farm) as a consequence of temporary land take and severance. The effects have been assessed as major adverse for Park Lodge Farm and moderate adverse for Home Farm and Denham Park Farm.	o	With the exception of the 700m gap to the south of the Chiltern tunnel southern portal and the National Grid Feeder Station to the south of Harvil Road, limited agricultural land would be removed permanently for the construction of the extended tunnel option and thus the permanent impact on agriculture, forestry and soil would be reduced if the Northolt extended tunnel options are constructed compared to the Proposed Scheme. However, the area of agricultural land that would be required temporarily during construction of Option B and C is assumed to be the virtually the same as the Proposed Scheme with the same areas of land required for sustainable placement in CFA6 and CFA7 and the same areas of land required for construction, logistics management, chalk dewatering and soil storage on the agricultural land below the Chiltern tunnel southern portal and thus the construction impacts Options B and C are assumed to be the same as the Proposed Scheme. However, there may be some benefits as a consequence of the avoidance of utility diversions.	o	As Option B.	o

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						1.1.11 Overall, the temporary construction impact on BMV agricultural land by Option B and C would be comparable to the Proposed Scheme. The three holdings affected would still experience comparable impacts to those identified for the Proposed Scheme. Once the land is restored to agriculture (if that is the intended end result) the permanent impact on agricultural land and the three land holdings would reduce. There would be minimal temporary or permanent impacts on forestry, and negligible impacts to the soil resource.			
		Op		No operational impacts.	o	No operational impacts.	o	As Option B.	o
	Land quality	Const		No construction impacts.	o	No construction impacts.	o	As Option B.	o
		Op		No operational impacts.	o	No operational impacts.	o	As Option B.	o
	Waste & material resources	Const		This option does not generate significant excavated material as the alignment is on viaduct or at or near grade. Sustainable placement areas are located within the Colne Valley area to accommodate surplus excavated from excavations. 1.1.12 1.1.13	o	The scale of below ground works associated with Option B would result in the generation of a large quantity of excavated material. Since the tunnel also removes the need for engineering fill material and mitigation earthworks, this would substantially increase the total volume of excavated material generated. The volume of surplus excavated material needing to be disposed would increase to 4.22 million cubic meters This assessment does not include any provision for additional local sustainable placement of site.	---	As Option B, although the volumes would be slightly less as there would be no requirement to create the caverns to accommodate the turnouts for the Heathrow Spur.	---
		Op		Not assessed at this stage	N/A	Not assessed at this stage	N/A	Not assessed at this stage	N/A
Overall Rating				Significant above ground construction and operational impacts have been identified for this option including; noise, visual and ecological impacts. The options will result in a number of utility diversions. Material derived from the Chiltern tunnel would be used to mitigate operational noise and landscape impacts, which would allow the vast majority of excavated material to remain on site.	o	This option would avoid the majority of the above ground impacts identified in Option A during construction and operation including indirect impacts as a consequence of utility diversions. The additional tunnelling will generate significant volumes of additional spoil. Spoil from the Chiltern tunnel that was to be used for on-site mitigation in Option A would no longer be retained on site as the requirement for mitigation would be removed in Option	+++	As Option B, although there would be a slight reduction in spoil generated and removed from site that would also slightly reduce construction traffic numbers compared to Option B. From an environmental perspective this option is considered the preferred option. However, further detailed assessment work of the implications for off-site disposal would need to be undertaken and options to reduce the volume of	+++

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						B. All excavated material would be removed from site via the M25 generating significant additional traffic movements with consequential temporary impacts on the road traffic network and possibly local air quality.. No detailed assessment of traffic and air quality impacts has been undertaken to confirm the severity of the potential impacts from off-site material disposal.		material to be removed off-site reduced.	

Assumptions

1. The appraisal has been based on the information provided by Atkins Engineering Design Team at the time of appraisal (please note: no digital information has been provided and appraisals have been undertaken from drawings only).
2. The comparison of options has been undertaken as instructed using the Proposed Scheme as a base case.
3. All impacts reported here are potential predicted impacts and will be subject to surveys, assessment and professional interpretation and judgement as part of the EIA process.
4. Advice has been obtained from topic specialists in agriculture, community, socio-economics, cultural heritage, landscape, noise, traffic and transport, ecology and water.
5. Potential impacts have been identified on the basis of a mitigated base case (the Proposed Scheme)
6. Construction noise impacts are based on qualitative judgement taking account of information provided by Atkins Engineering Design Team on potential construction methods. Where applicable, this information is also set out in section 6 and table 7.1 of the associated engineering sift report.
7. Property demolitions, loss, or direct impacts to designated features and resources are addressed as construction phase impacts.
8. Construction impacts for cultural heritage has assumed that all construction activity within the land required, temporarily or permanently, for the Proposed Scheme, will result in the removal of archaeological assets. Operational impacts for cultural heritage considers the impacts on the setting of heritage assets.
9. The assessments have been scored based on the HS2 Ltd guidance i.e. Proposed Scheme is scored as neutral and all other options are scored either better than or worse than the base case . Where there is no base case (e.g. for site compounds, road realignments etc, the scoring is reflective of the options on their own merit and will use the scoring matrix as below:

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

Instructions

1. This matrix has been prepared for the comparison of alternative engineering options at particular locations.
2. The entries should be abbreviated as much as possible and should report the key issues only. (This matrix should be a summary document for the comparison of alternative options, and it should be supported by more detailed assessments, where appropriate.)
3. The matrix has been prepared using the framework of key sustainability issues as set out in the Appraisal of Sustainability (AoS). Each sustainability issue is then subdivided into a number of topic headings, which broadly correspond with the section headings of the Environmental Statement, as set out in the EIA Scoping and Methodology Report (SMR).
4. It is intended that that the methodology set out in the SMR will be applied for the assessment of the magnitude of impacts.
5. The first column should include a brief written assessment of the likely impacts, drawing out the key issues and including any quantitative assessment made, such as the number of properties affected by a particular issue.
6. The second column, headed “Rating”, should be a colour coded assessment of the likely impact of the option, as follows:

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

7. Separate lines are provided for the construction and operational stages. For some topics, an assessment will be required at only one of these stages, but for others, assessments will be required at both the construction and operational stages. Any stage that is not relevant should be marked as N/A (Not Applicable). Reference should be made to the SMR for further guidance.

Level of SIFT

10.1 This report applies to Sift Level 2.

Summary and Recommendations

11.1 An engineering review of a tunnel under Colne Valley has been carried out in this report, which would link the Proposed Scheme Northolt tunnel with the Chiltern tunnel. Options B and C have been assessed and compared in engineering terms with the current Proposed Scheme (Option A). Option B is a subsurface alignment to include a 700m long 'gap' which provides compliance with the European Technical Specification of Interoperability (TSI) 2014, including passive provision for the future Heathrow spurs. Option C is similar to Option B, without the provision for Heathrow spurs.

11.2 An intervention gap would be located to the south of the M25 to meet the TSI recommendations for tunnel length and associated fire and safety requirements, and to also provide a location from where the Chiltern tunnel southern portal and tunnel drives could be situated. The intervention gap would need to be a minimum of 700m long, with a maximum width of 70m to include for the provision of Heathrow spur turnouts, and at this location of around 20m deep.

11.3 To provide passive provision for the Heathrow spurs, an underground cavern would be required on the south side of the Colne Valley. Provision for turnouts from the north would be accommodated within the intervention gap.

11.4 In terms of construction logistics a significant area is required to be available to support the launch and operation of the TBMs. Given concerns over the availability of additional train paths for extra spoil disposal from the Ruislip railhead, it is envisaged that the Colne Valley tunnel would need to be driven from the intervention gap by the M25. Four TBMs would be launched from the intervention gap, two driving north to construct the Chiltern tunnel and two driving south to construct the tunnel under Colne Valley. Northolt tunnel construction would commence from the location of ventilation shaft F southwards.

11.5 The extension of the Northolt Tunnel under the Colne Valley would create around 4.3million m3 of earthwork in total. This material wold principally comprise Chiltern tunnel spoil (no longer required for mitigation earthworks in this area) and the excavation material from the intervention gap as well as the new tunnel under the Colne Valley. Approximately 4.2million m3 of this would require disposal by road via the M25 from the construction compound adjacent to the Chiltern Tunnel south portal.

11.6 Key Rail systems issues and risks that the longer tunnel would introduce would include:-

- The need for an intermediate firefighting point, suitably equipped and potentially requiring special purpose rescue vehicles
- It is likely that some form of tunnel cooling will be required
- A specialised air supply system may be required for the rolling stock. Such a special measure might only be achievable on the captive rolling stock.

- Additional ventilation measures are likely to be required at the proposed turnout cavern, which could result in changes to the proposed configuration of stub tunnels. The necessary additional equipment may be challenging to maintain.

- A journey time increase is likely to result, due entirely to tunnel resistance increases and a significant increase in air mass movement. This impacts on the robustness of the operational timetable.

- There may be a potential requirement for a speed limit due to pressure waves generated when trains pass through the Heathrow spur cavern with likely impact to the signalling headway.

- Cable shaft(s) would need to be provided between Ickenham ATFS (Auto Transformer Feeder Station) at surface and the tunnels or the shaft size increased to allow for additional traction power cables.

- The loss of a maintenance siding will add risk to the maintenance strategy in undertaking the required work within the maintenance period.

11.7 The current estimated construction of Option B is £215.0 million more than the Proposed Scheme, and for Option C £185.1 million more than for the Proposed Scheme.

11.8 All construction cost estimates include associated civil engineering and rail systems works.

11.9 Options B and C both incur a potential increase of some 5 months in the construction programme due to longer construction and rail systems fit-out requirements.

11.10 It is recommended that the Proposed Scheme (Option A in this report) be retained, on grounds of cost, construction safety and programme implications and for avoidance of major traffic movements for the removal of tunnel excavated material.

Appendix A Options Drawings

A.1 C222-ATK-CV-DPP-020-000001

Main Line Sheet 20 of 49 Chainage 25+600 to 32+000
(Plan & Profile presenting Option A 'The Proposed Scheme')

A.2 C222-ATK-TN-DSK-020-990400

Community Forum Request Northolt Tunnel Extension
Options B Key Option Requirements

A.3 C222-ATK-TN-DSK-020-000340

Community Forum Request Northolt Tunnel Extension Option B
Plan & Profile Sheet 1 of 2

A.4 C222-ATK-TN-DSK-020-000341

Community Forum Request Northolt Tunnel Extension Option B
Plan & Profile Sheet 2 of 2

A.5 C222-ATK-RT-DSK-020-011303

Colne Valley Tunnel Eastern Heathrow Spurs Track Alignment
Plan & Profile

A.6 C222-ATK-RT-DSK-020-011304

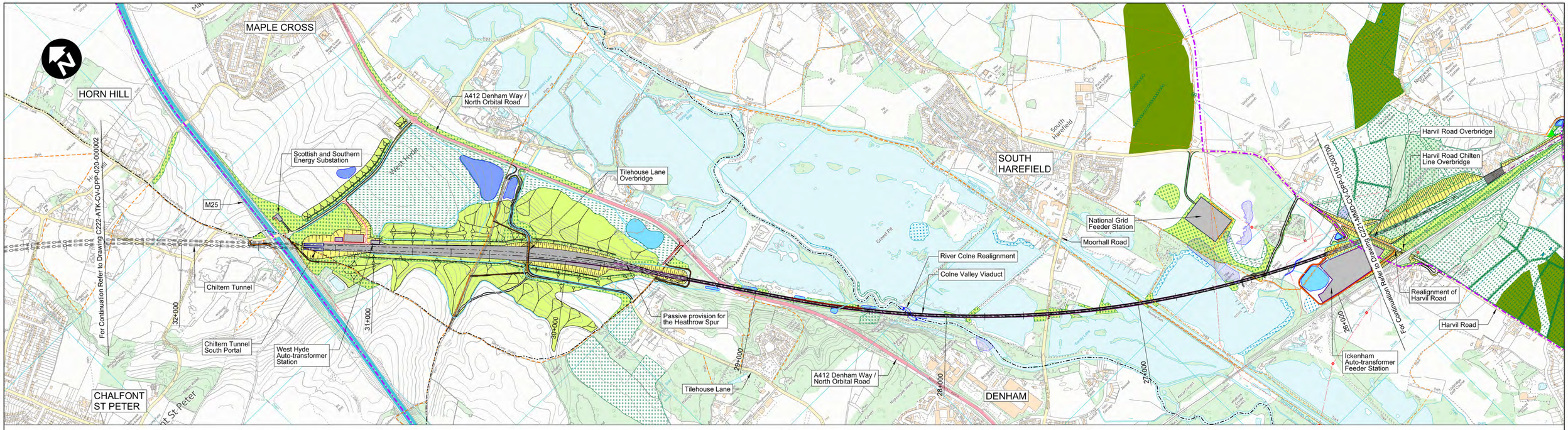
Colne Valley Tunnel Western Heathrow Spurs Track Alignment
Plan & Profile

A.7 C222-ATK-RT-DSK-020-011305

Colne Valley Tunnel Eastern Heathrow Spurs
Cross Sections

A.8 C222-ATK-RT-DSK-020-011306

Colne Valley Tunnel Eastern Heathrow Spurs
Cross Sections



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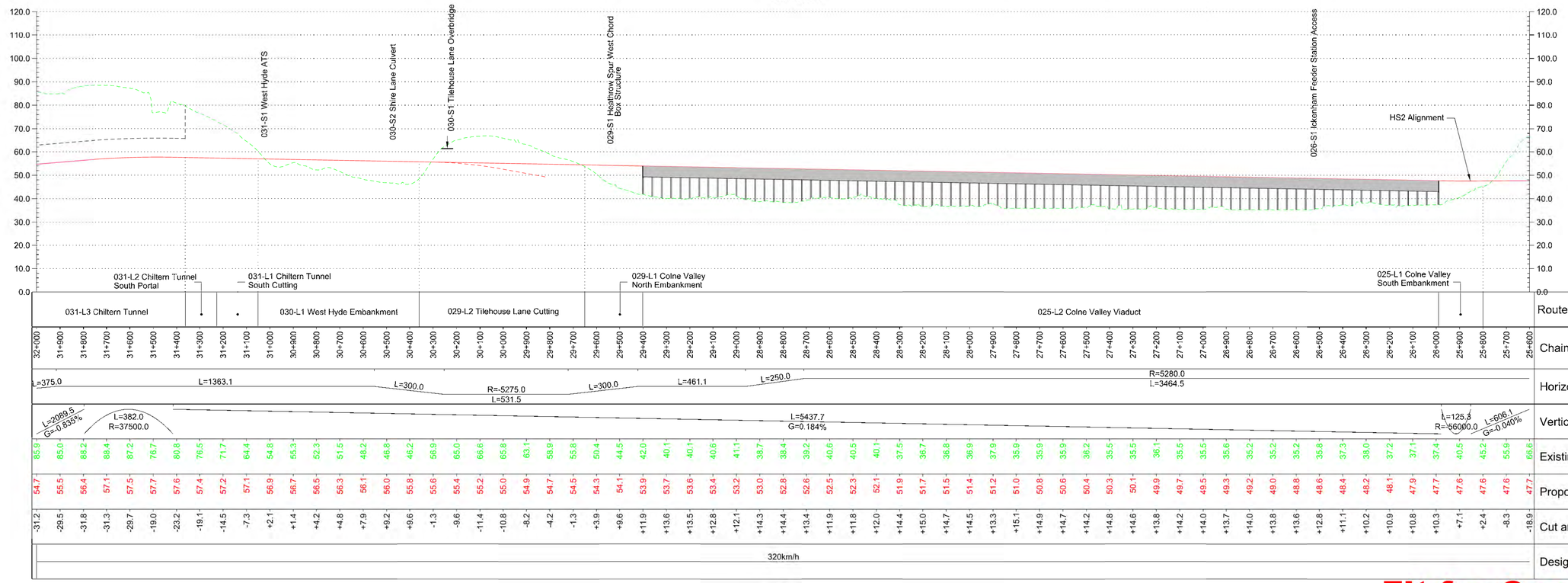

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Fit for Condition B

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METRES @ 1:1000 0 10 20 50 100

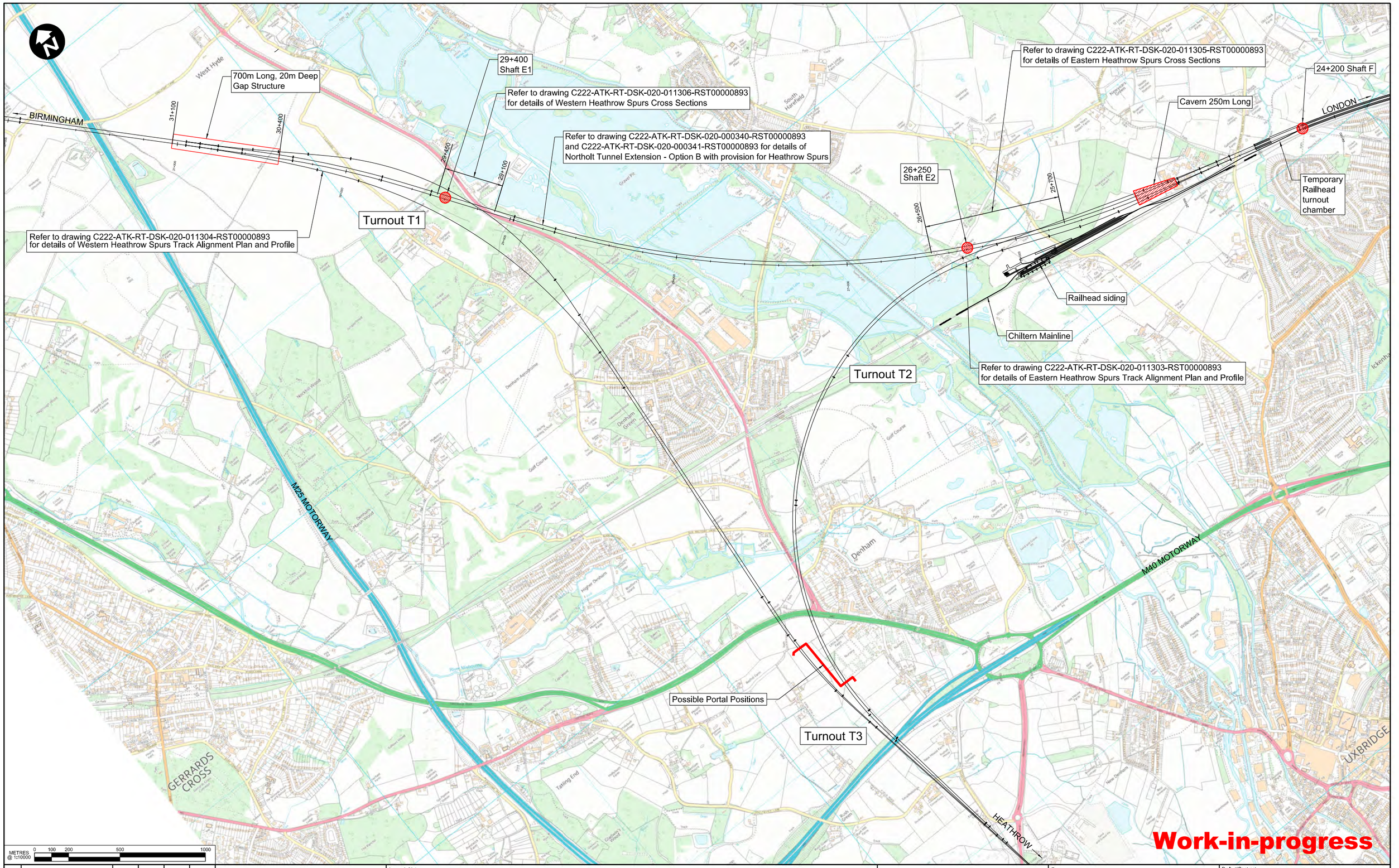
Rev	Description	Drawn	Checked	Con App	HS2 App
P02	Condition B. Code 1. Fit for hybrid bill submission	HMG 13/12/13	MH 13/12/13	JN 13/12/13	
P01	Condition B. Code 1. Fit for hybrid bill submission	TB 06/12/13	MH 06/12/13	JN 06/12/13	

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
- Engineering earthworks
- Landscape earthworks
- Rail alignment formation
- Returned to suitable development use
- County boundary
- Borough / District boundary
- Community forum boundary
- Watercourse diversion
- Existing watercourse
- Ditches - new
- Hedgerow habitat creation
- UT Main utility works
- Existing public right of way (PRoW)
- New, diverted or realigned PRoW
- Stopped-up PRoW
- Tunnels external extent
- Rail alignment
- HS2 Access road
- Noise fence barrier
- 10+000 Chainage (e.g. 10+000)

Registered in England
Registration No. 06791686
Registered office:
Eland House,
Bressenden Place,
London, SW1E 5DU

Creator/Originator	Atkins
HS2 Security Classification	INTERNAL
Zone	Country South
Design Stage	Preliminary - Interim for Hybrid Bill
Drawing Title	Main Line Sheet 20 of 49 Chainage 25+600 to 32+000
Project/Contract	Country South Design
Discipline/Function	Civil
Drawn	TB
Checked	MH
Approved	JN
Date	05/12/2013
Scale	AS SHOWN
Size	A1
Drawing No.	C222-ATK-CV-DPP-020-000001
Rev.	P02



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Rev	Description	Drawn	Checked	Con App	HS2 App
P00.1	FIRST DRAWN	---			

Legends/Notes:

OPTION B

Gap Structure + Access	chainage 30+400 to 31+100
Shafts	chainage 24+200, 26+250 & 29+400

Registered In England
Registration No. 06791686
Registered office:
One Canada Square,
London, E14 5AB

Creator/Originator
Atkins

Zone: Country South

Design Stage: DESIGN-FOR-PETITION

Drawing Title: Community Forum Request
Northolt Tunnel Extension
Option B - Key Option Requirements

Project/Contract: Country South Design

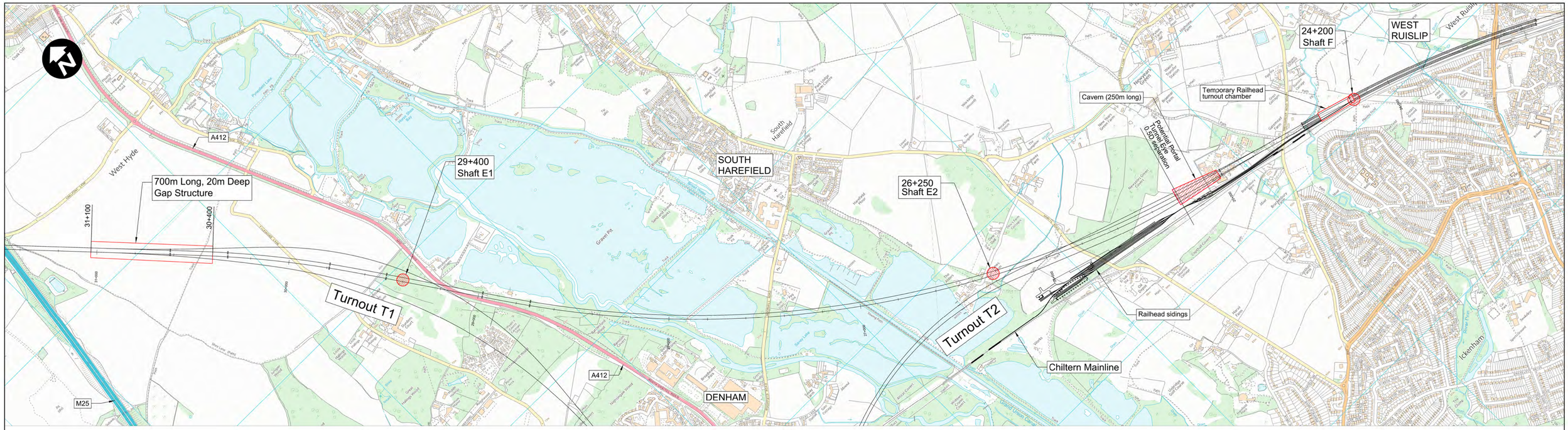
Discipline/Function: Tunnels

Drawn	Checked	Approved
HMG		

Date	Scale	Size
02/12/2013	AS SHOWN	A1

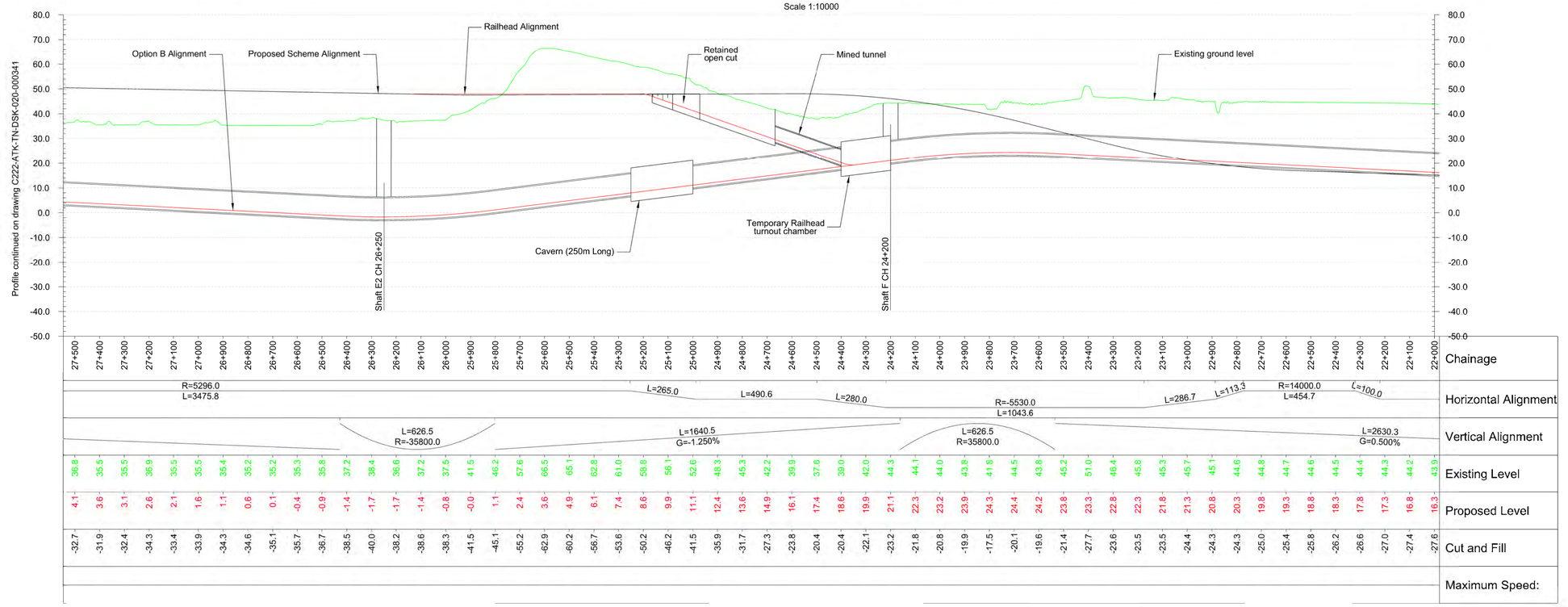
Drawing No.: C222-ATK-TN-DSK-020-990400-RST00000893

Rev.: P00.1



Plan

Scale 1:10000



Profile

Scale H 1:10000 V 1:1000

Work-in-progress

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METRES @ 1:1000 0 10 20 50 100

Rev	Description	Drawn	Checked	Con App	HS2 App
P00.1	FIRST DRAWN	---			

Legends/Notes:

1. Cavern at CH 25+000 to accommodate Heathrow Spurs (not required by Option C).

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Registration No. 06791686
Registered office:
One Canada Square,
London, E14 5AB

Creator/Originator: Atkins

Zone: Country South

Project/Contract: Country South Design

Design Stage: DESIGN-FOR-PETITION

Discipline/Function: Tunnels

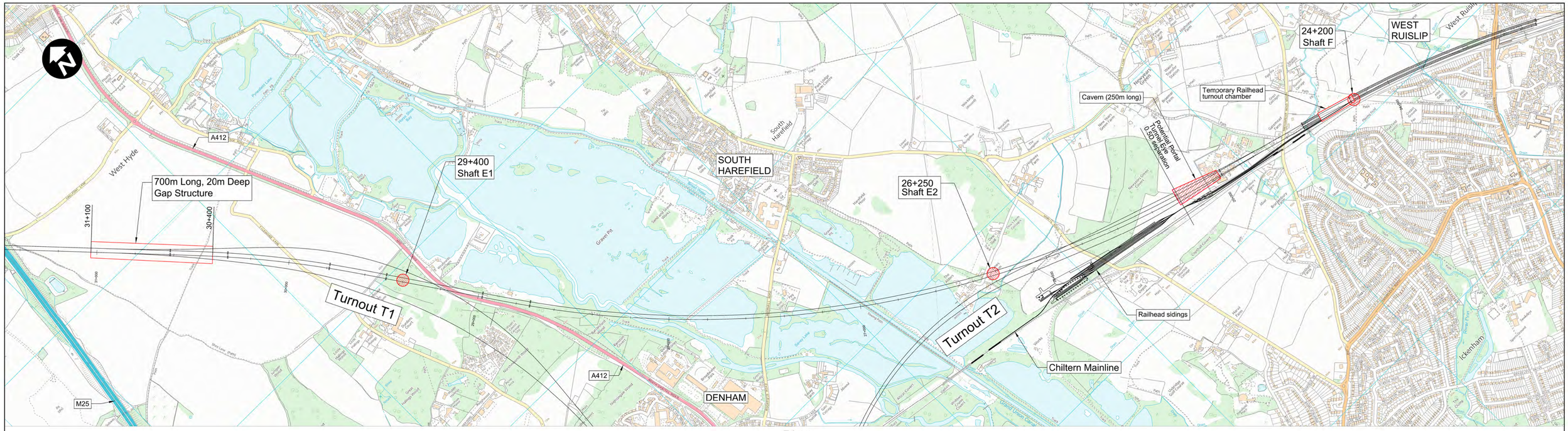
Drawing Title: Community Forum Request. Northolt Tunnel Extension. Option B with provision for Heathrow Spurs. Sheet 1 of 2,

Drawn	Checked	Approved
TB		

Date	Scale	Size
02/05/2014	AS SHOWN	A1

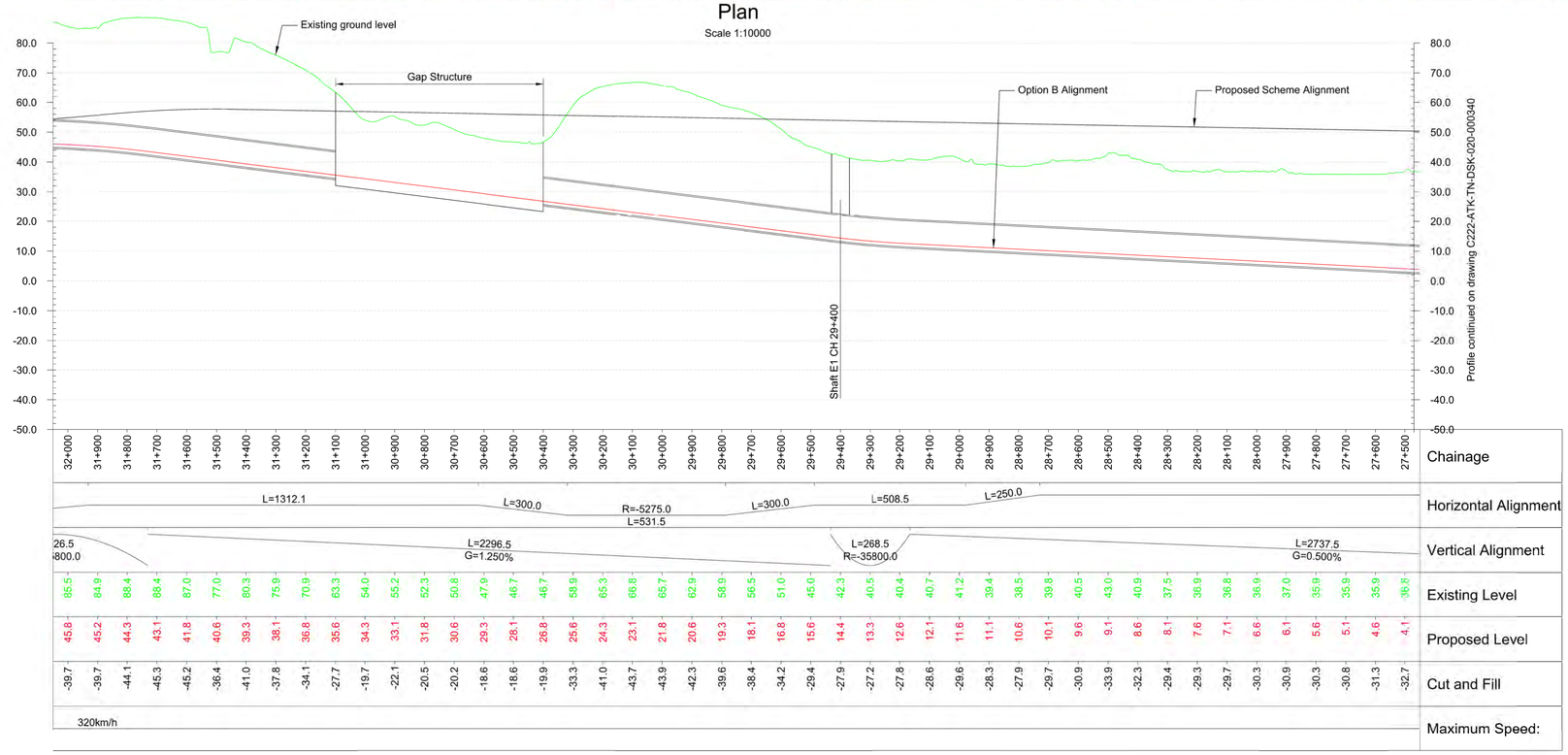
Drawing No.: C222-ATK-TN-DSK-020-000340-RST00000893

Rev.: P00.1



Plan

Scale 1:10000



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Horizontal Alignment		L=1312.1														L=300.0				R=-5275.0 L=531.5					L=300.0				L=508.5		L=250.0																
Vertical Alignment	26.5 800.0														L=2296.5 G=1.250%												L=268.5 R=-35800.0																		L=2737.5 G=0.500%			
Existing Level	85.5	84.9	88.4	88.4	87.0	77.0	80.3	75.9	70.9	63.3	54.0	55.2	52.3	50.8	47.9	46.7	46.7	58.9	65.3	66.8	65.7	62.9	58.9	56.5	51.0	45.0	42.3	40.5	40.4	40.7	41.2	39.4	38.5	39.8	40.5	43.0	40.9	37.5	36.9	36.8	36.9	37.0	35.9	35.9	35.9	36.8
Proposed Level	45.8	45.2	44.3	43.1	41.8	40.6	39.3	38.1	36.8	35.6	34.3	33.1	31.8	30.6	29.3	28.1	26.8	25.6	24.3	23.1	21.8	20.6	19.3	18.1	16.8	15.6	14.4	13.3	12.6	12.1	11.6	11.1	10.6	10.1	9.6	9.1	8.6	8.1	7.6	7.1	6.6	6.1	5.6	5.1	4.6	4.1
Cut and Fill	-39.7	-39.7	-44.1	-45.3	-45.2	-36.4	-41.0	-37.8	-34.1	-27.7	-19.7	-22.1	-20.5	-20.2	-18.6	-18.6	-19.9	-33.3	-41.0	-43.7	-43.9	-42.3	-39.6	-38.4	-34.2	-29.4	-27.9	-27.2	-27.8	-28.6	-29.6	-28.3	-27.9	-29.7	-30.9	-33.9	-32.3	-29.4	-29.3	-29.7	-30.3	-30.9	-30.3	-30.8	-31.3	-32.7
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Profile

Scale H 1:10000 V 1:1000

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
P00.1	FIRST DRAWN	---			

Legends/Notes:

1. Cavern at CH 25+000 to accommodate Heathrow Spurs (not required by Option C).

Registered in England
Registration No. 06791686
Registered office:
One Canada Square,
London, E14 5AB

Creator/Originator
Atkins

Zone: Country South

Project/Contract: Country South Design

Design Stage: DESIGN-FOR-PETITION

Discipline/Function: Tunnels

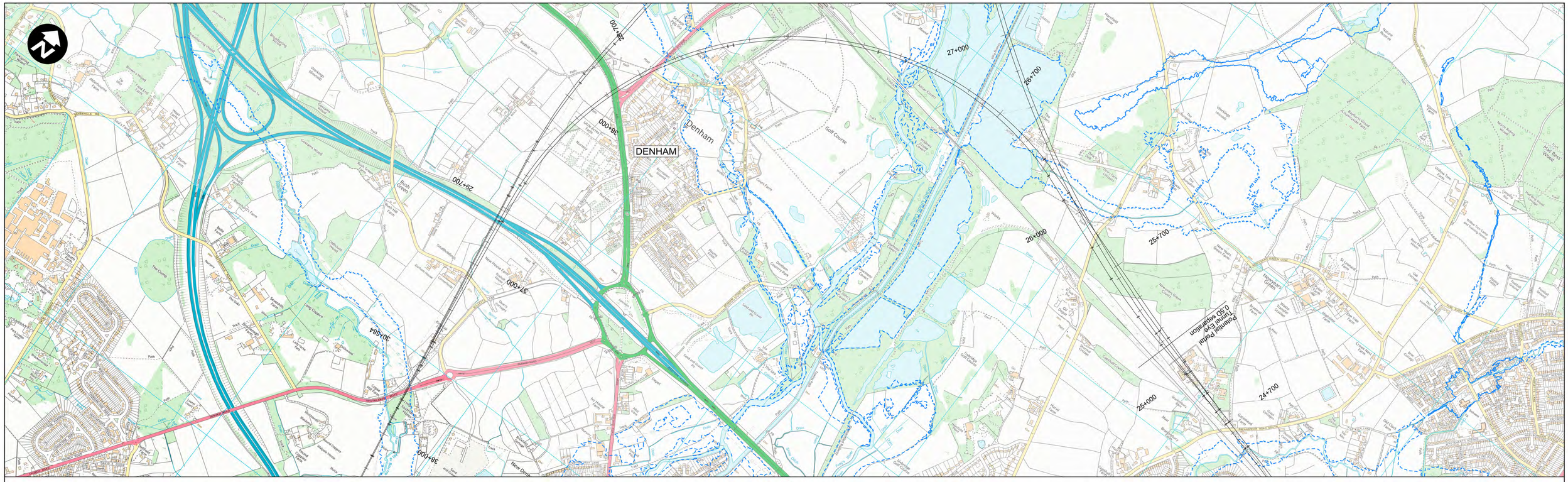
Drawing Title: Community Forum Request. Northolt Tunnel Extension. Option B with provision for Heathrow Spurs. Sheet 2 of 2,

Drawn	Checked	Approved
TB		

Date	Scale	Size
07/05/2014	AS SHOWN	A1

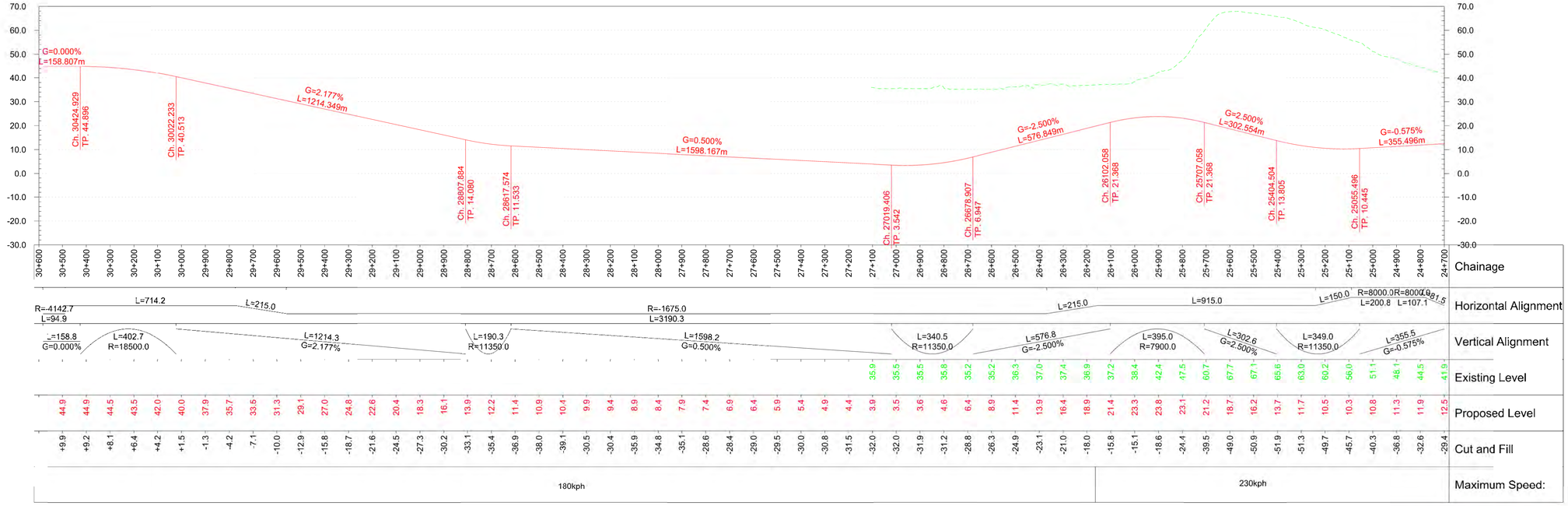
Drawing No.: C222-ATK-TN-DSK-020-000341-RST00000893

Rev.: P00.1



Plan

Scale 1:10000



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Scale H 1:10000 V 1:1000

Work-in-progress

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Rev	Description	Drawn	Checked	Con App	HS2 App
P00.1	FIRST DRAWN	---			

Legends/Notes:

1. For legend refer to drawing HS2-HS2-IM-DSC-000-000001.
2. Alignment is indicative only.

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Creator/Originator: Atkins

HS2 Security Classification:

Zone: Country South

Project/Contract: Country South Design

Design Stage: DESIGN-FOR-PETITION

Discipline/Function: Railway Track

Drawing Title: Colne Valley Tunnel — Eastern Heathrow Spurs Track Alignment — Plan and Profile

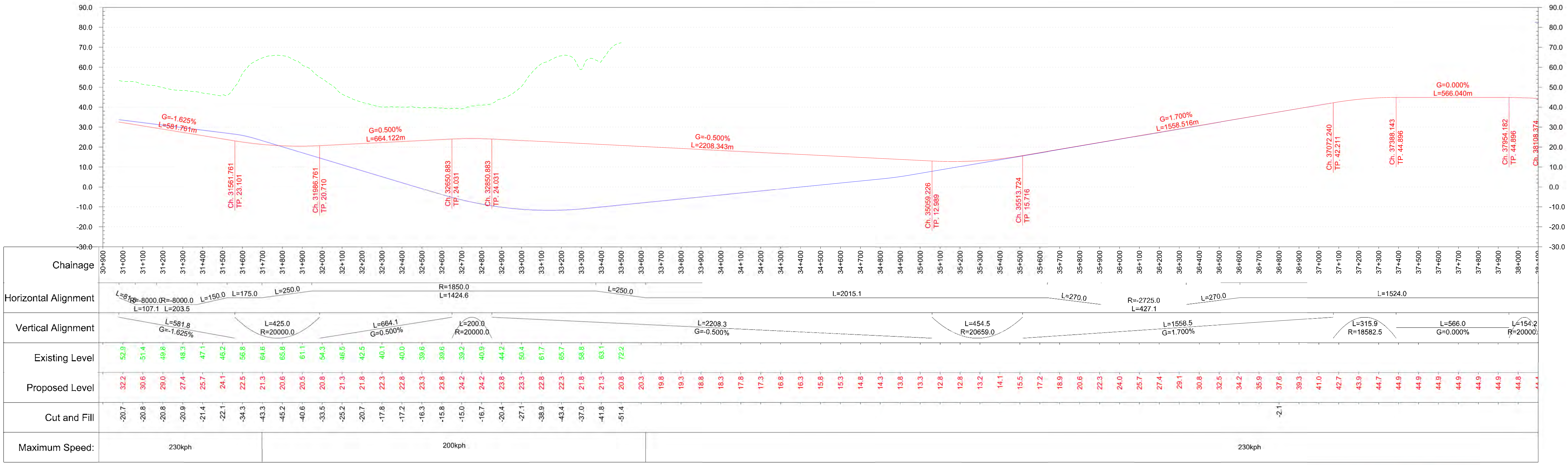
Drawn	Checked	Approved
SE		

Date	Scale	Size
08/11/2013	AS SHOWN	A1

Drawing No.: C222-ATK-RT-DSK-020-011303-RST00000893 Rev.: P00.1

Plan

Scale 1:10000



Profile

Scale H 1:10000 V 1:1000

Work-in-progress

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Rev	Description	Drawn	Checked	Con App	HS2 App
P00.1	FIRST DRAWN	---			

Scale with caution as cistortion can occur.

Legends/Notes:

1. For legend refer to drawing HS2-HS2-IM-DSC-000-000001.
2. Alignment is indicative only.

hs2

Registered in England
Registration No. 06791686
Registered office:
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Creator/Originator: Atkins

HS2 Security Classification

Zone: Country South

Project/Contract: Country South Design

Design Stage: DESIGN-FOR-PETITION

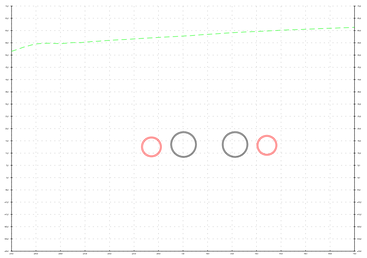
Discipline/Function: Railway Track

Drawing Title: Colne Valley Tunnel
Western Heathrow Spurs Track Alignment
Plan and Profile

Drawn: SE | Checked: | Approved:

Date: 08/11/2013 | Scale: AS SHOWN | Size: A1

Drawing No.: C222-ATK-RT-DSK-020-011304-RST00000893 | Rev.: P00.1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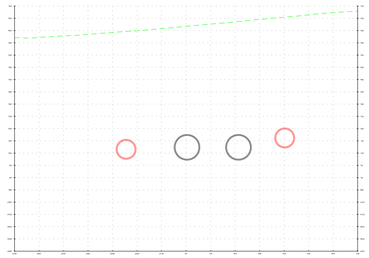
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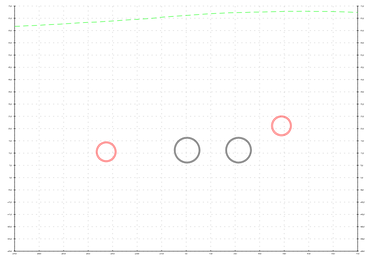
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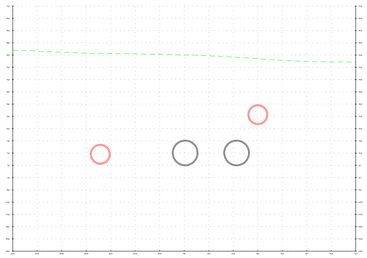
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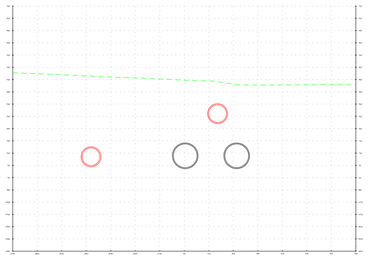
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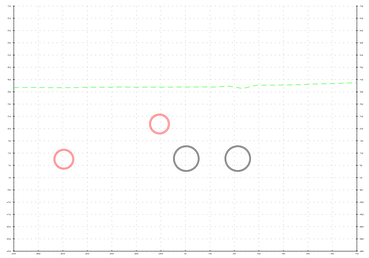
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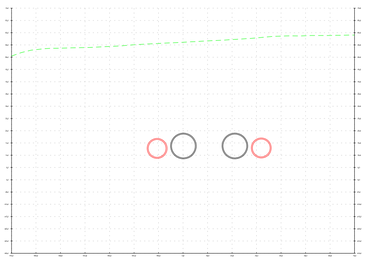
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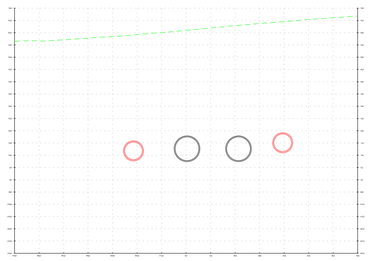
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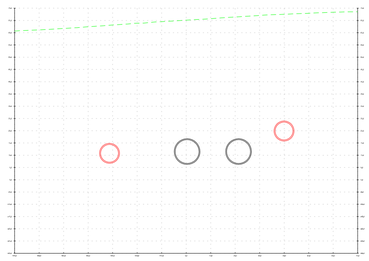
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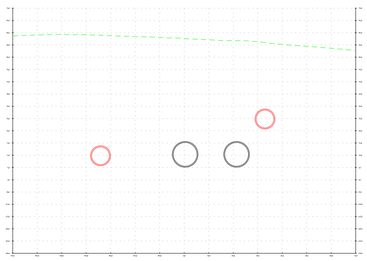
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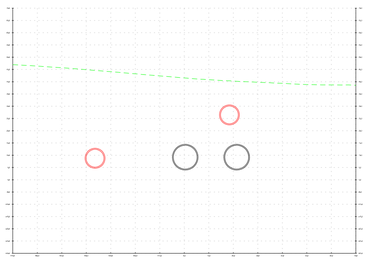
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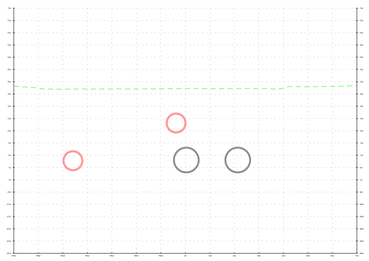
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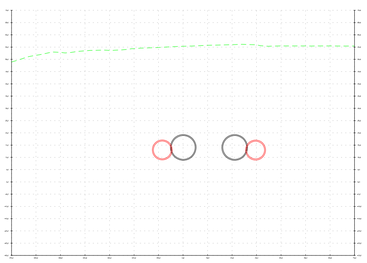
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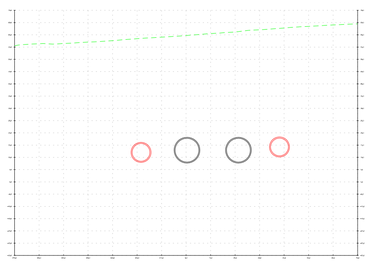
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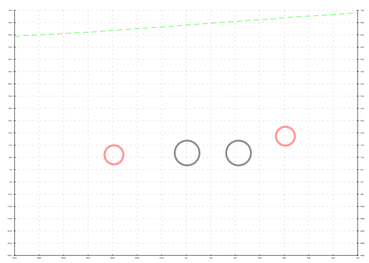
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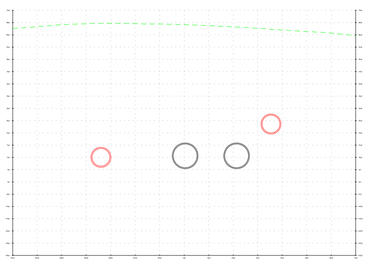
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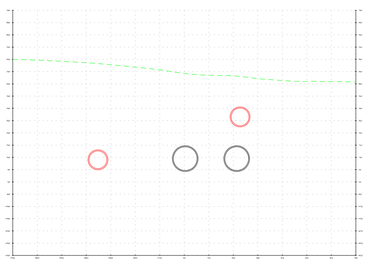
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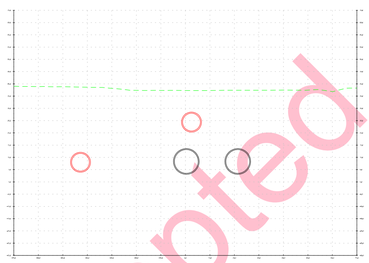
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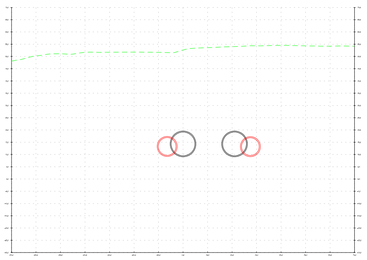
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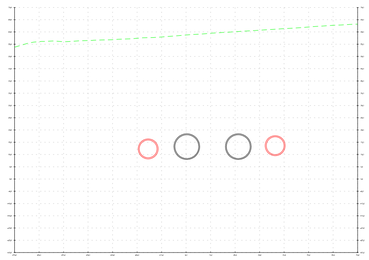
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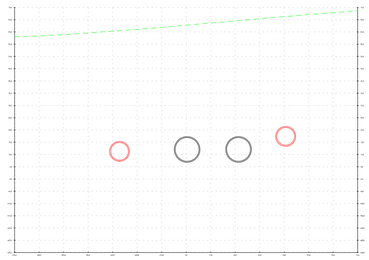
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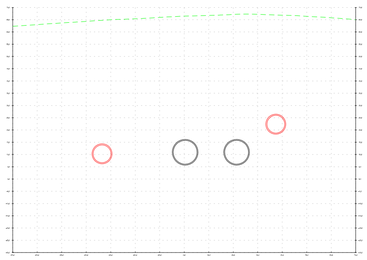
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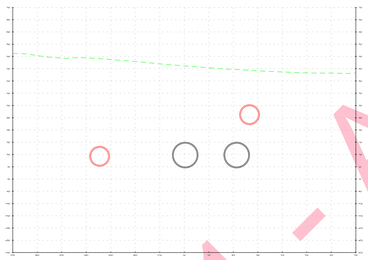
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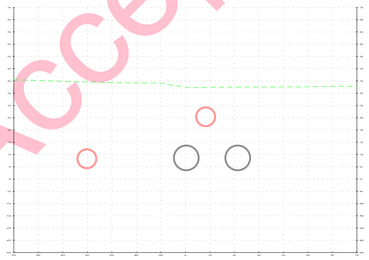
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METRES @ 1:10000 0 100 200 500 1000

METRES @ 1:1000 0 10 20 50 100

Rev	Description	Drawn	Checked	Con App	HS2 App
P00.1	FIRST DRAWN	---			

Legends/Notes:

1. Alignment is indicative only.

Registered in England
Registration No. 06791686
Registered office:
Eland House,
Bressenden Place,
London, SW1E 5DU

Creator/Orlginator: Atkins

HS2 Security Classification:

Zone: Country South

Project/Contract: Country South Design

Design Stage: DESIGN-FOR-PETITION

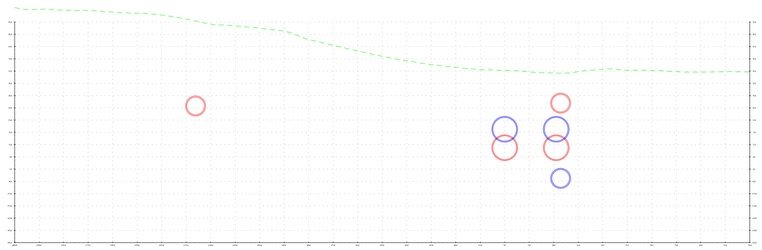
Discipline/Function: Railway Track

Drawing Title: Colne Valley Tunnel
Eastern Heathrow Spurs
Cross Sections

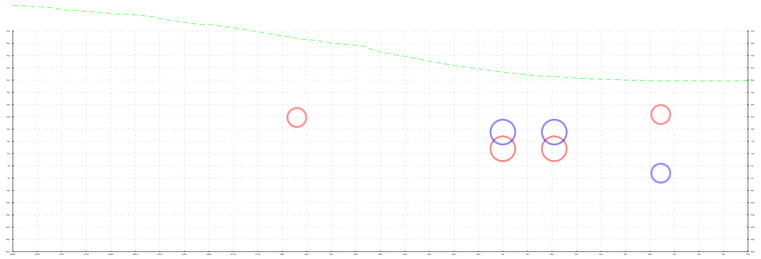
Drawn	Checked	Approved
SE		

Date	Scale	Size
08/11/2013	AS SHOWN	A1

Drawing No.: C222-ATK-RT-DSK-020-011305-RST00000893 Rev.: P00.1



Ch: 29+250



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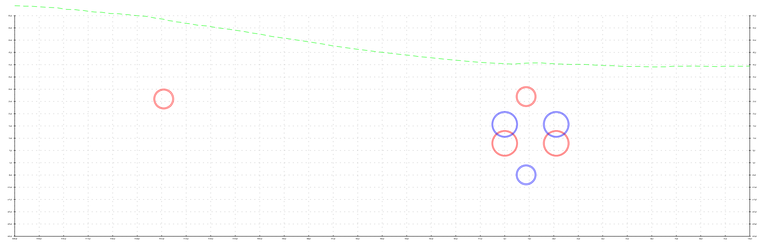

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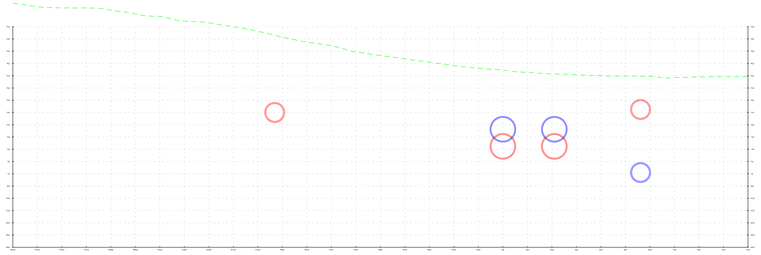

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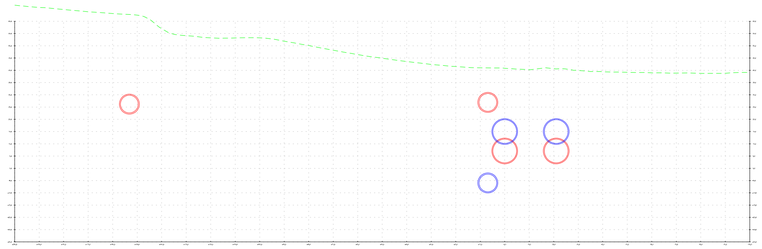

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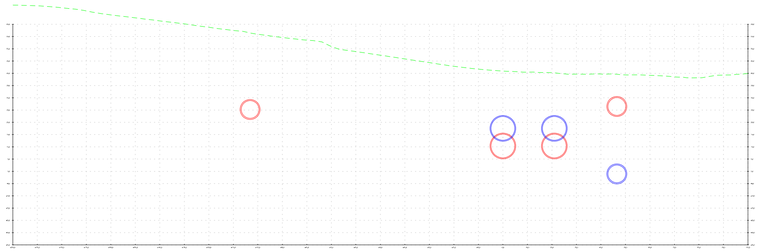

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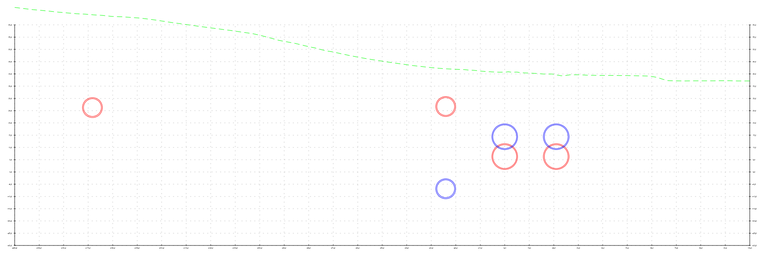

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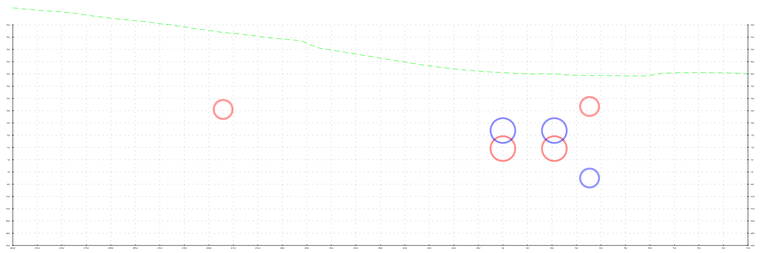

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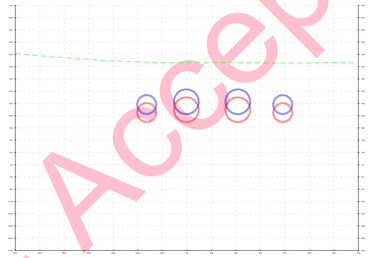

Ch: 30+400

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
P00.1	FIRST DRAWN	---			

Legends/Notes:

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Creator/Originator: Atkins

HS2 Security Classification

Zone: Country South

Design Stage: DESIGN-FOR-PETITION

Drawing Title: Colne Valley tunnel

Western Heathrow Spurs

Cross Sections

Project/Contract: Country South Design

Discipline/Function: Railway Track

Drawn	Checked	Approved
SE		

Date	Scale	Size
08/11/2013	AS SHOWN	A1

Drawing No.: C222-ATK-RT-DSK-020-011306-RST00000893

Rev.: P00.1