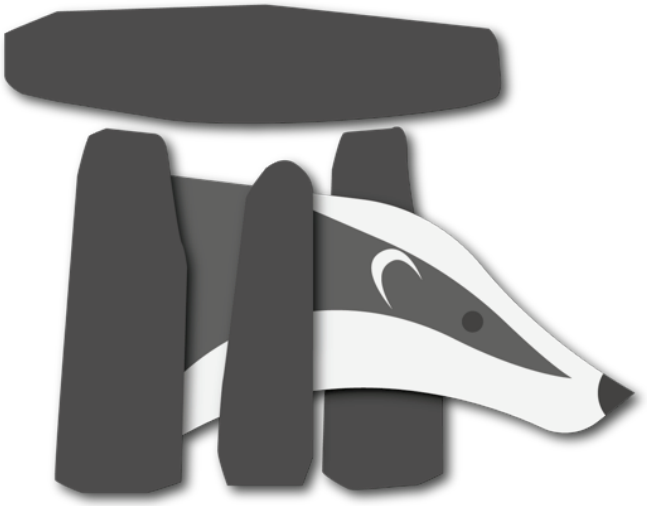


highways england

QS 6D
Outline M&E Approval in Principle (AIP) for Tunnel Bores and Cross-Passages

Contents

Project Details:....1
1. Highway Details....1
1.1. Type of Highway....1
1.2. Permitted traffic speed....1
1.3. General description....1
1.4. Any restriction to traffic including maintenance....1
2. Structure Operation & Maintenance Framework....2
2.1. Type of Structure....2
2.2. Accomodation of M&E services in the tunnel....2
2.3. Location of tunnel monitoring centre and maintenance building(s)....2
2.4. Proposed arrangements for inspection and maintenance....2
2.5. Location of tunnel services building....3
2.6. Design working life and estimated costs of M&E services including all running, maintenance and replacement costs and sustainabiilty considerations....3
3. Authorities Consulted....3
3.1. List of authorities consulted and any special requirements....3
4. Layout & Basic Design Criteria....3
4.1. Basic tunnel geometry....3
4.2. Environmental conditions within the tunnel plant rooms and buildings....4
4.3. Tehnical Approval Schedule (TAS)....4
4.4. Proposed Departures relating to departure from standards given in 4.3. 4
4.5. Proposed Departures relating to methods for dealing with aspects not covered by standards in 4.3. 5
4.6. Proposed safety critical fixings....5
4.7. Equality impact assessments....5
4.8. Resilience and security....5
5. Tunnel Ventilation....5
5.1. General description including justification....5
5.2. Design Criteria....6
5.3. Pollution and vehicle emissions....6
5.4. Fresh air requirements....6
5.5. Proposed Ventilation System....7
5.6. Ventilation fans....7
5.7. Monitoring and control....8
6. Tunnel Lighting....8
6.1. General description....8
6.2. Design criteria....9
6.3. Surface reflectivity....9
6.4. Special operating conditions....9

6.5. Monitoring and Control....9
7. Water Management....10
7.1. General description, design criteria....10
Tunnel drainage schematic....10
7.2. Effluent standards....10
7.3. Amounts to be handled....10
7.4. Pumping equipment....11
7.5. Safety precautions....11
7.6. Siting of sumps....11
7.7. Sizing of sumps....11
Low-point sump and pumping station....11
Impound sump....11
8. Fire Safety....12
8.1. Design Criteria....12
8.2. Active protection....12
8.3. Passive protection....12
8.4. Services building and plant rooms....12
9. Communications & Traffic Control....13
9.1. General description, design criteria. Traffic management authority....13
9.2. Telephone system....13
9.3. Emergency liasison....13
9.4. Traffic signs....14
9.5. Traffic monitoring....15
10. Tunnel Operation & Plant Control....15
10.1. Basis of tunnel operation. Operating and maintaining authority....15
10.2. Plant monitoring and control....15
10.3. Data logging and transfer....16
10.4. Safety integrity level....16
10.5. Plant inspection and maintenance....16
11. Electrical Power Supply & Distribution....16
11.1. General description and design criteria including an analysis of power requirements, supply costs and tunnel operating conditions in relation to security of supply 16
11.2. Supply distribution....17
High Voltage (HV) distribution....17
Low Voltage (LV) distribution....17
11.3. Emergency Arrangements....17
Backup power supply....17
Uninterruptable Power Supply (UPS)....18
11.4. Cabling....18

12. Tunnel Services Buildings & Plant Rooms 18
12.1. General description 18
12.2. Design criteria and layout 18
12.3. Building security and protection 19
13. Check 19
13.1. Give Proposals for checking M&E installation including the design of tunnel services buildings 19
13.2. Name of proposed checker 19
14. Drawings and Documents 19
14.1. List of drawings (including numbers) and documents accompanying the submission 19
15. The above is submitted for acceptance 20
16. THE ABOVE IS REJECTED/AGREED SUBJECT TO THE AMENDMENTS AND CONDITIONS SHOWN BELOW 20
References 20
Appendix A – CDM Risk Register ..... **¡Error! Marcador no definido.**
Appendix B – TAS schedule ..... **¡Error! Marcador no definido.**

Project Details:

Name of Project: A303 Amesbury to Berwick Down

Name of Structure: Stonehenge Tunnel

Structure Reference No.: To be confirmed.

1. Highway Details

1.1. Type of Highway

This is a proposed Dual 2-lane all-purpose carriageway (D2AP) with traffic lane widths in the tunnels in accordance with CD 127 as shown in Figure 1 below.

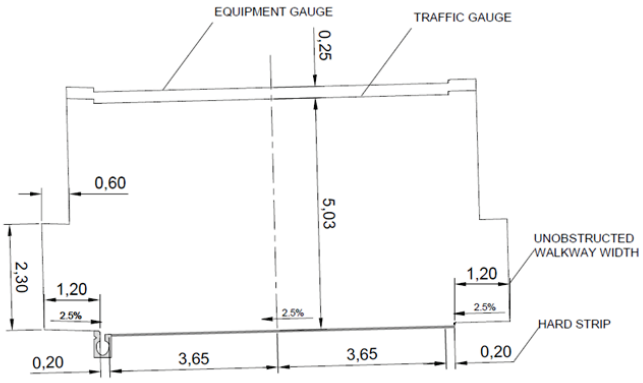


Figure 1 Tunnel Cross Section (Traffic Gauge)

1.2. Permitted traffic speed

The normal speed limit within the A303 Stonehenge tunnel will be 70 mph. Contraflow operation will be operated during maintenance activities which will enforce a speed limit of 40 mph.

1.3. General description

The A303 Stonehenge Tunnel comprises of 2 bores, each containing 2 uni-directional traffic lanes with a length from portal to portal of 3,285m.

1.4. Any restriction to traffic including maintenance

The A303 route requires no restrictions on the transport of registered dangerous goods.

Non-motorised users (NMUs) are restricted from using the tunnel or its approaches. Automatic detection of NMU's will be installed to enforce this restriction and to provide operators with a warning should a NMU approach the tunnel and allow them to instigate mitigation measures.

2. Structure Operation & Maintenance Framework

2.1. Type of Structure

Road tunnel comprises of cut & cover and bored sections.

2.2. Accomodation of M&E services in the tunnel

To improve availability and allow safe maintenance access to the in-tunnel M&E equipment without shutting a lane/bore, an under-road gallery space will be provided in the tunnels, **(TQ2C1.1 & TQ4A5)**. These TQs will be led and managed by the BADGER Design Manager, with specialist teams supporting the progression through the design, construction, commissioning, and maintenance phases. Please refer to QS3A Drawing HE551506-STU-Z3ML000Z-DR-C-0004 Detail eastbound tube cross section - Drawing HE551506-STU-Z3ML000Z-DR-C-0007 Cross section at low point sump at chainage 9137.65 - Drawing HE551506-BGR- STU-Z3ML000Z-DR-C-0005 cross section at emergency cross-passages - QS-4A Drawing HE551506-STU-SWSRWP0Z-DR-S-0003 Road Level Plan on Western Tunnel - QS-5A Drawing HE551506-STU-SWSREP0Z-DR-S-0003 Road Level Plan on Eastern Tunnel.

The gallery space will be connected to the TSB, the cut and cover tunnel sections at each portal and at selected cross passages in the main bored tunnel. The gallery has been sized with a clear width of 2.3m x 2.3m in accordance with the contents of DQ 148 and will not exceed classification beyond a low-medium risk confined space. Access will be via staircase at the portals and at the nominated cross passages, along with access holes in the TSBs for lifting in equipment/spares and casualty evacuation should an incident occur in the gallery. As it is proposed to use the space between the two bores in the cut and cover portal section for Fixed Fire Fighting System (FFFS) water tanks, pumps and ancillaries, access to that space will also be provided. It is proposed to have the floor of that space be at the same level as the under-deck gallery, this will allow step free access which will allow a more efficient use of the space **(TQ1B1.2, TQ1B2.1),** led by the Design Manager during design stages and the Construction Tunnel Manager during construction stages into maintenance**.**

2.3. Location of tunnel monitoring centre and maintenance building(s)

The Tunnel Control and Monitoring System (TCMS) will be provided to integrate the various mechanical and electrical systems provided within the tunnel. It will allow the tunnel to be operated from:

- The South West Regional Operations Centre at Aztec West (primary operating centre)
- The South East Regional Operations Centre at Godstone (resilient operating centre)
- The two tunnel service buildings which will provide Silver Command facilities

The Tunnel will be maintained by maintenance operatives using the tunnel service building as a temporary base only when there are works taking place at the tunnel. The TSBs will be used to provide mess facilities, a briefing space for operatives starting a shift and to permit the shift supervisor to effect control over the mechanical and electrical systems (including the isolation of high energy systems to prevent their inadvertent operation when operatives could be close to them). A separate maintenance base will be commissioned a short distance away from the tunnel for the duration of the Maintenance Period.

2.4. Proposed arrangements for inspection and maintenance

The tunnel will be operated in contraflow, running bi-directional traffic in one bore, while the other is closed for planned maintenance or inspection works. Contraflow operation will only occur between 22:00 and 06:00. Robust operational plans for contraflow operation will be developed at detailed design in consultation with key stakeholders.

2.5. Location of tunnel services building

The Tunnel Service Buildings (TSBs) are located at road level at the entrance to each portal. They are cut and cover structures to blend them into the landscape and minimise the visual impact on the World Heritage Site (WHS).

2.6. Design working life and estimated costs of M&E services including all running, maintenance and replacement costs and sustainabiilty considerations

The tunnel systems and installations will be designed to have a service life of 20 years for Plant Control and monitoring equipment and 25 years for electrical equipment as required by CD 352. Components and materials will be selected to maximise their design life while minimising life cycle costs. The maintenance cycles and procedures for all elements of the tunnel will be defined to support tunnel lane availability requirements.

All running, maintenance and replacement costs will be investigated at further stage.

3. Authorities Consulted

3.1. List of authorities consulted and any special requirements

No consultations have been carried out by the Badger Consortium, but this Outline Approval in Principal is based upon the work carried out by Highways England in the earlier stages. This Outline Approval in Principal will be subject to formal review with stakeholders during the initial stages of detailed design and will be presented to the Technical Approval Authority (TAA) for formal ratification.

4. Layout & Basic Design Criteria

4.1. Basic tunnel geometry

The 3.285km A303 Stonehenge Tunnel comprises two tunnel tubes each carrying two lanes of traffic in unidirectional flow to D2AP dual carriageway standard.

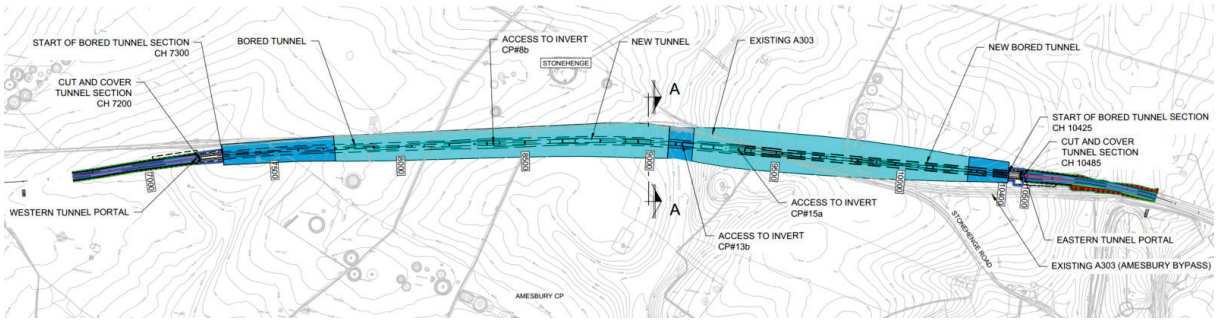


Figure 2 Tunnel Alignment

The A303 Stonehenge Tunnel comprises three distinct tunnel sections, as follows:

- CH 7+200 - CH 7+300: Western Portal: A 100m Cut & Cover tunnel providing the transition from the western approach road to the deeper bored tunnel portal.
- CH 7+300 – CH 10+425: Bored tunnel: A 3,125m tunnel constructed using a closed face Tunnel Boring Machine (TBM).
- CH 10+425 – CH 10+485: Eastern Portal: A 60m Cut & Cover tunnel providing the transition from the deeper TBM portal to the eastern approach road.

The twin tubes of the TBM bored tunnel will be connected by 22 Emergency Evacuation cross passage tunnels. Three additional cross passages are proposed to provide safe intermediate access between the main tunnel bore and the underdeck gallery.

An under deck gallery configured with two pre-cast elements and a roof slab will provide space for the sump at the low point of each bore and the pumps. Other services such as the tunnel gravity drainage system, pumping pipe to the impound sump, FFFS main and valves, Fire hydrant main and busbars.

4.2. Environmental conditions within the tunnel plant rooms and buildings

The tunnel plant rooms will be maintained at 19°C with a heating, ventilation and air conditioning system, whereas occupied spaces will be kept at between 20-25°C. The pump, tank & transformer spaces will be maintained at a temperature ranging from 10°C to 35°C.

4.3. Tehnical Approval Schedule (TAS)

The tunnel Mechanical, Electrical and Public Health systems will be designed, checked and approved in accordance with the schedule presented in Appendix B:

4.4. Proposed Departures relating to departure from standards given in 4.3.

There are several proposed Departures necessary to complete the works across the scheme. This section of the report is concerned solely with those Departures required to provide the A303 Stonehenge Tunnel. The four Departures are proposed as listed in Table 1 below.

Table 1 Summary of Departures from Standard in the Tunnel

Departure ID	Description	DAS Criticality Scale
100850	Cross Passages at 150m	3
101959	Stonehenge Tunnel: Use of Steel fibres for the Reinforcement of Concrete – Material	4
101950	Stonehenge Tunnel: Use of Steel fibres for the Reinforcement of Concrete – Design	4
TBD	Tunnel Ventilation System is not designed for the full design fire load conditions (FFFS)	-

4.5. Proposed Departures relating to methods for dealing with aspects not covered by standards in 4.3.

None Proposed

4.6. Proposed safety critical fixings

To be confirmed.

4.7. Equality impact assessments

A formal Equalities Impact Assessment has not been carried out, but the design adopts best practice for accessibility.

4.8. Resilience and security

During the detailed design, a full threat and vulnerability assessment will be carried out on the Tunnel Complex and its systems. The findings of this assessment will form part of the TMCS fundamental requirements. At this stage, our proposal is that the tunnel will be provided with resilient electrical power supplies, and uninterruptible power supplies. The two tunnel bores will be cabled independent, only being connected at the tunnel service buildings. The tunnel will feature holding tanks for the firefighting water. The TCMS will be hardened to prevent unauthorised access and recorded CCTV with 100% coverage (including cross passages, niches and tunnel service buildings) will discourage hostile actions. The TSB and invert access cross passages will be provided with an access control system to prevent unauthorised access. All cabinets housing tunnel control equipment in areas to which the public have access will be fitted with locks that prevent unauthorised access.

5. Tunnel Ventilation

5.1. General description including justification

The tunnel ventilation system (TVS) is a longitudinal concept, a total of 28 jet fans per bore arranged in banks of two grouped near each portal to ensure electrical power cable requirements through the tunnel can be optimised. During normal and contraflow operation the TVS will maintain pollution levels in the tunnel at acceptable levels.

In case of a fire emergency during normal operation, the TVS will generate a longitudinal air flow in excess of critical velocity to control the propagation of smoke within the tunnel for both the self-rescue and intervention phases under the normal operating condition of unidirectional traffic flow.

In case of a fire emergency during congestion or contraflow traffic, the longitudinal ventilation system will be used in the most appropriate way (this will either be to switch the ventilation off and allow natural stratification or to blow gently in one direction as appropriate), which will be confirmed at detailed design.

During normal operation the TVS will be managed by the TCMS, and if the in-tunnel pollutant measuring sensors detect a rise in a monitored pollutant level jet fans will be sequentially activated until the levels fall below specified levels when they will be deactivated. Under free-flowing traffic conditions, the A303 Stonehenge Tunnel will ventilate naturally by means of the traffic generated piston effect, with forced mechanical ventilation for pollutant control potentially necessary during periods such as slow moving or congested traffic.

In the event of a fire emergency, the automatic fire detection systems will put the tunnel systems into an alarm mode with operator confirmation of an emergency mode, activating the jet fans in the direction of traffic flow within the incident bore. The non-incident bore jet fans will also be activated in a configuration that prevents smoke re-circulation between the bores

at the portals and also ensures a positive air flow into the incident bore through any open cross passages, maintaining a smoke free evacuation route for tunnel users.

5.2. Design Criteria

The TVS will control the pollution levels in the tunnel for both uni-directional and bi-directional (contraflow) operation. The design criteria used are based on the most onerous period for vehicle emissions, determined by national statistics [2] for fleet technology age to be the year of opening. CD 352 specifies the maximum permissible in-tunnel pollution levels, in addition to EH40 [1] and the latest PIARC guidance [3]. The ventilation system is specified to be reversible.

During a fire emergency involving uni-directional traffic flow within the tunnel bores, the ventilation system generates a longitudinal air flow in excess of critical velocity in the direction of traffic to prevent smoke back layering. The system is also capable of producing critical velocity in the reverse direction should the emergency services instruct this. In case of contraflow operations, the ventilation system will be operated to minimise risk to evacuees, working in tandem with the FFFS and evacuation facilities.

The target noise level produced by the ventilation system at a plane 1.5m above the roadway will be below the NR85 level as prescribed in CD 352.

The tunnel site aspects and environmental effects, for instance the portal orientation and background wind from historical data from the Met Office monitoring station located at the Boscombe Down Airfield, have been considered in the design.

5.3. Pollution and vehicle emissions

The pollution thresholds in tunnel for different pollutants are showed in Table 2.

Table 2 Admissible pollutant level limit used in Stonehenge Tunnel

Pollutant	Limit
NO_2	1 ppm
CO	70 ppm
PM	K = 0.005 m^{-1}

The vehicle emission depends on the fleet distribution, road gradient and traffic speed. The fleet distribution data are taken from Section 7 of the ITPD (Design and Technical Requirements) and DQ171. The HGV percentage is 8.4% for uni-directional traffic, and 23% and 32% for eastbound and westbound respectively for contraflow traffic. To determine a more refined fleet distribution these data are combined with the latest NAEI data [2] for vehicle categories and technology on a ‘rural road’ in the opening year, 2026.

This traffic data are then input to the PIARC calculation from Vehicle Emissions and Air Demand for Ventilation [2019R02EN] [3] to obtain the vehicle emissions in tunnel.

5.4. Fresh air requirements

The tunnel ventilation system will draw outside air in from the portals in order to dilute vehicle emissions in the tunnel and maintain pollutant concentration levels below safe limits. No intermediate shafts are permitted within the WHS in order to meet the requirements of the DCO hence the outside air will be supplied by the jet fan longitudinal ventilation system. Ambient concentrations (C_{amb}) of NO_2 and CO have been taken from PIARC [4] and are displayed in Table 3 below. A lack of references exist for ambient concentrations of (PM), however from

experience it can be stated that particulate matter will not be the worst case metric. Hence an ambient concentration of PM is not included, however its generation within the tunnel for different vehicle speeds and roadway gradients is considered.

Table 3 Background concentrations of NO_2 and CO

Pollutant	Concentration	Unit
NO_2	0.11	ppm
CO	5	ppm

IDA Tunnel, 1D simulation software package, is used to simulate the tunnel environment during the fire emergency scenarios and verify the design of tunnel ventilation system to achieve critical velocity to control the smoke in tunnel.

5.5. Proposed Ventilation System

The tunnel ventilation system proposed consists of 56 jet fans across both bores mounted in pairs with 100m separation between banks and the portals. This results in four groupings of fans near each portal, stretching 700m into the tunnel with 14 banks total per bore.

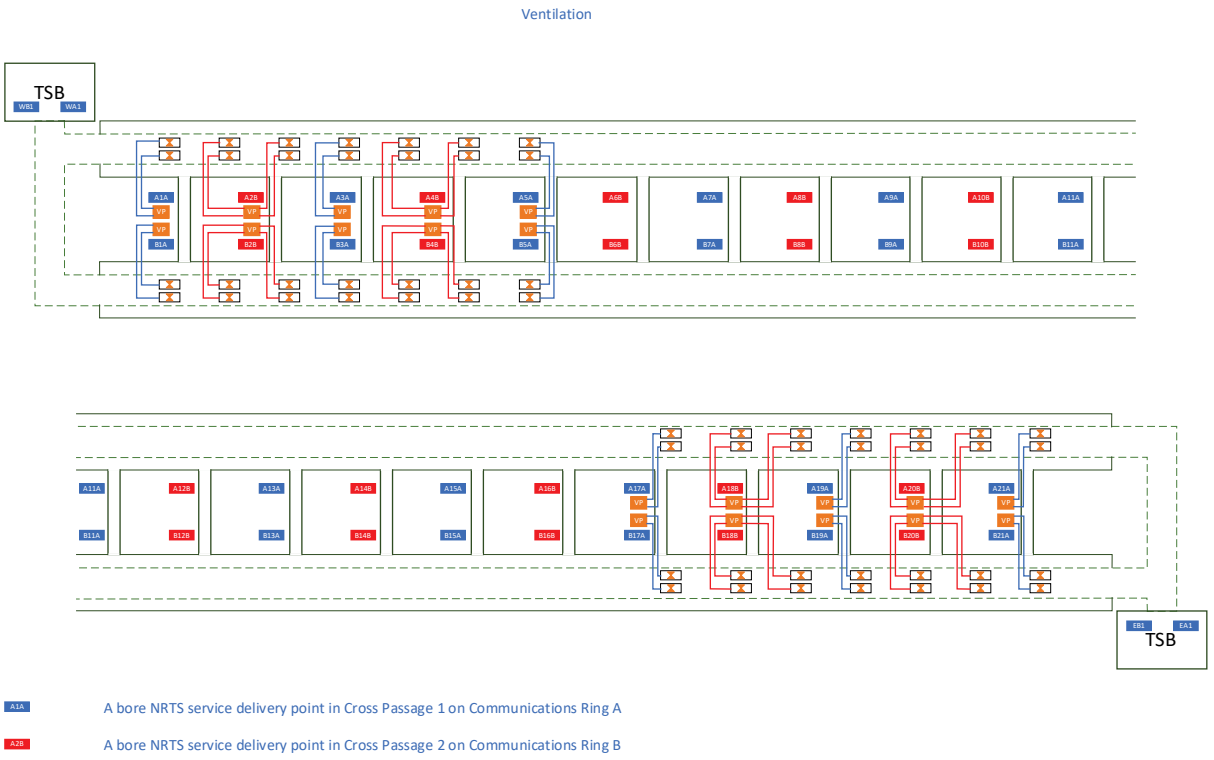


Figure 3 Schematic Line Drawing of TVS

5.6. Ventilation fans

The jet fan used for the tunnel ventilation system design is specified in Table 4.

Table 4 - Jet fan properties

Property	Value
Internal Diameter	1200 mm

Property	Value
Fan Thrust	1345 N @ 20 °C
Jet Velocity	31.5 m/s

5.7. Monitoring and control

The tunnel ventilation system will be automatically controlled during normal operation via a feedback loop monitoring the in-tunnel pollution levels. CO, NOx and visibility sensors will be installed at both portals and the midpoint of each bore to facilitate contraflow and reverse operation. The fans will be automatically started and operated in steps by increasing the number of jet fans operating when the levels breach the trigger and alarm limits as laid out in CD 352. Air speed sensors will be installed in the tunnel and outside to monitor the speed and direction of air flow to assist with the control of the tunnel ventilation system.

An automatic fire detection system will be installed within the tunnel, utilising linear heat and smoke detectors to provide resilience and dependency in fire detection. Upon detection of a fire, the tunnel control system will activate the jet fans in both bores to generate an air flow in the direction of the incident bore traffic flow under unidirectional traffic flow conditions in both bores. The jet fans in the non-incident bore will be utilised to generate an airflow through the open cross passages near the incident to support self-rescue and intervention.

6. Tunnel Lighting

6.1. General description

The tunnel lighting will follow the key standards and best practice guidance requested by Highways England. The tunnel lighting systems will be chosen based upon the following key drivers:

- Health and Safety;
- Driver comfort;
- Capital cost;
- Operating costs;
- Maintenance costs;
- Aesthetic treatment.

The tunnel lighting will utilise the latest LED lighting utilising high efficiency LEDs with a service life of 100,000 hours. The lighting will consist of continuous luminaires parallel the centreline of the carriageway arranged as two lines cornice mounted on the walls. These high performance tunnel lighting luminaires will be monitored and controlled to extend their lifetime and reduce WLC (**TQ4A2**, Team BADGER's proposal will deliver WLC benefit by removing the need to replace the tunnel lighting luminaires during the 25 year period). This TQ will be led and managed by the BADGER Design Manager.

The LED luminaires will be mounted in an arrangement such that the light appears uniform and continuous, eliminating light flicker to drivers following high sided vehicles. The lighting will be designed to meet BS5489 Part 2 and will be suitable for traffic flowing:

- In the conventional directions in both bores;
- In the reverse direction in either bore;
- In contraflow in either bore.

The lighting will be designed utilising proprietary tunnel lighting software.

Integrated architectural LED lighting will be provided to illuminate the tunnel cladding panels and enhance the visual experience for tunnel users; these will have a specific mode which can be activated in the event of an incident to supplement the tunnel safety systems and aid vulnerable users in the evacuation of the tunnel by giving a visual indication of the nearest evacuation point thus improving safety in the tunnels **(TQ1C1.1 & TQ1C3.1)**, led by the Design Manager during design stages and Construction Tunnel & HSW managers during construction stage into maintenance. In addition to the LED lighting, projectors will be mounted at the tunnel mid-point to display images on the tunnel walls and further enhance the tunnel user experience.

6.2. Design criteria

The driver comfort criteria of the tunnel will be Class 3 but with a longitudinal uniformity in excess of 0.7.

The length of the lighting zones within the tunnel is determined by the maximum permissible speed of traffic within the tunnel. Hence the zone lengths have been prescribed as follows:

- Threshold zone = 215m
- Transition zone = 500m
- Interior zone = 2450m
- Exit zone = 120m

6.3. Surface reflectivity

The design reflectance of the carriageway will be that of a standard black asphalt make up and will be 10%.
The reflectance of the cladding panels will be that of white vitreous enamel and is taken to be 70%. The walls above the cladding have been taken to have a surface reflectance of 30%.

6.4. Special operating conditions

The lighting will be designed to allow for two special conditions for traffic flow reverse flow and contraflow.

Reverse-flow will be the worst condition requiring full threshold and transition lighting at what is normally the exit portal of the tunnel for a speed limit of 85Kph (53Mph). The normal entrance portal to the tunnel would be set to the light scene for an exit zone for the same speed (85 Kph). The threshold, transition and exit zones lengths would be 60m, 500m, 85m respectively.

Contra-flow will require transition and threshold zones to be programmed at both ends of the tunnel for a speed limit of 70Kph (44Mph). These lighting zones will be less in length and brightness than the normal and reverse-flow threshold and transition zones so will be achieved by a pre-programmed scene on the tunnel management system and the lighting control systems. The threshold, transition and exit zones lengths would be 45m, 300m, 35m respectively.

6.5. Monitoring and Control

The lighting system will have a full lighting control system following the DALI 2.0 protocol which will enable switching, dimming and luminaire diagnostics to be controlled and communicated to the Tunnel Management System. Emergency lighting testing regimes will be enabled through the control system.

7. Water Management

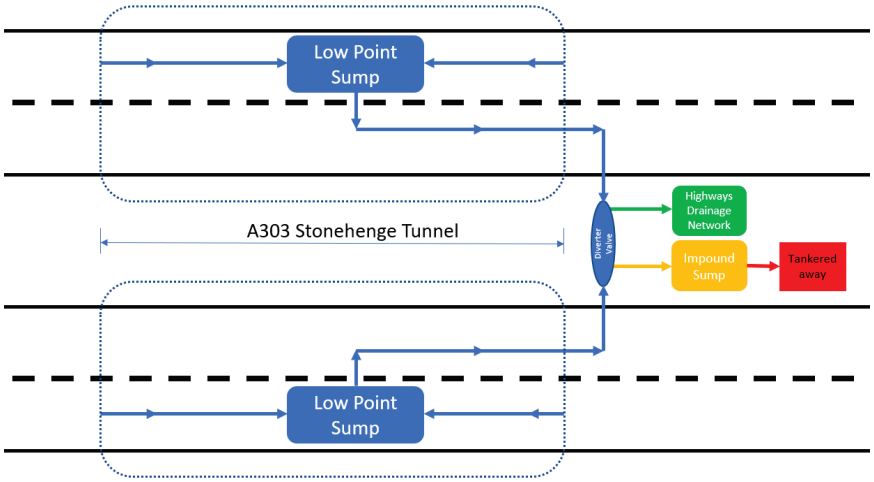
7.1. General description, design criteria

The tunnel drainage system operates independently of the schemes other drainage networks. All drainage inflows beyond the tunnel portals are managed by the highway drainage system. Therefore, the tunnel drainage network has been designed with the following tunnel inflow volumes in mind:

- Tunnel wall washing after a fire (1 bore only);
- Tunnel wall washing (2 bores);
- FFFS discharge (2 hours);
- 1 hour of fire hydrant discharge (1500 litres/minute);
- 1 tanker spillage
- Allowance for lining infiltration; and
- Allowance for water carried in by vehicles.

These flows are in line with CD 352 recommendations for wall washing and fire hydrant discharge, in addition to the FFFS performance determined flow rate and vehicle and lining inflows based on previous project experience. The carriageway has a 2.5% crossfall to channel flows into the slot drains located at the near-side of the carriageway and along the gravity drainage pipe to the low point sump where the flow is pumped out of the tunnel up to the diverter valve.

Tunnel drainage schematic



7.2. Effluent standards

Tunnel service buildings will feature a packaged treatment works discharging fluids in accordance with EA guidance. The solids will be stored on site and tankered away as required.

The tunnel drainage system will discharge clean water (e.g. rainwater run-off and fire-fighting system test discharges) in accordance with EA guidance but will divert into the impounding sump in the event of wall washing or an incident.

7.3. Amounts to be handled

The drainage system will have sump sizes as follows:

- Low Point Sump – 50m^3 (in each bore);
- Impounding sump – 1,650m^3.

There will be a pumping system to empty the low point sumps into the impounding sump at a minimum rate of 660m^3/hr (approx. 200l/s).

7.4. Pumping equipment

Duty & standby pumps will be provided at the low point sump. The low point pumping station shall comprise of two pumps in a duty/standby configuration. The pumps will be ATEX rated to ensure they can continue pumping in the presence of hydrocarbons to prevent pooling on the carriageway in case of an incident.

7.5. Safety precautions

The low point sump will be equipped with a hydrocarbon and fire detection systems and will have a foam blanket fire suppression system. The low point sumps will have a ventilation system in accordance with CD 352.

7.6. Siting of sumps

The low point sump will be housed in the undercroft (in the outside quadrant) at low point of the tunnel.

7.7. Sizing of sumps

Low-point sump and pumping station

The low-point sump will be 50m^3 in volume and has been sized according to CD 352 requirements to manage all the inflows outlined in the tunnel drainage summary above.

There will be access to the low point sump and pumping station via the invert gallery. This will support servicing and rodding to any components as necessary in addition to sludge deposit removal from the sump.

Impound sump

The tunnel impounding sumps location is at the east end of the tunnel following confirmation of the portal structure designs. The impound sump is sized to contain the total volume of all inflows which could arise during emergency operation of the low point sump. These are listed below and result in a capacity of 1,650 m^3. Its location will allow for safe and easy emptying using bowsers, without compromising the safety of A303 road users.

- Tunnel wall washing after a fire (1 bore only);
- Tunnel wall washing (2 bores);
- FFFS discharge (2 hours);
- 1 hour of fire hydrant discharge; and
- 1 tanker spillage.

No pumps are provided within the impound sump but it will be equipped with level sensors to signal high water levels, this will be connected to the TCMS and relayed to the SW-ROC at Aztec West.

8. Fire Safety

8.1. Design Criteria

The design fire size (design maximum peak heat release rate) for in-tunnel safety systems for the A303 Stonehenge Tunnel, in line with expectations for tunnels on major roads allowing the free passage of dangerous goods, is proposed to be 200MW (without interaction of FFFS). This complies with the minimum requirement in the ITPD of 100MW.

With the provision of a fixed firefighting system (FFFS), the design fire size for the tunnel ventilation system may be contained to around 20MW - 50MW total HRR. Considering the energy balance for a suppressed fire case, the convective HRR is expected to be controlled to $25MW_{conv}$ (or lower). The ITPD requires a minimum design fire load of 30MW (unstated as to whether this is convective or total load in the ITPD). It is proposed, therefore, that the ventilation system be designed for, with FFFS, a convective HRR of 30MW. The effectiveness of the FFFS in suppressing the peak HRR will be verified at detailed design stage in line with CD 352 Section 8.

8.2. Active protection

A Fixed Fire Fighting System (FFFS) is to be provided in line with the ITPD (Design and Technical Requirements) in the A303 Stonehenge Tunnel. The FFFS comprises part of the overall fire and life safety provisions to deliver an integrated design solution for the A303 Stonehenge Tunnel. Alongside the other installed safety systems, the FFFS will provide for the reduction of risk to as low as reasonably practicable (ALARP).

8.3. Passive protection

The tunnel bores will be protected by a combination of passive fire protection built into the primary tunnel lining, the provision of a fixed fire-fighting system to reduce the maximum intensity of any fire and a tunnel ventilation system to remove fire smoke and heat from the tunnel. In addition, the tunnel lining will be provided by an impact resistant secondary lining to a height of 1.5m above carriageway level.

Cross-passages will be provided between both bores at 150m intervals (maximum).

8.4. Services building and plant rooms

Service building will be provided at each end of the tunnel adjacent to the entry portal. These will contain the following facilities:

- **HV Incomer room;**
- **Incoming 33kv/11kv transformer room (west TSB only);**
- **Metering and DNO SCADA room;**
- **HV Switch room;**
- **Transformer room;**
- **LV Switch rooms (2 off);**
- **Lighting UPS room;**
- **Lighting UPS battery room;**
- **Communications systems UPS room;**
- **Communications system UPS battery room;**
- **TCMS Equipment room;**
- **ITS Equipment room;**
- **Infiltration drain pump plant room;**
- Silver command room;

- Mess / briefing room (west TSB only);
- Mess Room (East TSB only);
- Briefing Room (east TSB only);
- Welfare facilities;
- **TSB Plant Room (HVAC and Air Handling) room.**

All occupied rooms will be supplied with a full HVAC system. Rooms with heat or gas generating equipment will be provided with cooling and or fresh air supplies as required. All rooms will be provided with a fire detection system linked to a building wide fire alarm system. Rooms shown in bold above will also be provided with an inert gas fire suppression system. Occupied rooms will be provided with suitable portable fire extinguishers.

9. Communications & Traffic Control

9.1. General description, design criteria. Traffic management authority

The tunnel communications network will be implemented over an Internet Protocol (IP) communications network provided by the National Roads Telecommunications Service (NRTS). We will define which standards are to be implemented during the detailed design. The details in this section are the preliminary design and will be further developed during the detailed design. NRTS will provide high integrity, high bandwidth connections to each Service Delivery Point (SDP) which will be located at appropriate points. In order that the roadside technologies may be connected to the Client's Telecommunications Service Provider (TSP) (also known as NRTS) communication network, the locations, quantities and transmission requirements of each device is to be identified to allow the circuit provision. The Client's TSP will be permitted to provide, install, terminate and test its own transmission equipment and cabling up to the SDP. We will provide cabling and local PLC interfaces beyond the SDP that connect to the works, including any cables that interconnect these systems that are beyond the SDP. The Reliability, Availability and Maintainability of the Communications and Traffic Control systems will be sufficient to achieve the functional safety requirements determined by the Tunnel Systems Safety Case and by inference achieve the required Lane Availability.

The local communications to items such as the emergency telephones, the CCTV, the AID system, the LCS and the VMS will be connected by means of Ethernet running in copper cables. Connections to the emergency way finding signs, the photometers and the air quality monitors will be made using copper cables and low bandwidth communications from the PLC remote I/O units.

9.2. Telephone system

An emergency telephone system will be provided to allow road users experiencing difficulties to seek assistance. Emergency telephones will be provided at both portals, at 50m intervals throughout the tunnel on the nearside of the carriageway, at the midpoint between cross passages, in the entrance to cross passages and within the interior of every cross passage.

9.3. Emergency liasison

Emergency Liaison will be provided to all stakeholders as follows:

Travelling public:

- Road user signage (including LCS, VMS and FTMS);
- Radio rebroadcast system with Radio Break-in;
- Highway advisory radio station both inside the tunnel and within the Project Road area
- Public Address Voice Alarm system;
- Emergency roadside telephones;
- Emergency wayfinder signage.

Emergency services

- A radio rebroadcast system providing two-way access to all the emergency services network facilities.

Maintenance Workers

- A radio rebroadcast system providing two-way access to both operating and maintenance authority radio networks.

9.4. Traffic signs

Temporary Traffic Management signs are provided in the verge and central reserve on the approach to the crossover points within Longbarrow and Countess junctions. In addition, illuminated LED road studs will be provided to guide vehicles through the crossovers. These signs are controlled from the TCMS as part of the traffic management plans and are placed in order to manage lane closures and vehicle speeds in advance of crossovers setup for tunnel contraflow operations. Average speed cameras will be installed to enforce the reduced speed limits (i.e. 40mph) set between the junctions and tunnel portals, and also within the tunnel. There will be two average speed enforcement zones covering the tunnel and its approaches. One will cover each of the tunnel approaches up to the portals in the East and West, and one will cover the tunnel itself. These zones will have modes of operating for both normal and maintenance operation. Variable Mandatory Speed Limit (VMSL) indicators will have speed limit repeater indicators installed between the junctions, in the tunnel and the tunnel portals to reinforce the speed limit.

BADGER propose a design solution which will improve the Variable Message Signs (VMS) including Lane Control Signals and Speed Limit Repeater Signs durability by housing certain parts of the systems within a robust cabinet placed in the undercroft (a cleaner environment), thus reducing the WLC due to wear and ease of maintenance access**, (TQ4A4 – led by our Design Manager).** Our proposal is to change the design, manufacturing, and permanent installation of the Variable Message Signs, by separating the CPU and Control Board from the main sign box and installing these modules in a small standalone ruggedized cabinet in the service galleries. This TQ will be led and managed by the BADGER Design Manager, with specialist teams supporting the progression through the design, construction, commissioning, and maintenance phases.

At the Longbarrow and Countess junctions traffic signals will be provided on the roundabouts.

The tunnel safety assessment supports the need for Variable Message Sign (VMS). The VMS will be regularly spaced through the tunnel providing a continuum of information, without causing driver overload. The VMS, controlled from the TCMS will be placed at the portal and at 600m intervals throughout the tunnel. The 600m spacing will ensure that the driver is reminded of key safety message not less than once every 34 seconds at the lowest regularly used speed limit.

Lane Control Signal (LCS) capable of displaying Lane Closed (Red X), mandatory speed limits and Lane Open (Green arrow) are provided to separately control traffic in each running lane and employ contraflow working when required. Inter-visibility of Indicators is important to ensure that the road user can see at least one set of signals beyond them. Software interlocking on these Lane Control signals will be provided to avoid the need for non-standard equipment. The LCS will be controlled from the TCMS. The Lane Control Signals will be capable of displaying Green arrows if it is subsequently decided that this is the preferred method of indicating a lane is open. The Portal Lane Control signals, supported by their red flashing lanterns and the Portal Variable Message Sign will form the tunnel closure system.

In order to facilitate the safe implementation of contraflow operation, S-A-B Gates will be installed at the crossovers. The S-A-B Gates will be operable by hand without the need for any

tools and will improve safety for maintenance personnel and the public during the start and end of contraflow operation **(TQ1C2.1 TQ2C1.3, TQ4A6**), which will be led by our Design Manager.

9.5. Traffic monitoring

Roadside devices on the tunnel approaches will be controlled over an IP communications network provided by NRTS. The Average Speed Enforcement Cameras however will operate using encrypted data packages over the mobile data network to the Evidence Recovery Control Unit (ERCU) at the local Safety Camera Partnership. There are two Variable Message Signs (VMS) signs, controlled from the TCMS on the approaches to the junctions to warn of tunnel closures, restrictions and congestion.

CCTV coverage is provided on the tunnel approaches and throughout the tunnel providing 100% coverage. Additional CCTV/ video feeds to the control room will be provided around and within the tunnel services buildings for security with extra cameras at the tunnel portal for traffic management **(TQ2C3.1**, which will be led by our Design Manager). In addition to the CCTV cameras, the AID sensors will be enabled for video output to provide redundant and enhanced coverage of the tunnel.

The AID detectors within the tunnel will be integrated with the stopped vehicle detectors on the immediate approaches to the to provide the operators at the ROC with a coherent interface alerting them to any stopped vehicles in the Stonehenge Tunnel Corridor. The system will alert the operator within 10 seconds from a vehicle coming to rest.

Within the tunnel, speed enforcement will be provided by the average speed enforcement system. We are not proposing to enforce against prohibited vehicles or Red X violations.

10. Tunnel Operation & Plant Control

10.1. Basis of tunnel operation. Operating and maintaining authority

The plant monitoring concept is that the TCMS will control the network of field devices by means of two pairs of redundant PLCs (one pair in each TSB communications room) and remote input output devices (RIOs) located at each communications outstation. The PLCs will provide the basic input / output processing, interlocking and low-level emergency responses. The TCMS will provide higher level responses to various stimuli and will provide the ability for the operator to control various tunnel functions. The TCMS will provide the facilities to allow the operator to be located remote to the tunnel service buildings. Should the local PLCs detect a loss of the remote TCMS heartbeat signal (without an operator being logged on in one of the Silver Command rooms within the TSB), it will automatically implement a transition to the tunnel safe state and close the tunnel. The Reliability, Availability and Maintainability of the Communications and Traffic Control systems, and in particular the TCMS, will be sufficient to achieve the functional safety requirements determined by the Tunnel Systems Safety Case. The systems will be hardened to meet the general cybersecurity guidance published by the National Cyber Security Centre and the Cabinet Office and to meet the findings of the information security systems assessment carried out in accordance with BS ISO 27001.

The tunnel will be operated from the Highways England South West Regional Operations Centre. There will be backup operational desks at the South East Regional Operations Centre at Godstone.

10.2. Plant monitoring and control

Monitoring and control of the tunnel plant and systems including tunnel ventilation, lighting, drainage, pollution monitors, smoke panels, switchgear, doors and intruder alarms and inert

gas and UPS systems will be provided by the TCMS. The TCMS executive layer will provide some autonomous control of plant (for example turning on pumps to pump out the low point sump or to maintain the pressure in the fire main), it will also provide the control path for the operator commands originating from the remote control centre.

The TCMS operator interface will provide a graphic representation of all tunnel plant with options to control the equipment and manage alarms. All equipment will have an alarm and status management screen and all controllable equipment will have a control input. This control input will be interlocked to prevent commands that could cause damage (for example running the sump pumps dry).

10.3. Data logging and transfer

The TCMS will maintain a time stamped log on the login status and activity of all TCMS users.

The TCMS will retain historic data within the system capturing the following information:

- system activity;
- audit logs;
- Service change of state;
- event faults;
- user actions.

TCMS will provide capabilities for historic data to be:

- retained within the system for a minimum of two (2) years;
- archived for a minimum of six (6) years; and
- able to be exported and downloaded in SQL, CSV and ODF (for word processing and spreadsheets) formats.

10.4. Safety integrity level

The required safety integrity level for the plant monitoring and control systems will be assessed during the detailed design in accordance with the requirements of BS EN 61508. We will carry out a full functional safety assessment of all TCMS functionality and will apply the principle of reducing the risk to all stakeholders to As Low As Reasonably Practicable (ALARP). To further harden the TCMS, a full assessment to BS ISO 27001 will be carried out and appropriate measures taken to prevent unauthorised access to TCMS data and functionality. This will include the use of functional isolation, firewalls, disabling all unused physical and software ports and the removal of all unnecessary software processes.

10.5. Plant inspection and maintenance

The approach to plant inspection and maintenance will be to close one bore overnight (between 22:00 and 06:00) when traffic is at its lightest and operate the remaining bore in contraflow with a reduced speed limit.

11. Electrical Power Supply & Distribution

11.1. General description and design criteria including an analysis of power requirements, supply costs and tunnel operating conditions in relation to security of supply

A dual redundant electrical power supply system will be created throughout the tunnel with the separate supplies interleaved throughout the tunnel to provide a reliable and redundant power supply system. The two supplies will be derived from different points on the national electricity grid and both supplies will be able to support the full load of the tunnel in the event of a failure

of one incoming supply. A bus coupler will be used to link the two supplies together in the event of a supply failure. Uninterruptible supplies will be provided for lighting and safety critical communications loads. The IP ratings for the various areas of the works will be as specified in CD352 and the 7000 series of the Manual of Contract Documents for Highway Works. Where there is a conflict, the most onerous will be implemented.

11.2. Supply distribution

High Voltage (HV) distribution

Two incoming distribution network operator (DNO) HV power supplies are being procured by Highways England and will be made available at each TSB: The DNO switchgear associated with these supplies will need to be incorporated into the design of the TSB. We will develop HV and LV distribution system designs that are compatible with the incoming supplies provided. The distribution system designs will be DNO compliant customer HV distribution networks suitable for supporting the main HV/LV electrical substations.

The HV system shall be configured so that all tunnel systems can remain fully operational with a failure of either incoming HV electrical power supply, and so that any individual incoming main or interconnecting circuit breaker can be isolated without affecting the safe operation of the tunnel.

Two independent HV Ring Circuits, “A” and “B” supply will be provided through the tunnels. HV “A” and “B” supplies will be available at both TSBs. Either supply will be capable of powering the entire tunnel, if required. Normally, the tunnel load will be shared between the “A” and “B” incoming supplies.

The HV cables associated with the “A” and “B” supplies will be routed in separate tunnel bores for maximum security. The incoming HV power supply to the transformers at the East end are derived from Ratfyrn Primary substation at 11kV. The incoming HV power supply to the transformers at the West end are derived from Salisbury BSP (Bulk Supply Point) at 33kV where it will be transformed to 11kv within the West TSB. The DNO equipment requirements will be incorporated into the design of the TSB.

Low Voltage (LV) distribution

HV power will be transformed down to 400 volts at the main HV/LV electrical substations for final distribution to plant and equipment via Low Voltage Switchboards. Each TSB will contain an LV Switchboard for distributing power to serve LV plant and equipment.

Each LV switchboard will be fed from a separate transformer and a bus bar or cable link will be installed between the LV Switchboards located in separate rooms. The transformers will be sized to provide power to both sides of the switchboard in the event of loss of “A” or “B” supply. The automatic change-over connection at the LV switchboards will allow for one transformer to be out of commission and isolated, and all circuits to be connected to the remaining functioning transformer. To minimise the risk of a complete failure of services in any section of the tunnel, luminaire circuits and other electrical loads such as the jet fans will be connected alternately to the “A” and “B” supplies as far as practical. Cables and containment from both supplies will be routed separately to minimise the risk of loss of both circuits simultaneously.

11.3. Emergency Arrangements

Backup power supply

Connection points for diesel generators are to be installed at both TSBs so that it is possible for Stonehenge Tunnel to operate in the event of a simultaneous failure of both incoming HV electrical power supplies until the failed incoming HV electrical power supplies can be restored.

Uninterruptable Power Supply (UPS)

Uninterruptable Power Supply (UPS), which uses battery power to maintain supplies without a break to connected equipment in the event of mains power failure, will be installed at both TSBs. This would provide power to all essential items of plant such as communications equipment and the tunnel mains failure lighting. Each UPS will have autonomy for 2 hours.

11.4. Cabling

Cables will be low smoke and fume types and will be run in the underdeck gallery or in ducts cast into the tunnel structure. Cables will be unarmoured.

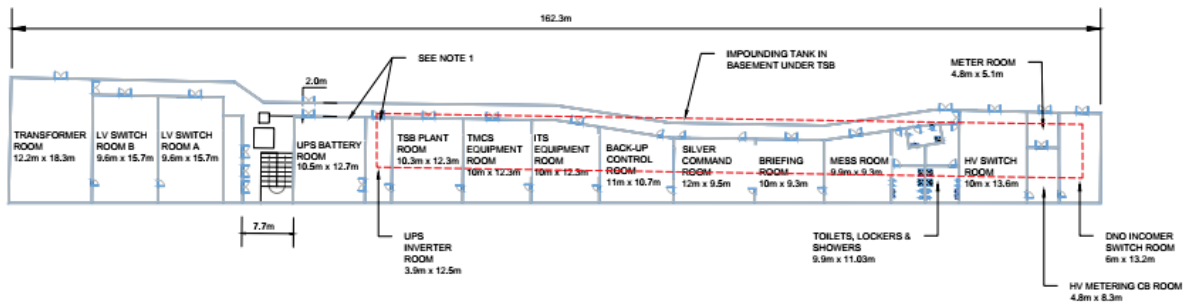
12. Tunnel Services Buildings & Plant Rooms

12.1. General description

The Tunnel Service Buildings are located at road level at the entrance to each portal. They are cut and cover structures to blend them into the landscape and minimise the visual impact on the WHS. All structures will be fully integrated into the design vision for the scheme, with particular attention paid to transition at the tunnel portal and retained cut end, as well as driver experience/distraction and minimising impact on the WHS.

12.2. Design criteria and layout

The tunnel service buildings will have the rooms listed in section 8.4 above. The buildings will be built underground on the verge adjacent to the normal entry portal of each bore. The layout of the rooms is shown in HE551506-BGR-HOS-SWGN000Z-DR-TE-0106 and reproduced below for convenience



EAST TSB

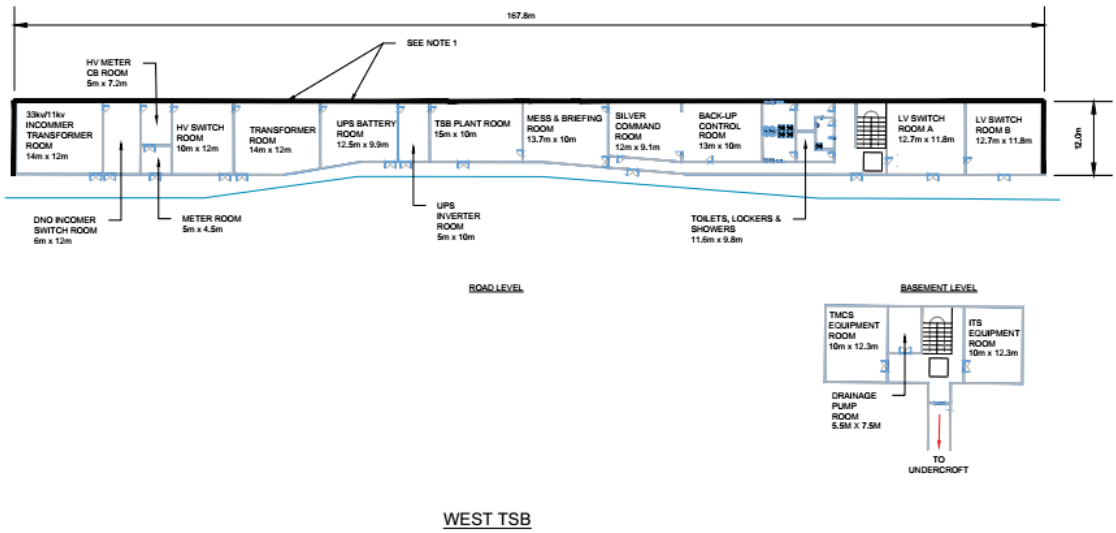


Figure 4 TSB layouts

12.3. Building security and protection

The tunnel service buildings will be secured with a combination of physical keyed locks and an electronic access system. An intruder alarm will also be fitted with both silent and annunciated alarm responses. The building security system will record all access and all intruder detector activations.

The TSBs will be equipped with automatic fire detection systems and alarms to alert occupants to the presence of a fire or other risk to life. Where required automatic fire suppression systems will be provided in the TSBs. The TSB will be fire protected for a minimum of 120 minutes with the equivalent minimum 120 minutes protection provided between the TSBs and the invert gallery. All individual rooms with the TSBs will be provided with a means of escape to a place of ultimate safety.

Full audio and visual communications are provided in the TSB in line with the ITPD (Design and Technical Requirements), CCTV, call points, public address voice alarm, and full mobile phone coverage.

13. Check

13.1. Give Proposals for checking M&E installation including the design of tunnel services buildings

In accordance CG 300 Clause 6.3 CAT 3 checks on all Mechanical and Electrical services are required. The Checker will be appointed by the Contractor.

13.2. Name of proposed checker

The Checker has not been named at this time.

14. Drawings and Documents

14.1. List of drawings (including numbers) and documents accompanying the submission

To be confirmed.

15. The above is submitted for acceptance

Signed To be confirmed.

Name To be confirmed. Design Team Leader

Engineering Qualifications To be confirmed.

Name of Organisation To be confirmed.

Date To be confirmed.

Signed To be confirmed.

Name To be confirmed. Check Team Leader

Engineering Qualifications To be confirmed.

Name of Organisation To be confirmed.

Date To be confirmed.

16. THE ABOVE IS REJECTED/AGREED SUBJECT TO THE AMENDMENTS AND CONDITIONS SHOWN BELOW

Signed To be confirmed.

Name To be confirmed.

Position held To be confirmed.

Engineering Qualifications To be confirmed.

TAA To be confirmed.

Date To be confirmed.

References

[1] [Online]. Available: https://www.hse.gov.uk/pubns/priced/eh40.pdf. [Accessed 28 7 2020].

[2] [Online]. Available: https://naei.beis.gov.uk/data/ef-transport. [Accessed 8 12 2020].

[3] PIARC, "Road Tunnels: Vehicle Emissions and Air Demand for Ventilation," 2019.

[4] PIARC, "Road Tunnels: Vehicle Emissions and Air Demand for Ventilation," 2012

Appendix A – CDM Risk Register

Identified Hazard	Designer's intervention	Residual risk	Safety file information
High energy bus bars	Insulated bus bars placed out of normal reach and hazard marked	Low risk under normal maintenance activities. Hazard to be considered for more invasive works.	Description of location of hazard, Instructions for mitigating hazard during works
Weight of bus bars	Install the majority of busbars in precast segments on surface	Risk during demolition and refurbishment	Manual handling instructions
Access required to sumps (both low point and impounding). Sumps are confined space	Risk cannot be eliminated. Provision for High risk CS entry to be provided at each sump entry point	Sump will need to be inspected after each pollution / fire incident. Inspection to be carried out using drone or endoscopic techniques	
Sumps within controlled space	Access to all sumps is via a controlled space where provision has been made for improved ventilation and task lighting has been made	Medium risk but under normal circumstances, the sumps are sealed from the controlled spaces	
Controlled space in Undercroft	Forced ventilation will be provided. Access control system will be implemented for controlled space	Low risk	
High pressure water pipes	High pressure water pipes will be appropriately labelled	Low risk	Location of high pressure pipes to be clearly identified
Dual supplies and maintained supplies	All dual supplied and maintained supplied equipment will be within appropriately labelled locked doors. Hazard labels identifying		Instructions relating to access to equipment with dual or maintained supplies. Schedule of locations
Cross passage cabinet doors interfering with evacuation envelope	Cross passage doors to be specified to hinge to 90 and 180 degrees		
Noise from PA system	TCMS will provide ability to isolate all such high energy systems		Instructions how to isolate equipment during works using TCMS and schedule of locations affected to be provided
Noise from fans	TCMS will provide ability to isolate all such high energy systems		Instructions how to isolate equipment during works using TCMS and schedule of locations affected to be provided

Radiation from antennae and leaky feeders	TCMS will provide ability to isolate all such high energy systems		Instructions how to isolate equipment during works using TCMS and schedule of locations affected to be provided
Fire isolation from undercroft	Fire doors between undercroft and access passages to be provided at each entrance to the undercroft		Schedule of locations and routine maintenance tasks to maintain fire rating of doors
TSB fire suppression system operation affecting occupied areas.	Provision of vents from affected plant rooms, Provision of hold-off 'panic' switches in occupied rooms, provision of count-down warning system		

Appendix B – TAS schedule

Schedule of documents relating to design or assessment of Highway Bridges and Structures

Schedule of Design Documents Relating to Highway Bridges and Structures (All documents are taken to include revisions current at the date of this TAS).

1. British Standards

BS 1376:1974	Specification for colours of light signals
BS 5266-1:2016	Code of Practice - Emergency lighting
BS 5489-1:2020	Design of road lighting. Lighting of roads and public amenity areas. Code of practice
BS 5489-2:2016	Code of practice for the design of road lighting. Lighting of tunnels
BS 5760	Reliability of Systems, Equipment and Components
BS 6667 (IEC 60801)	Electromagnetic compatibility for industrial-process measurement and control equipment.
BS 6701:2016+A1:2017	Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance
BS 7430:2011+A1:2015	Code of Practice for protective earthing of electrical installations
BS 7671:2018	Requirements for Electrical Installations. IEE Wiring Regulations 18th Edition
BS 8519:2020	Selection and installation of fire-resistant power and control cable systems for life safety, fire-fighting and other critical applications. Code of practice

2. British Standards: Eurocodes

BS EN 12966 2014+A1:2018	Road vertical signs. Variable message traffic signs
BS EN 60079-1:2014	Electrical apparatus for potentially explosive atmospheres. Flameproof enclosure 'd'
BS EN 50172:2004	Emergency escape lighting systems
BS EN 50173-1:2011	Information technology. Generic cabling systems. General requirements
BS EN 50174-3:2013 + A1:2017	Information technology. Cabling installation. Installation planning and practices outside buildings
BS EN 50293:2012	Road traffic signal systems. Electromagnetic compatibility.
BS EN 50310:2016	Telecommunications bonding networks for buildings and other structures
BS EN 12966 2014+A1:2018	Road vertical signs. Variable message traffic signs
BS EN 60079-1:2014	Electrical apparatus for potentially explosive atmospheres. Flameproof enclosure 'd'
BS EN 50172:2004	Emergency escape lighting systems
BS EN 50173-1:2011	Information technology. Generic cabling systems. General requirements
BS EN 50174-3:2013 + A1:2017	Information technology. Cabling installation. Installation planning and practices outside buildings
BS EN 50293:2012	Road traffic signal systems. Electromagnetic compatibility.
BS EN 50310:2016	Telecommunications bonding networks for buildings and other structures
BS EN 60529:1992 + A2:2013	Degrees of protection provided by enclosures (IP code)
BS EN 60598	Luminaires
BS EN 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems. Requirements for electrical/electronic/ programmable electronic safety-related systems
BS EN 62262:2002	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
BS EN 62305-4:2011	Protection against lightning. Electrical and electronic systems within structures
BS EN ISO 9223	Corrosion of metals and alloys. Corrosivity of atmospheres. Classification, determination and estimation
BS EN ISO 9241	Ergonomics of human-system interaction
BS EN 12966 2014+A1:2018	Road vertical signs. Variable message traffic signs
BS EN 60079-1:2014	Electrical apparatus for potentially explosive atmospheres. Flameproof enclosure 'd'
BS EN 50172:2004	Emergency escape lighting systems

BS EN 50173-1:2011	Information technology. Generic cabling systems. General requirements
BS EN 50174-3:2013 + A1:2017	Information technology. Cabling installation. Installation planning and practices outside buildings
BS EN 50293:2012	Road traffic signal systems. Electromagnetic compatibility.
BS EN 50310:2016	Telecommunications bonding networks for buildings and other structures
BS EN 60529:1992 + A2:2013	Degrees of protection provided by enclosures (IP code)
BS EN 60598	Luminaires
BS EN 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems. Requirements for electrical/electronic/ programmable electronic safety-related systems
BS EN 62262:2002	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
BS EN 62305-4:2011	Protection against lightning. Electrical and electronic systems within structures
BS EN ISO 9223	Corrosion of metals and alloys. Corrosivity of atmospheres. Classification, determination and estimation
BS EN ISO 9241	Ergonomics of human-system interaction

3 Design Manual for Roads and Bridges

GG 101 Revision 0	Introduction to the Design Manual for Roads and Bridges
GG 102 Revision 0	Quality Management Systems for Highway Design
GG 103 Revision 0	Introduction and general requirements for sustainable development and design
GG 104 Revision 0	Requirements for Safety Risk Assessment
GG 184	Specification for the use of Computer Aided Design
CG 300 Revision 0	Technical approval of highway structures
CG 302 Revision 0	As-built, operational and maintenance records for highway structures
CG 303 Revision 0	Quality assurance scheme for paints and similar protective coatings
CG 305 Revision 0	Identification marking of highway structures
CG 501 Revision 2	Design of highway drainage systems
CD 127 Revision 1	Cross-sections and headrooms
CD 350 Revision 0	The design of highway structures
CD 351 Revision 0	The design and appearance of highway structures
CD 352 Revision 0	Design of road tunnels
CD 355 Revision 0	Application of whole-life costs for design and maintenance of highway structures

CD 366 Revision 0	Design criteria for collision protection beams
CD 372 Revision 0	Design of post-installed anchors and reinforcing bar connections in concrete
CD 373 Revision 0	Impregnation of reinforced and prestressed concrete highway structures using hydrophobic pore-lining impregnants
GD 304 Revision 2	Designing health and safety into maintenance
LA 104 Revision 1	Environmental assessment and monitoring
LA 113 Revision 1	Road drainage and the water environment