TRANSPORT FOR LONDON

RIVER CROSSINGS: SILVERTOWN TUNNEL

SUPPORTING TECHNICAL DOCUMENTATION

NEW THAMES RIVER CROSSING: SILVERTOWN TUNNEL OPTION –

VOLUME 1

Mott MacDonald

November 2009

This report investigates the feasibility of road tunnel crossings at Silvertown.

This report is part of a wider suite of documents which outline our approach to traffic, environmental, optioneering and engineering disciplines, amongst others. We would like to know if you have any comments on our approach to this work. To give us your views, please respond to our consultation at www.tfl.gov.uk/silvertown-tunnel

Please note that consultation on the Silvertown Tunnel is running from October – December 2014.

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Content

Abbreviations

BT	Blackwall Tunnel
EHW	Edmund Halley Way
ITT	Immersed Tube Tunnel
JHW	John Harrisson Way
MD	Millennium Dome
NB	Northbound as in A102-NB
NTRC	New Thames River Crossings
RBT	Roundabout
SB	Southbound as in A102-SB
TBM	Tunnel Boring Machine
JLE	Jubilee Line Extension

Executive Summary

In this report conservative feasible design options for 2 lane twin road tunnel crossings approximately 1400m long beneath the river Thames linking Greenwich and Silvertown are presented. The designs identify;

1. The primary tunnel structures being 11m internal diameter segmentally lined bored tunnel structures to carry the 2 lane road system.

2. The required ancillary support structures such as primary and secondary substations at either end of the tunnels some 30m by 20m and 20m by 10m in plan respectively, the vitiated air exhaust chimneys near the outbound tunnel portals some 9m outside diameter and 30m high, the emergency escape cross passages interlinking the road tunnels proper at 100m centres some 11 in number of which 5 are beneath the river bed.

3. The temporary construction worksites and associated construction support buildings required to build the tunnels. The principal construction site on Silvertown side being sized to store 1 week of peak production i.e. stockpiles of tunnel arisings and tunnel segment supplies.

4. A project specific construction programme supporting a construction period of some 4 years

The designs have been progressed in the absence of a location specific site investigation, however, due to extensive development in the immediate vicinity the local geology is relatively well known and the presented designs are considered robust with respect to the geology to be encountered. The geology will be variable and on the large excavated tunnel diameter of 12.4m mixed face tunnelling conditions will be encountered. Should it be decided to progress design on the proposed tunnel alignment then it will be important to instigate a detailed alignment specific site investigation in advance.

In preparing the designs a number of critical decisions or assumptions are required as a basis of design such as;

1. The type of tunnel boring machine to be employed. An earth pressure balance TBM is chosen based on experience world wide on large diameter tunnels and experience on JLE on smaller diameter tunnels but local to the Greenwich Peninsula.

2. A minimum alignment plan radius of 450m. This radius was confirmed as safely practical through discussion with machine manufacturers. The tunnelling is planned to commence on a plan radius of 450m and this is a significant but unavoidable challenge. Normally a

tunnel drive would commence with a straight length of tunnel drive to help with the learning process.

3. An absolute maximum tunnel gradient of 5% and desirable maximum of 3%. These requirements emanate from the RTSR 2007 and are applicable to un-restricted design speeds. The proposed design is based on 2% maximum gradient on the Greenwich side with 4% on the shorter Silvertown side and this is considered acceptable particularly having regard to the 30mph speed restriction which applies.

4. A minimum desirable tunnel crown ground cover of 1 tunnel diameter. A minimum tunnel cover of 0.66 is proposed and this is justified by benchmarking against international practice in similar circumstances and comparison with other Thames tunnels

The proposed designs are based on a number of significant construction related issues such as;

1. TBM launch site and drive direction. The TBM launch site is located on the Silvertown side as it; a) provides an available large brown-field site sufficient to hold 1 weeks worth of peak production estimated at 200m of tunnel drive, b) provides barge access for delivery of materials such as tunnel segments and export of tunnel arisings, c) provides convenient location for the outbound/east tunnel exhaust chimney and associated fan housing shed also the tunnels secondary substation building, d) includes within is footprint the cut and cover tunnels structures, e) has minimal impact on the public.

2. TBM reception and dismantling site on Edmund Halley Way. In the permanent condition the tunnel structures are located beneath and do not interfere with operation of Edmund Halley Way and Millennium Way. In the temporary condition during construction the tunnel cut and cover structures disrupt both Edmund Halley Way and Millennium Way and it is necessary to temporarily divert both around the cut and cover structures.

3. Location of ventilation chimney and primary tunnel substation on road-locked islands west of Millennium Way. These are significant structures both in height and footprint requiring ready road access for removal of large items of equipment and requiring to be located near the tunnel portals to minimise power loss. The land islands created by the slip roads to and from the tunnels to Millennium Way provide a suitable location.

4. Direction of tunnel drives. The proposed designs assume that the westbound tunnel is drive first from Silvertown to Greenwich where the TBM is dismantled and taken across the river to be re-launched from Silvertown. A number of possibilities are available; a) dis-assemble the machine and transport back to Silvertown, b) turn the machine around at Greenwich and drive the second tunnel from Greenwich towards Silvertown, c) remove the assembled machine and transport back to Silvertown. The decision is complicated by

the location of the bored tunnel portal east of the DLR and the need therefore to lift the TBM or its component parts across the DLR. These issues will need to be revisited in more detail at a more advanced design stage.

TfL instructed that consideration be given to integrating a cyclist and pedestrian crossing into the tunnel. The tunnel depth from road surface to invert intrados is some 3.8m and there is ample space to include for a cyclist and pedestrian passageway in the tunnel invert. It is not clear at this early stage of the design process whether it is more economical to fill the tunnel invert with free draining material or create an invert void using precast concrete elements as shown on the drawings and this concept should be revisited at the next design stage.

1. Introduction

1.1 Background

TfL, in September 2009, commissioned Mott MacDonald to develop designs for a road link across the river Thames to link Greenwich and Silvertown, referred to hereafter as the New Thames River Crossing (NTRC). In particular the link was to connect with the A102 on Greenwich and both a high level bridge crossing and tunnel crossing were to be investigated. This report addresses the designs associated with a tunnel crossing of the Thames, a separate report addresses the designs associated with the High Level Bridge option.

1.2 Tunnel options

TfL envisaged an immersed tube tunnel option as most appropriate as it allowed the shallowest crossing of the Thames, a significant consideration because of the constrained approach length on both banks of the river. In the course of initial examination of the immersed tunnel alignments it became clear that a bored tunnel alignment was feasible at approximately similar vertical alignment. TfL, conscious of the significant negative impact on navigation in the Thames during construction of the Immersed Tube Tunnel instructed that the bored tunnel options be revisited.

1.3 Structure of this Report

The report hereafter is divided under 5 chapters being;

- Chapter 2 Design - Tunnels Sizing and Layout,
- Chapter 3 Construction - Tunnels
- Chapter 4 Recommendations, conclusions, risks opportunities, sustainability

Appendices are included which address;

- Appendix A – Large diameter tunnel boring machines
- Appendix B – Drawings
- Appendix C – Construction Drawings
- Appendix D – Construction Programme

2. Design - Tunnels Sizing and Layout

2.1 Background

2.1.1 Function

The proposed tunnel provides a dual 2 lane all traffic connection between the A102 on Greenwich Peninsula and the Tidal basin roundabout on Silvertown Way with the option of a cyclist and pedestrian connection and or services in the tunnel invert. Alternative cross section arrangements for the tunnel system are shown on drawing MMD-267759-TUN-201.

2.1.2 Form

The running tunnels are of circular cross section each some 1130m in length portal to portal. The tunnels are longitudinally ventilated using jet fans in the tunnel crown to ensure ventilation in normal operation and provide smoke control in the event of an emergency. Near the outbound tunnel portals vitiated/exhaust air is drawn from the tunnel and is expelled at high level through a tall ventilation stack to minimise impact on adjacent high rise buildings. The tunnels are cross connected at 100m centres by pedestrian cross passages to facilitate escape in an emergency. The maximum gradient in the tunnels and approaches is limited to 4% and the minimum alignment plan radius is limited to 450m in plan. The general form of the tunnels as described here is shown on drawings; MMD-267759-TUN-001 to MMD-267759-TUN-005.

2.1.3 Impact

The construction of the NTRC whether by bridge or tunnel has the potential to very severely impact;

1. The travelling public using the A102 and in particular the through traffic using the Blackwall tunnels

2. Navigation on the river Thames during construction of the under river tunnels

3. The public using the now rapidly developing facilities on the Greenwich Peninsula and the owners of these facilities

The impact on the A102 and discussion of alternative route options is discussed in Volume 3 Highways Considerations as the proposed tunnels terminate before reaching the A102. In this chapter the impact of the tunnel construction on; a) Navigation in the river Thames and b) future operation and development in the vicinity of the proposed tunnel alignment on the Greenwich Peninsula are considered. The tunnel construction process will require a very significant construction site on the Silvertown side as shown on drawing MMD-267759-TUN-602 and for the Greenwich side a much smaller worksite as shown on drawing MMD-267759-TUN-604. The construction of the cross connecting emergency escape pedestrian cross passages will require ground treatment from pontoons in the Thames as shown on drawing MMD-267759-TUN-102, 103 and this operation will require coordination with river navigation. The construction impact and will have a duration of some 4 to 5 years as shown in Appendix D.

2.2 Introduction

The required diameter of the tunnel as dictated principally by the traffic gauge, the competency of the local geology and the possible longitudinal alignment gradient including the tunnel crown cover to diameter ratio together with the minimum alignment plan radius are potentially the most significant factors in road tunnel design. These issues are addressed in the following subsections.

2.3 Tunnel excavated diameter

The bored tunnel cross section is shown on drawing MMD-267759-TUN-201. The excavated tunnel diameter of 12.4m and the corresponding internal lining diameter of 11m are determined principally by the demands of the required traffic gauge as defined in BD78/99. We have allowed a minimum footway width of 1200mm as has been allowed on the A3 Hindhead tunnel to allow a wheelchair to travel on the footway and turn through a right angle and enter a cross passage exit. The walkway width must be considered in checking sightline distance, see minimum alignment plan radius below. A tunnel driving tolerance of +/- 80mm has been allowed which is in line with experience for tunnels of this diameter. A spatial allowance of 250mm has been allowed for internal cladding of the tunnel lining. A cladding has been allowed for to provide a bright pleasing surface finish and as a precaution against rogue seepage ingress through the notionally watertight tunnel lining. Should the tunnel lining prove watertight it is possible that a bright pleasing internal finish could be achieved by simply painting the segments. It is worth noting the internal finishing on some well known existing UK road tunnels;

1. Vitreous enamel cladding – Blackwall tunnels, First Dartford Tunnel, Clyde Tunnel, Cuilfail Tunnel

2. Painted internal lining – 2nd Dartford Tunnel, Roundhill Tunnel, Southwick Tunnel

The Airside Road Tunnel at Heathrow Airport is a segmentally lined tunnel left in as constructed state neither painted nor clad see figure 2.1. It is worthy of note that this tunnel is located in the impermeable London Clay and is not accessible to the public except as transfer passengers on an inter-terminal airport coach and it was judged therefore that a bright decorative finish was not required.

The Cuilfail Tunnel in Lewes was originally painted but has been clad in 2009 to mask unsightly water staining of the original cast in situ lining see figure 2.2.

The Round Hill Tunnel on the A20 (see figure 2.3) and the Southwick tunnel on the A27 are both constructed above the water table and are of cast in situ concrete lining construction with a waterproof sheet membrane behind.

Figure 2.1: Airside Road Tunnel at Heathrow Airport

Figure 2.2: Cuilfail Tunnel in Lewes

Figure 2.3: Round Hill Tunnel on the A20

2.4 Minimum alignment plan radius

Variable ground conditions and construction beneath the river Thames dictate that the tunnel boring machine for this project will be a closed face machine of the slurry or earth pressure balance type. In particular the segments for ring construction will be erected within the machine tailskin. The TBM for a 12.4m excavated diameter will be approximately 12m long and segment widths of about 1.8m are envisaged. In the limit as the alignment radius reduces the tunnel boring machine fouls the erected segmental lining as it leaves the tailskin. This radius is partly a function of TBM manufacture. We have been in contact with TBM manufacturers and their advice e is that the minimum TBM plan radius is 400m and a 50m TBM driving error/correction should be allowed giving a minimum design plan radius of 450m.

It is usual to commence tunnel driving on a straight section of alignment to allow an operative/system learning opportunity. In the present instance this has not proved possible because of tight alignment constraints and the tunnel drive commences on a maximum 4% gradient and minimum plan radius of 450m.

2.5 Minimum tunnel crown cover

A circular segmental tunnel lining performs best when acting under uniform compression a situation which arises naturally when the tunnel is located at depth. A common rule of thumb for design purposes is that tunnel overburden cover should be at least 1 tunnel diameter. For tunnels beneath the water table, as in the present project, as tunnel cover reduces below a tunnel diameter a few concerns arise;

1. the pressure in the ring becomes less uniform and bending becomes significant

2. Buoyancy forces can exceed the strength/frictional resistance in the ground above the tunnel

In the present instance it is not possible because of geography and consequent alignment constraints to provide the desired 1 tunnel diameter minimum tunnel crown cover. The minimum cover available is 6.8m at mid river location, river bed level -25mOD, where the minimum water head, coinciding with mean low water Springs -2.9OD, is 28.9m. At the crossing beneath the DLR the crown cover reduces to some 5.3m and in this area it is proposed that the overburden height is increased before commencement of tunnelling to a minimum of 7m commencing from the bored tunnel portal (Chainage 2480) for a length of some 50m until a natural overburden height of 7m is gained

It is worth comparing the present proposal with previous experience as presented in table 2.1 below.

Table 2.1: Comparison among tunnels with low cover

Tunnel	Outer Diameter (m)	Internal Diameter (m)	Cover from river bed to tunnel crown (approximately)	C/D ratio	Ranking
Jubilee Line Extension - Westbound (North Greenwich to Victoria & Albert Dock cut)	4.90	4.40	4.94	1.01	8
Jubilee Line Extension - Eastbound (North Greenwich to Victoria & Albert Dock cut)	4.90	4.40	4.53	0.92	7
Blackwall Tunnel - Northbound	8.85	8.23	1.50	0.17	1
Blackwall Tunnel - Southbound	9.00	8.28	5.05	0.56	3
Dartford Tunnel - West	9.30	8.59	6.00	0.65	4
Dartford Tunnel - East	10.30	9.70	9.00	0.87	6
4th Tube Elbe Tunnel - Hamburg	13.75	12.35	7.00	0.51	2
Proposed NTRC Tunnel	12.10	11.20	8.00	0.66	5

2.6 Maximum alignment gradient

Directive 2004/54/EC of the European Parliament in clause 2.2 states; 'Longitudinal gradients above 5% shall not be permitted in new tunnels, unless no other solution is geographically possible', and goes on to state in clause 2.2.3; 'In tunnels with gradients higher than 3%, additional and/or reinforced measures shall be taken to enhance safety on the basis of a risk analysis'. There are a number of reasons to seek shallow gradients since steeper gradients;

1. increase the probability of accidents
2. in the event of in tunnel fire on the descending ramps greatly increase the effort required to push buoyant hot smoke down the gradient.
3. increase the exhaust output particularly of HGV's on the ascending gradients

However, steeper gradients allow greater tunnel crown overburden cover and in the present instance a compromise must be reached and hence the gradient value of 4% is adopted. With reference to the Directive requirement for reinforced or additional measures it is suggested that the imposition of strict speed limits and the enforcement of average speed detection will be sufficient.

2.7 Traffic, equipment and structure gauge

The derivation of the traffic, equipment and structure gauge is explained in drawing MMD-267759-TUN- 201 for circular TBM bored tunnel and in drawing MMD-267759-TUN-303 and MMD-267759-TUN-302 for cut and cover and open cut construction respectively. The dimensions are generally as adopted for the A3 Hindhead tunnel now under construction and the dimensions are principally as follows;

2.7.1 Vertically

1. 5.03m maintained headroom
2. 250mm clearance allowance for vehicle 'bounce', flapping lorry covers and the like
3. 1.5m allowance for traffic signs, luminaires, ventilation fans and the like.

2.7.2 Horizontally

1. 7.3m between kerb faces
2. 75mm battered kerb to ease access onto the footway in particular for wheel chair access
3. 1.2m verge with 2000mm headroom to allow wheelchairs to travel on the footway and to negotiate a 90 degree turn into an emergency cross passage
4. 600mm horizontally from edge of kerb for full maintained headroom height to electrical and mechanical equipment

2.8 Pedestrian and cyclist gauge

A minimum height of 2.4m and a width of 3m are recommended in the Metric Handbook Planning and design Data (3rd edition) for a cycle path shared with pedestrians. Such a facility is possible in the invert of the proposed tunnel, see drawing MMD-267759-TUN-201. The Metric Handbook in figure 31.19 implies a maximum bikeway gradient of 3% for lengths greater than 200m. The proposed alignment satisfies this requirement on the Greenwich side with a gradient generally of 2% but the gradient on the Silvertown is some 4% over a length of some 600m.

2.9 Fire life safety

Fire in a confined space such as a tunnel is a significantly greater hazard than on the open road. Following significant loss of life in tunnel fires at the start of the century e.g. Mont Blanc, Tauern, Kaprun a European Directive was introduced defining minimum requirements for significant road tunnels in Europe. This Directive, 2004/54/EC, has subsequently been enacted into UK law by means of the Road Tunnel Safety Regulations 2007 (RTSR). The Directive is strictly applicable for tunnels longer than 500m located on the Trans European Road Network (TERN route). The UK Highways Agency considers the Directive as a manual of good practice to be followed unless it is not cost effective to do so.

Tunnels are required to be provided with facilities and systems which in case of emergency incident minimise and manage the hazard e.g. fire or spillage and;

1. Support self rescue, e.g. uninterrupted power supply to a lighting and signage system indicating escape direction
2. prevent, detect and suppress the incident, e.g. CCTV fire detection
3. provide infrastructure which is incident resistant e.g. passive or active fire resistance
4. provide emergency exits to a place of safety e.g. cross passage connections to adjacent tunnel
5. provide vehicle crossovers at minimum 1500m centres
6. enable communication with tunnel occupants via radio rebroadcast, public address, in tunnel emergency telephones and the like

The above issues are discussed in the following report sections

2.9.1 Self rescue

The EC Directive states ‘Safety measures should enable people involved in incidents to rescue themselves, allow road users to act immediately so as to prevent more serious consequences, ensure that emergency services can act effectively and protect the environment as well as limit material damage.’

To comply with the above requirements the tunnel will include at least the following;

1. emergency exits between road tunnels at a minimum 100m centres in accord with the stipulations of BD78/99 (the EC Directive specifies minimum spacing of 500m and NFPA 502 paragraph 7.14.7.2 specifies 200m)
2. Lighted directional signs indicating the distance to the 2 nearest emergency exits will be provided on the side walls at distances of no more than 25m. An uninterruptible power source will maintain minimum lighting levels in the tunnel following an incident. A public address system will allow the Control Centre to broadcast to the tunnel occupants. Emergency stations will be provided at 50m centres (EC Directive 150m minimum centres) and contain a telephone connected to the control centre and 2 fire extinguishers.
3. Fire hydrants will be provided for use of emergency services at 50m minimum intervals (EC Directive 250m minimum)

2.9.2 Incident resistant infrastructure

The tunnel lining will be of reinforced concrete construction in the bored tunnel approaches and of precast concrete segmental construction in the bored tunnel and in both instances fine (about 0.18mm diameter) plastic fibres will be included in the concrete mix at a dosage of not less than

1kgm^3 to impart fire resistance. These provisions are as successfully tested on the Airside Road Tunnel at Heathrow airport and on the A3 Hindhead tunnel.

2.9.3 Incident prevention detection and management

Statistics generally support the contention that there are fewer traffic incidents per vehicle kilometre in road tunnels than on the adjoining road network. However the consequence of an incident in a road tunnel can be significantly greater than on the open road. The EC Directive requires that; 'Special consideration shall be given to safety when designing the cross-sectional geometry and the horizontal and vertical alignment of a tunnel and its access roads, as these parameters have a significant influence on the probability and severity of accidents.' The EC Directive also stipulates; 'longitudinal gradients above 5% shall not be permitted in new tunnels, unless no other solution is geographically possible.

The bored tunnel alignment is chosen such that the limiting gradient limits are met even though this has meant that providing a longer and therefore more expensive bored tunnel alignment.

The tunnel will be monitored from the Control Centre and CCTV cameras will be employed to automatically detect traffic incidents and raise alarms so that the incident can be rapidly managed.

2.9.4 Emergency Exits

Emergency pedestrian exits connecting the two tunnels, see drawing MMD-267759-TUN-001, 201 are provided at 100m centres. The exits have automatically closing fire doors at either end and allow a minimum pedestrian gauge of 3m wide by 2m high. These cross passages allow pedestrians to cross from the incident to the non-incident tunnel and the non-incident tunnel is maintained as a place of safety by the ventilation system. A frangible safety barrier opposite the door helps prevent pedestrians entering the traffic space of the non-incident tunnel. Traffic entry to both incident and non-incident tunnels will be prevented in case of a serious incident.

2.9.5 Vehicle Cross-overs at 1500m centres

The EC Directive requires; 'In twin-tube tunnels where the tubes are at the same level or nearly, cross-connections suitable for the use of emergency services shall be provided at least every 1500m.' Vehicle crossovers will not be provided as the tunnels are less than 1500m long being approximately 1400m long between cut and cover portals.

2.9.6 Communication Control Centre to tunnel occupants

See commentary on Self Rescue above

2.10 Tunnel Ventilation

The tunnel will be ventilated longitudinally in the direction of traffic flow using jet fans located in the tunnel crown in pairs above the traffic envelope at 80m centres with an absorbed power of some 16.2KW. An exhaust chimney will be located adjacent to the cut and cover portal on the outbound tunnel to conduct vitiated air vertically clear of adjacent buildings, with 5 fans located in a double stacked configuration delivering some 400cumecs, see drawings MMD-267759-TUN-

301, 401, 503, 504. Jet fans at the tunnel portals will be reversible so that they may be used in e.g. the event of an in-tunnel fire incident to increase the relative pressure in the non incident tunnel and thereby prevent passage of smoke from incident to the non-incident bore.

2.11 Soil contamination

The soil on the Greenwich peninsula at least in the vicinity of the Millennium Dome is known to be contaminated. The assumptions made here are;

1. Arisings associated with cut and cover tunnel approaches are likely to suffer at least some contamination

2. Arisings from the bored tunnel drives, having a minimum ground cover of some 8m ar unlikely too be contaminated.

In consequence the design presented aims to maximise the length of bored tunnel and minimise the length of cut and cover tunnel and open cut tunnel approaches.

2.12 Flood protection

The Thames flood protection works including the Thames Barrier provide protection in the project area to a safe defence level of 5.23m O.D., (email Biggs Environment Agency to Rock Mott MacDonald 12/03/2009). The Silvertown tunnel approaches tie into existing roundabout at some 1mOD. Millennium Way and Edmund Halley Way junction at some 2mOD while the proposed NTRC road level beneath the junction is some -6.5mOD. It is proposed therefore that reliance is placed on the flood protection works and no tunnels specific protection works are required or will be provided. The normal tunnel design good practice of intercepting water flows at the cut and cover tunnel portals will be followed. It is noted that the existing Blackwall Tunnels have flood protection gates installed. The intention of these gates is that they provide protection to London in the event of a breach of the tunnel linings. The perceived risk arises primarily because of the extremely low ground cover beneath the river especially true of the northbound Blackwall Tunnel. The ground cover to the proposed NTRC crossing is more secure and floodgates are not deemed necessary.

2.13 Structural and Geotechnical considerations

2.13.1 TBM bored tunnels – segment details

The main bores will be constructed by TBM and will have a lining of reinforced precast concrete segments. The segments will be bolted longitudinally and radially and will be fitted with rubber gaskets on the extrados to render the lining nominally watertight. The tunnel geometry is shown on drawing MMD-267759-TUN-202, 203. The tunnel rings will comprise 7 segments and a key having internal diameter 11.0m and external diameter 12.1m and an excavated diameter of some 12.4m. The segments will be 550mm thick and 1.8m wide with 55mm taper to support a minimum theoretical alignment radius of 450m, in addition to a tunnel driving error of some 50m on radius. The distance from lining crown extrados is 7.72m. It is proposed that the tunnel rings will be left and right tapered so that straight alignment is achieved using successive left and right rings and curved alignment achieved using the appropriate combination of left and right tapered rings. The bored tunnels generally will be located in plan at 24m centres reducing at the launch and reception chambers to 18m over an alignment length of 120m, i.e. 1 in 40 taper.

The bored tunnel will be located in water bearing ground with a pressure head of some 20m to 30m. The tunnel will have rubber gaskets located towards the lining extrados which are intended to provide a watertight lining, however, experience shows that while 99% or thereabouts of the rings will be watertight it will not prove practical to achieve total water tightness. The odd incidences of rogue seepage ingress could prove unsightly which is undesirable particularly in a well lighted tunnel clearly visible to the public. The tunnel will therefore be internally clad from a height of 1m above carriageway to 4m above carriageway level. The principal performance requirements of the cladding include;

1. have a useful life and maintain a reflectance level >60% for a minimum of 15 years
2. be soap and water brush washable at a maximum 2 weekly frequency
3. be demountable and re-erectable albeit infrequently
4. be resistant to carriageway chippings flung up from vehicle tyres
5. be exhaust fume, water and salt spray resistant
6. be available as 3m high panels easily handled.

The adjacent Blackwall Tunnels upstream and the Dartford tunnel downstream are clad with vitreous enamel panels and similar panels will be used for pricing purposes on the present project, however, it is possible that cementitious panels would afford a first and whole life cost saving while meeting the specification above.

2.13.2 Choice of Tunnel Boring machine

The choice of tunnel boring machine is dictated by the nature of the ground to be excavated. The vertical gradient and plan alignment constraints are such that there is negligible freedom to choose the tunnelling medium. While a project specific site investigation remains to be carried out nevertheless the geology of the area is well known and understood due to extensive tunnelling and civil engineering works effected in the immediate area. In particular the bored tunnel face will be mixed throughout the length of the drive encountering, terrace gravels, alluvium, London Clay, Harwich formation, Thanet beds, Upnor Formation, Woolwich and Reading Beds. Many of the above strata have the potential to be water bearing. In the building of the Jubilee Line Extension tunnels in this area it is worthy of note that EPB tunnelling machines were employed and tunnelling from North Greenwich to Canary Wharf was executed in closed mode and with difficulty. However, improved ground conditions meant that tunnelling from North Greenwich to Canning Town was effected using EPB machines in open mode and with relative ease. The London Clay is likely to extend over the majority of the project area and provide an acquiclude between the Thames and those formations beneath the clay. The mixed ground conditions, the likelihood of encountering water bearing strata beneath the river, the experience on the Jubilee Line Extension indicate that an EPB or Slurry type machine be employed. It is suggested that until an alignment specific Site Investigation is effected a Slurry type TBM be assumed for project costing purposes.

2.13.3 Bored Tunnel Approaches

The bored tunnel approaches comprise open cut ramp and cut and cover tunnels at either end of the bored tunnels. These structures are constructed using diaphragm wall, side retaining walls, with cast in-situ reinforced concrete roof and floor slabs. The roof slab is located generally at 1.5m below finished ground level to allow limited room for buried services above and maintained at this level even as the carriageway beneath descends to avoid increasing the earth load on the roof slab. Immediately adjacent to the cut and cover portal the cover to the roof slab reduces to 0.5m giving a distance from finished ground level to the road level at the cut and cover portal of 8.5m. The structure is constructed top down and temporary propping may be internal props or ground anchors as the Construction Contractor desires. The open cut ramps will also comprise diaphragm wall retaining walls and reinforced cast in situ concrete floor slabs. The ground water level was assumed at ground level and tension piles were designed to prevent uplift of cut and cover and open cut structures.

2.14 Emergency Cross Passages

As discussed above cross passages are required at 100m centres for fire life safety reasons. The mid river cross-passage coincides with the tunnel low point where a drainage sump and pump are located. Some 5 cross passages are located directly beneath the river bed and a further 6 are located under land, see drawing MMD-267759-TUN-001. The cross passages are some 14m in length connecting between 12m diameter running tunnels at 24m centre distance separation. The cross passages are mechanically mined and may be lined usually using hand built tunnel segments or sprayed concrete. In the past such cross passages have not been constructed, e.g. Blackwall tunnels, Dartford tunnels either because they were not considered necessary or more generally because of the challenges posed. There are three principal challenges;

1. Breaking out of the running tunnel into the mixed and water bearing London Clay strata
2. Mechanically mining for the cross passages through the variable London Clay strata
3. Achieving a water tight junction between the running tunnels and the cross passages

Three generic construction processes have traditionally been employed;

1. Compressed air
2. Ground freezing
3. Ground improvement by grouting

Compressed air methods are rejected because of the associated health hazard. Ground freezing is rejected on cost, programme and hazard grounds but chiefly on cost grounds. Ground treatment using cementitious or other grouts can be used to improve the ground strength and is considered the most appropriate strategy. The grouting may be effected from above using jack-up pontoons in the river bed or tracked equipment on land and using jet grouting methods. Alternatively it should be possible to grout from within the bored tunnels. Jet grouting is possibly the most robust approach although unlikely to be the most economical. For present purposes jet grouting from the surface or from a pontoon is assumed. For each cross passage a ground prism some 8m by 8m in cross section and 16m long and centred on the cross passage axis is assumed see drawing MMD-267759-TUN-102.

3. Construction - Tunnels

3.1 Introduction

In this chapter the proposed design is examined and compared with current practice considering in particular;

1. Construction Feasibility
2. Impact on 3rd party stakeholders
3. Construction programme
4. Cost

3.2 Construction feasibility

3.2.1 Running Tunnels

The ground conditions are challenging comprising mixed geology in the tunnel face including Lambeth beds, London clay etc. This geology has been successfully mined in the past notably the Jubilee Line Extension which runs close by and the Blackwall and Dartford tunnels also across the Thames. However the proposed tunnels at 12.4m excavated diameter are larger than previously attempted across the Thames with Dartford East tunnel of excavated diameter 10.3m. The proposed excavated diameter of 12.4m is large but again there is a growing body of equal or larger diameter tunnels in soft ground e.g. 4th tube Elbe Tunnel in Hamburg13.75m, Dublin Port Tunnel 11.77m and Miami Port tunnels about to start construction at 12.8m excavated diameter. In Appendix A, some examples of recently constructed large diameter tunnels are presented.

The TBM technology has progressed rapidly in recent years and it is now the case that a TBM technology is available to overcome any ground condition including mixed ground conditions. In this respect the NTRC tunnels while challenging are not extreme. It is likely that EPBM will be appropriate as employed at nearby North Greenwich for the JLE tunnels. A detailed site specific site investigation is required to inform the specification for the TBM.

3.2.2 Cross Passages

The emergency cross passages interconnecting the running tunnels are proposed to be mechanically mined using a backactor or similar excavator and lined using sprayed concrete as detailed on drawing MMD-267759-TUN-204. While the cross passages are of comparatively small diameter, excavated diameter of 4.55m, in the prevailing ground conditions their construction poses a significant challenge and it is necessary to effect ground treatment before excavation.

Two methods of ground treatment are proposed jet grouting and permeation grouting. Jet grouting would be effected in advance of constructing the running tunnels, see drawing MMD-267759-TUN-102 and permeation grouting would be effected from within the already constructed running tunnels, see drawing MMD-267759-TUN-103. Jet grouting would be effected from the surface vertically down and this would entail, for the 5 cross passages beneath the riverbed, the use of a spud pontoon and this could constitute a hazard to shipping. Permeation grouting can be effected from within the running tunnels and it is likely that this method of grouting would be adequate but this needs to be confirmed in the first instance by executing a project specific site investigation.

3.2.3 TBM Launch Chamber – East or West of DLR

Locating the TBM Launch Chamber immediately west of the crossing of the DLR would confer the significant advantage of avoiding the need to transport large TBM components across either beneath or above the DLR viaduct. The disadvantage of this choice arises from the need to then build cut and cover tunnels east of the launch chamber and beneath the DLR viaduct in an area of low headroom and with high tidal water table level.

For the present the choice has been made to locate the TBM launch chamber east of the DLR line on the assumption that the TBM will be assembled on site at the Launch Chamber and the TBM backup will be assembled in the cut and cover tunnels which will have been previously constructed. This is considered the least risk of the 3 possible options; a) crane a 1300tonne assembled TBM across the DLR, b) turn the TBM around at the Greenwich Reception Chamber and tunnel eastwards towards Silvertown, c) as described above assemble the machine in the Silvertown Launch Chamber, dis-assemble in Greenwich Reception Chamber and transport in parts to second Launch Chamber at Silvertown then tunnel to Greenwich and dis-assemble and remove from site.

This decision has been discussed by the Design Team with TBM manufacturers but will be worth revisiting should the tunnel option be further progressed.

3.3 Construction Impact on 3rd party Stakeholders

The design objective has been to minimise tunnels construction and operation impact. During construction the aim is to export and import materials to the project by river transport wherever possible. The tunnels construction impact can be considered under 3 broad headings; a) Silvertown landfall, b) Greenwich landfall, c) navigation in river Thames.

3.3.1 Silvertown Landfall

The proposed construction working site lies within the ‘safeguarded area’. A significant working site footprint is required primarily to store spoil arisings and tunnel segment supplies, see drawings MMD-267759-TUN-601 to 603. The footprint is sized to store 1 week of peak tunnel production assumed at 200m of tunnel drive requiring bulk storage of some 43000m^3 of spoil giving a storage footprint of some 10000m^2 assuming storage to a height of some 4m. Likewise tunnel segments for production of 200m of tunnel need to be stored i.e. some 112 rings at 1.8m wide requiring a storage area of some 90m by 30m i.e. some 2700m^2.

The secondary substation and the fan housing structure to the vitiated air chimney are both located above ground on the Silvertown side. Some or all of these structures are commonly located below ground in shafts and above the cut and cover tunnel structures. The structures are cheaper to construct above ground and moreover the siting location between the underground tunnel structure and the off slip from Silvertown Way is effectively frozen to development.

3.3.2 River Thames -Port of London Authority – Department of Environment

At peak production some 50000 tonnes of spoil would be exported per week equivalent to some 100 large, 1000 tonne, spoil barge movements. Likewise some peak tunnel segment import rates of 18000 tonnes per week could be envisaged requiring some 40 large barge movements per week. Such size and frequency of movement would require discussion with PLA.

The proposed design includes some 11 emergency pedestrian cross passages linking the 2 running tunnels. These tunnels are to be mechanically excavated as opposed to excavated using a TBM. Given the anticipated ground conditions, ground treatment will be required before excavation can commence. The proposed design considers 2 options for treatment permeation grouting from within the running tunnel as shown on drawing MMD-267759-TUN-103 and jet grouting from a spud pontoon in the river as shown on drawing MMD-267759-TUN-102.

The permeation grouting option will be the cheaper option and will not impact river navigation. The jet grouting option is likely to be the more robust approach from a ground improvement viewpoint; however, the spud pontoon will have a significant impact on river navigation, requiring about 1 month on location for each cross passage and discussion with PLA is recommended. The jet grouting has the potential to cause significant turbidity potential to the river bed as a direct result of drilling and also arising from escape of cement grout and discussion with Department of the Environment is recommended.

3.4 Greenwich Landfall

The cut and cover tunnels are located beneath Edmund Halley Way and Millennium Way and these roads must be temporarily diverted as shown on drawing MMD-267759-TUN-605. There are many ways in which the road interruptions can be effected e.g. the cut and cover structures could be constructed in phases and the roads be diverted accordingly. The possible phasing and location of road diversions should be discussed with the O2 Operator.

The tunnel cut and cover structures extend some 300m with an associated bulked excavation volume of some 150,000m^3. It is envisaged that this material would be moved by conveyor belt at high level alongside Edmund Halley Way and discharged into a barge; again this proposal needs to be discussed with the O2 Operator.

3.5 Construction Programme

The time chainage construction programme is presented in appendix D together with explanatory sheet outlining task durations. The programme is dominated by the TBM elements and in particular the allowance of 12 months from start of contract to procure and deliver the TBM to site then 3 months to assemble the TBM in the Launch chamber followed by a 4 month period for excavation of the westbound tunnel at an average excavation rate of 75m per week. The TBM is then disassembled and transported to the Silvertown portal of the eastbound tunnel and reassembled and relaunched to drive the eastbound tunnel, requiring a period of 4 months, and then be disassembled and taken off site in a period of 1 month. The running tunnels are complete within 27months of contract start and the tunnel construction and commissioning is shown to be complete within 48 months of start. The construction programme as presented is believed to be challenging but achievable.

3.6 Tunnel Solution Cost Estimate

The tunnel construction estimate has been developed by Mott MacDonald's in-house cost consultants Franklin + Andrews. Using historical cost data, Franklin + Andrews have produced composite rates and lump sums to estimate the tunnel solution, excluding the associated highways works. The estimate is at current day (4Q09) prices.

COST ESTIMATE SUMMARY

Franklin+Andrews

Job Title:	***New Thames River Crossing - Tunnel Option***		
Job No:		**Base Date:**	***Dec-09***
Cost Est. No:	***Feasibility***	**Area (m^2):**	***n/a***

Description		**£**
Enabling Works		2,250,000
Tunnel		
Bored Tunnel (incl. cross passages)		206,568,180
Cut & Cover Tunnel		10,134,281
M&E Systems		26,789,000
Accommodation Works		1,000,000
Services/Statutory Diversions		3,000,000
Toll System		1,500,000
Landscaping/Environmental		1,000,000
	Sub-total	252,241,461
Contractors On Costs		Included
	Sub-total	252,241,461
Risk/Contingency	15%	37,836,219
TOTAL BUDGET CONSTRUCTION COST		**£290,077,680**

The estimate has been benchmarked against similar type projects, with the most representative one being the Dublin Port Tunnel.

New Thames River Crossing Tunnel	£193,000/route metre
Dublin Port Tunnel	£182,000/route metre

The table identifies some of the key pricing issues applicable to the various components, and identifying the potential price range on the estimate.

GENERAL NOTES & EXCLUSIONS

Franklin+Andrews

Job Title:	***New Thames River Crossing - Tunnel Option***		
Job No:		**Base Date:**	***Dec-09***
Cost Est. No:	***Feasibility***	**Area (m^2):**	***n/a***

General Notes & Exclusions;

Enabling Works	This has been based on layout drawings for the site establishment on the North side including the riverside materials/spoil handling works. Risks: Addt riverside works, contaminated land, planning issues Potential Cost Impact : -10% to +50%
Highways	Not Included
Bored Tunnel	Estimate based on longitudinal and cross-sections of the tunnels, identifying the size of the tunnel bores, together with cross passages. In addition Risks: Detailed site investigation required, aquifer, detailed design incomplete, pricing Potential Cost Impact : -10% to +30%
Cut & Cover Tunnel	Estimate based on longitudinal and cross-sections of the tunnel Risks: Detailed site investigation required, detailed design incomplete, pricing Potential Cost Impact : -10% to +30%
M&E Systems	Allowance made based on historical scope and cost data Risks: Detailed design incomplete, pricing Potential Cost Impact : -10% to +50%
Accommodation Works	Allowance made based on historical scope and cost data Risks: Assessment of requirements not fully established Potential Cost Impact : -25% to +50%
Services/Stat Diver.	Allowance made based on historical scope and cost data Risks: Assessment of requirements not fully established Potential Cost Impact : -50% to +75%
Toll System	Allowance made based on historical scope and cost data Risks: Assessment of requirements not fully established Potential Cost Impact : -10% to +50%
Landscaping/Env	Allowance made based on historical scope and cost data Risks: Assessment of requirements not fully established Potential Cost Impact : -50% to +50%

4. Recommendations, conclusions, risks opportunities, sustainability

4.1 Recommendations

Should the tunnel design option be progressed further then the following recommendations are made;

1. A detailed Site Investigation should be commissioned
2. The outline designs presented here should be discussed with the various Stakeholders
3. The TDSCG should be asked to address the issue of frequency of emergency escape cross passages through discussion with the relevant authorities such as LFEPA and the Department for Transport.
4. Carry out a safety audit of the proposed links and tie-in to Millennium Way and the A102
5. Investigate further the opportunities identified below, particularly the possibility in an emergency incident of passengers making emergency exit into the tunnel invert.

4.2 Conclusions

The following conclusions are drawn;

1. Constructing 2 lane twin TBM bored tunnels beneath the river Thames between Greenwich and Silvertown is feasible
2. The construction impact on navigation in the Thames will be small and possibly negligible dependant on how ground treatment at cross passage locations is effected, grouting from pontoons in the river causing more impact than ground treatment from within the running tunnels.
3. Construction of the proposed running tunnels to be effected from a construction worksite on the Silvertown side.
4. A pedestrian and or cycleway can be provided in the tunnel invert.
5. In addition to a pedestrian and cycleway provided in one tunnel invert the same or indeed the 2nd tunnel invert could be used to carry utilities such as hot water for communal heating, power supply, communications etc.
6. A construction period of some 4 years from start on site is envisaged.
7. A cost estimate of some £XXX

4.3 Risks

The risk register presented below is restricted to high level risks from a global project perspective. All of the risks identified are considered susceptible to mitigation through management

New Thames River Crossings - Bored Tunnel Option – Global Project Risks		
Risk ref.	Risk description	Mitigation
1	Project delay giving rise to increased development immediately adjacent to tunnel route and associated increased cost.	Establish a safeguarded zone. Expedite planning and construction.
2	Department of Environment does not allow jet grouting beneath the riverbed to facilitate cross passage construction because of cement and mud/arisings pollution, see drawing MMD-267759-TUN-102	Employ permeation grouting from within the running tunnels, see drawing MMD-267759-TUN-103
3	PLA imposes a restrictive cap on the number of barge movements per day or per tide etc.	Design for barge convoys, maximise barge movements during the night, use 1000 tonnes barges.
4	The tie-in at Millennium way is considered overly complex from a signage and safety viewpoint	Carry out a rigorous safety audit, consider signalising the junction
5	Thames flood defences are breached and tunnel is flooded.	Locate critical equipment above flood level e.g. tunnel standby generator
6	Low ground cover to bored tunnel crown.	Detailed Site Investigation and if shown necessary ground treatment. Considered remote risk.
7	Bored tunnel portal in proximity to DLR viaduct increases project complexity particularly having regard to TBM assembly etc.	More detailed investigation in next design phase

4.4 Opportunities

In preparing this study a conservative approach to design has generally been observed the natural consequence of which is that there are a number of opportunities which remain to be explored which should lead to cost reduction. The concept of emergency escape from the roadway to the tunnel invert would most probably lead to cost savings, however, this concept leads to the more fundamental opportunity to allow independent alignments for the northbound and southbound carriageways. This freedom would for example allow the southbound carriageway to be aligned with Edmund Halley Way and the Northbound carriageway to be aligned with Sir John Harrison Way. The opportunities listed below are again restricted to high level global project opportunities

New Thames River Crossings - Bored Tunnel Option – Global Project Opportunities		
Opportunity Ref	Opportunity	Action
1	Follow RTSR 2007 requirement to locate pedestrian emergency escape at 500m centres as opposed to 100m requirement of BD78/99 and thereby avoid cross passages beneath river bed	Contact and meet with LFEPA and raise issue with TDSCG
2	Install latest technology fire suppression in tunnels and install emergency escape passages at wider centres	As above
3	Create services route and pedestrian/cycle way by creating void in tunnel invert using precast concrete segments	TfL talk with utilities e.g. EDF, LUL etc.
4	Increase alignment vertical gradient on Greenwich side above current 2.55% so that length of cut and cover structure is reduced and cost is thereby reduced and possibly volume of contaminated arisings is minimised.	Highway designer to talk with Environment team following detailed Site Investigation.
5	Create pedestrian emergency escape passages from road tunnel to void in tunnel invert and thereby eliminate inter-linking cross passages between tunnels.	Address in Phase 2
6	Investigate independent northbound and southbound tunnel alignments having eliminated cross passages as outlined above	ditto

4.5 Sustainability

Sustainability at global Project level, social regeneration, congestion relief and the like is discussed elsewhere, here, the contribution of the tunnel design to sustainability is considered. The design as developed to-date contributes in the following respects;

1. The vertical alignment as developed is energy efficient utilising shallow gradient, peak of 4% but generally 2%. The natural sag curve is regenerative in that vehicles naturally coast down the descending gradient while the ascending gradient approaching the roundabouts at either end acts as a natural brake. This energy saving compares favourably with most bridge crossing alignments where the ascending gradient is encountered first. The vertical alignment will also favour change in vehicle propulsion philosophy to electric/hybrid etc.

2. Tunnel logistics have been organised, working site location and layout, to allow import and export of materials by barge.

3. The tunnel invert may be designed to provide other services as discussed elsewhere such as pedestrian and cycle ways and other utilities thereby maximising the value of the infrastructure asset.

4. Designing the alignment to maximise the length of bored tunnel minimises the volume of contaminated arisings likely to be encountered.

Appendix A. Large diameter tunnel boring machines

TBM Manufacturer	Feature	Country	Year	TBM Type	TBM Diameter mm	Tunnel length m	Tunnel type	Geology
Mitsubishi	Obayashi JV	Japan	1994	EPB	14,140	13500	Trans Tokyo Bay	
Mitsubishi	Tobishima JV	Japan	1994	EPB	14,140	13500	Trans Tokyo Bay	
Herrenknecht	4. Röhre Elbtunnel Hamburg	Germany	2004	Mixshield	14,200	2560	Road	Sand, boulder clay, silt and gravel, erratic blocks
Herrenknecht	Silberwald	Russia	2007	Mixshield	14,200	3010	Road	Sand, clay, rock
Herrenknecht	Lefortovo	Russia	2003	Mixshield	14,200	4112	Road	Fine to coarse sand, clay, limestone (medium strength, partially very fissured)
Robbins	Largest Hard Rock TBM Assembled Onsite	Canada	2006	Main Beam TBM	14,400	10400	Hydroelectric	limestone, dolostone, sandstone and mudstone
Wirth / NFM	Groene Hart	Netherlands	1991	Benton Air	14,870	8606	Railway	Sand
Herrenknecht	M-30 By-Pass Sur Túnel Norte, Madrid	Spain	2007	EPB Shield	15,200	3526	Road	Peñuela, Peñuela + gypsum, massive gypsum
Herrenknecht	Shanghai Changjiang Under River Tunnel Project	China	2008	Mixshield	15,430	7472	Road	Sand, clay, rubble
Hitachi Zosen	Osaka Subway	Japan	1993	3-multi-face	17300 x 7800		Subway	

Appendix B. Drawings

Drawing Number MMD-267759-TUN-	Drawing title
1	New Thames River Crossing Bored Tunnel Option Scheme layout plan Scale 1:2500
2	New Thames River Crossing Bored Tunnel Option Scheme layout long section Scale, Hor. 1:2500, Ver. 1:250
3	New Thames River Crossing Bored Tunnel Option Scheme layout plan and long section Sheet 1 of 3 Scale Hor. 1:1250, 1:1000, Ver. 1:250
4	New Thames River Crossing Bored Tunnel Option Scheme layout plan and long section Sheet 2 of 3 Scale Hor. 1:1250, 1:1000, Ver. 1:250
5	New Thames River Crossing Bored Tunnel Option Scheme layout plan and long section

	Sheet 3 of 3 Scale Hor. 1:1250, 1:1000, Ver. 1:250
101	New Thames River Crossing Bored Tunnel Option Geotechnical long section Scale N.T.S
102	New Thames River Crossing Bored Tunnel Option Cross Passages ground treatment Alternative 1 – Jet grouting
103	New Thames River Crossing Bored Tunnel Option Cross Passages ground treatment Alternative 2 – Permeation grouting
104	New Thames River Crossing Bored Tunnel Option Low point sump ground treatment Alternative 1 – Jet grouting
105	New Thames River Crossing Bored Tunnel Option Low point sump ground treatment Alternative 2 – Permeation grouting
201	New Thames River Crossing Bored Tunnel Option

	Bored Tunnel Spatial Cross section
202	New Thames River Crossing Bored Tunnel Option Tunnel segment layout left hand ring
203	New Thames River Crossing Bored Tunnel Option Tunnel segment layout right hand ring
204	New Thames River Crossing Bored Tunnel Option Emergency escape cross passages Cross section
205	New Thames River Crossing Bored Tunnel Option Emergency escape cross passage with sump Cross section for in-filled invert
206	New Thames River Crossing Bored Tunnel Option Emergency escape cross passage with sump Cross section for precast void in invert
301	New Thames River Crossing Bored Tunnel Option Silvertown Approach Structures plan layout
302	New Thames River Crossing Bored Tunnel Option

	Silvertown Open cut structures
303	New Thames River Crossing Bored Tunnel Option Silvertown cut and cover structures
304	New Thames River Crossing Bored Tunnel Option Silvertown TBM Launch Chamber
401	New Thames River Crossing Bored Tunnel Option Greenwich Approach Structures plan layout
402	New Thames River Crossing Bored Tunnel Option Greenwich cut and cover structures
403	New Thames River Crossing Bored Tunnel Option Greenwich TBM Reception chamber
501	New Thames River Crossing Bored Tunnel Option Silvertown secondary substation
502	New Thames River Crossing Bored Tunnel Option Greenwich primary substation
503	New Thames River Crossing Bored Tunnel Option

	Silvertown Ventilation Station General arrangement, Sections and Details
504	New Thames River Crossing Bored Tunnel Option Greenwich Ventilation Station General arrangement, Sections and Details
601	New Thames River Crossing Bored Tunnel Option Silvertown Worksite layout Local mapping omitted
602	New Thames River Crossing Bored Tunnel Option Silvertown Worksite layout With background mapping
603	New Thames River Crossing Bored Tunnel Option Silvertown Worksite layout Details of temporarily site office complex
604	New Thames River Crossing Bored Tunnel Option Greenwich Worksite layout With existing background mapping
605	New Thames River Crossing Bored Tunnel Option

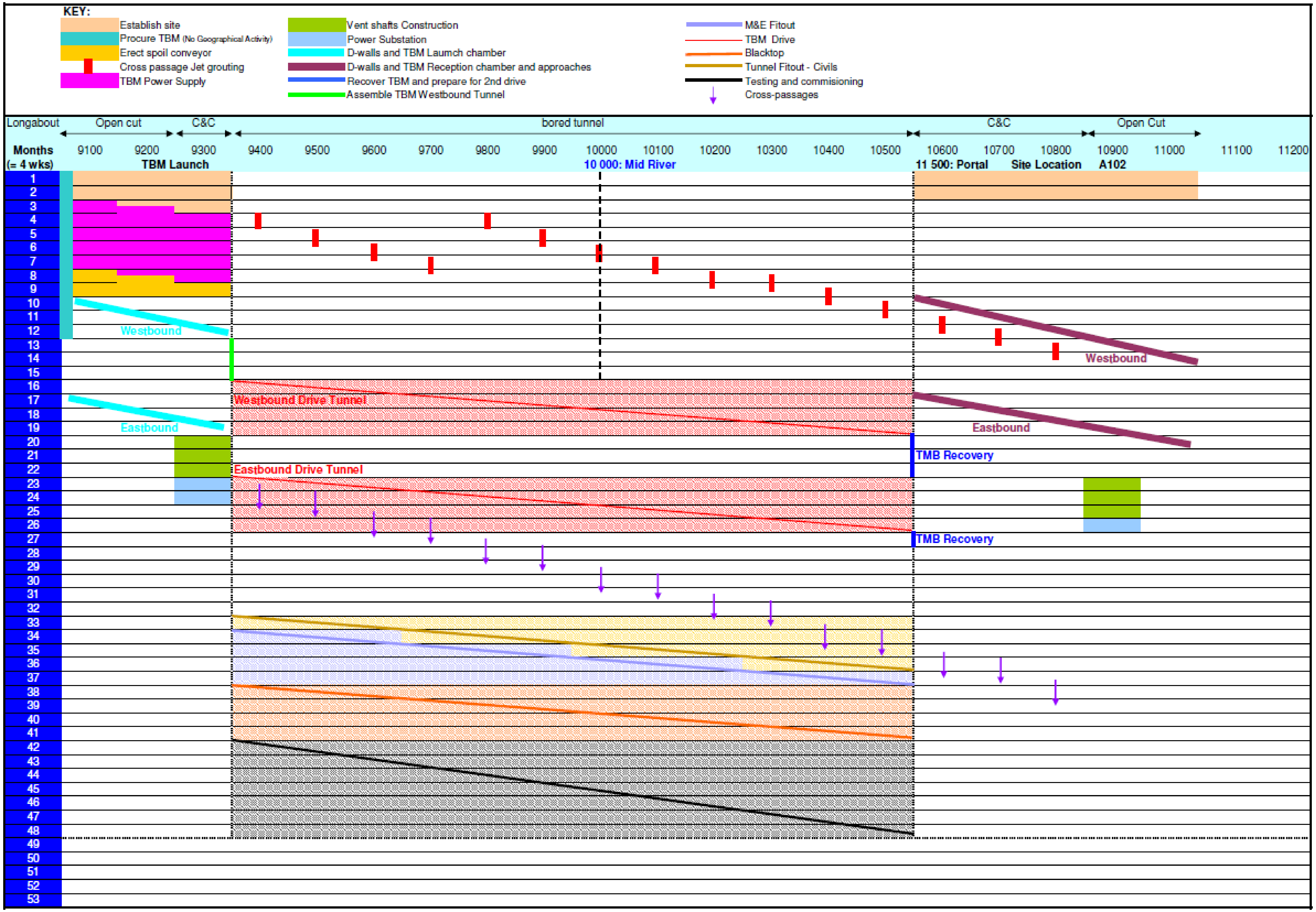
	Greenwich Worksite layout With proposed background mapping

Appendix C. References of low cover tunnels

Tunnel	References
Jubilee Line Extension - Westbound (North Greenwich to Victoria & Albert Dock cut)	- Design and Construction of the Jubilee Line Extension Tunnel, Proc. Instn Civ. Engrg, Jubilee Line Extension 1999, 132, 26-35 - Mott MacDonald Library Information
Jubilee Line Extension - Eastbound (North Greenwich to Victoria & Albert Dock cut)	- Design and Construction of the Jubilee Line Extension Tunnel, Proc. Instn Civ. Engrg, Jubilee Line Extension 1999, 132, 26-35
Blackwall Tunnel - Northbound	- Mott MacDonald Library Information – Sketches of tunnel sections
Blackwall Tunnel - Southbound	- Mott MacDonald Library Information – Sketches of tunnel sections
Dartford Tunnel - West	- Mott MacDonald Library Information – Sketches of tunnel sections - The Dartford Tunnel by Jasper Kell, reprinted from Proc. Instn civ. Engrs, vol.24, pp.359-372, March 1963
Dartford Tunnel - East	- Mott MacDonald Library Information – Sketches of tunnel sections - Tunnelling'79, Paper 33, Design and construction of second Dartford tunnel by G.B.Shutter & G.A.Bell, 1979 - The Second Dartford Tunnel, Dartford Tunnel Joint Committee
4th Tube Elbe Tunnel - Hamburg	- Tunnel Construction 5th International Symposium on Tunnel Construction, Munich, 1-2 April 1998, MESSE MUNCHEN INTERNATIONAL

Appendix D. Construction Programme

Ref	Task Description	Duration (weeks)	Link
1	Establish Site (Silvertown Site)	12	
2	Establish Site (Millenium Way Site)	8	
3	Procure TBM	52	
4	Utilities re-routing	12	
5	Procure TBM Power Supply	24	
6	Erect spoil conveyor	8	
7	Cross passage ground improvement	140 columns at 10/day 5 weeks/ cross Passage 1 rigs on land and 1 rigs on river to be assumed	
8	Westbound tunnel approach and TBM launch chamber diaphragm walling	Rig producing 10m/day, 1 rig and 600m wall 12 weeks	
9	Eastbound tunnel approach and TBM launch chamber diaphragm walling	Rig producing 10m/day, 2rigs and 600m wall 6 weeks	
10	Westbound tunnel approach and TBM reception chamber diaphragm walling	12	
11	Eastbound tunnel approach and TBM reception chamber diaphragm walling	6	
12	Assemble TBM in westbound tunnel	12	FS - 3
13	Drive Westbound tunnel	Assume Progress a 75m/week and 1200m length, 16 weeks	
14	Recover TBM and re-assemble in Eastbound tunnel launch chamber	Assume barge across river, crane lifting over DLR viaduct, 12 weeks	FS - 14
15	Drive Eastbound tunnel	Assume Progress a 75m/week and 1200m length, 16 weeks	
16	Recover TBM from Eastbound tunnel	4	
17	Construct ventilation stack - Silvertown	12	
18	Construct ventilation stack - Millenium Way	12	
19	Construct Primary Substation	8	
20	Construct Secondary Substation	4	
21	Drive crosspassages Primary Lining	Break out from opening set in Westbound tunnel and advance at 1m/day in treated ground 8 weeks/cross passage with 2 gangs 15 crosspassages 64 weeks	FS - 7 & 16
22	Tunnel fitout - Civils	100m/weeks, total of 16	FS - 21
23	M&E Fitout, lighting, jet fans, communications	100m/weeks, total of 16	
24	Blacktop	100m/weeks, total of 16	FS - 22 & 23
25	Testing and commissioning	24	


KEY:
Establish site
Procure TBM (No Geographical Activity)
Erect spoil conveyor
Cross passage Jet grouting
TBM Power Supply
Vent shafts Construction
Power Substation
D-walls and TBM Laumch chamber
D-walls and TBM Reception chamber and approaches
Recover TBM and prepare for 2nd drive
Assemble TBM Westbound Tunnel
M&E Fitout
TBM Drive
Blacktop
Tunnel Fitout - Civils
Testing and commisioning
Cross-passages
Longabout
Open cut
C&C
bored tunnel
C&C
Open Cut
Months
(= 4 wks)
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9200
9300
9400
9500
9600
9700
9800
9900
10000
10100
10200
10300
10400
10500
10600
10700
10800
10900
11000
11100
11200
TBM Launch
10 000: Mid River
11 500: Portal
Site Location
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52
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Westbound
Westbound
Westbound Drive Tunnel
Eastbound
Eastbound
TMB Recovery
Eastbound Drive Tunnel
TMB Recovery

Rev	Date	Drawn	Description	Ch'k'd	App'd

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

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Notes

Key to symbols

Reference drawings

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Scheme Layout Plan

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1: 1:2500	Status: PRE	Rev: P1	

Drawing Number
MMD-267759-TUN-001

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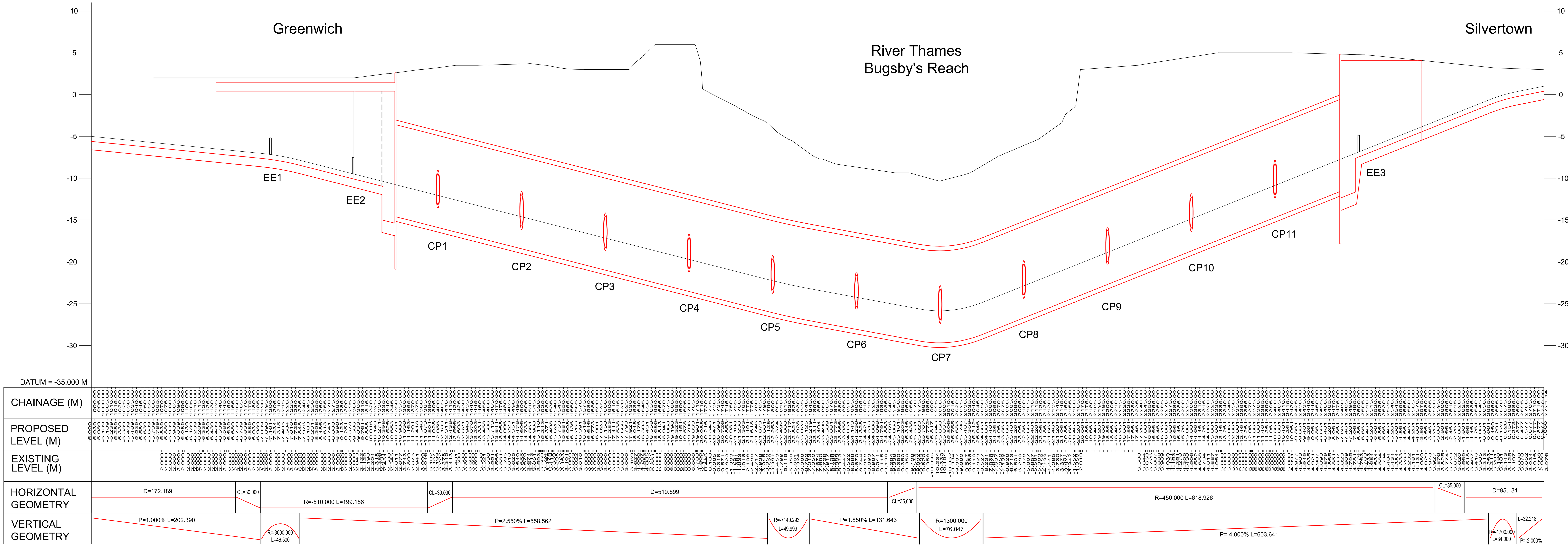

Scheme Layout Long Section

Horizontal Scale 1:2500 Vertical Scale 1:250

Notes

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Scheme Layout
Long Section

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1	Status PRE		Rev P1

Drawing Number
MMD-267759-TUN-002

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NOT FOR CONSTRUCTION
Date : 27-11-2009

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1:2500 0 125m 250m

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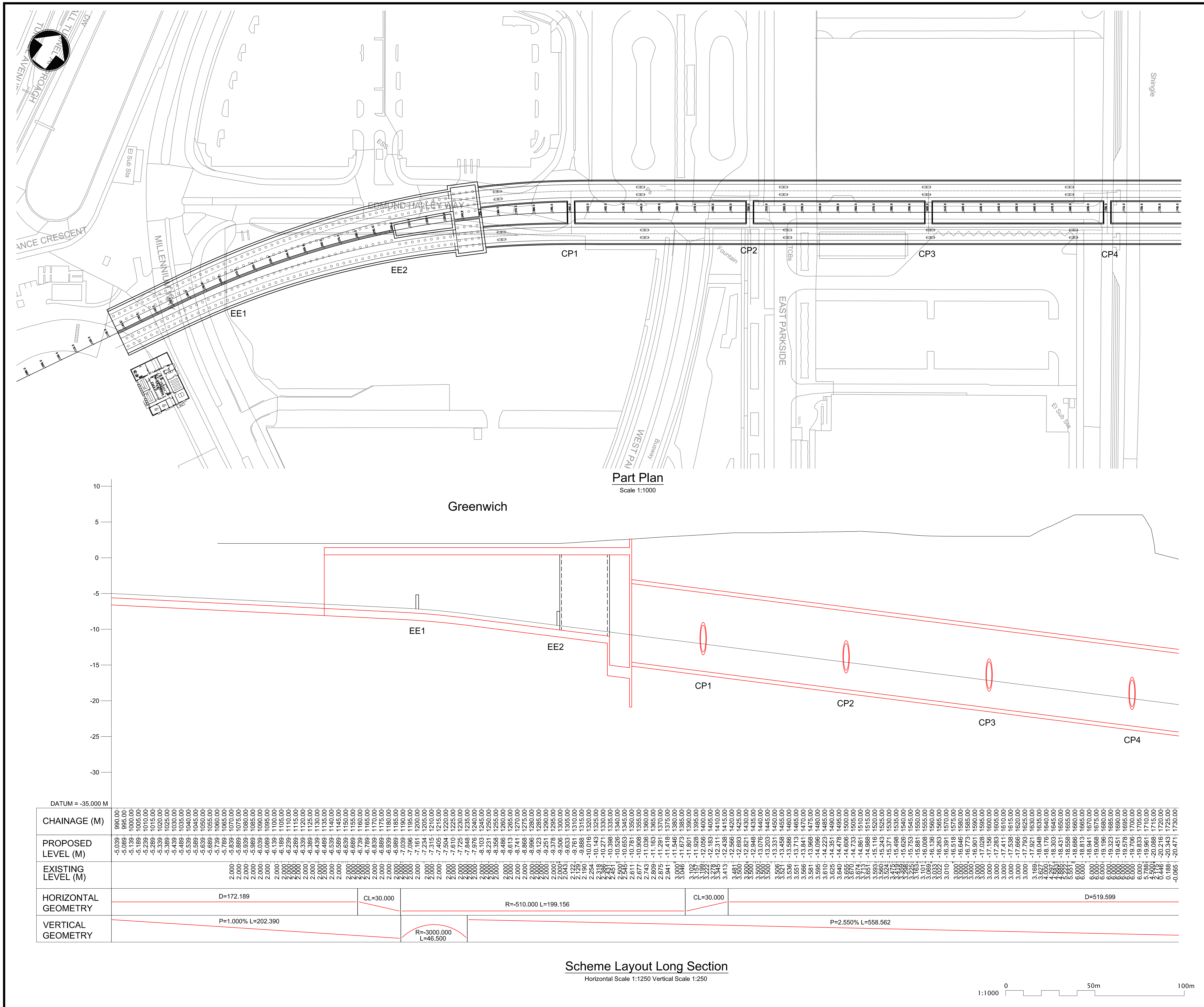

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Notes

Key to symbols

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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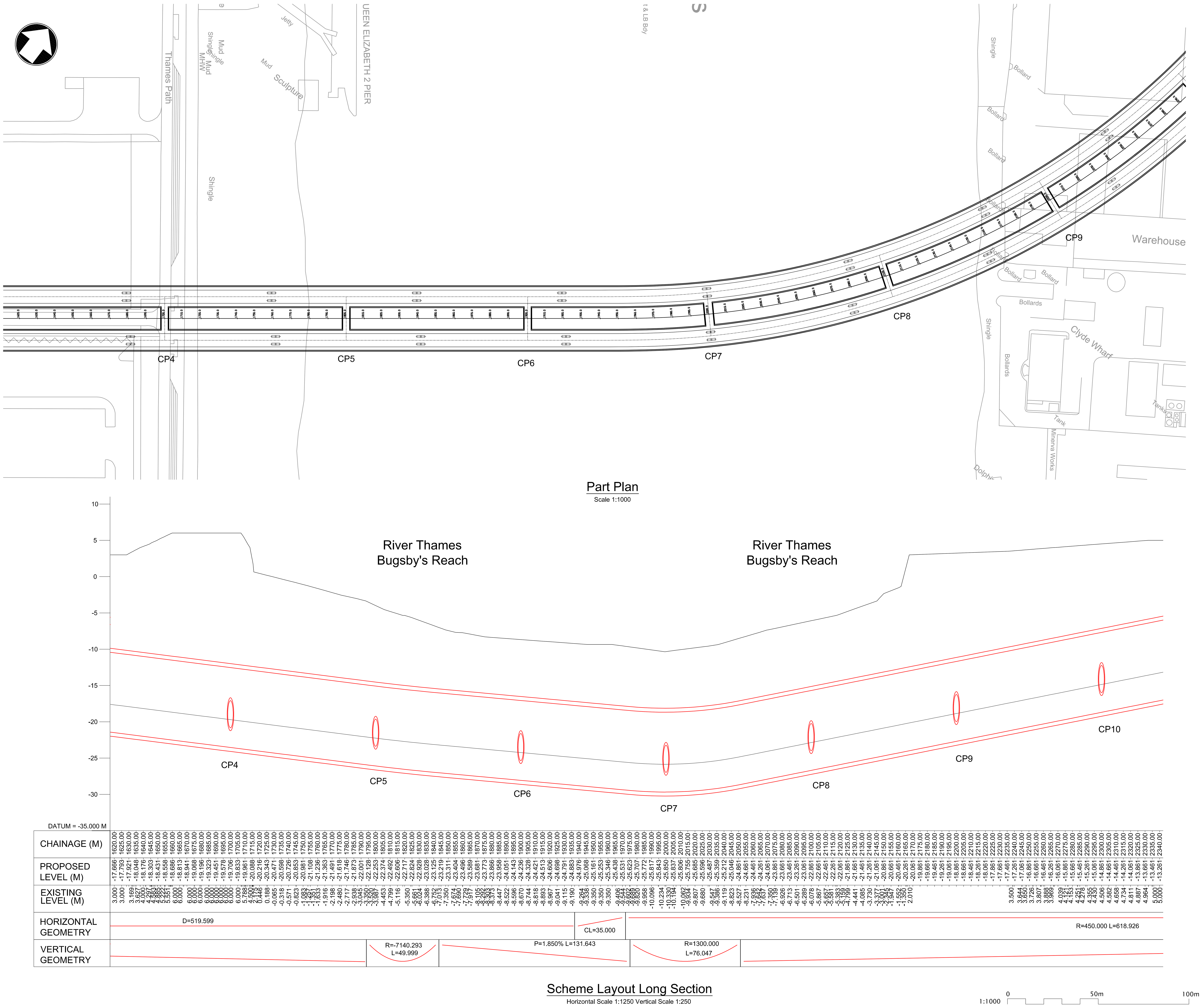
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Scheme Layout Plan & Long Section
Sheet 1 of 3

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR

Scale at A1: As Shown
Status: PRE
Rev: P1

Drawing Number
MMD-267759-TUN-003



Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

Mott MacDonald

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Client

Transport for London

Title

New Thames River Crossing
Bored Tunnel Option
Scheme Layout Plan & Long Section
Sheet 2 of 3

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR

Scale at A1	Status	Rev
As Shown	PRE	P1

Drawing Number
MMD-267759-TUN-004

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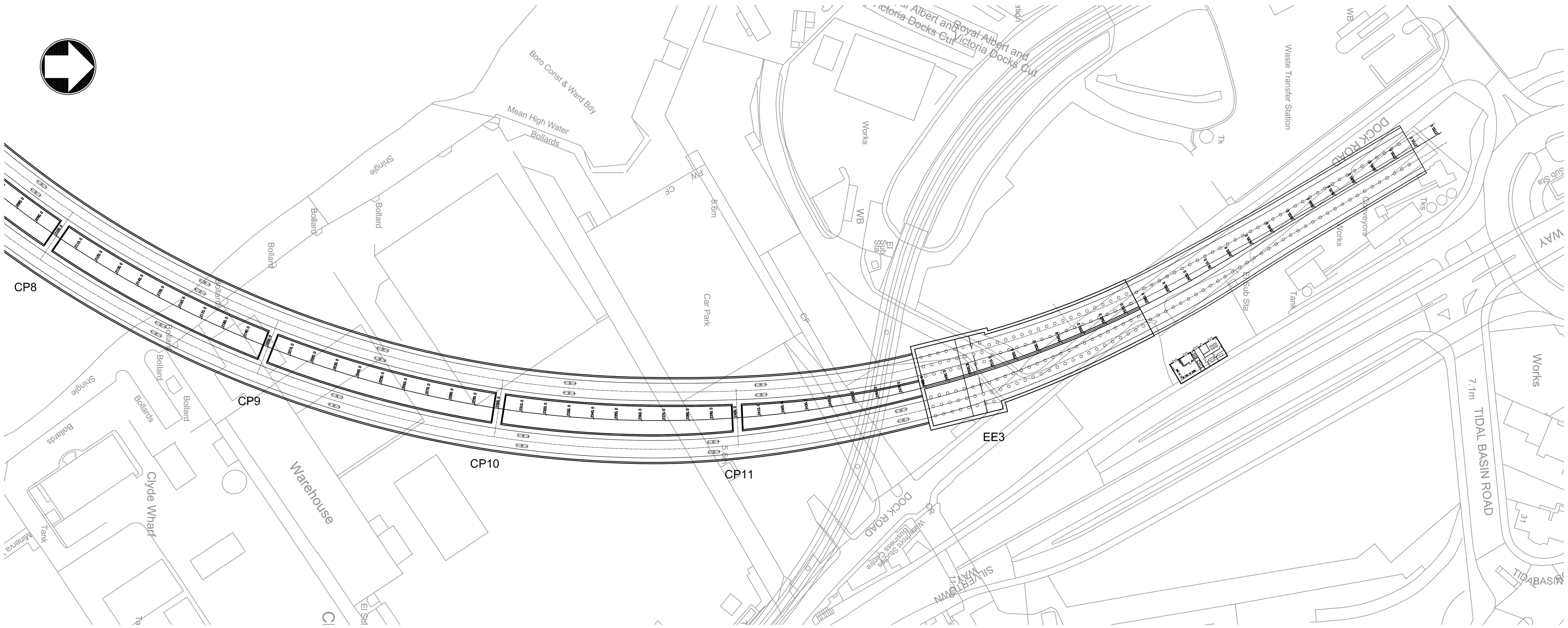
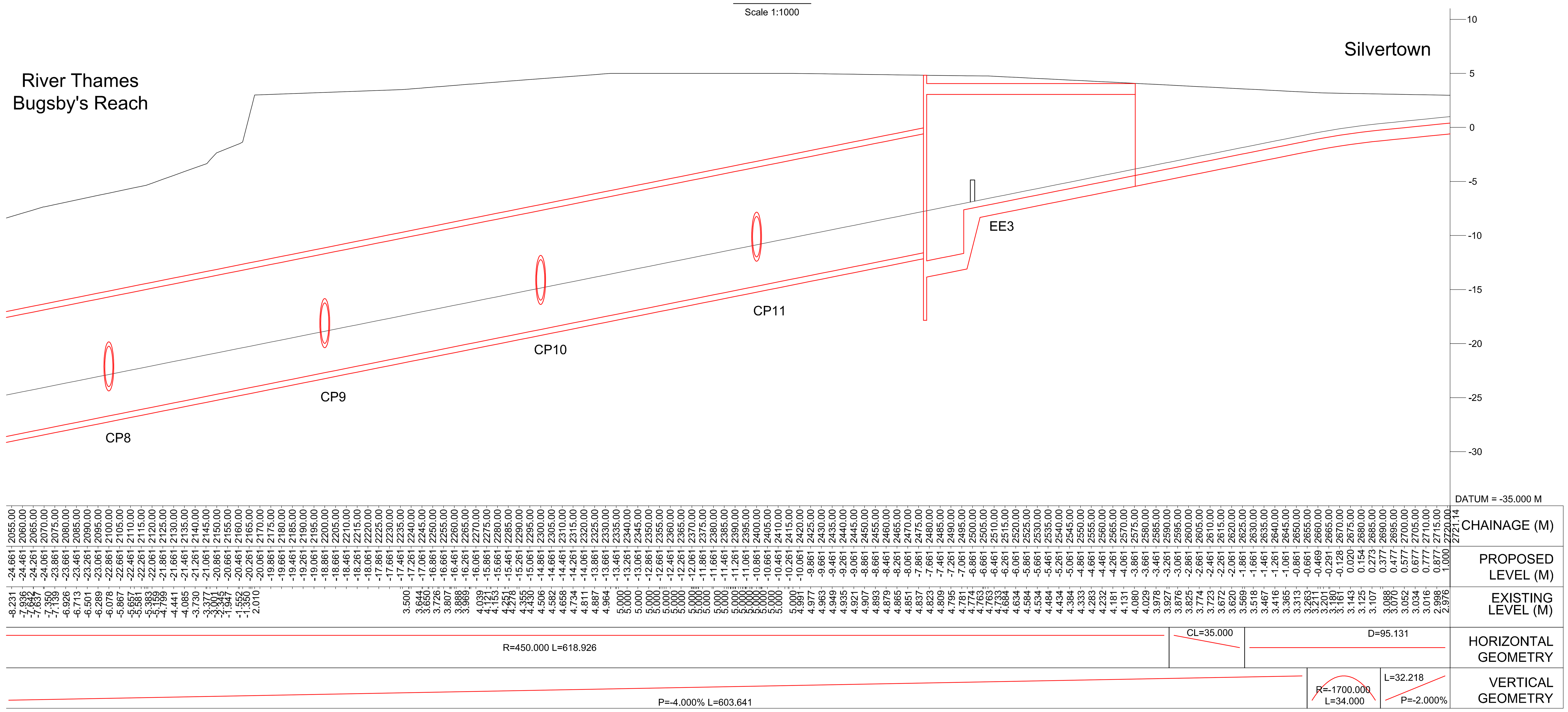


Part Plan

Scale 1:1000



Scheme Layout Long Section

Horizontal Scale 1:1250 Vertical Scale 1:250

1:1000 0 50m 100m

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Scheme Layout Plan & Long Section
Sheet 3 of 3

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR

Scale at A1	Status	Rev
As Shown	PRE	P1

Drawing Number
MMD-267759-TUN-005

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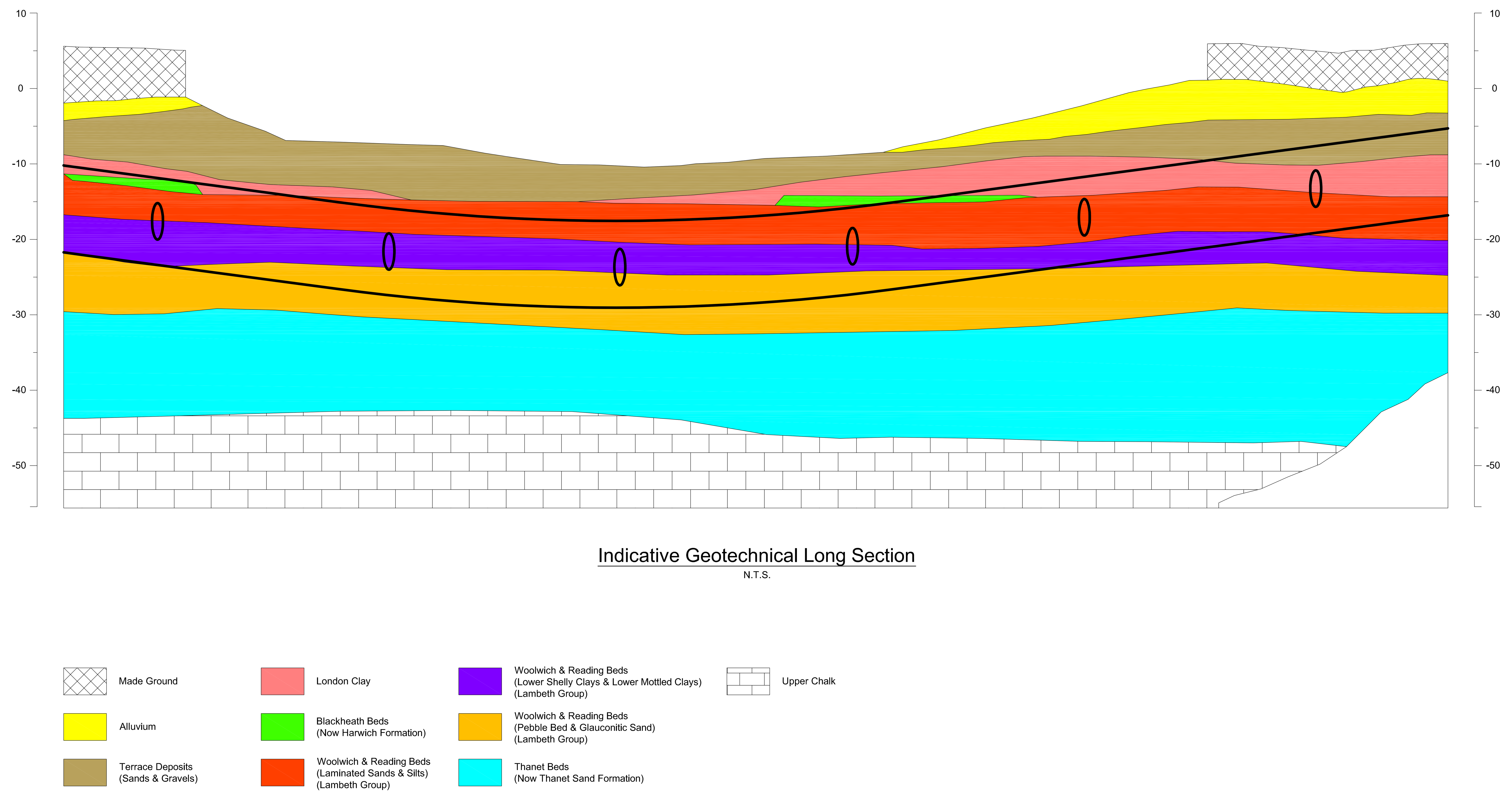

Indicative Geotechnical Long Section

N.T.S.

Notes

Key to symbols

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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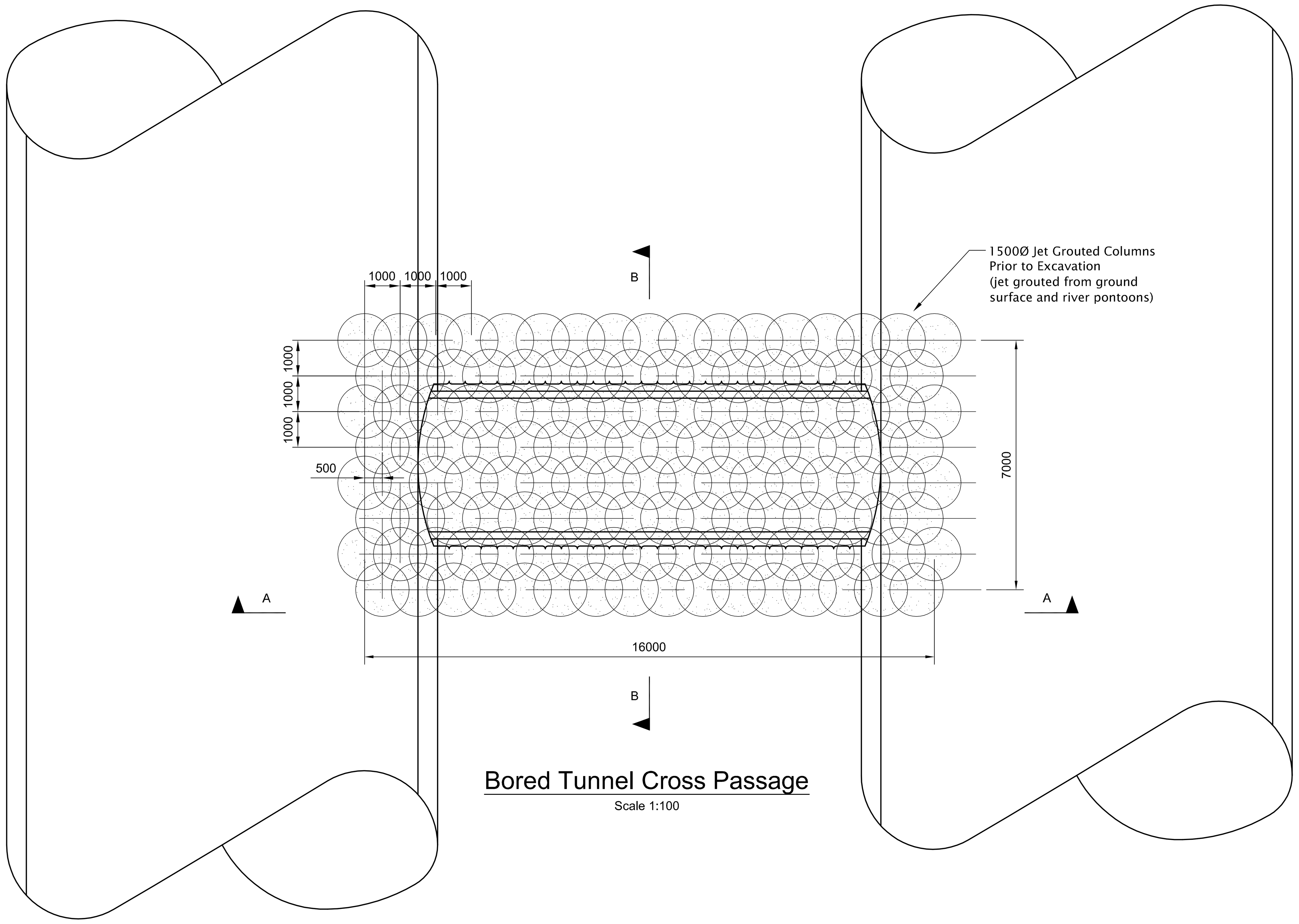
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Geotechnical Long Section

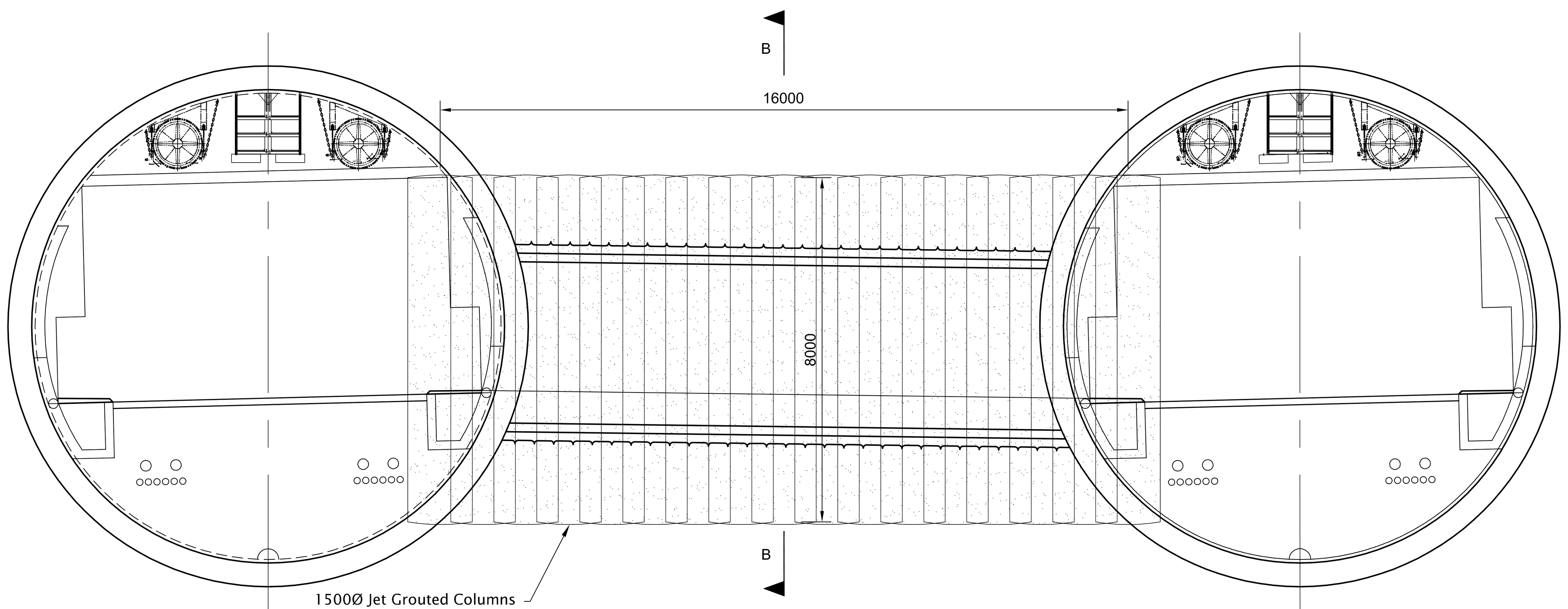
Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: N.T.S.		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-101



Bored Tunnel Cross Passage

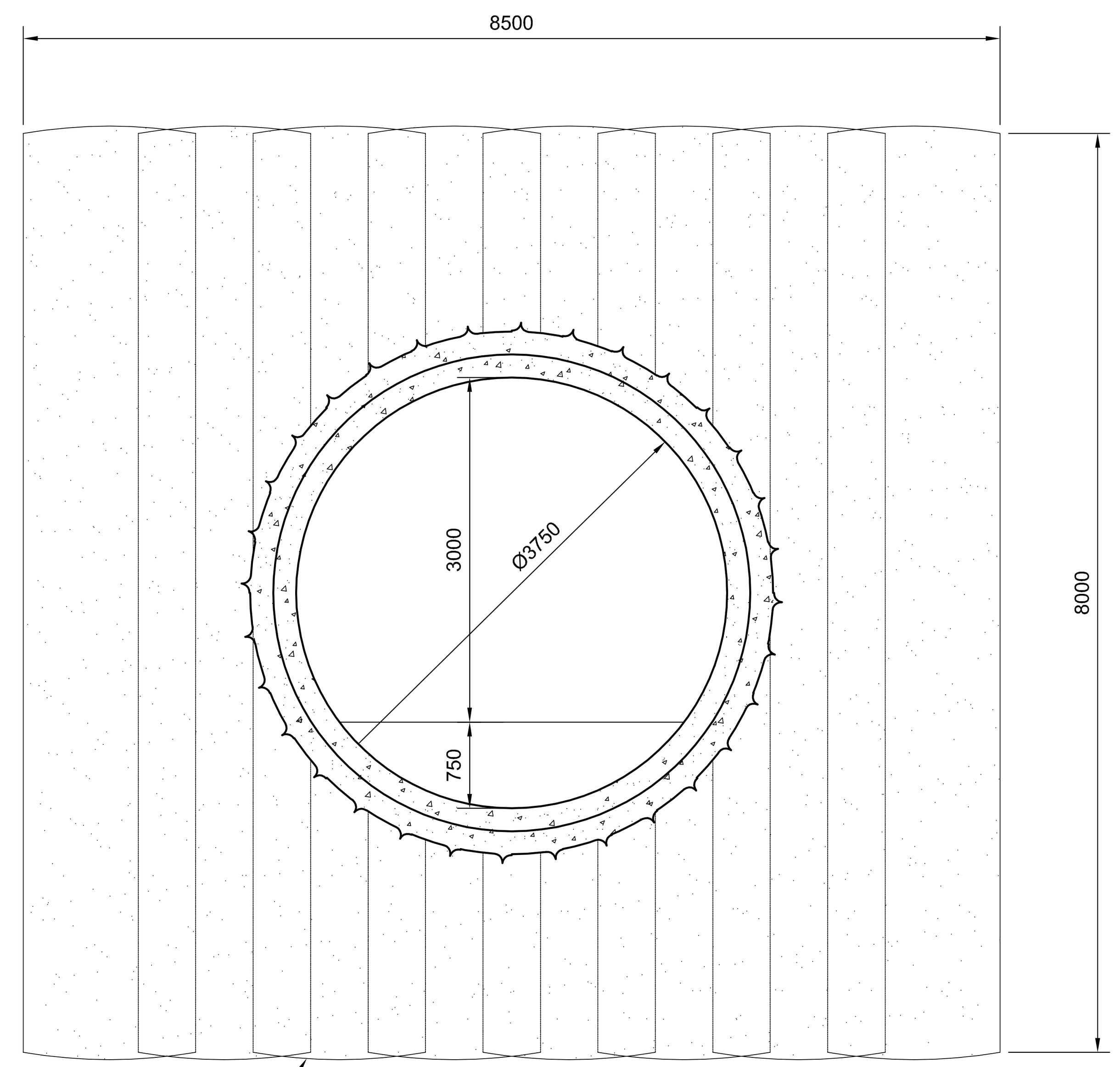
Scale 1:100



1500Ø Jet Grouted Columns
Prior to Excavation
(jet grouted from ground
surface and river pontoons)

Section A-A

Scale 1:100



1500Ø Jet Grouted Columns
Prior to Excavation
(jet grouted from ground
surface and river pontoons)

Section B-B

Scale 1:50

1:50 0 2.5m 5m

1:100 0 5m 10m

Notes

Key to symbols

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client

Transport for London

Title

New Thames River Crossing
Bored Tunnel Option
Cross Passages Ground Treatment
Jet Grouting Alternative

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE		Rev P1

Drawing Number

MMD-267759-TUN-102

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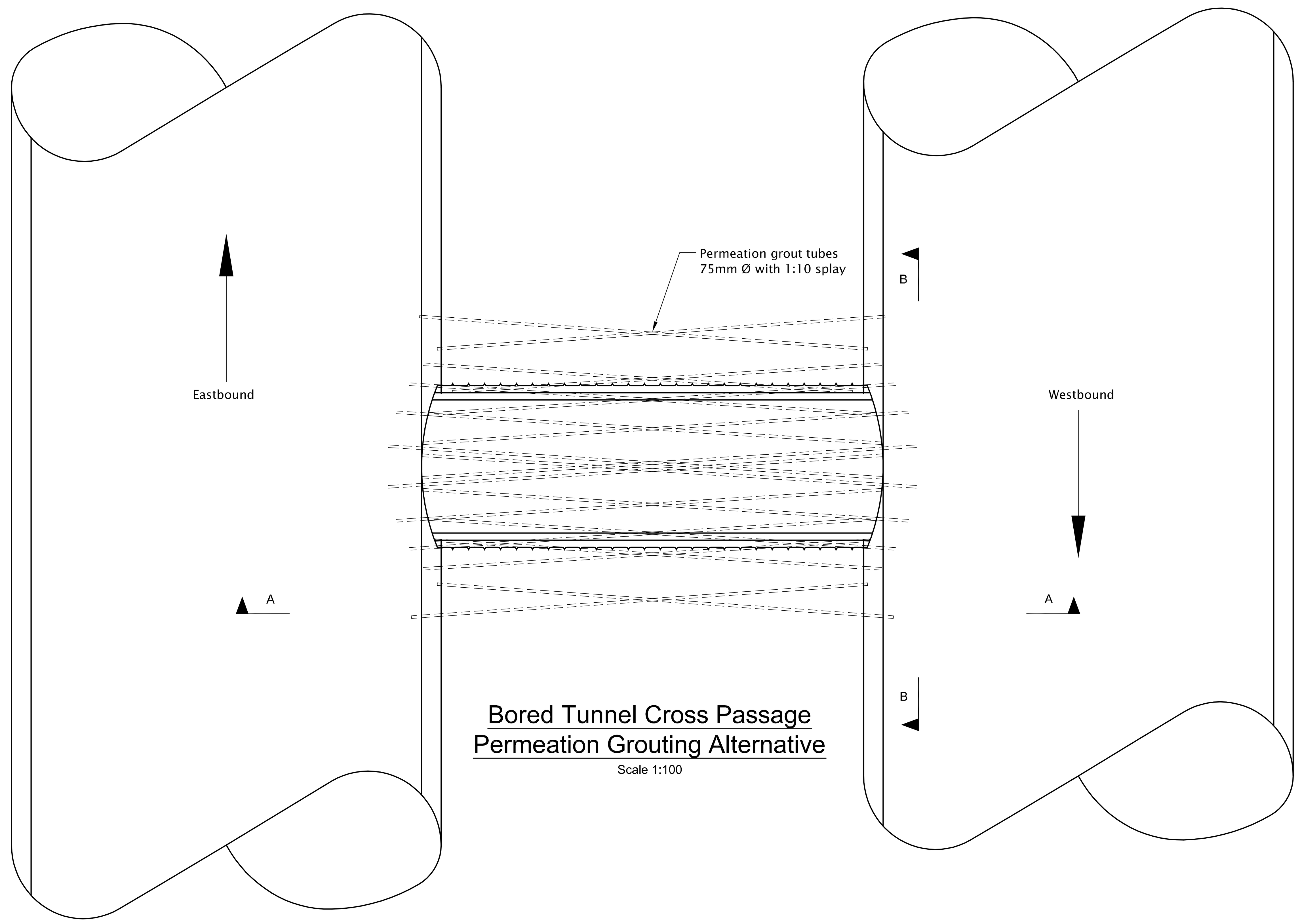
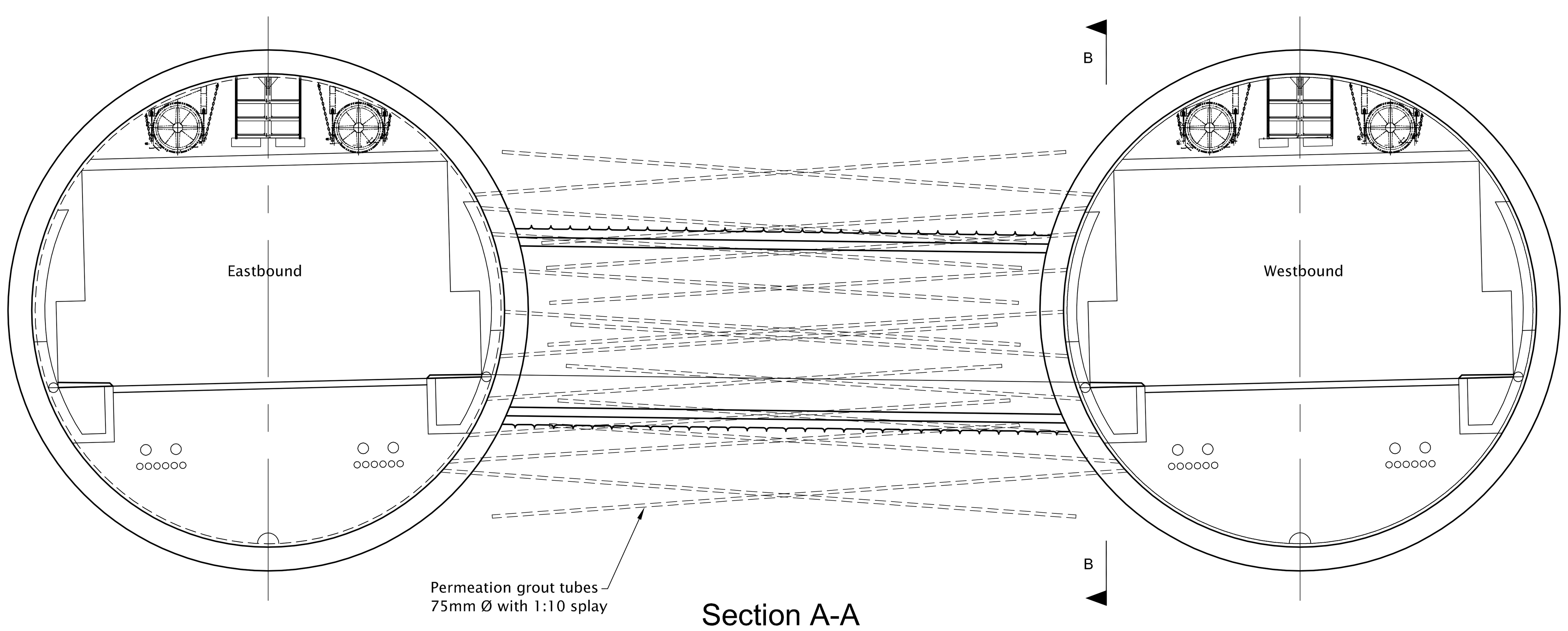


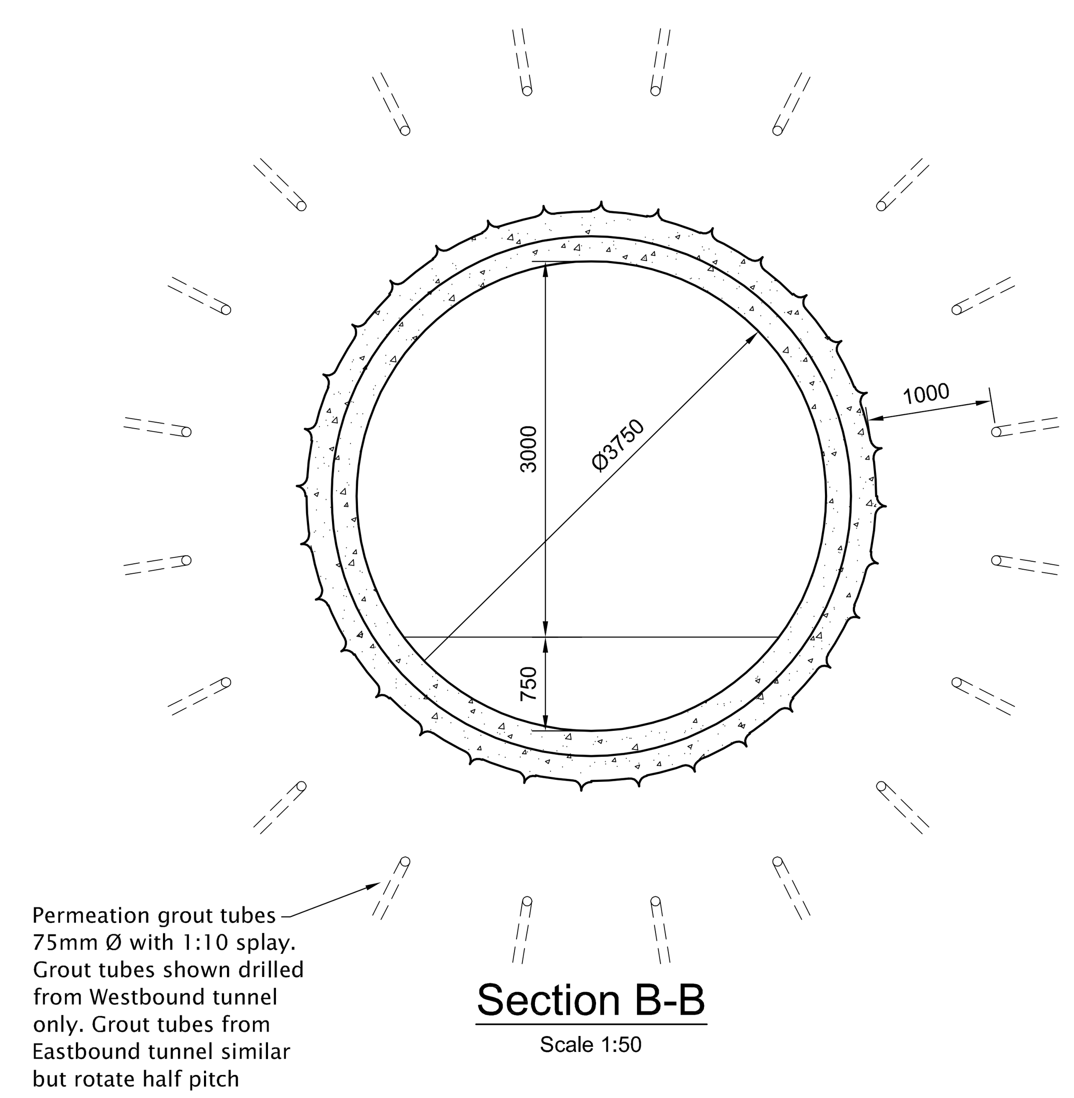
Bored Tunnel Cross Passage Permeation Grouting Alternative

Scale 1:100



Section A-A

Scale 1:100



Section B-B

Scale 1:50

1:50 0 2.5m 5m
1:100 0 5m 10m

Notes

Key to symbols

Reference drawings

DRAFT
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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Cross Passages Ground Treatment
Permeation Grouting Alternative

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE		Rev P1

Drawing Number
MMD-267759-TUN-103

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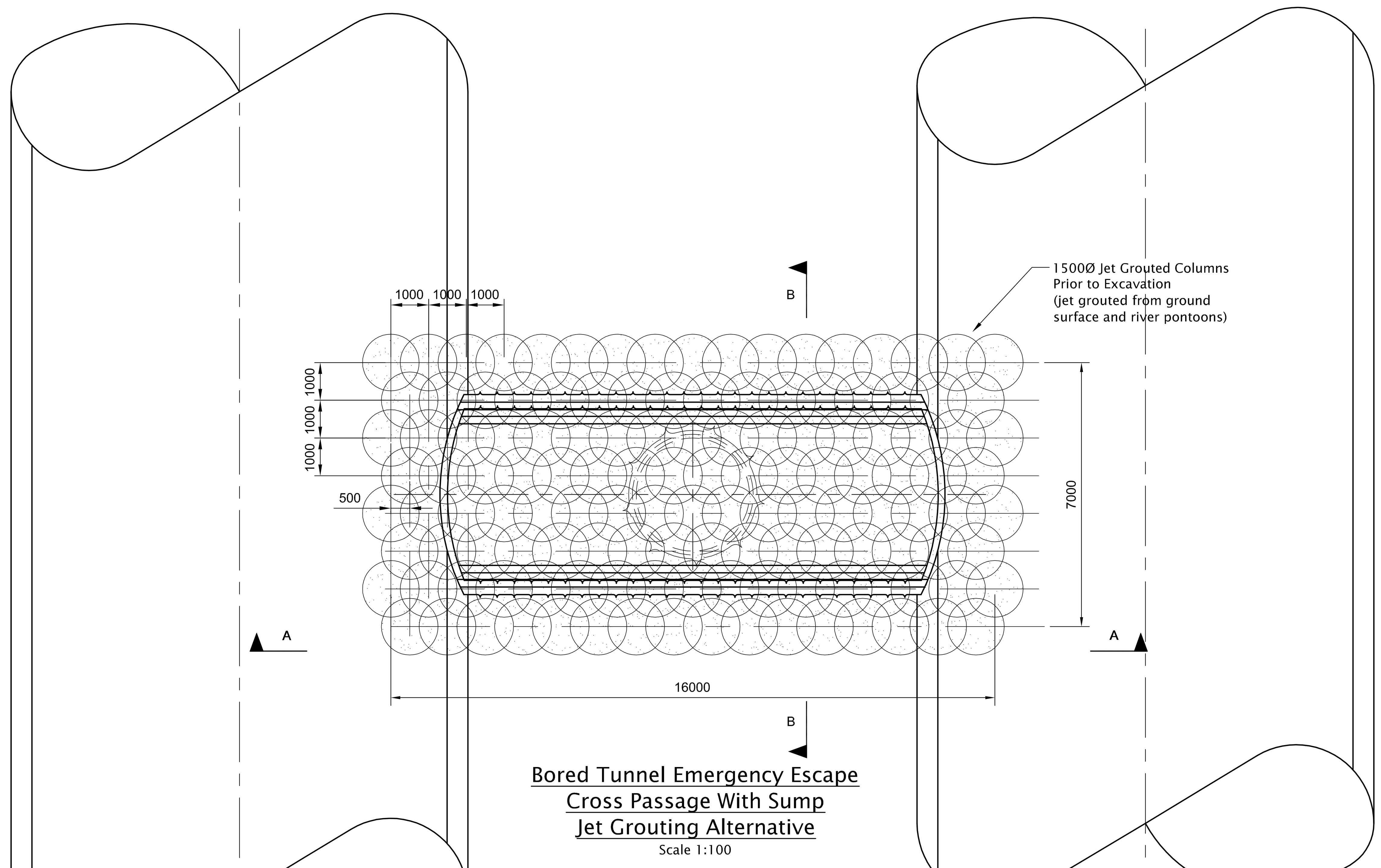
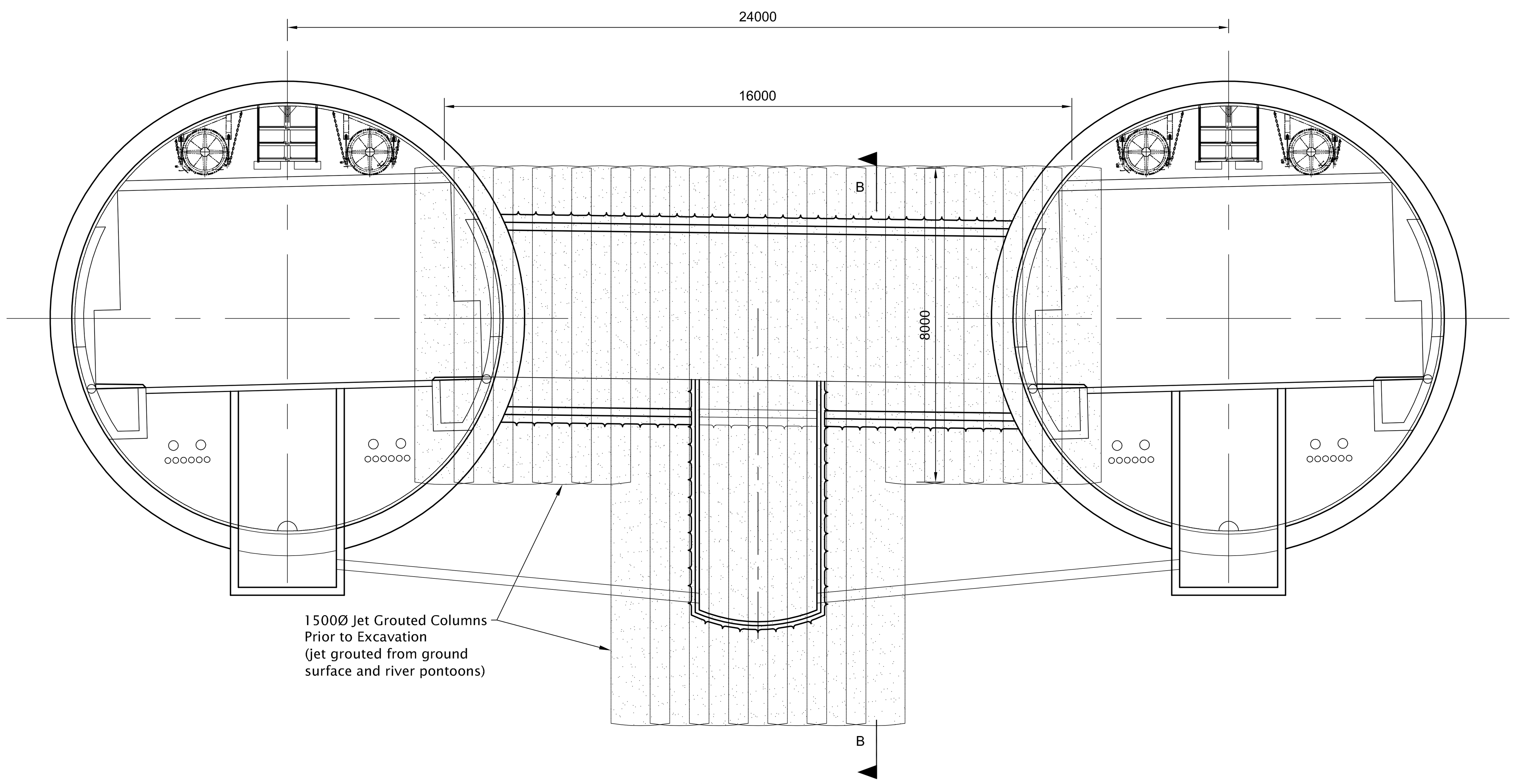
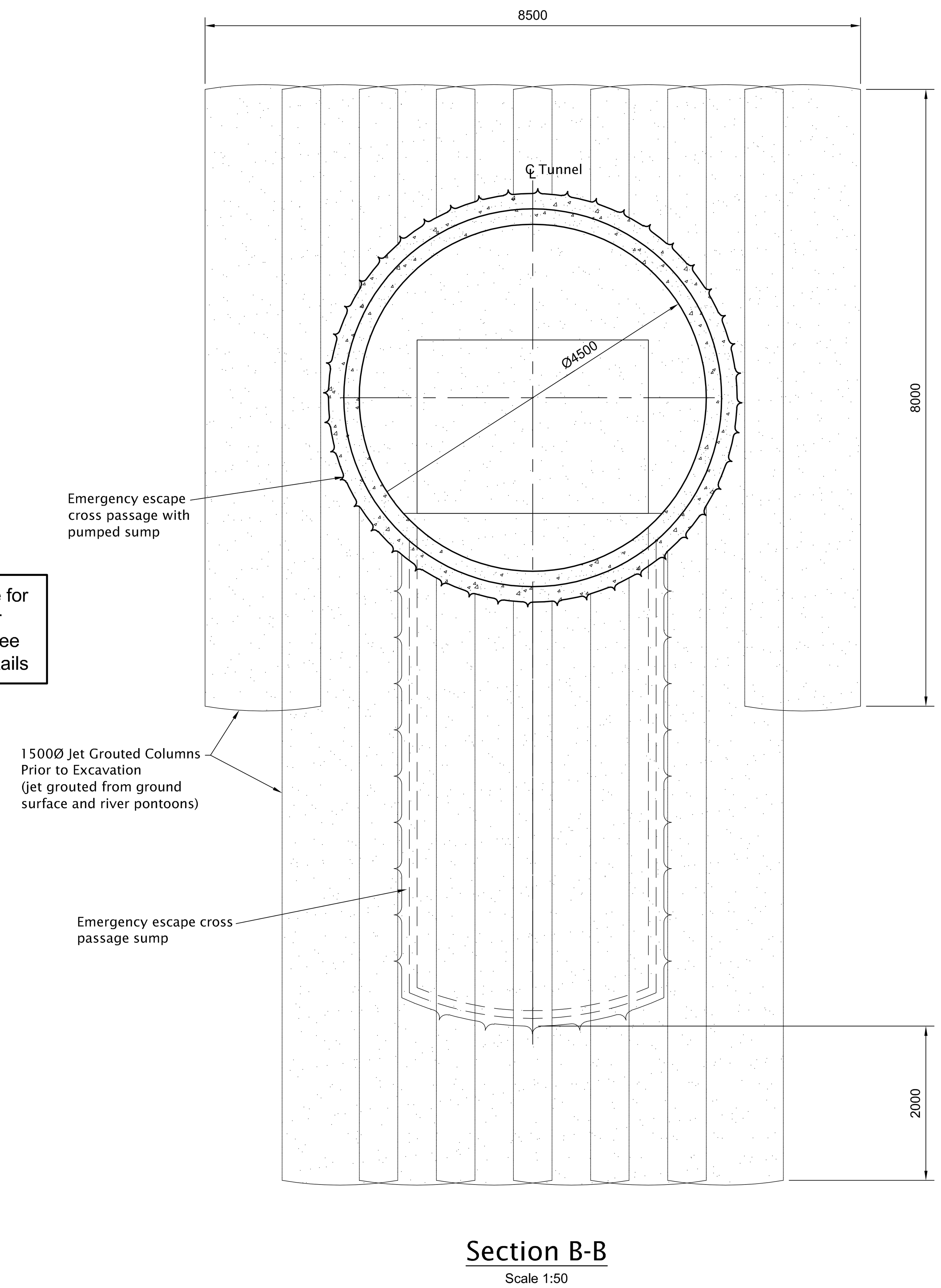


Bored Tunnel Emergency Escape
Cross Passage With Sump
Jet Grouting Alternative
Scale 1:100

Ground treatment and sump shown are for bored tunnel Alternative 1 details for Alternative 2 are similar but deeper. See drawing 267759-TUN-206 for sump details



Section A-A
Scale 1:100



Section B-B
Scale 1:50

1:50	0	2.5m	5m
1:100	0	5m	10m

Notes

Key to symbols

Reference drawings

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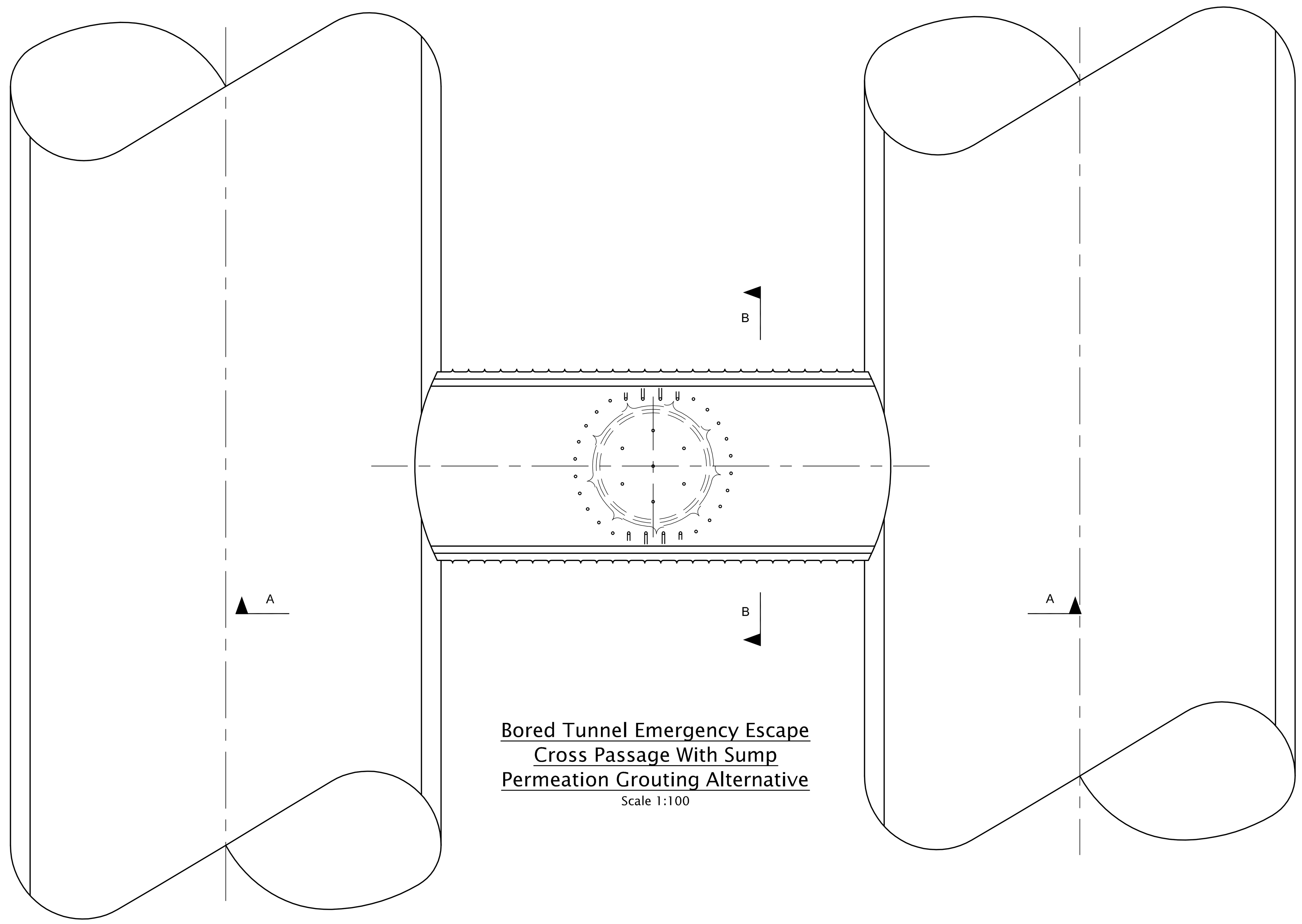
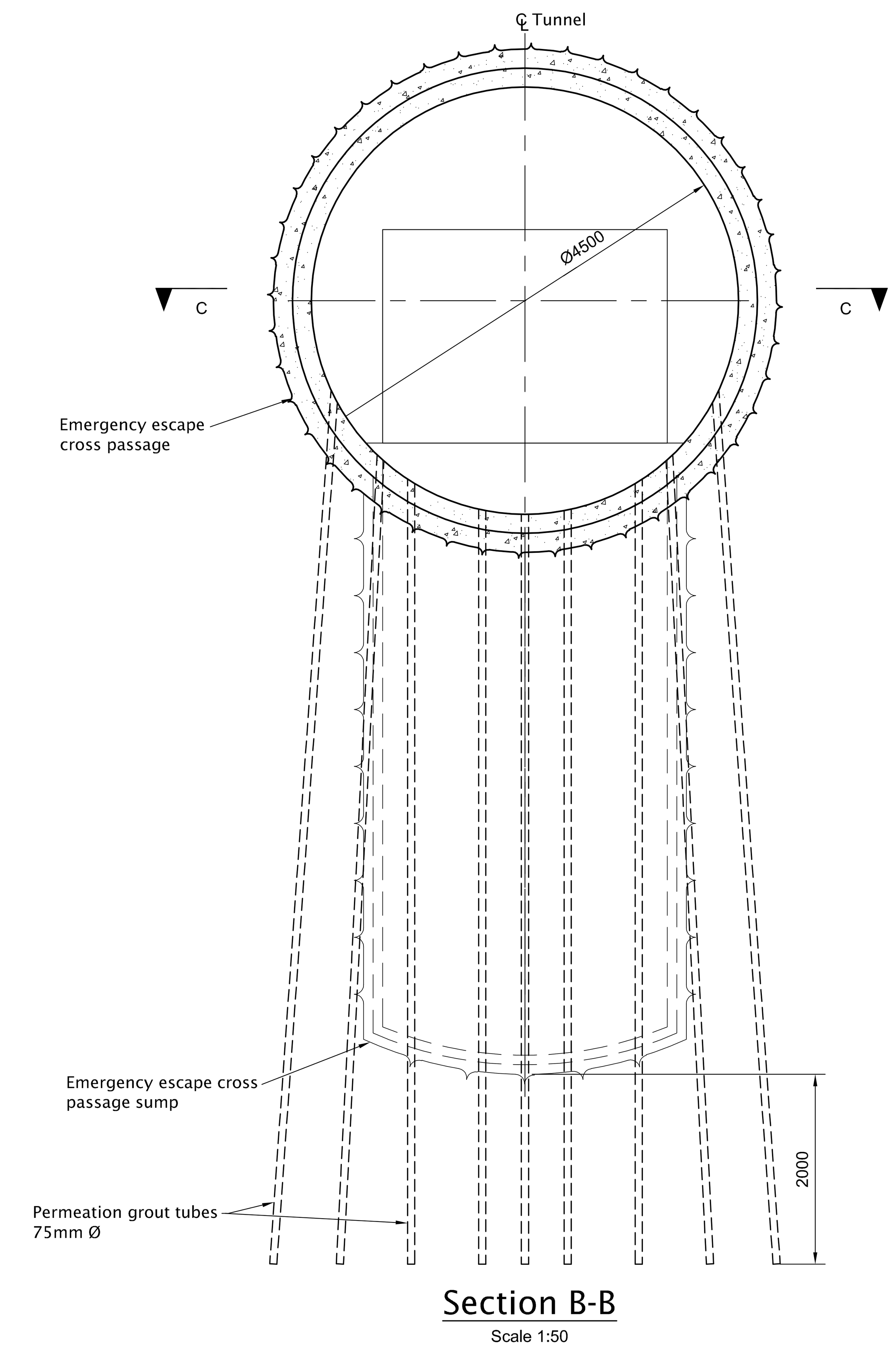
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Cross Passage Sump Ground Treatment
Jet Grouting Alternative

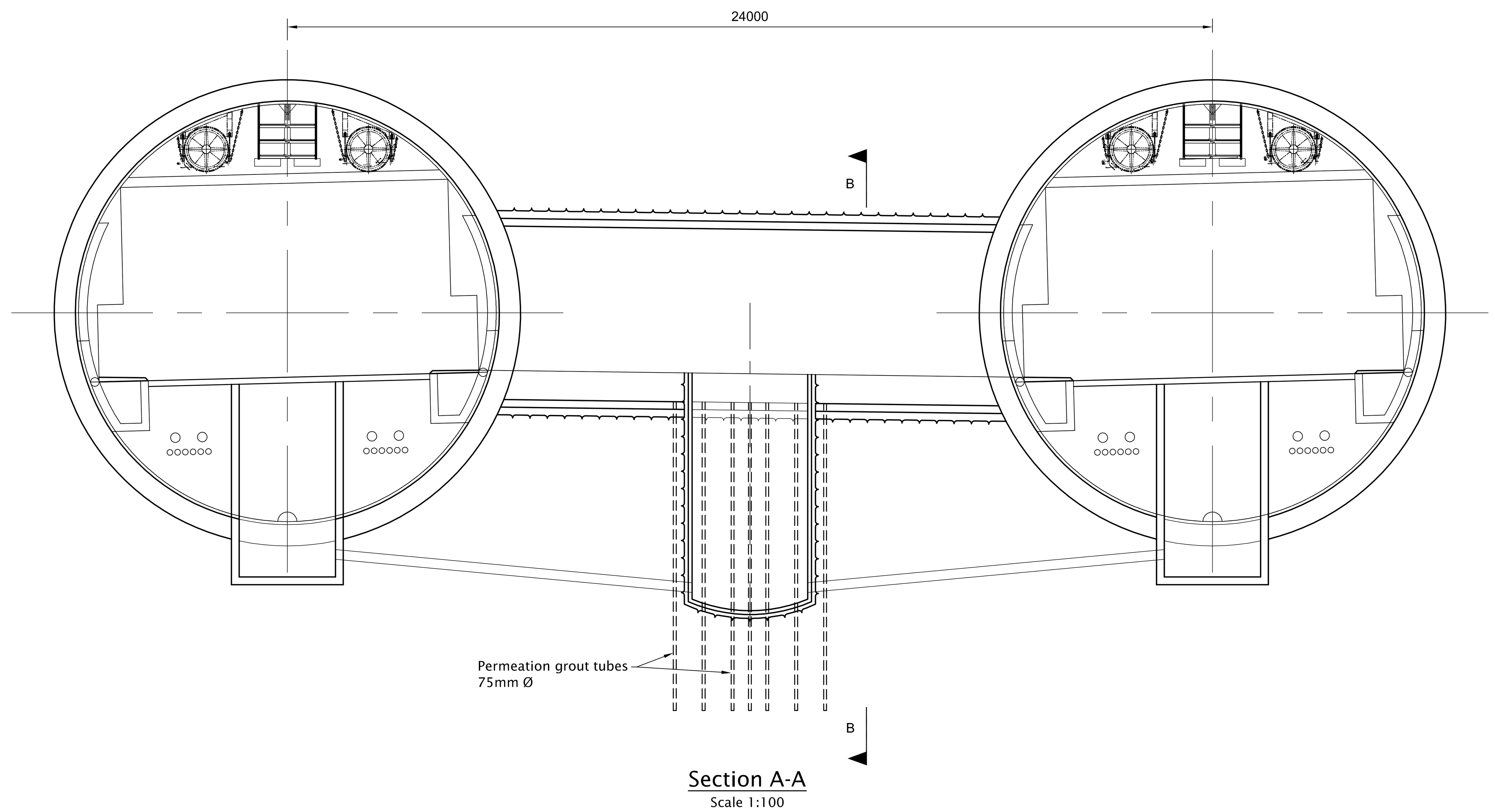
Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE		Rev P1

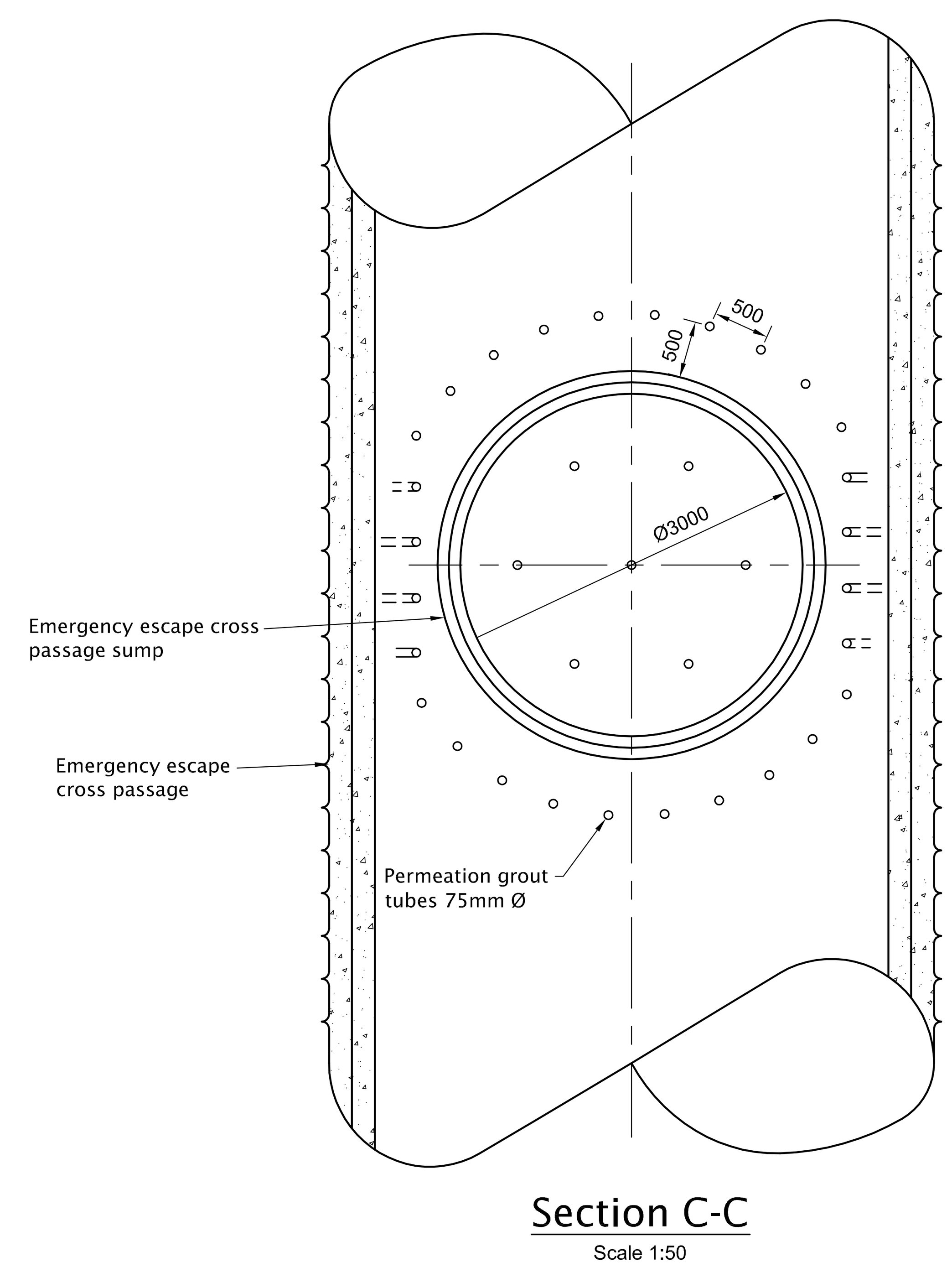
Drawing Number
MMD-267759-TUN-104





Ground treatment and sump shown are for bored tunnel Alternative 1 details for Alternative 2 are similar but deeper. See drawing 267759-TUN-206 for sump details





1:50	0	2.5m	5m
1:100	0	5m	10m

Notes

Key to symbols

Reference drawings

DRAFT
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Date : 27-11-2009

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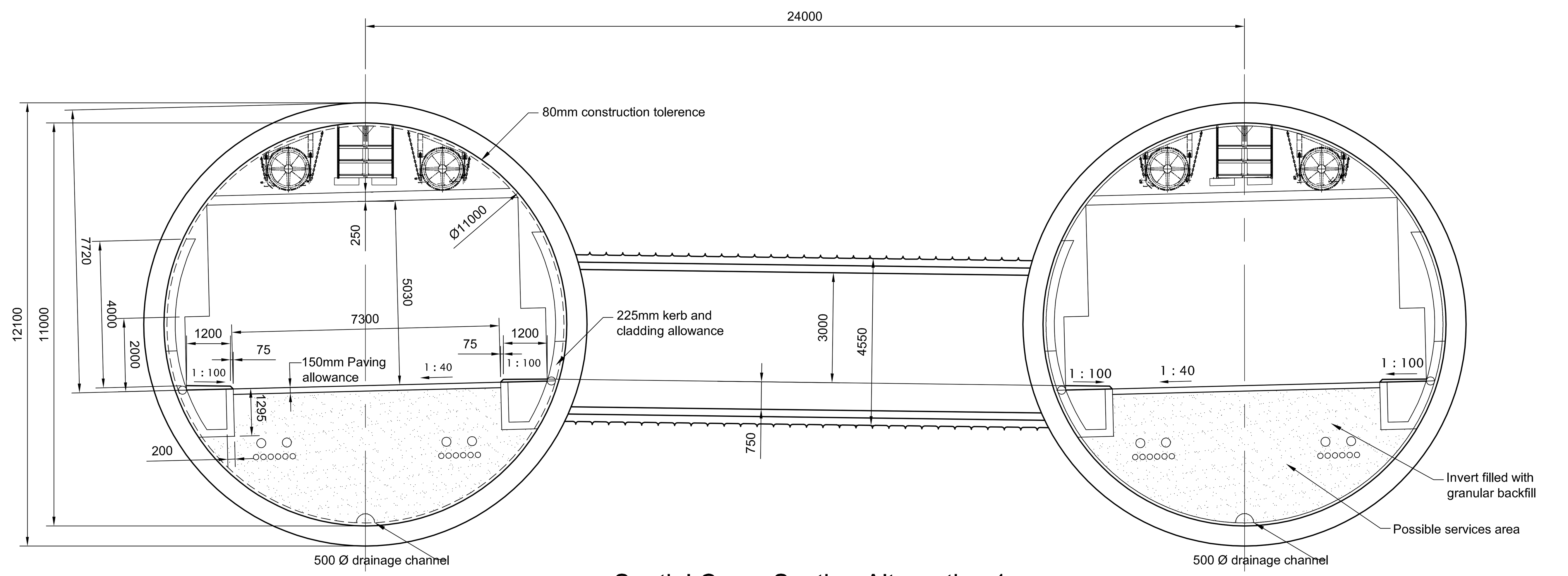
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Cross Passage Sump Ground Treatment
Permeation Grouting Alternative

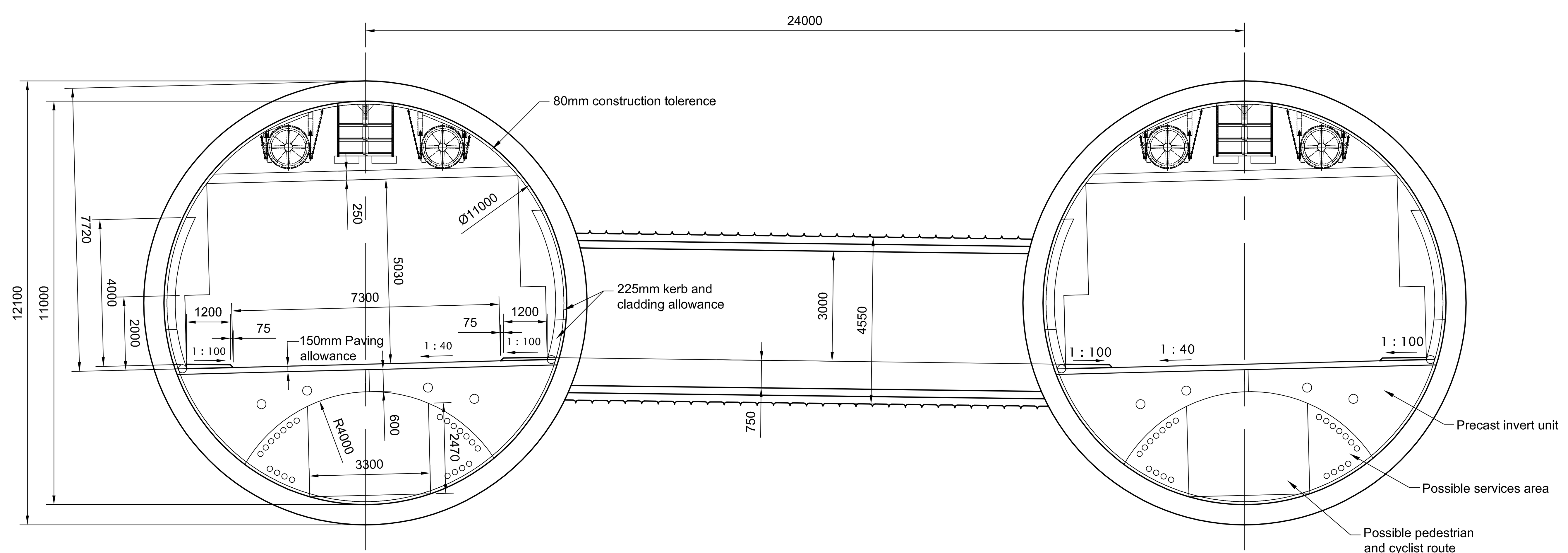
Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-105



Spatial Cross Section Alternative 1

Scale 1:100



Spatial Cross Section Alternative 2

Scale 1:100

1:100 0 5m 10m

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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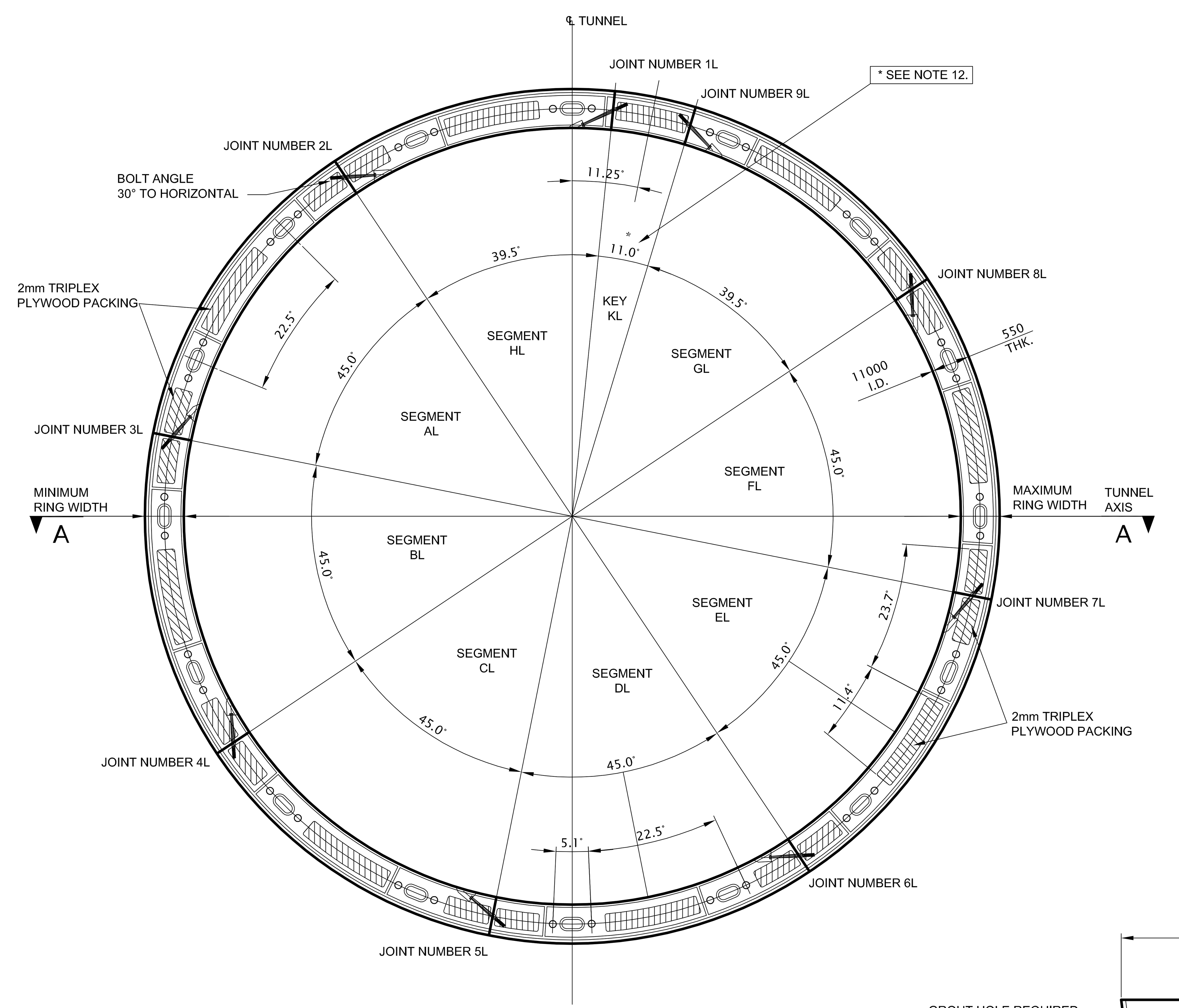
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Bored Tunnel Spatial Cross Sections

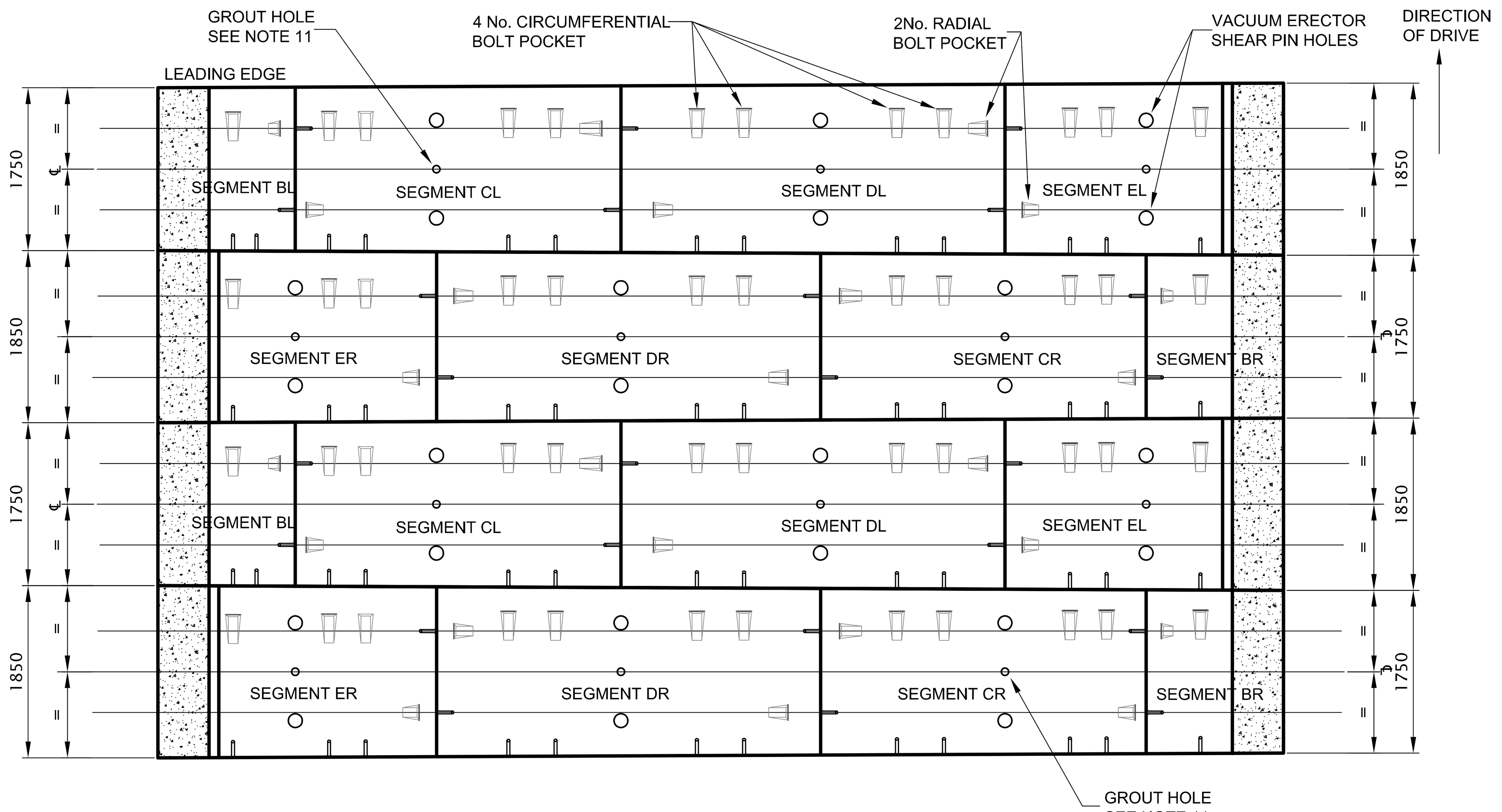
Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: 1:100		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-201



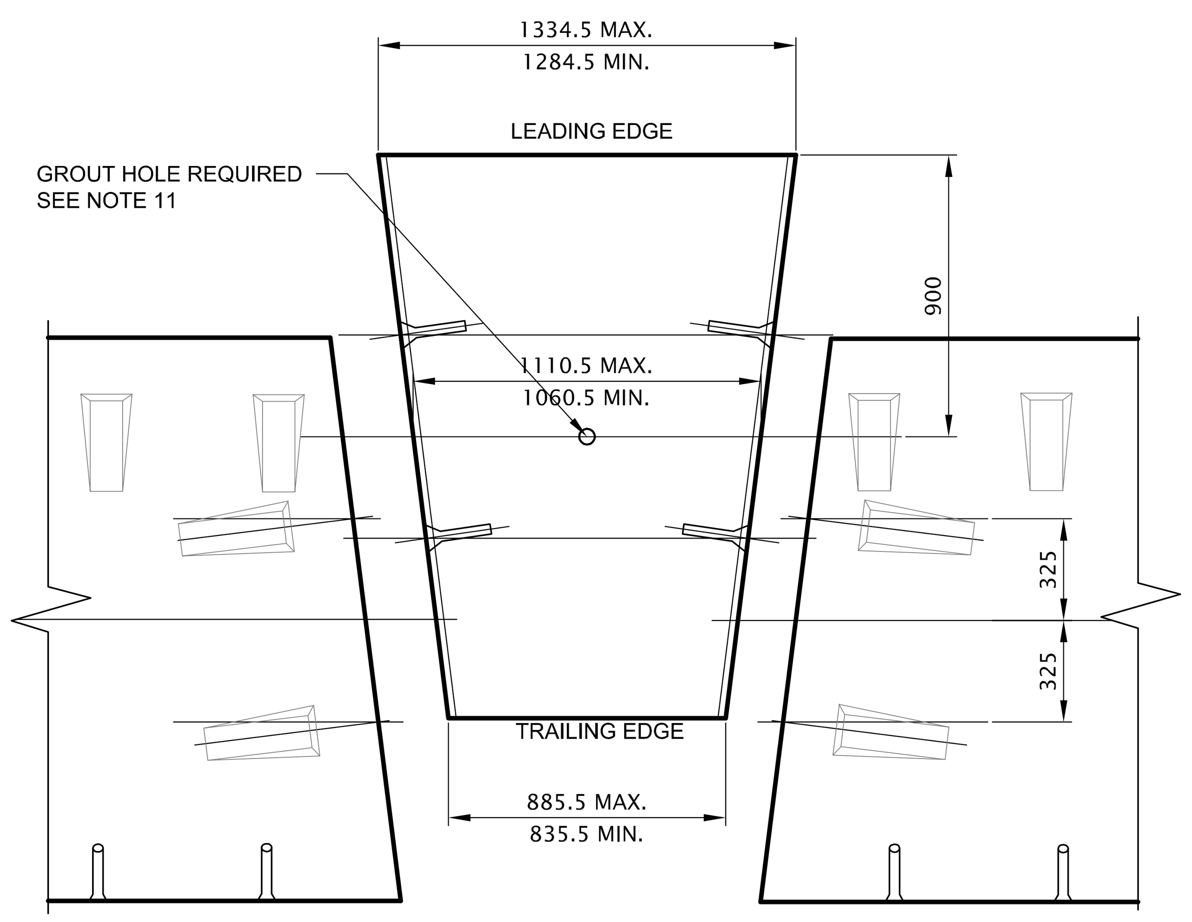
TYPICAL SECTION OF LEFT HAND TAPER RING (TRAILING EDGE)

Scale 1:50



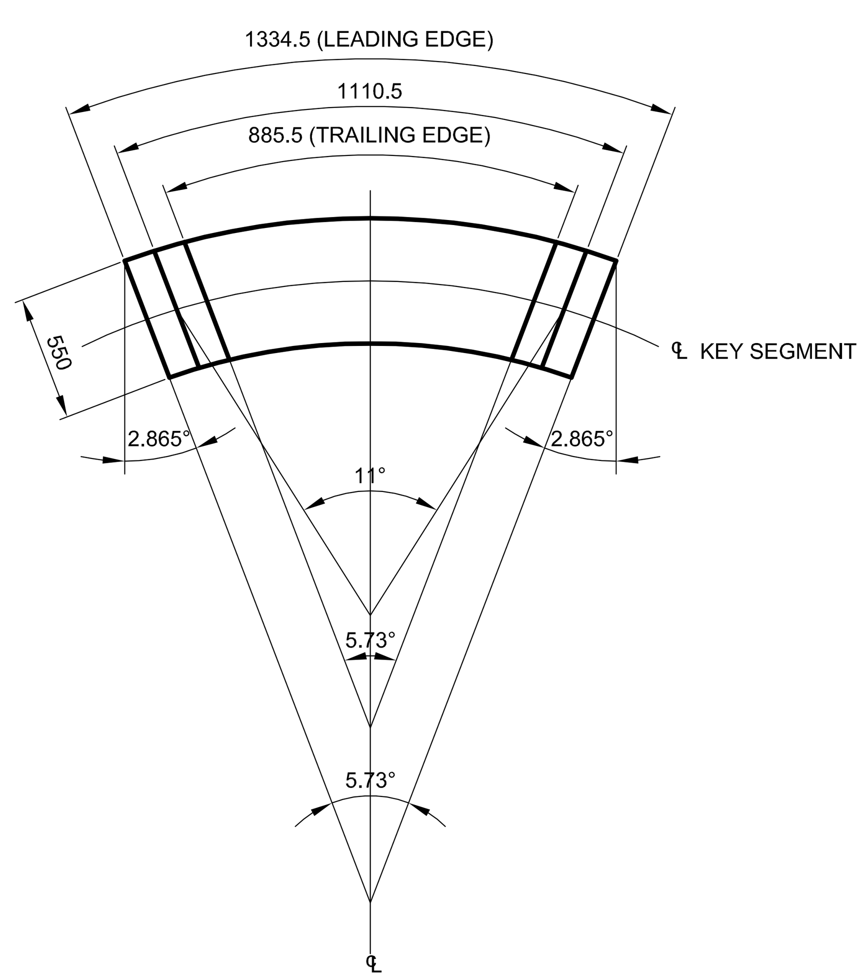
SECTION A-A THROUGH 4 No. RINGS

Scale 1:50



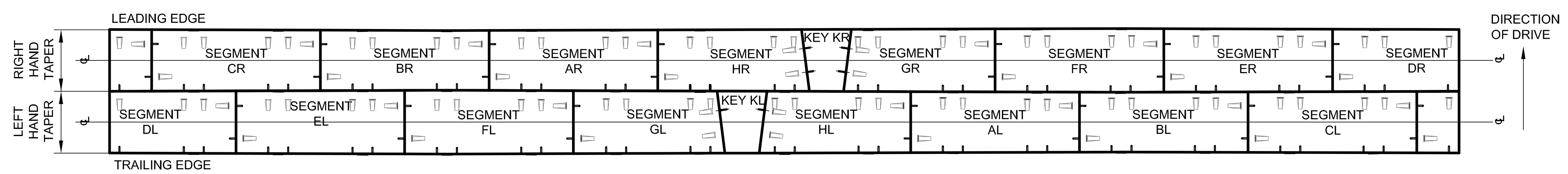
KEY SEGMENT VIEWED FROM MID-POINT OF LINING

Scale 1:20



KEY SEGMENT RADIAL JOINT GEOMETRY

Scale N.T.S.



DEVELOPED PLAN VIEW ON INTRADOS

N.T.S

Notes

1. This drawing to be read in conjunction with all relevant drawings and contract documentation.
2. Do not scale - use written dimensions only. if in doubt, contact the designers.
3. All dimensions are in millimetres except where otherwise stated.
4. Concrete to segmental lining to have a characteristic strength of 50n/mm at 28 days.
5. Minimum concrete cover to reinforcement to be 40mm.
6. Taper of the rings to be taken from the trailing edge of the left hand and right hand rings.
7. Mould manufacturers to propose segment lifting positions for approval by the designer.
8. Design of segment lifting system to be coordinated with tbm supplier.
9. Minimum cube strength of concrete for mould de-moulding is 10 n/mm.
10. All bolts to be m24 grade 8.8.
11. Grout holes to be provided on each segment.
12. Angles taken at mid-point of ring.

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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United Kingdom
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W www.mottmac.com

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
11000 I.D. Precast Segmental Lining
Left Hand Taper Ring

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: As Shown		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-202

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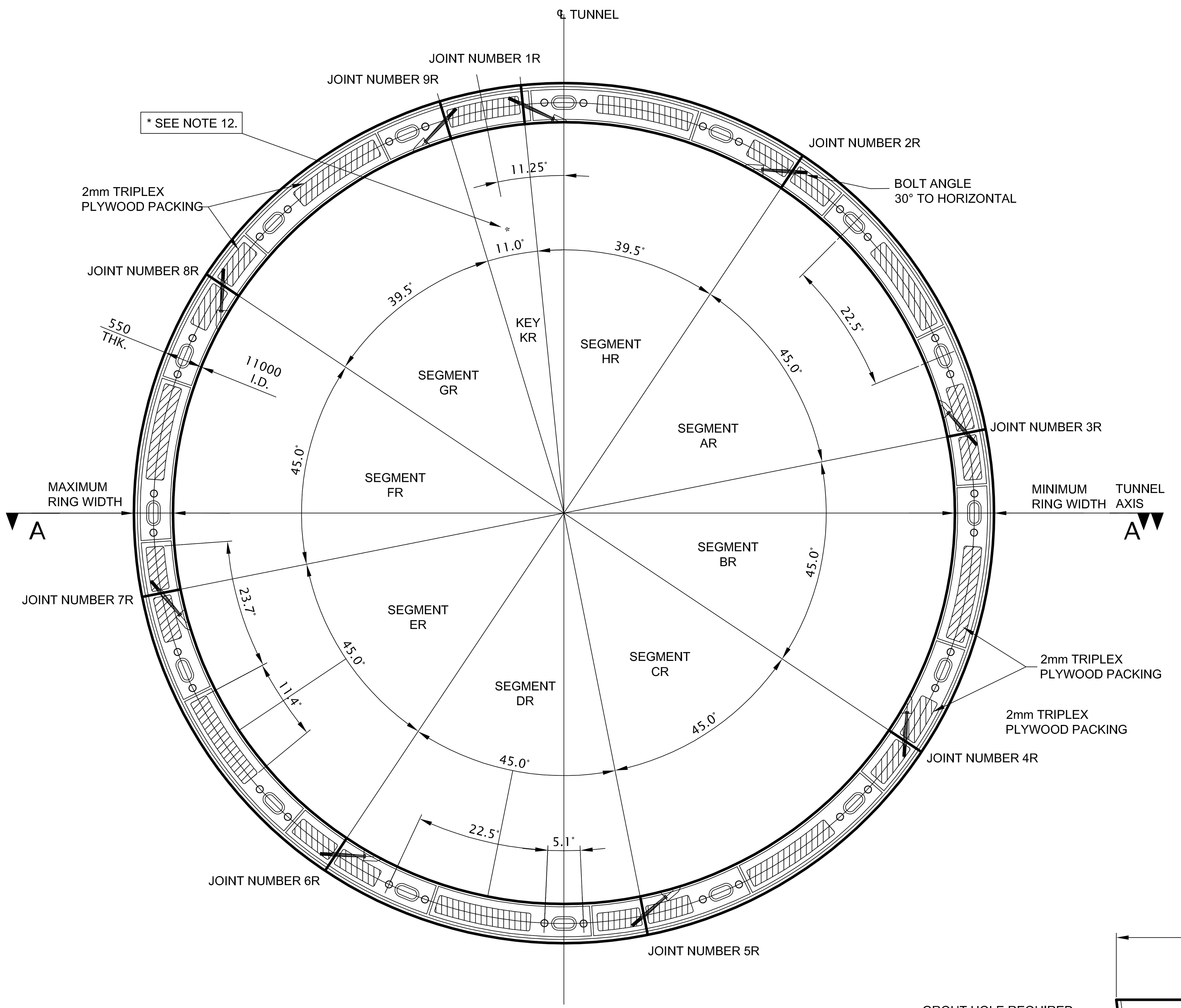
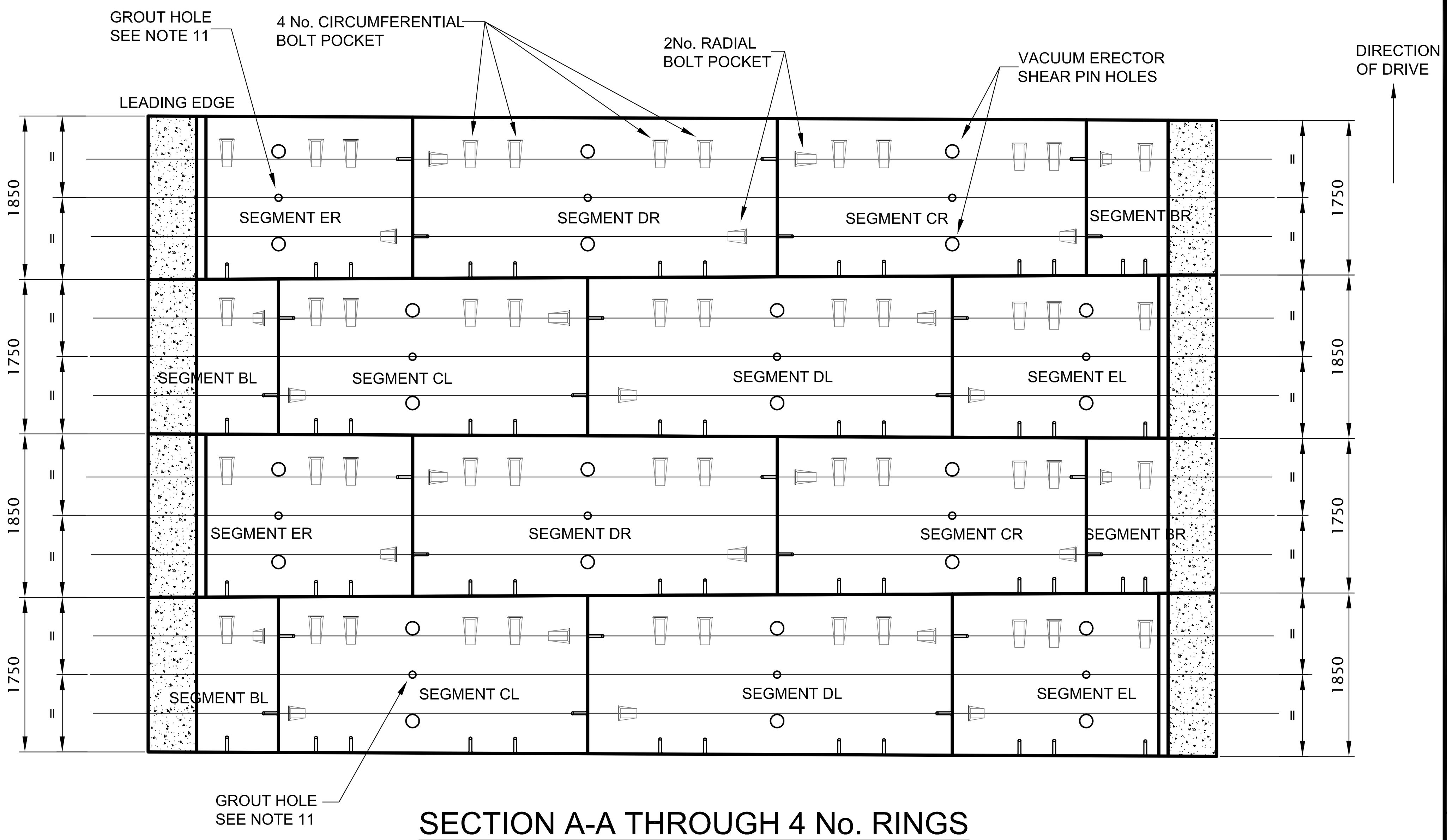


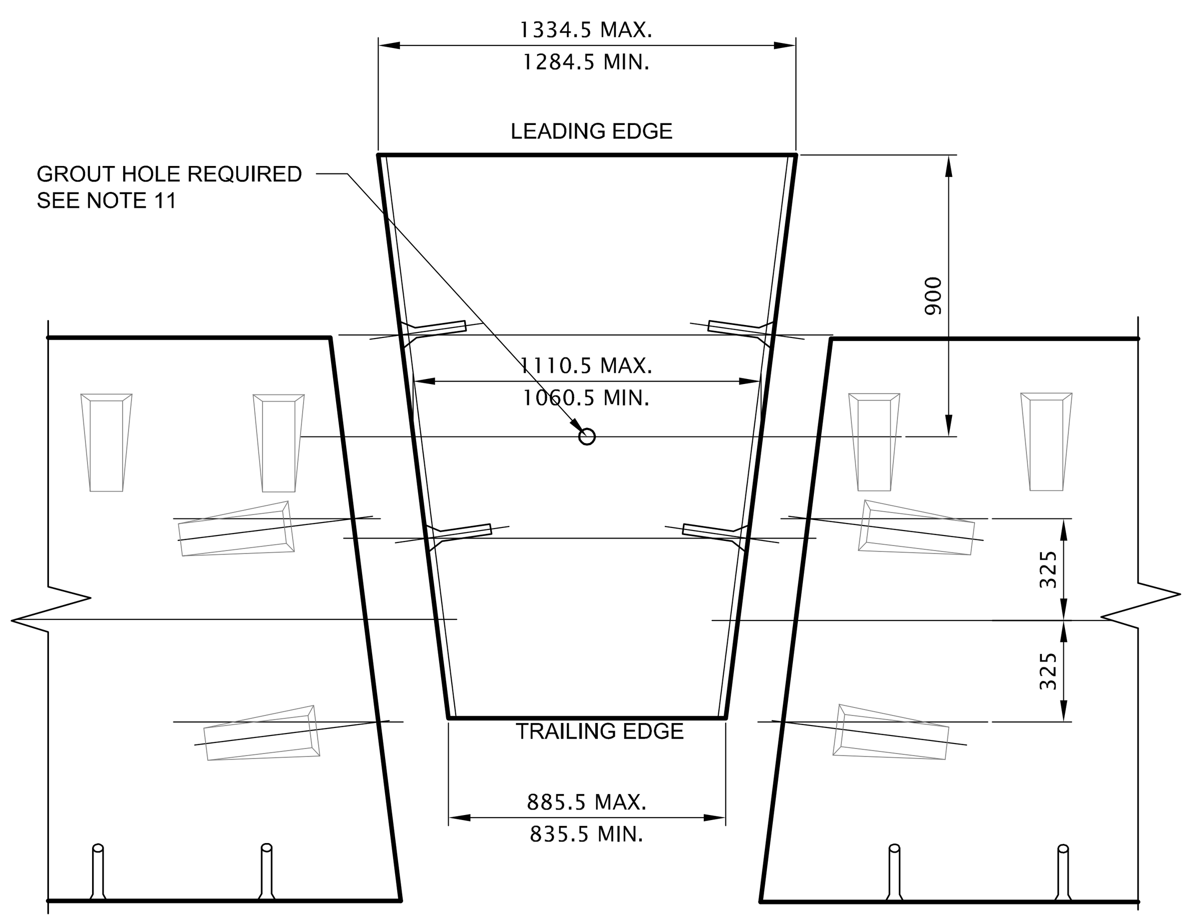
TYPICAL SECTION OF RIGHT HAND TAPER RING (TRAILING EDGE)

Scale 1:50



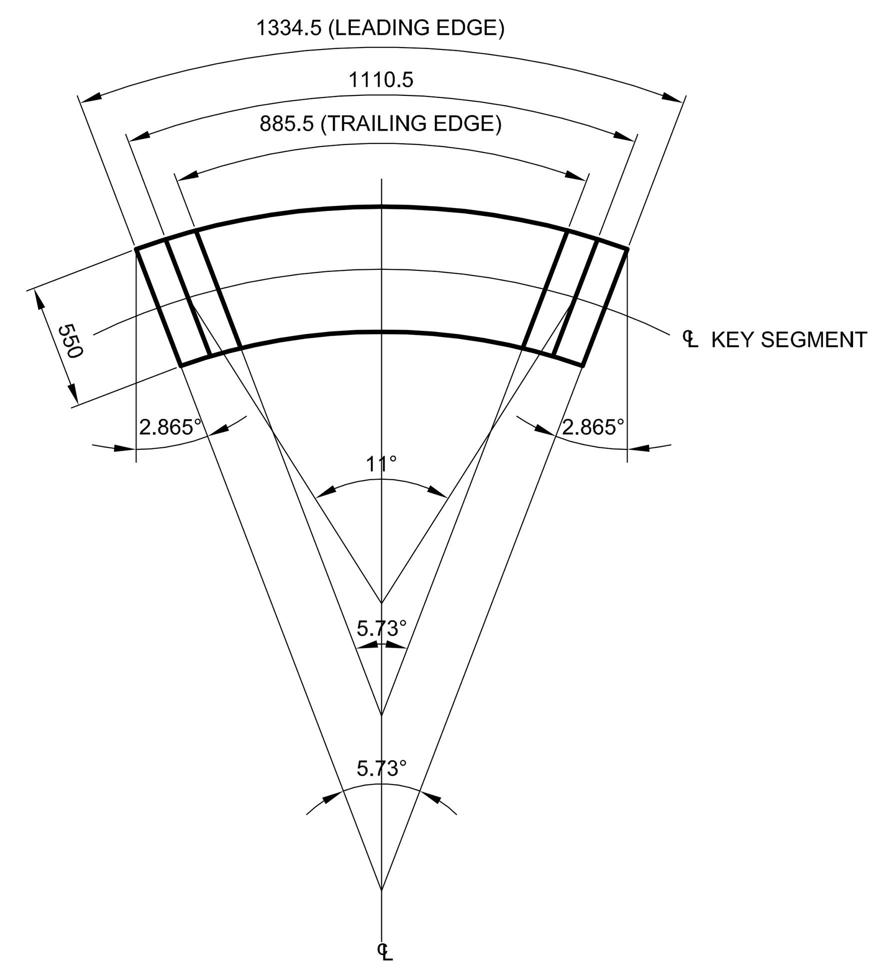
SECTION A-A THROUGH 4 No. RINGS

Scale 1:50



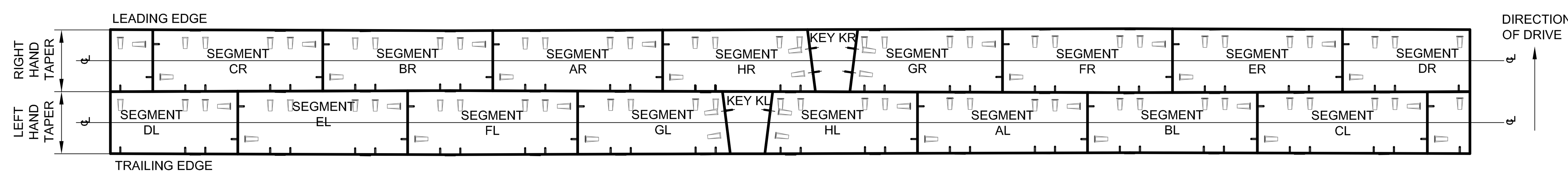
KEY SEGMENT VIEWED FROM MID-POINT OF LINING

Scale 1:20



KEY SEGMENT RADIAL JOINT GEOMETRY

Scale N.T.S.



DEVELOPED PLAN VIEW ON INTRADOS

N.T.S

Notes

1. This drawing to be read in conjunction with all relevant drawings and contract documentation.
2. Do not scale - use written dimensions only. if in doubt, contact the designers.
3. All dimensions are in millimetres except where otherwise stated.
4. Concrete to segmental lining to have a characteristic strength of 50n/mm at 28 days.
5. Minimum concrete cover to reinforcement to be 40mm.
6. Taper of the rings to be taken from the trailing edge of the left hand and right hand rings.
7. Mould manufacturers to propose segment lifting positions for approval by the designer.
8. Design of segment lifting system to be coordinated with tbm supplier.
9. Minimum cube strength of concrete for mould de-moulding is 10 n/mm.
10. All bolts to be m24 grade 8.8.
11. Grout holes to be provided on each segment.
12. Angles taken at mid-point of ring.

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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W www.mottmac.com

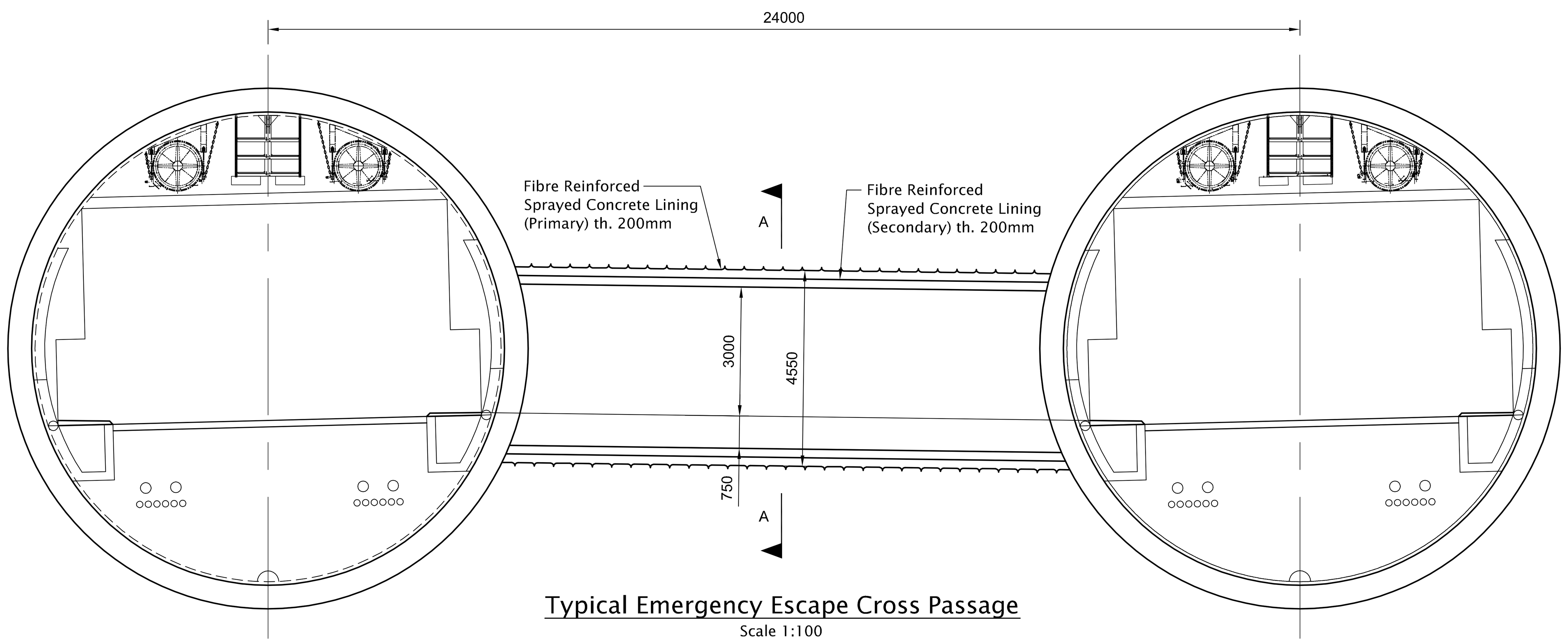
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
11000 I.D. Precast Segmental Lining
Right Hand Taper Ring

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR

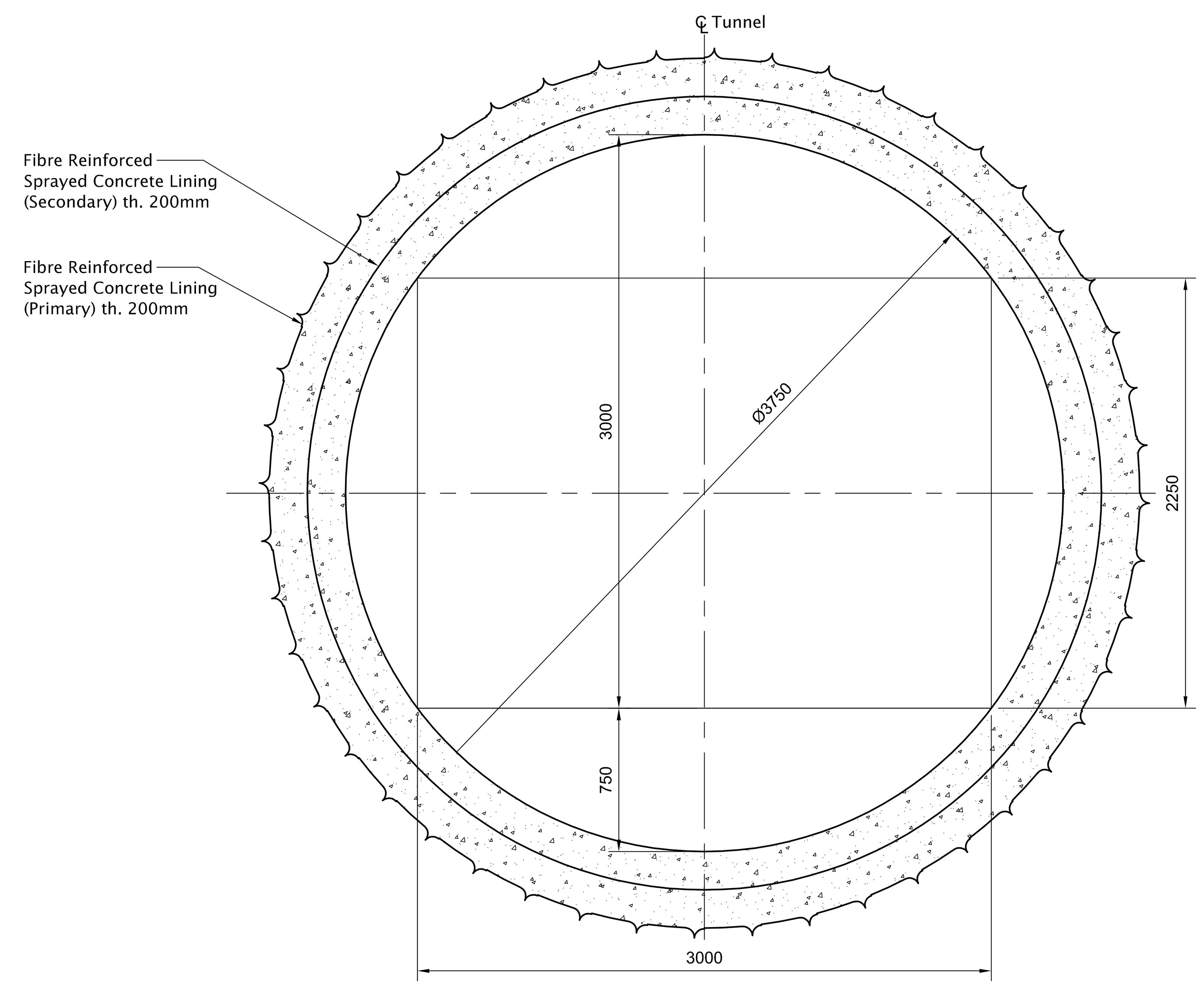
Scale at A1	Status	Rev
As Shown	PRE	P1

Drawing Number
MMD-267759-TUN-203



Typical Emergency Escape Cross Passage

Scale 1:100



Emergency Escape Cross Passage Section A-A

Scale 1:25

1:25 0 — 1.250m — 2.5m

1:100 0 — 5m — 10m

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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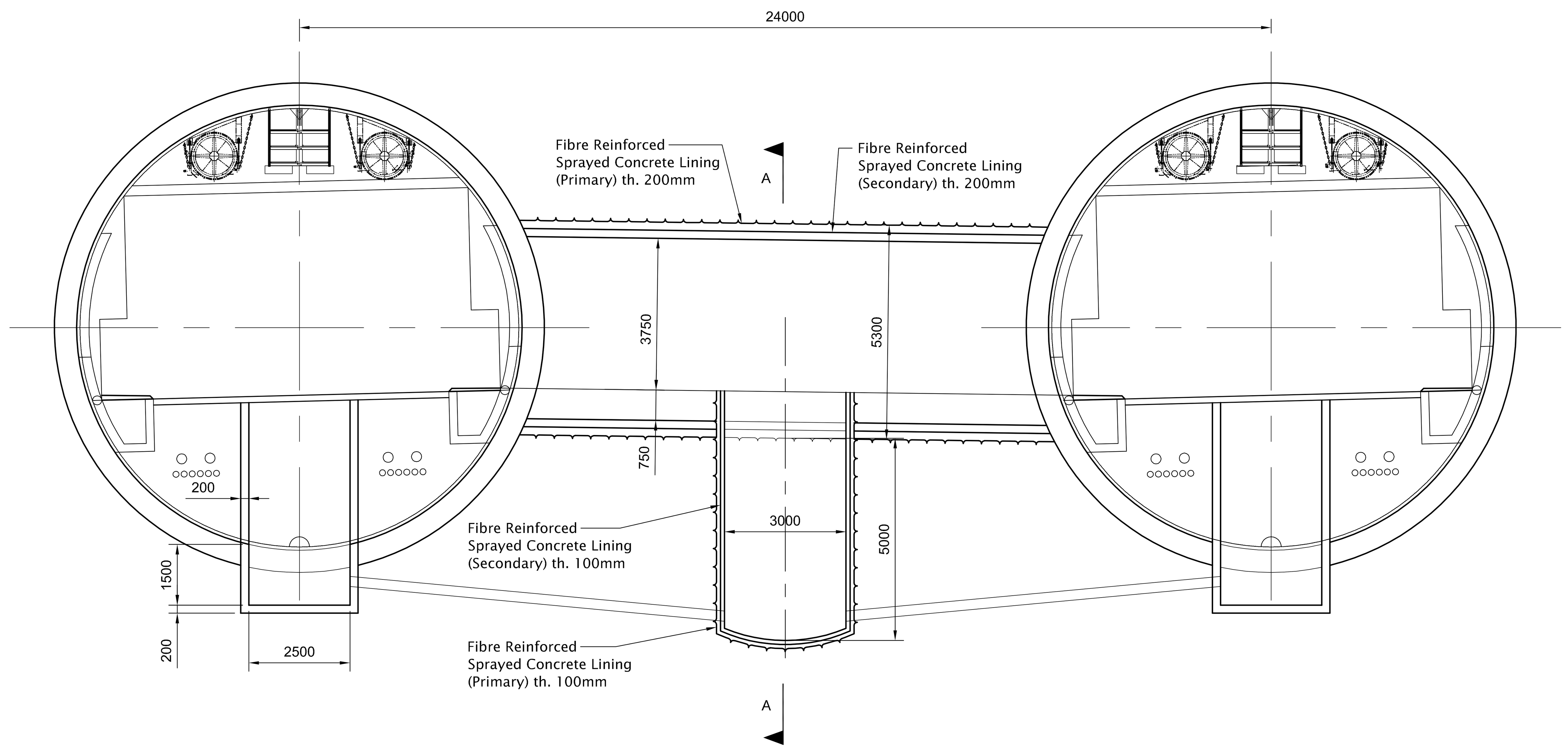
W www.mottmac.com

Client
Transport for London

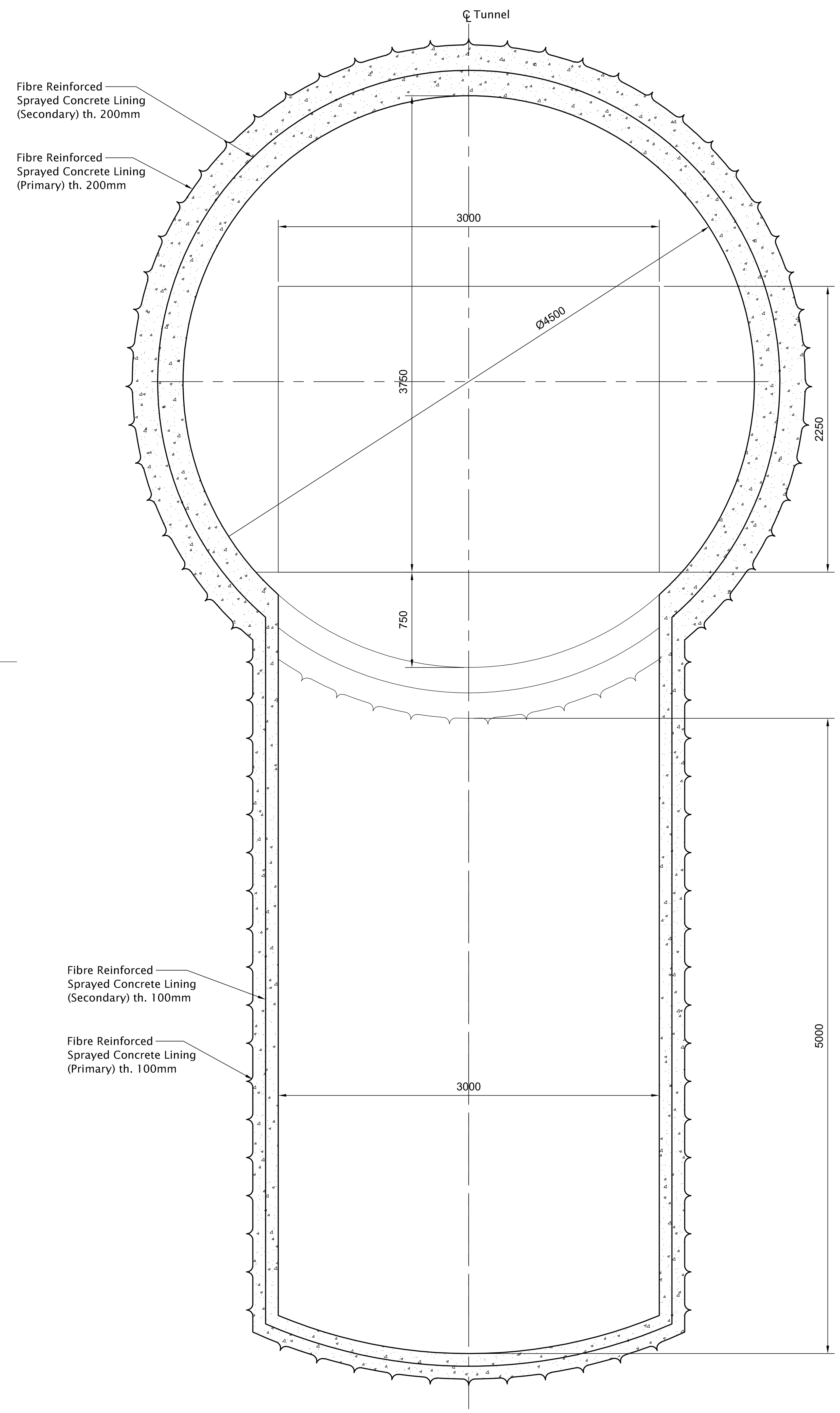
Title
New Thames River Crossing
Bored Tunnel Option
Emergency Escape Cross Passages
Cross Section

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE		Rev P1

Drawing Number
MMD-267759-TUN-204



Emergency Escape Cross Passage With Sump
Bored Tunnel Alternative 1
Scale 1:100



Emergency Escape Cross Passage With Sump Section A-A
Scale 1:25

1:25	0	1.250m	2.5m
1:100	0	5m	10m

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

Mott MacDonald

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United Kingdom
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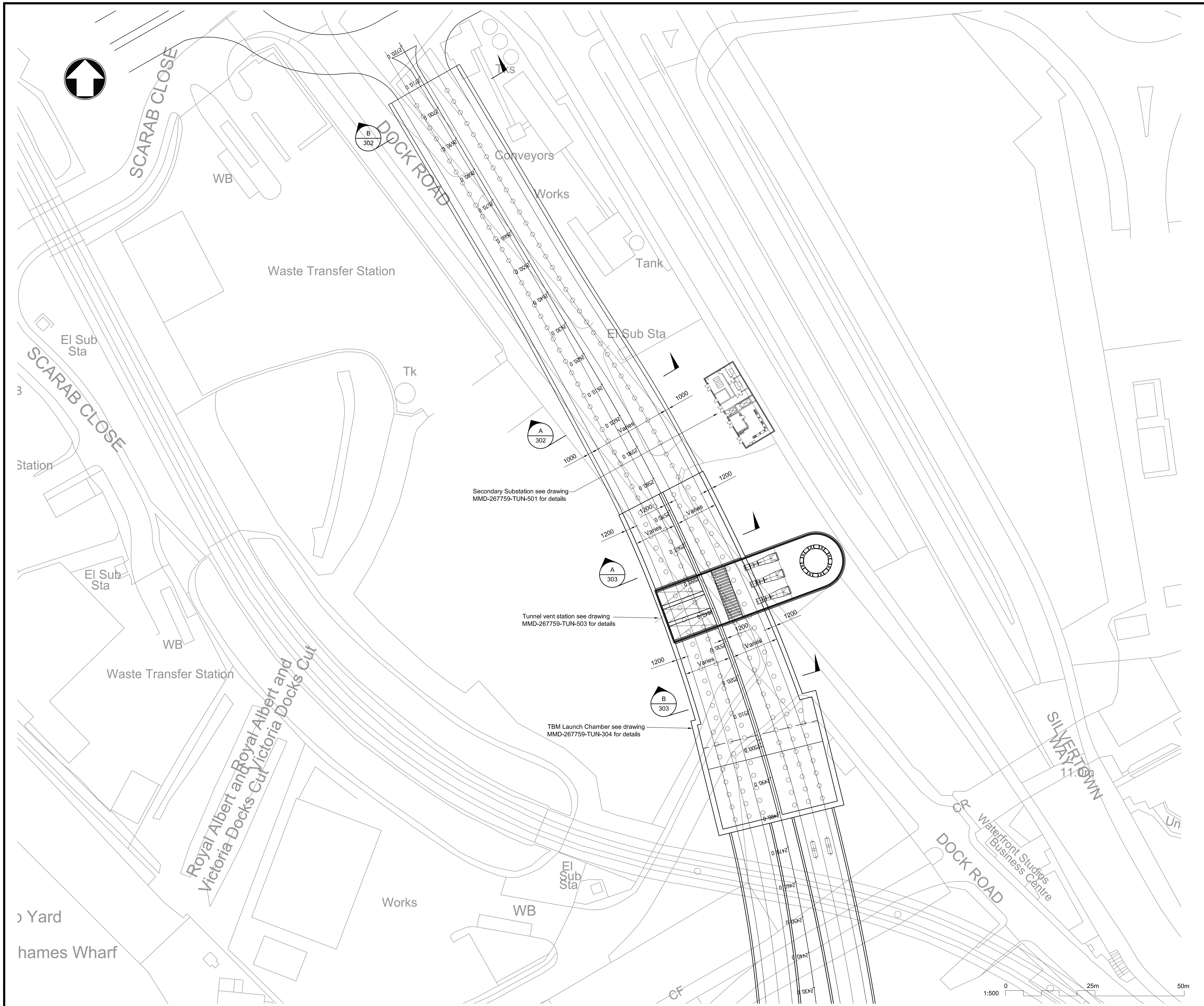
W www.mottmac.com

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Cross Passage & Sump Cross Section
Tunnel Alternative 1

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE	Rev P1	

Drawing Number
MMD-267759-TUN-205



Notes

Key to symbols

Reference drawings

DRAFT
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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

Mott MacDonald

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W www.mottmac.com

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Silvertown Approach
Structures Plan Layout

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1: 1:500	Status: PRE	Rev: P1	

Drawing Number
MMD-267759-TUN-301

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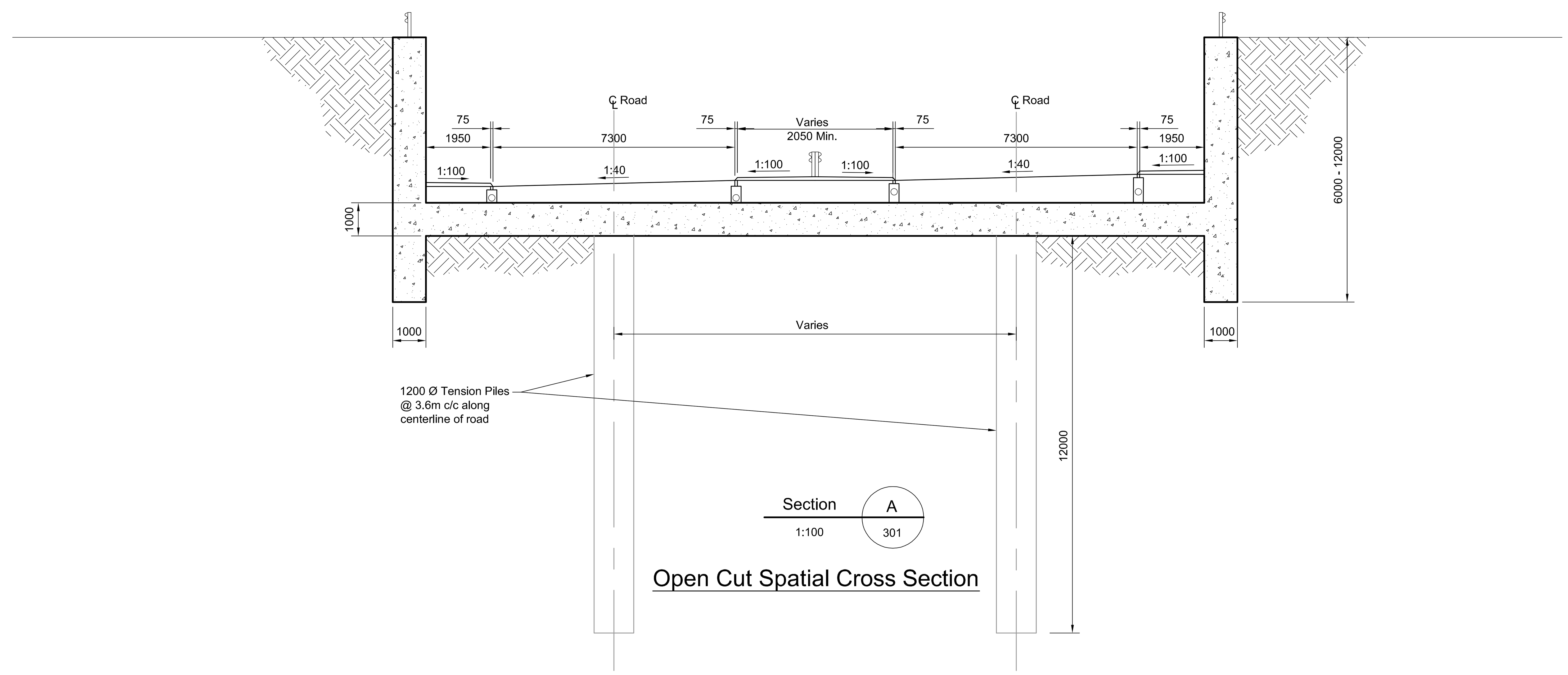
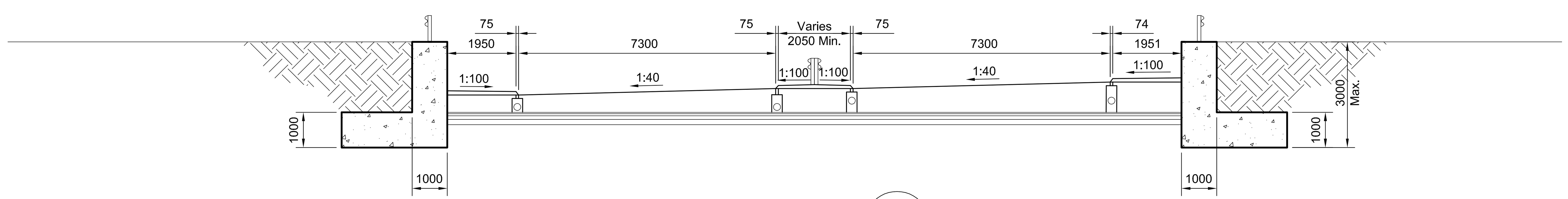


Section A
1:100 301

Open Cut Spatial Cross Section



Section B
1:100 301

Open Cut Spatial Cross Section

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

Mott MacDonald

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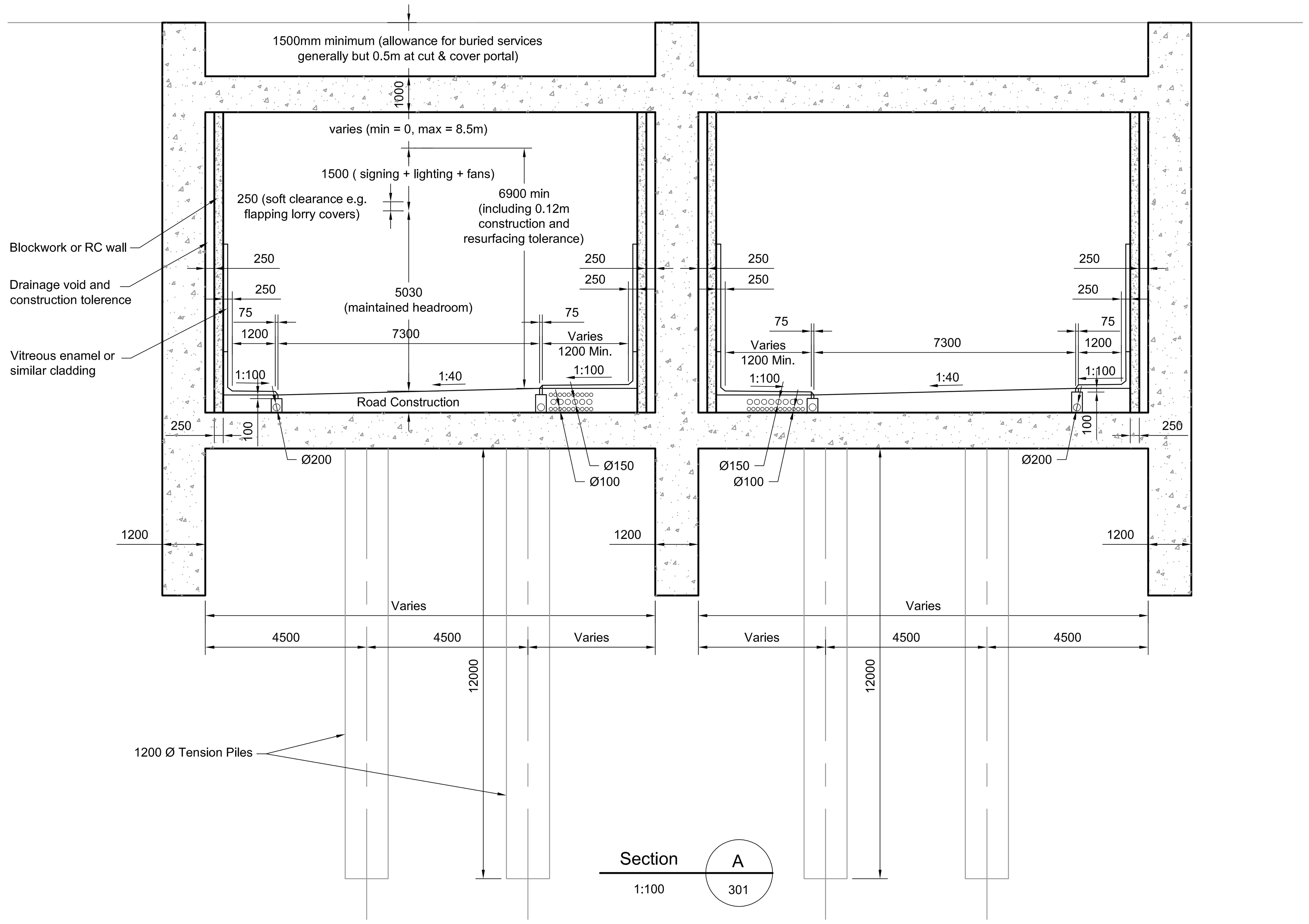
Client
Transport for London

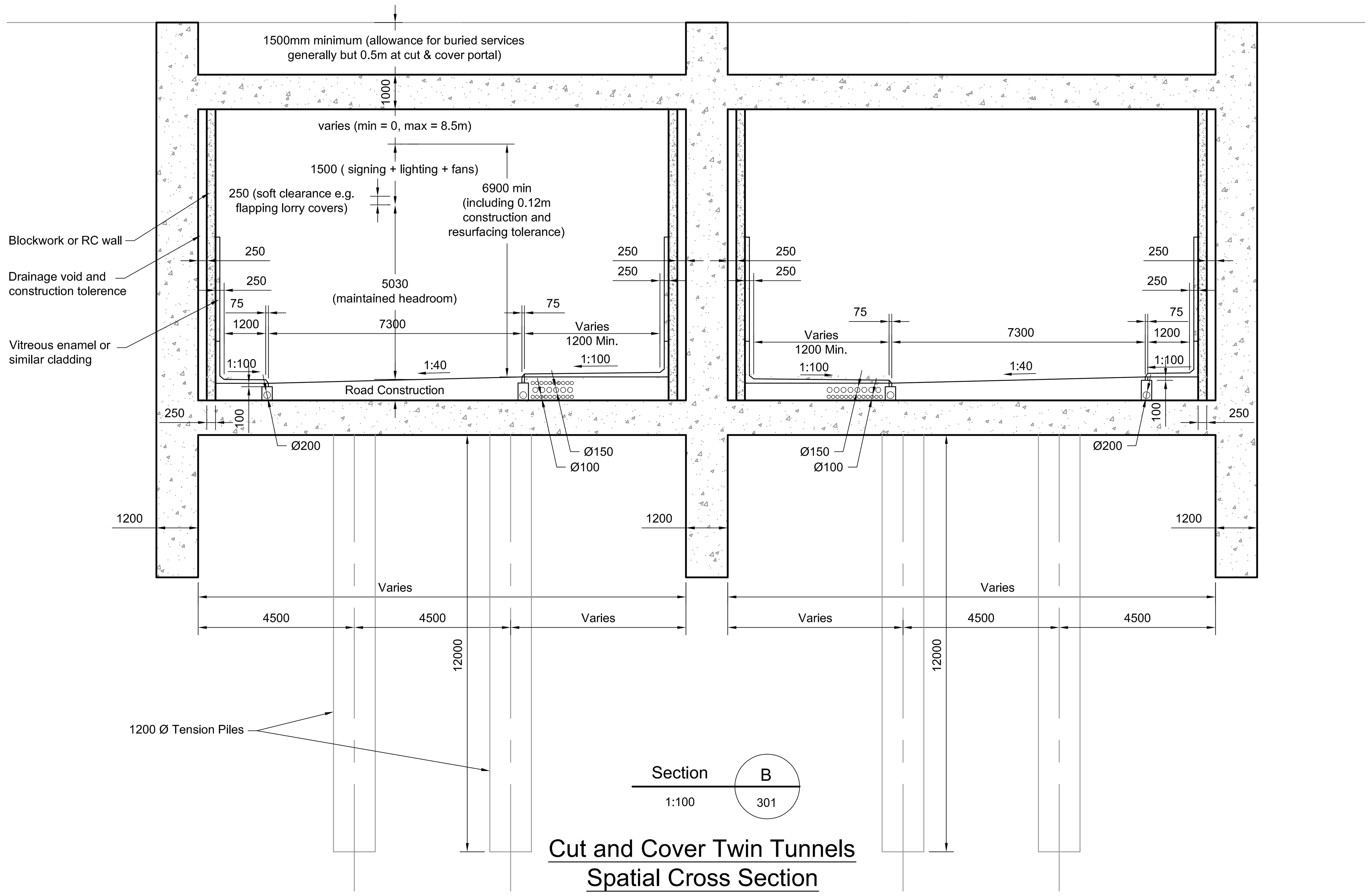
Title
New Thames River Crossing
Bored Tunnel Option
Silvertown
Open Cut Structures

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE	Rev P1	

Drawing Number
MMD-267759-TUN-302



Cut and Cover Twin Tunnels
Spatial Cross Section



Cut and Cover Twin Tunnels
Spatial Cross Section

1:100 0 5m 10m

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : ...27-11-2009....

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Silvertown Cut and Cover
Spatial Cross Sections

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: 1:100		Status: PRE	Rev: P1	

Drawing Number
MMD-267759-TUN-303

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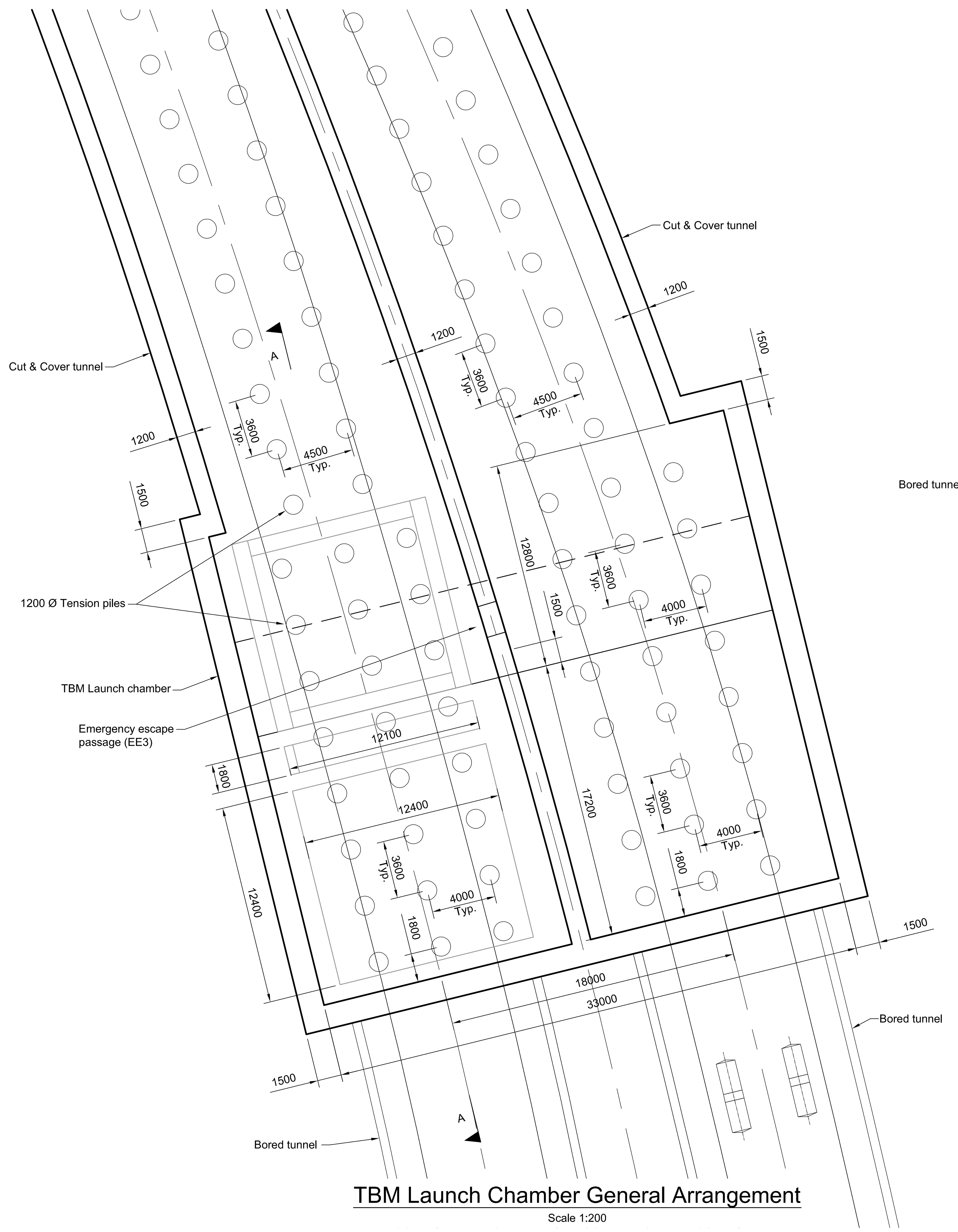
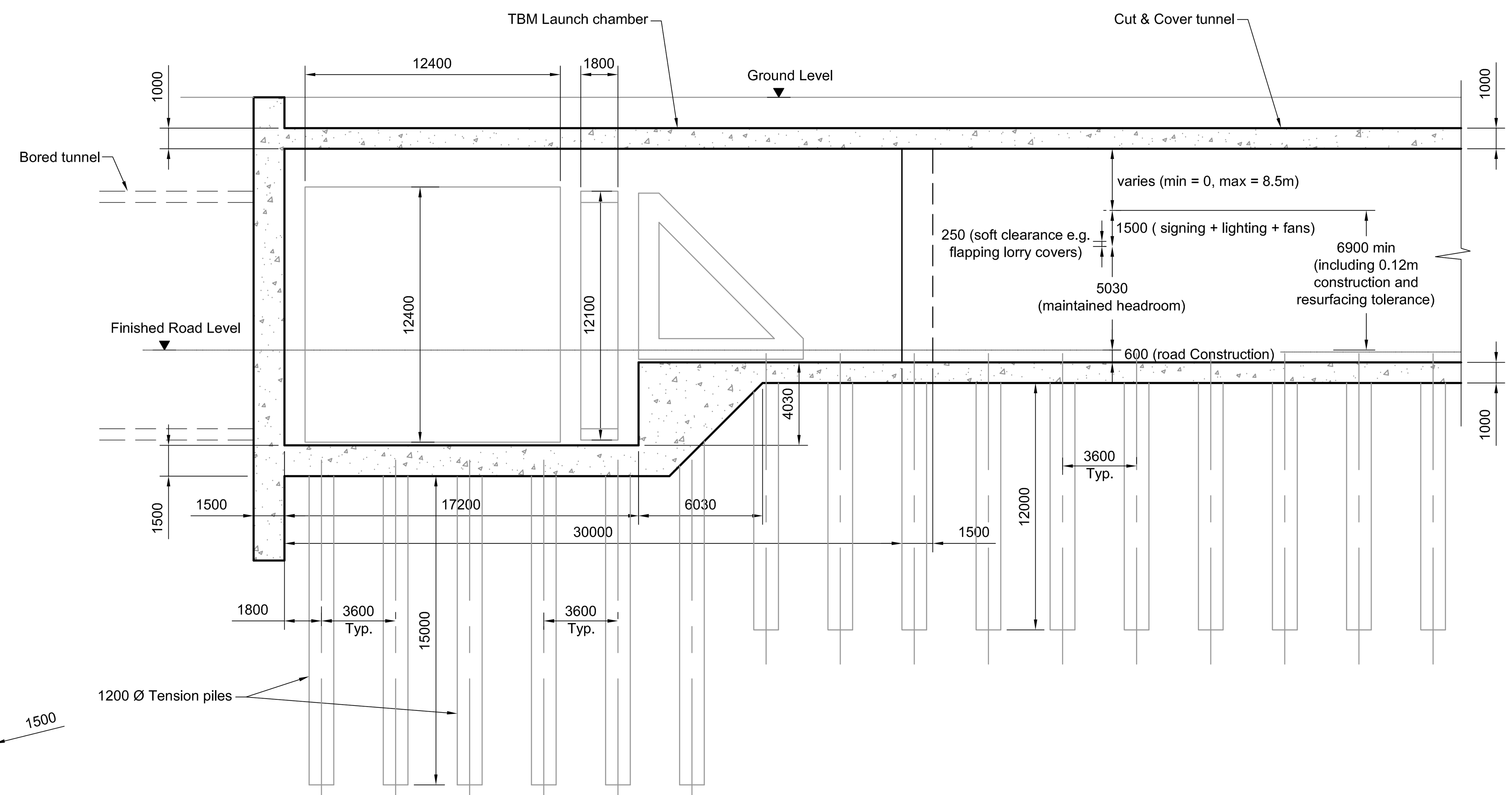


TBM Launch Chamber General Arrangement

Scale 1:200



Section A-A

Scale 1:200

1:200 0 10m 20m

DRAFT
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Date : 27-11-2009

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Silvertown Cut and Cover
TBM Launch Chamber

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: 1:200		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-304

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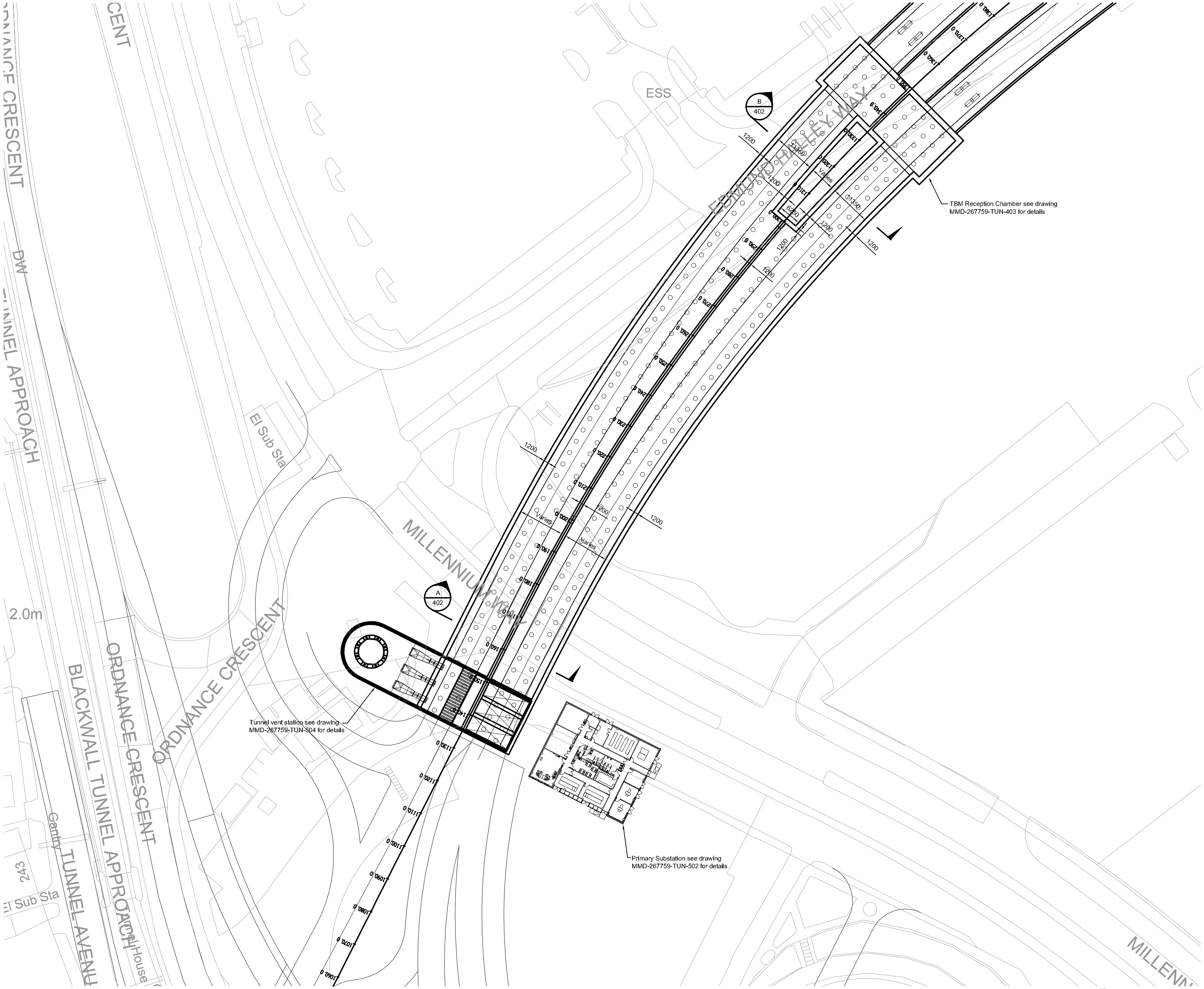

Notes

Key to symbols

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Greenwich Approach
Structures Plan Layout

Designed	TAR		Eng check	TAR	
Drawn	SRM		Coordination		
Dwg check	TAR		Approved	TAR	
Scale at A1 1:500		Status PRE		Rev P1	

Drawing Number
MMD-267759-TUN-401

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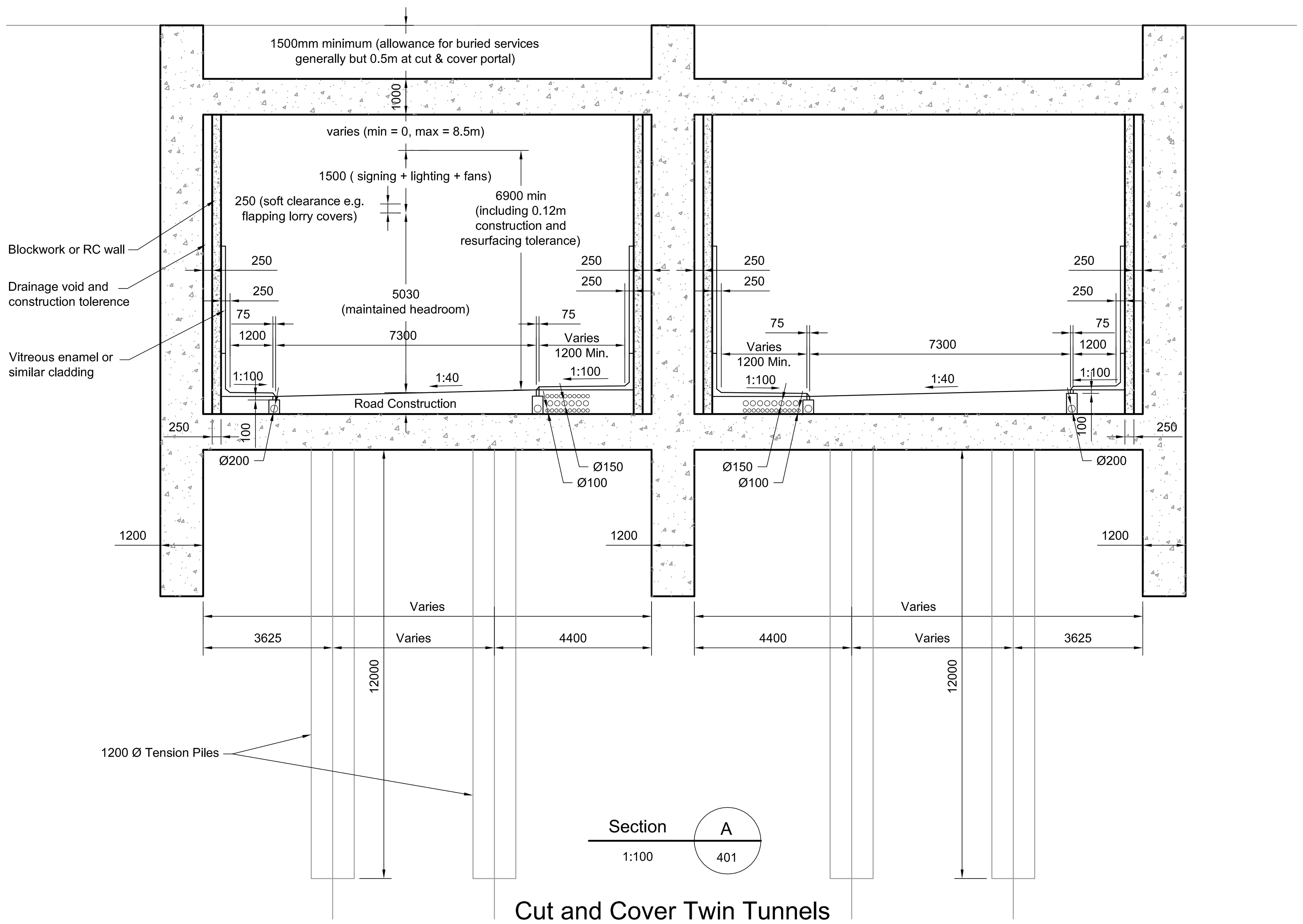
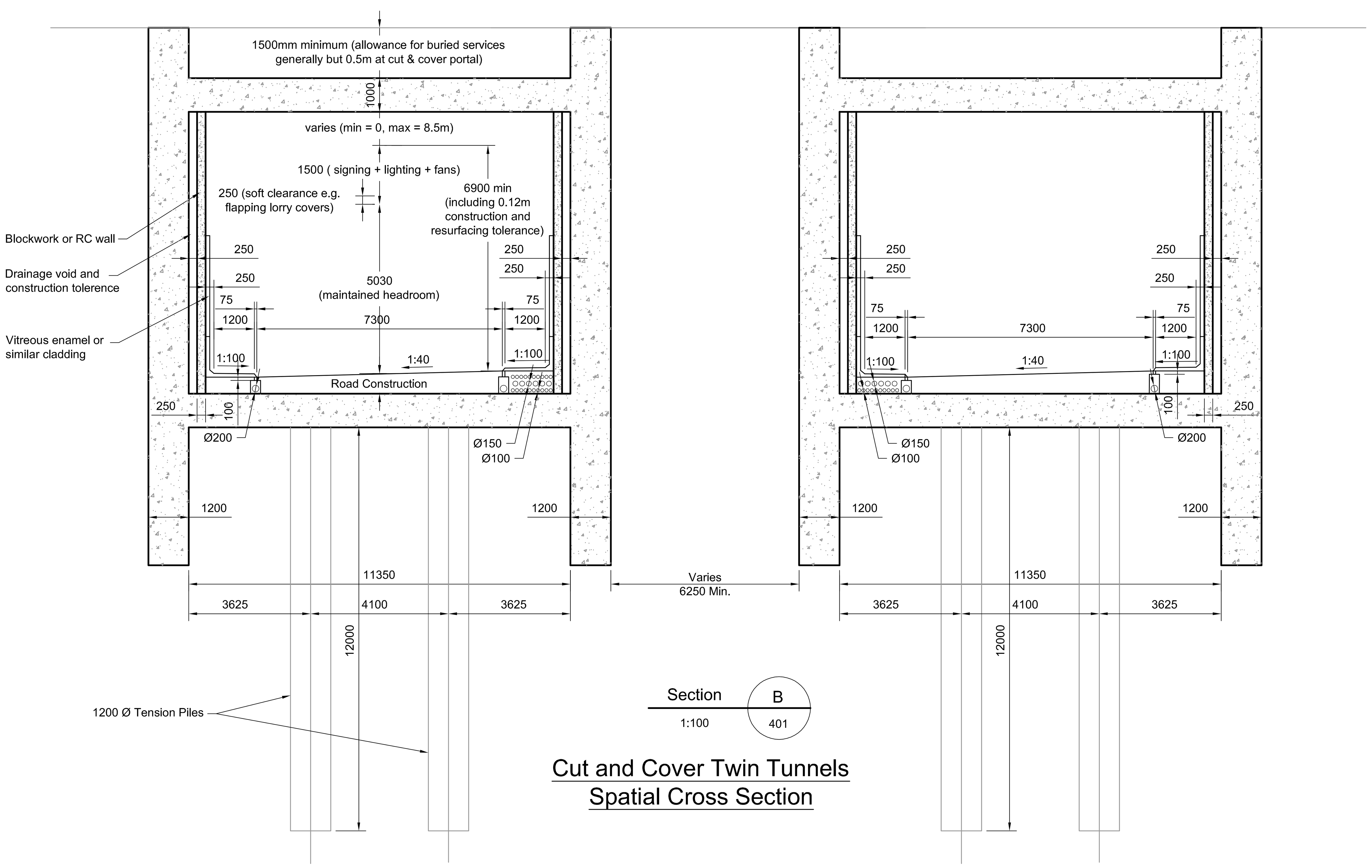


Cut and Cover Twin Tunnels
Spatial Cross Section



Cut and Cover Twin Tunnels
Spatial Cross Section

Notes

Key to symbols

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Greenwich
Cut and Cover Structures

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE	Rev P1	

Drawing Number
MMD-267759-TUN-402

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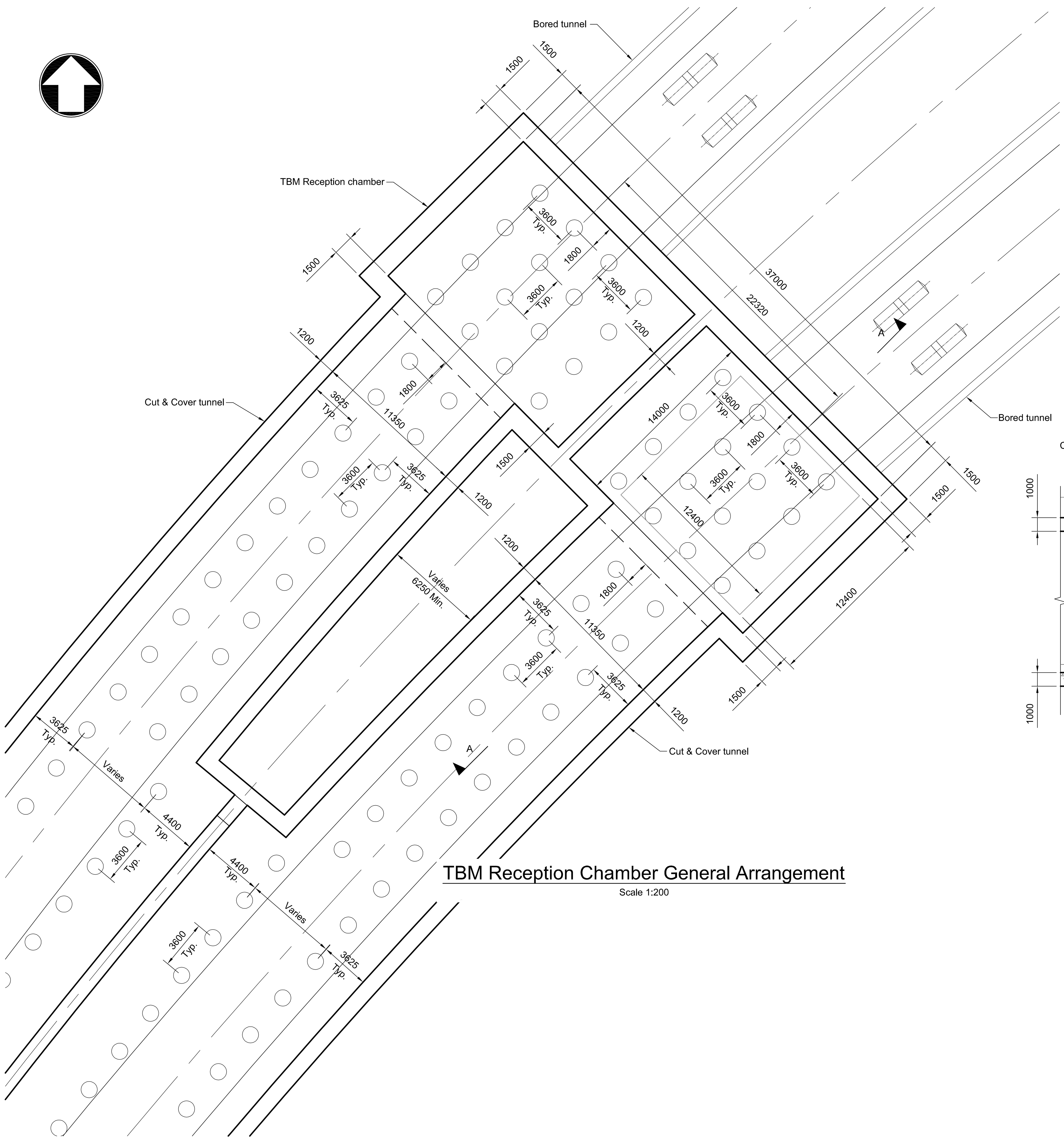
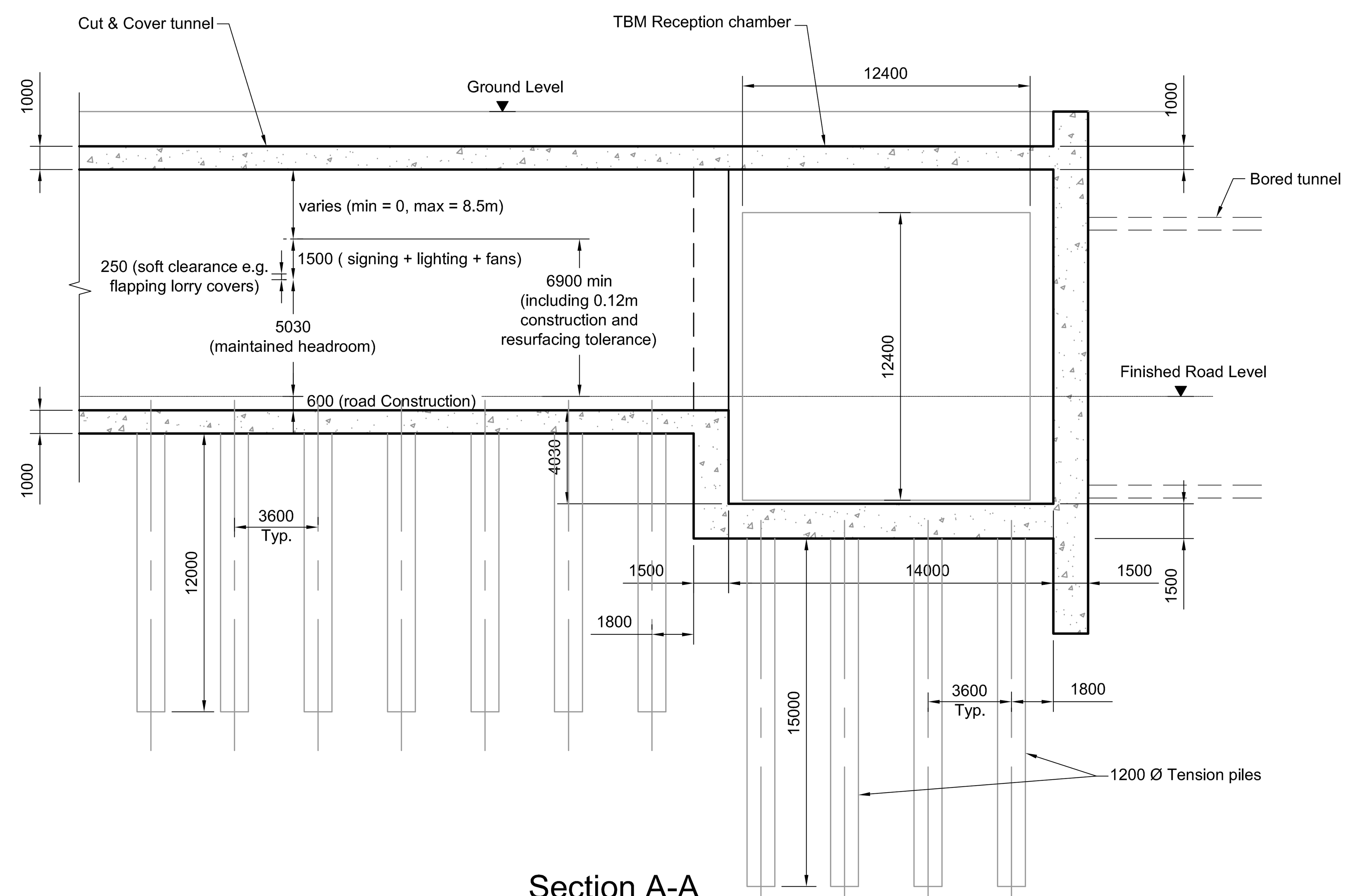


TBM Reception Chamber General Arrangement
Scale 1:200



Section A-A
Scale 1:200

1:200 0 10m 20m

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Greenwich Cut and Cover
TBM Reception Chamber

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1 1:200	Status PRE		Rev P1	

Drawing Number
MMD-267759-TUN-403

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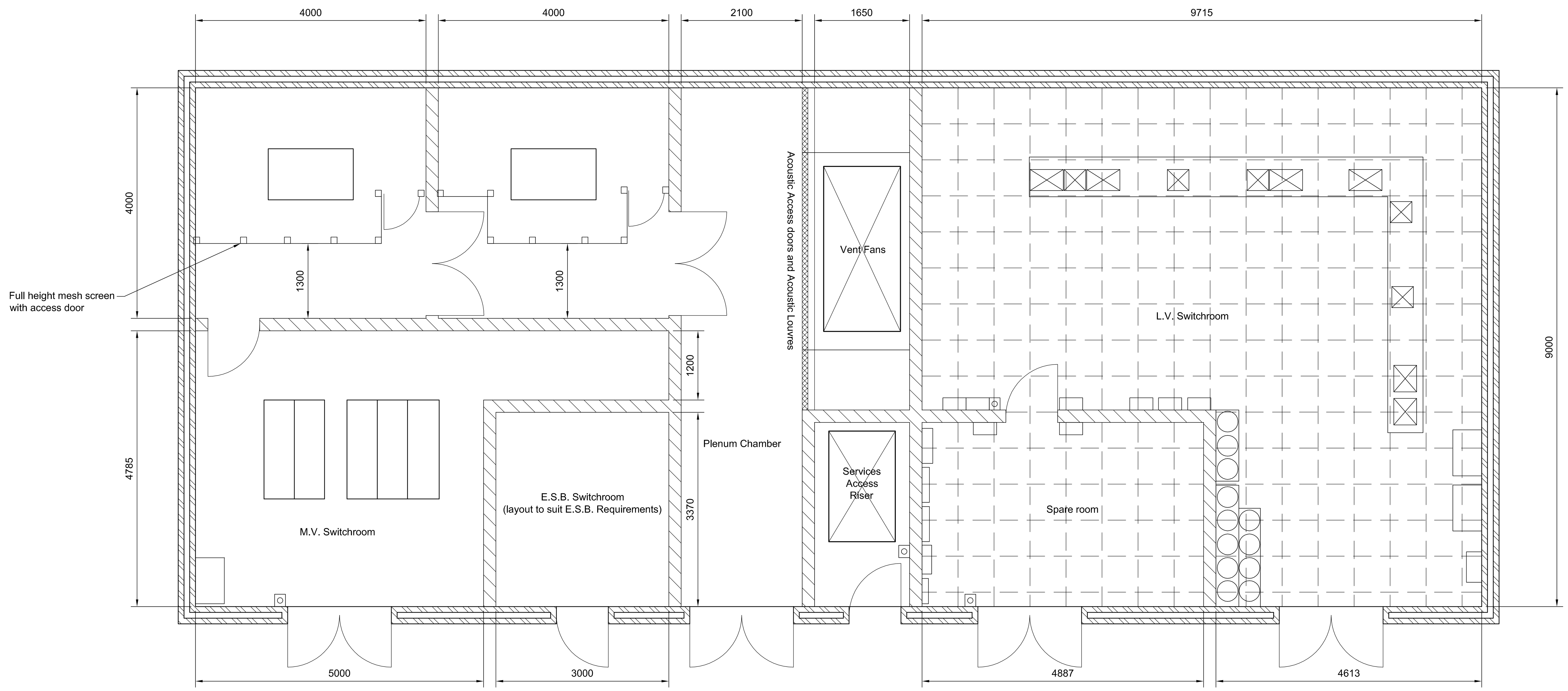

Silvertown Secondary Substation

Scale 1:50

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client

Transport for London

Title

New Thames River Crossing
Bored Tunnel Option
Silvertown
Secondary Substation

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE		Rev P1

Drawing Number

MMD-267759-TUN-501

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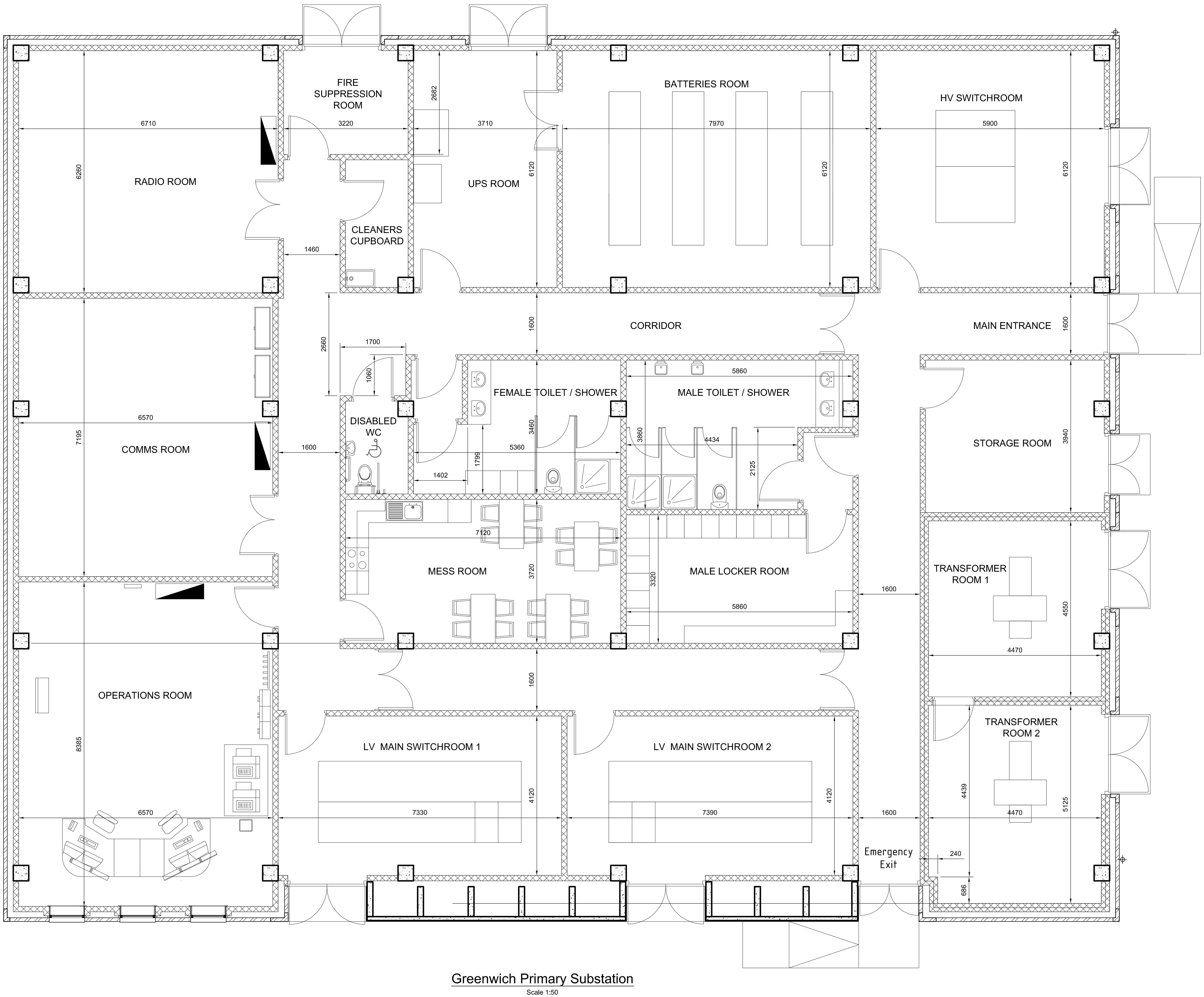

Greenwich Primary Substation

Scale 1:50

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Greenwich
Primary Substation

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1	Status PRE	Rev P1	

Drawing Number
MMD-267759-TUN-502

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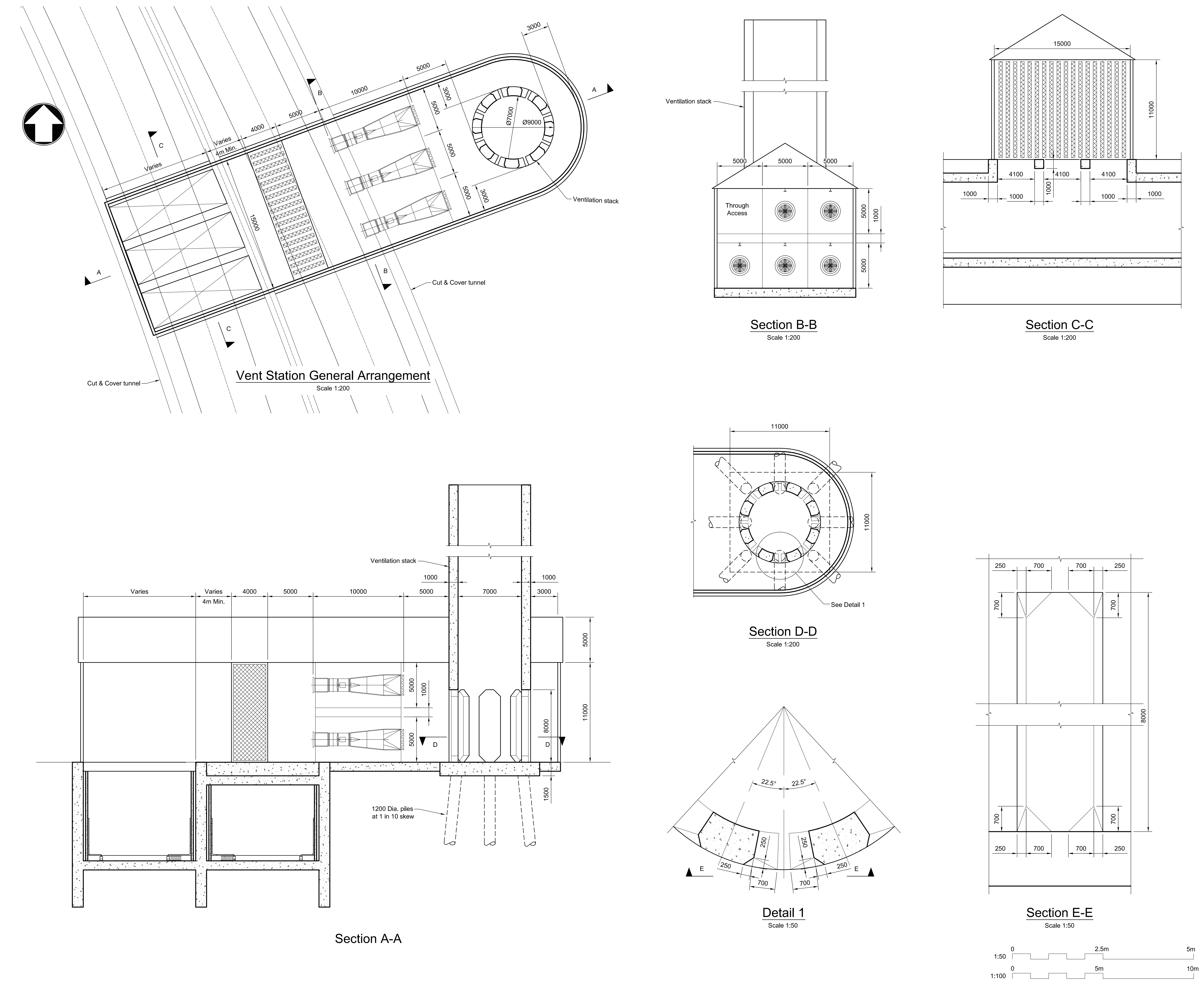

Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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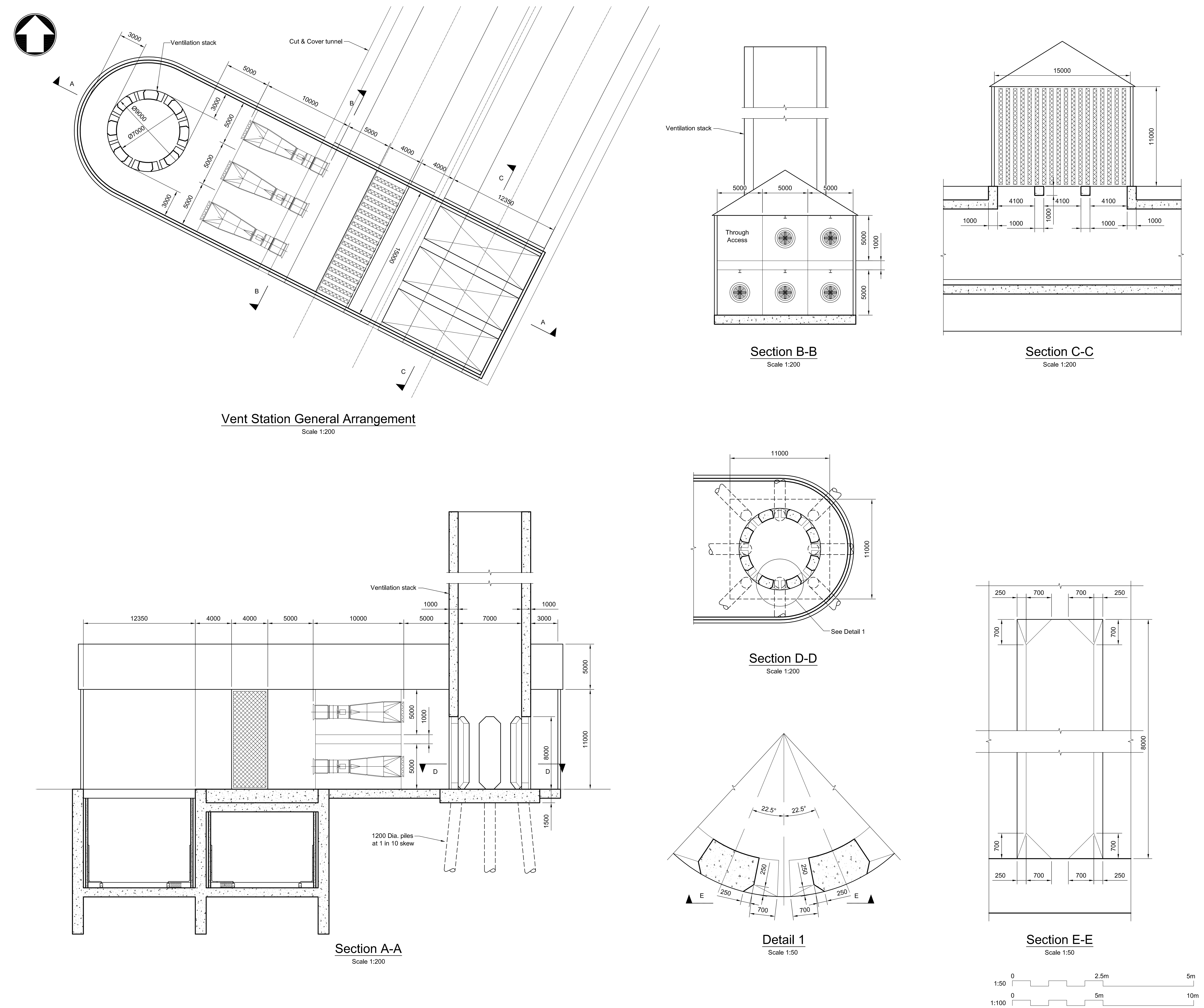
Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Silvertown Vent Station
GA, Sections and Details

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1	Status PRE	Rev P1	

Drawing Number
MMD-267759-TUN-503



Notes

Key to symbols

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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W www.mottmac.com

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Greenwich Vent Station
GA, Sections and Details

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1		Status PRE		Rev P1

Drawing Number
MMD-267759-TUN-504

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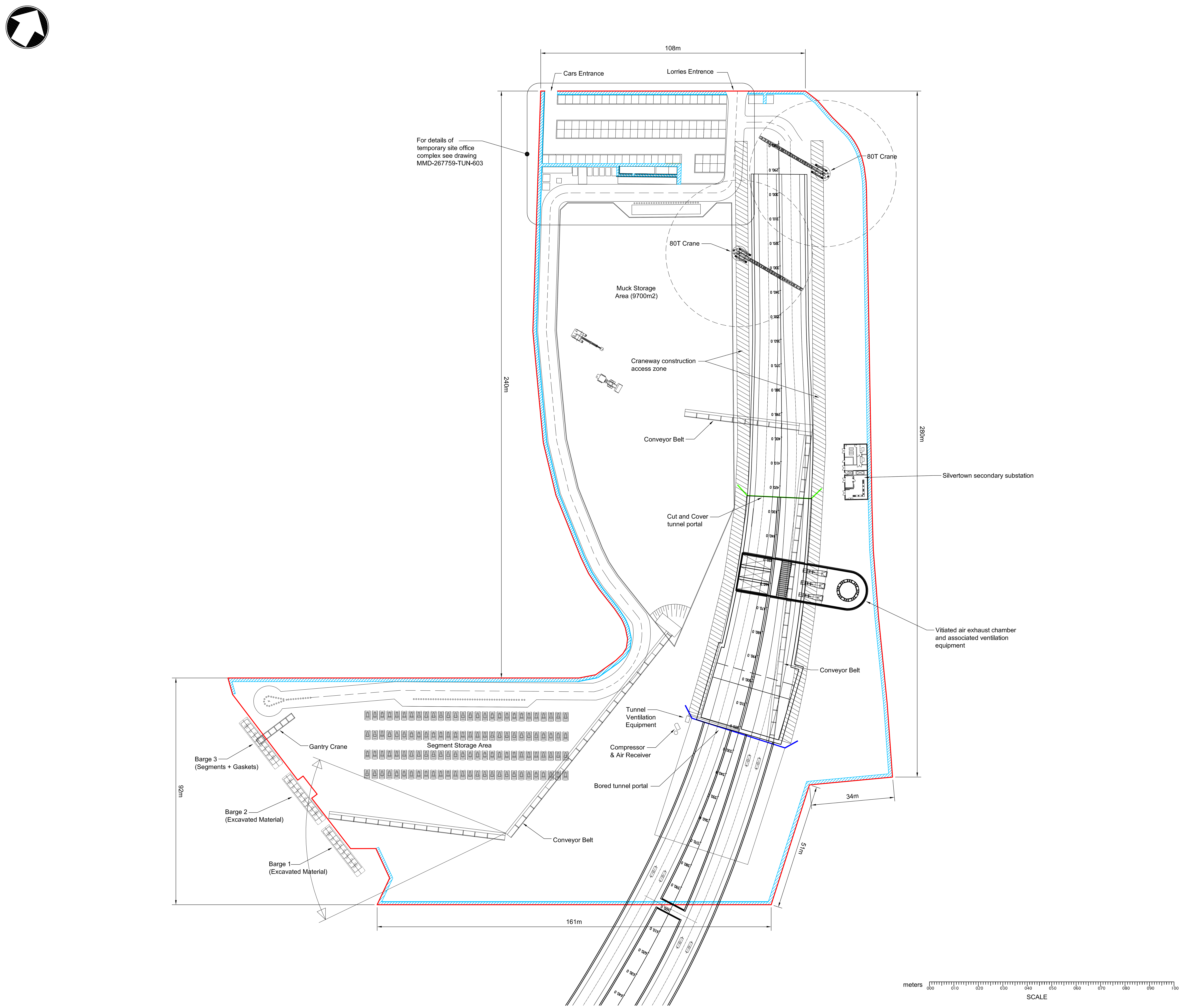

Notes

Key to symbols

- Site Boundaries
- Pedestrian Way (1.5m Wide)
- Cut and Cover Tunnel Portal
- Bored Tunnel Portal

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Silvertown Worksite Layout
Local Mapping Ommitted

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: N.T.S.		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-601

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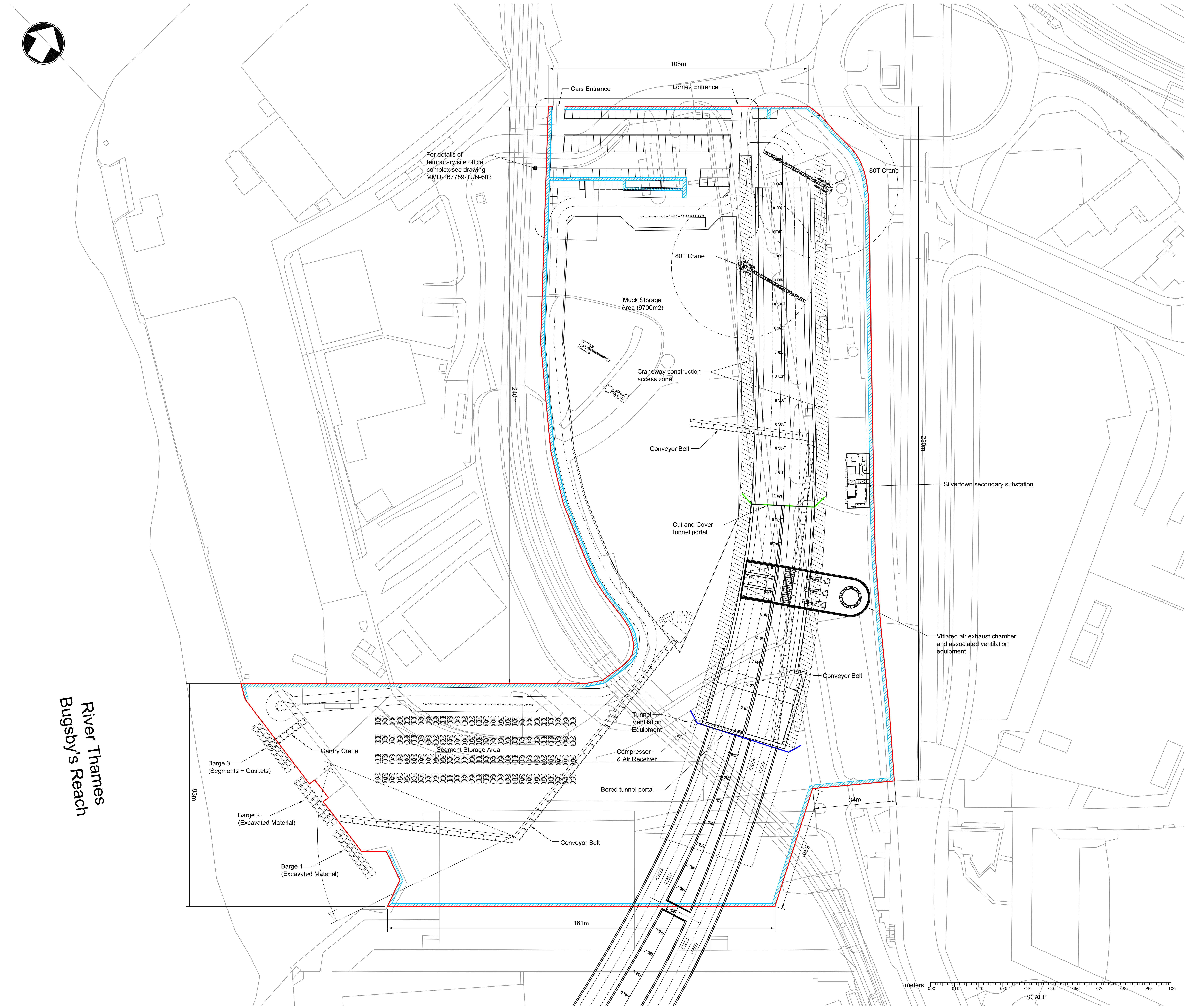

Notes

Key to symbols

- Site Boundaries
- Pedestrian Way (1.5m Wide)
- Cut and Cover Tunnel Portal
- Bored Tunnel Portal

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client

Transport for London

Title

New Thames River Crossing
Bored Tunnel Option
Silvertown Worksite Layout
With Background Mapping

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1: N.T.S.	Status: PRE	Rev: P1	

Drawing Number

MMD-267759-TUN-602

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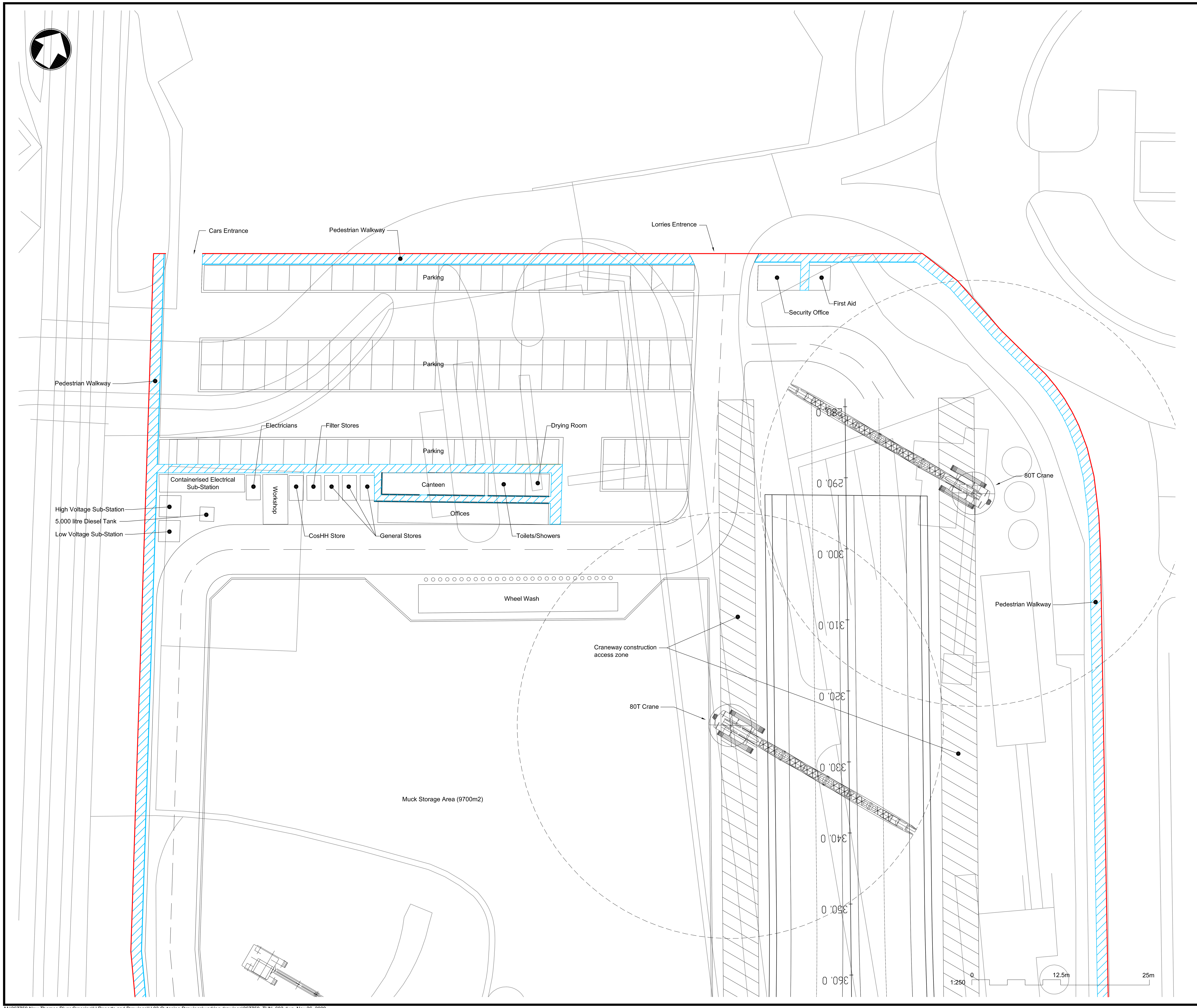

Notes

Key to symbols

- Site Boundaries
- Pedestrian Way (1.5m Wide)

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client

Transport for London

Title

New Thames River Crossing
Bored Tunnel Option
Silvertown Worksite Layout
Details of Temp Site Office Complex

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR
Scale at A1 1:250		Status PRE	Rev P1

Drawing Number
MMD-267759-TUN-603

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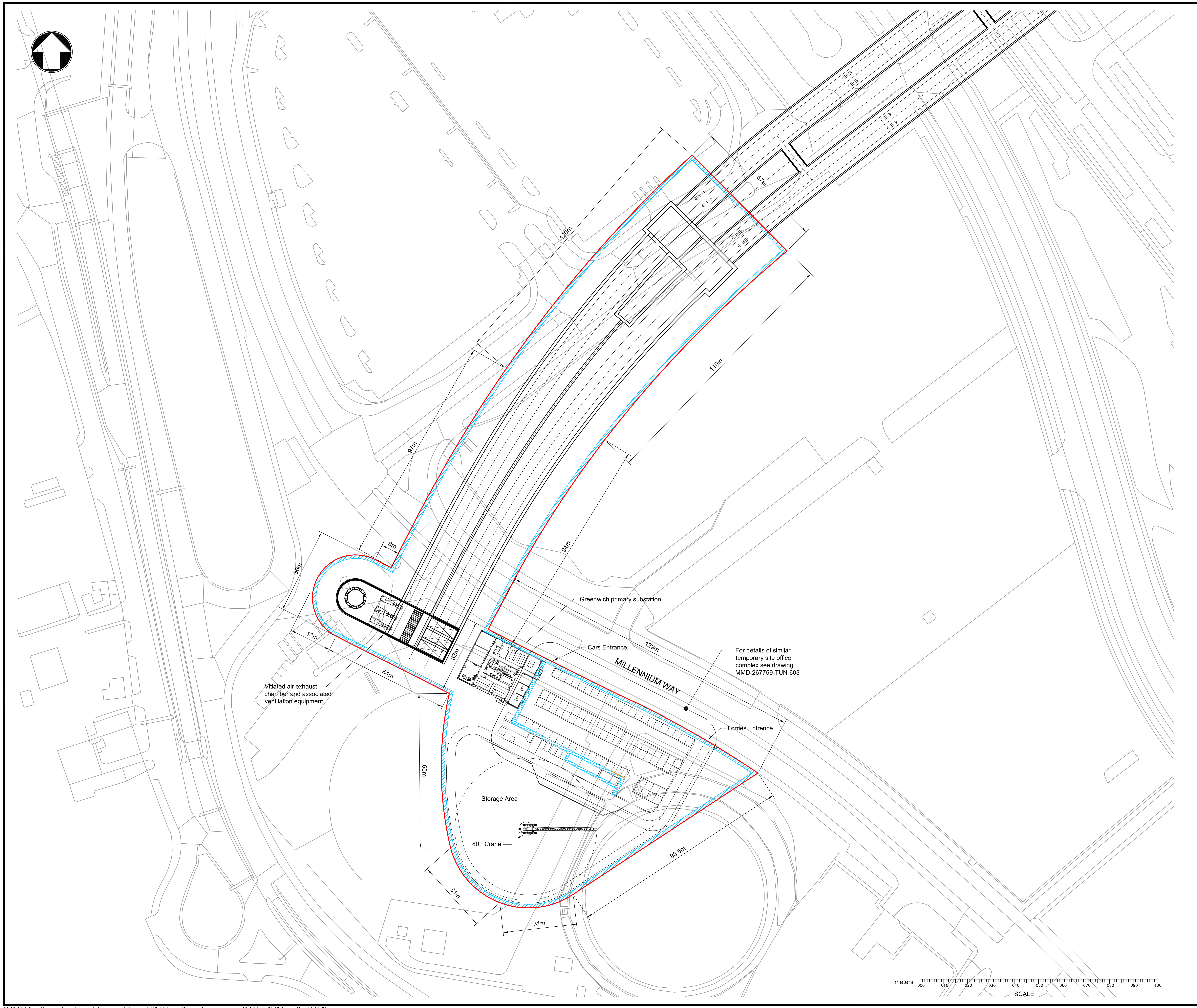

Notes

Key to symbols

- Site Boundaries
- Pedestrian Way (1.5m Wide)

Reference drawings

DRAFT
NOT FOR CONSTRUCTION
Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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W www.mottmac.com

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Greenwich Worksite Layout
With Background Mapping

Designed	TAR	Eng check	TAR
Drawn	SRM	Coordination	
Dwg check	TAR	Approved	TAR

Scale at A1	Status	Rev
N.T.S.	PRE	P1

Drawing Number
MMD-267759-TUN-604

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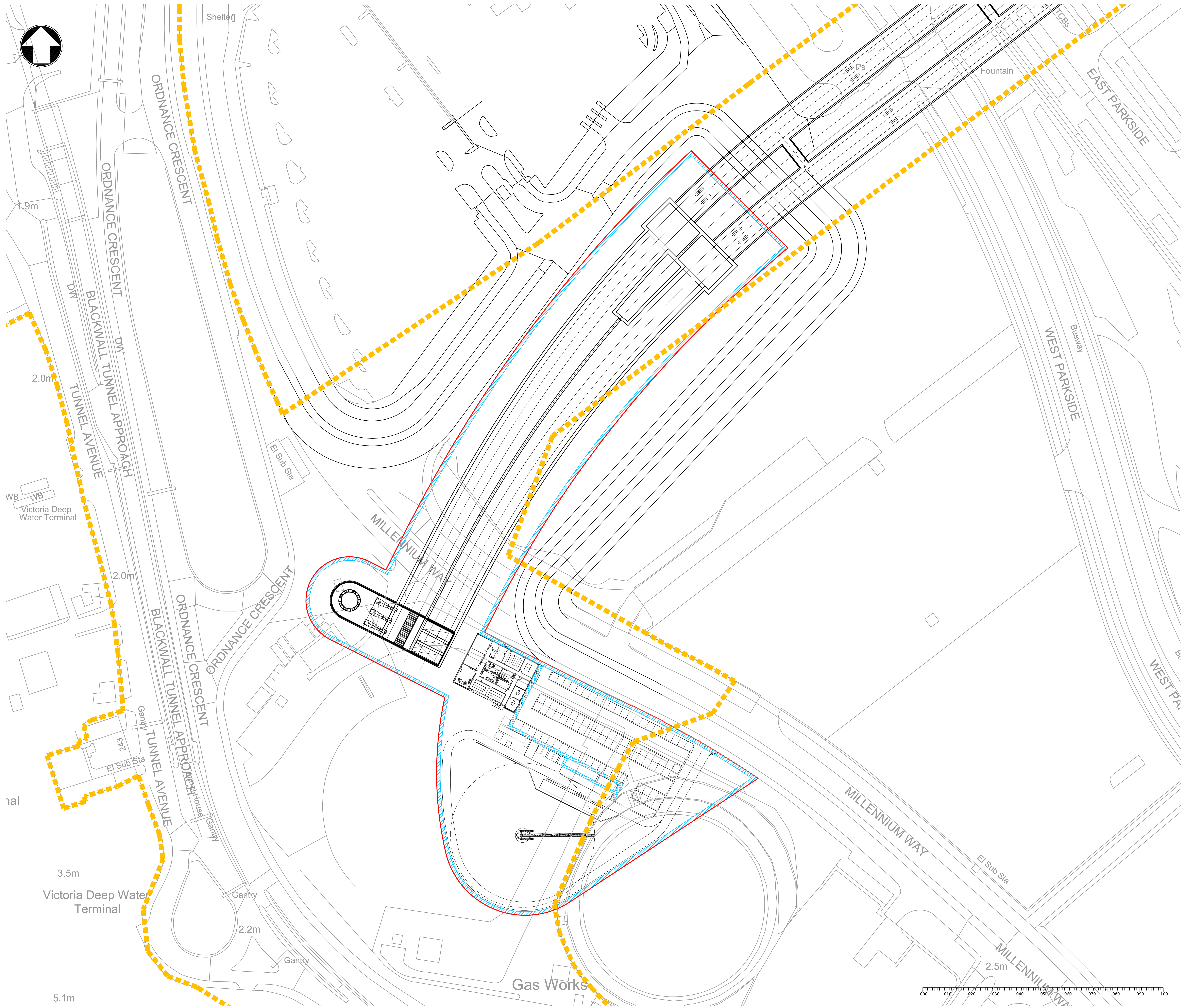

Notes

Key to symbols

- Site Boundaries

- Pedestrian Way (1.5m Wide)

Reference drawings

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Date : 27-11-2009

Rev	Date	Drawn	Description	Ch'k'd	App'd

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United Kingdom
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W www.mottmac.com

Client
Transport for London

Title
New Thames River Crossing
Bored Tunnel Option
Millennium Way Diversion

Designed	TAR		Eng check	TAR
Drawn	SRM		Coordination	
Dwg check	TAR		Approved	TAR
Scale at A1: N.T.S.		Status: PRE		Rev: P1

Drawing Number
MMD-267759-TUN-605

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