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Fire and Rescue Authorities Operational Guidance

GRAs
generic risk assessments

GRA 2.7

Rescues from tunnels
and underground structures

Generic Risk Assessment 2.7

Rescues from tunnels
and underground structures

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SECTION 1

Generic Risk Assessment 2.7 Rescues from tunnels and underground structures

Scope

This generic risk assessment examines the hazards, risks and control measures relating to fire and rescue personnel, the personnel of other agencies and members of the public when attending incidents in tunnels and underground structures.

For the purposes of this generic risk assessment a tunnel or underground structure is defined as a natural or manmade structure, where all or part is below ground level or covered, to where people can resort to for work, pleasure or transit. This includes underpasses, or any associated shafts, but excludes basements.

The locations can range from a strategic transport tunnel such as the Channel Tunnel to a utilities tunnel that may allow for occasional access for maintenance purposes.

Included within the scope of this generic risk assessment are:

- tunnels for transportation (eg road, rail, pedestrian, waterways, cycle)
- tunnels for utilities (eg cabling, water supply and drainage, gas, steam, oil)
- manmade and natural underground structures (eg caves, mines, bunkers, storage facilities, military installations)
- tunnels under construction (eg bored tunnels, cut and cover technique, sprayed concrete lining, or undergoing significant refurbishment).

Depending on the nature and scale of the operational incident a variety of significant hazards may be present; therefore, Fire and Rescue Authorities may need to consider the contents of other specific generic risk assessments in this series:

- 2.1 Rescues from confined spaces
- 2.1.1 Rescues from sewers
- 2.4 Rescues – flooding and water safety
- 2.6 Rescues of trapped persons
- 5.1 Generic hazards – Electricity
- 5.9 Generic hazards – Incidents involving asbestos containing materials
- 5.10 Generic hazards – Working at heights.

Details of documents that contain technical and supporting information can be found in the Technical Reference section of this generic risk assessment.

Fire and Rescue Authorities must conduct their own assessments and produce their own safe systems of work (which include standard operating procedures, training programmes, provision of equipment, levels of response etc.) within the context of integrated risk management plans, local conditions, knowledge and existing organisational arrangements.

This generic risk assessment will be reviewed for its currency and accuracy three years from date of publication. The Operational Guidance Strategy Board will be responsible for commissioning the review and any decision for revision or amendment.

The Operational Guidance Strategy Board may decide that a full or partial review is required within this period.

Significant hazards and risks

There are several key hazard areas that have the potential to cause harm associated with incidents in tunnels and underground structures:

- the contents and use (traffic and machinery movement, electricity, water, hazardous materials and stored items, construction phase hazards, human behaviour)
- structure (spalling, collapse, underfoot conditions, restricted space/access and egress)
- complexity (disorientation, loss of communication, travel distances, difficulties associated with evacuation of public/casualties, difficulty determining and applying firefighting tactics, media and resources)
- physiological (temperature, humidity, fatigue, restricted space)
- environmental (heat, smoke and smoke travel, darkness, irrespirable atmosphere, oxygen deficiency, inundation, pollution, weather/wind conditions/unexpected fire spread direction and intensity).

Contents and use

TRAFFIC AND MACHINERY MOVEMENTS

Tunnels used for transport (road or rail), tunnels under construction, and underground structures may pose a hazard to personnel by:

- physical obstruction, hindering access to the incident
- collision of moving vehicles with emergency vehicles or personnel
- collision of moving vehicles with people evacuating from the incident, for example within the opposite bore of a twin bore tunnel
- automated industrial processes such as warehousing, baggage handling that may start up/move unexpectedly

- the fire loading of the vehicles and fuel sources
- concentration of exhaust fumes and smoke from combustion
- noise from traffic and exhaust/extraction fans.

ELECTRICITY

Electricity may be present within tunnels and underground structures in various forms for example:

- where the tunnel is a conduit for a high-voltage electrical supply
- to power transport systems, overhead line equipment/third rail
- to power systems within the tunnel such as lighting/ventilation
- to supply construction operations and equipment.

Tunnels and underground structures under construction present specific electrical hazards:

- Dangers from temporary connections
- Isolation could be problematic if circuits are not clearly identified
- Delays in availability of site engineers to isolate and discharge circuits
- Dirty conditions could cause difficulty identifying cables
- Electrical connections to tunnel boring machines require regular joints as the tunnel boring machine advances. These may present a hazard if damaged and submerged.

WATER

Water may be present in the tunnel and underground structure as:

- a natural feature of the tunnel and underground structure (eg as in a cave)
- water levels may rise or fall suddenly and unpredictably
- open water in a tunnel (eg in a canal tunnel)
- water in pipes running through the tunnel and underground structure
- part of the structural design/characteristics that a certain level of water ingress expected/required
- the tunnel and underground structure is part of a water supply/drainage system.

Water in the tunnel and underground structure may present:

- biological hazards such as leptospirosis or sewerage
- drowning hazards
- slip hazards
- inundation/flooding hazards
- floating debris.

Hazardous materials and stored items

Hazardous materials present within the tunnel/underground structure may include:

- materials in storage
- materials/items being transported through such as hazardous materials, animals/livestock
- construction materials such as asbestos
- substances accidentally or deliberately introduced, toxic waste products, pollution or chemical, biological, radiological, and nuclear incidents
- gases and materials created by the environment.

Construction phase hazards

Tunnels and underground structures under construction or under significant refurbishment introduce additional hazards:

- electrical hazards (see **ELECTRICITY** above)
- dead end conditions
- potential for structural collapse
- fire loading of construction equipment, ignition sources, energy sources, fuels and materials, presence of hazardous materials including explosives
- reduced fire and safety management systems and equipment
- pressurised workings
- oxygen deficient or rich/irrespirable/explosive atmospheres
- additional difficulties for safe access/egress and evacuation arrangements
- loss of inherent communication systems
- laser hazards associated with tunnel boring equipment
- lack of planning and access arrangements for fire and rescue personnel.

Human behaviour

People involved in an incident in a tunnel or an underground structure may behave in an unexpected or unpredictable manner. This can impact on fire fighting and rescue operations as the occupants may have remained within the tunnel/underground complex rather than evacuating.

Structure

SPALLING/COLLAPSE

A fire or another incident that affects the structural integrity of the tunnel or underground structure may result in spalling or collapse. Structural collapse may be a constant factor within some underground structures such as caves or mines, for example:

- Constructed of brick have a high resilience to fire but will eventually fail, leading to a potential for sudden collapse
- Constructed of sprayed concrete or concrete segments (pre 1996) will spall when exposed to direct flame contact and high ambient temperatures due to internal pore pressure
- Constructed post-1996 are likely to contain polypropylene within the concrete mix thus allowing the pore pressure to release when the temperature exceeds 249°C. The release of the water vapour within the concrete makes it less susceptible to spalling and collapse.

The collapse of a tunnel or underground structure may also have an effect on any of the structures above. This is of particular significance in built-up areas where a tunnel or underground structure collapse could lead to damage/collapse in buildings or roadways above.

UNDERFOOT CONDITIONS

Slips, trips and falls, eg railway shingle/sleepers/rails, sumps and other service pits.

RESTRICTED SPACE AND ACCESS/EGRESS

Underground working may be affected by:

- the number of access/egress points available eg either end of a tunnel, or single point for some caves
- manual handling in restricted spaces
- the ability to assess risks clearly
- the ability to use equipment
- problems associated with access for personnel and equipment.

Complexity

DISORIENTATION

Tunnels or underground structures may lack the means of visual way finding features and may lead to disorientation in terms of distances and direction of travel. This will be exacerbated in smoke or dark conditions.

LOSS OF NORMAL COMMUNICATION SYSTEMS

The topography and/or construction of the tunnel or underground structure can detrimentally affect the Fire and Rescue Authority's communication systems and will often rely on the use of third party systems and equipment.

TRAVEL DISTANCES TO INCIDENT LOCATION

Incidents within tunnels and underground structures may be difficult to precisely locate, and may involve significant travel distance for resources.

The hazards associated with this include:

- difficulties estimating working durations and resource requirements

- delays in reaching the incident location and crew rotation
- delays or difficulties with the flow of information to and from incident command
- delays or difficulties with the flow of logistical/welfare support
- fatigue
- limitations of breathing apparatus duration.

DIFFICULTIES ASSOCIATED WITH EVACUATION OF PUBLIC/CASUALTIES

The complexity of the tunnel or underground structure may hinder evacuation due to the above hazards, which may be further affected by unexpected human behaviour (see also **Human behaviour** above).

DIFFICULTY DETERMINING AND APPLYING FIREFIGHTING TACTICS, MEDIA AND RESOURCES

Determination of the appropriate tactics to apply may be hindered due to the lack of ability to predict the fire behaviour because of the complexity of the structure, and for the potential of limited information being available due to location, distance, limited access and intensity of the incident.

Physiological

HEAT AND HUMIDITY

The physiological effects of heat and humidity in a tunnel or underground structure environment will be exacerbated by the inability for heat to be readily dissipated or ventilated. This will severely restrict the duration of physical exertion of fire and rescue personnel.

COLD

In addition to the ambient environmental conditions within the tunnel or underground structure, processes such as cold storage or ventilation systems may significantly affect the working temperature.

FATIGUE

Fatigue of fire and rescue personnel will be affected by:

- travel distances
- work rate
- temperature/humidity
- duration and nature of activities
- fitness levels.

RESTRICTED SPACE

Working within restricted space may lead to manual handling activities being more hazardous, and raises the potential for musculo-skeletal injuries.

Environmental

HEAT, SMOKE, SMOKE TRAVEL

The nature of fire development and spread within a tunnel or underground structure may rapidly create an extremely intense environment for Fire and Rescue Authority operations.

Smoke control and travel can be affected by external environmental conditions such as wind direction and strength. This may influence the control of integrated ventilation systems.

IRRESPIRABLE ATMOSPHERE, OXYGEN DEFICIENCY AND OXYGEN ENRICHMENT

The environment within the tunnel or underground structure may become irrespirable, enriched or oxygen deficient, presenting additional risks to fire and rescue personnel for a number of reasons:

- fire and smoke
- exhaust from vehicles/equipment
- fumes drawn in through ventilation systems from external sources
- naturally occurring gases
- oxygen deficiency may cause internal combustion engine driven vehicles and equipment to fail
- gas leaks or being artificially introduced, including raised oxygen levels.

FLOODING

The tunnel or underground structure may become flooded or inundated due to:

- the intended purpose
- weather conditions
- structural failure
- failure of water removal/control systems.

POLLUTION

The proximity of many tunnels and underground structures to natural watercourses may increase the risk of environmental pollution due to Fire and Rescue Authority operations, particularly fire water run-off.

Smoke, other products of combustion or contamination may be released from the tunnel or underground structure into unexpected areas remote from the incident.

DARKNESS

Darkness or low lighting levels within a tunnel or underground structure may mask the presence of other hazards.

WEATHER AND WIND CONDITIONS

Weather and wind conditions present the following hazards:

- inclement weather affecting physiological capabilities of fire and rescue personnel (heat and cold)
- objects being blown/carried by the wind along the tunnel and underground structure
- unexpected fire spread, direction and intensity, see also **HEAT, SMOKE, SMOKE TRAVEL** above.

NOISE

Noise levels may be intensified within the structure of a tunnel or underground structure as the sound energy is contained. This may hamper communications, or lead to conditions where hearing damage may occur.

Noise sources include:

- Traffic
- Machinery
- Ventilation systems and fans
- Fire and Rescue Authority operations.

Key control measures

Planning

Planning is key to enhancing the safety of firefighters and others likely to be affected by Fire and Rescue Authority operations. Each Fire and Rescue Authority's integrated risk management plan will set standards and identify the resources required to ensure safe systems of work are maintained.

Each Fire and Rescue Authority must assess the hazards and risks in their area relating to this generic risk assessment and site-specific plans must be considered for locations where these are significant. This assessment must include other Fire and Rescue Authority's areas where 'cross border' arrangements make this appropriate.

Such contingency plans must include:

- Levels of response
- Relevant standard operating procedures; and
- Tactical considerations, including rendezvous points, appliance marshalling areas and access points
- Liaison with the contractor or site owner/operator to ensure that any specialist intervention equipment is provided. Separate provision must be made for the transport of equipment and personnel.

Planning is underpinned by information gathering, much of which will be gained through inspections or visits by fire and rescue personnel – for example, those covered by section 7(2)d of the *Fire and Rescue Services Act 2004*.

Information must also be gathered and used to review safe systems of work from sources both within and outside the Fire and Rescue Authority, including:

- fire safety audits
- incident de-briefs
- health and safety events
- local authorities; and
- local resilience forum.

Involving others in planning is also an effective way to build good working relations with partner agencies and other interested parties, such as site owners/operators.

Fire and Rescue Authorities must ensure systems are in place to record and regularly review risk information and to ensure that new risks are identified and recorded as soon as practicable.

Fire and Rescue Authorities must ensure that the information gathered is treated as confidential, unless disclosure is made in the course of duty or is required for legal reasons.

Fire and Rescue Authorities must consider the benefits of using consistent systems and formats to record information from all sources. Consideration must also be given to how timely access will be provided to information to support operational decision-making.

Information needs and the capacity of fire and rescue personnel to assimilate information will vary, in proportion to the nature and size of incident and what stage the operational response has reached. Arrangements need to be flexible and may be based on more than one system.

Further guidance on planning can be found in the national guidance manual *Provision of operational information system*: www.gov.uk/government/uploads/system/uploads/attachment_data/file/5914/2124406.pdf

Specific planning for this generic risk assessment must include:

- agreement of Fire and Rescue Authority intervention strategies with infrastructure managers
- identification of built environment controls – suppression systems, detection systems, ventilation, firefighting facilities including access/egress arrangements.
- establishing communication systems effectiveness and contingency plans for their loss
- liaison with other agencies with responsibilities such as the Mines Rescue Service, Ministry of Defence, Caves Rescue, Ambulance Services, Hazardous Area Response Teams, Defence Fire and Rescue Authorities, Police Services.

Competence and training

When formulating a competence and training strategy a Fire and Rescue Authority must ensure:

- specific risk assessments for this incident type are suitable and sufficient
- those tasked with carrying out the assessment and developing procedures are competent to do so
- their personnel are adequately trained to deal with hazards and risks associated with the generic risk assessment
- the level and nature of training undertaken be shaped by an informed training needs analysis taking account of Fire and Rescue Authority guidance on the competency framework, national occupational standards and any individual training needs.

Training and development programmes must:

- follow the principles set out in national guidance documents
- generally be structured so that they move from simple to more complex tasks and from lower to higher levels of risk typically cover standard operational procedures, as well as ensuring knowledge and understanding of equipment and the associated skills that will be required to use it
- consider the need for appropriate levels of assessment and provide for continuous professional development, to ensure maintenance of skills and to update personnel whenever there are changes to procedure, equipment, etc
- involve personnel involved in other processes that support the emergency response, such as planners devising procedures and people procuring equipment.

Training outcomes must be evaluated to ensure that the training provided is effective, current and meets defined operational needs as determined by the Fire and Rescue Authority's integrated risk management plan.

Specific training requirements for 'rescues from tunnels and underground structures', will include the standard operating procedure and the equipment to be used.

Site-specific tactical exercises must be undertaken with other agencies or staff likely to assist at an actual incident.

Specific training for tunnels and underground structure incidents must be undertaken to familiarise and train operational personnel for conditions which may be encountered at such sites. The level of training provided must be appropriate to the role expected of personnel responding in accordance with the pre-determined response/attendance.

Fire and Rescue Authorities must have arrangements in place to ensure the continued competence of those personnel who are liable to attend such incidents.

In some locations the Ambulance Service provides a Hazardous Area Response Team. This team is capable of supporting Fire and Rescue Authorities with casualty assessment and care in the hazard zone of an incident. Where appropriate, Fire and Rescue Authorities must make arrangements to train with these teams.

Command and control

The Incident Commander must follow the principles of the current national incident command system.

Prior to committing personnel into any hazard area, the Incident Commander must take account of the actual information regarding the incident that is available at the time. This will assist them in making operational decisions in what are recognised as sometimes dangerous, fast moving and emotionally charged environments.

A thorough safety brief prior to deployment of personnel within the hazard zone must be carried out.

Communication of new or changed risks must continue throughout the incident.

Safety Officer(s)

The early appointment of one or more Safety Officer(s) will help ensure that risks are either eliminated or reduced to an acceptable level.

A safety decision-making model must be used to brief Safety Officers regarding the nature of the incident, the allocated task and prevailing hazards and risks. The Incident Commander must confirm that the Safety Officer understands:

- their role and area of responsibility
- allocated tasks
- current information about site, site hazards and risks
- lines of communication.

Those undertaking the Safety Officer role must:

- be competent to perform the role
- ensure personnel are wearing appropriate personal protective equipment
- monitor the physical condition of personnel and/or general or specific safety conditions at the incident, in accordance with their brief
- take any urgent corrective action required to ensure safety of personnel
- update the Incident Commander or senior safety officer regarding any change in circumstances; and
- not be engaged in any other aspect of operations, unless this is required to deal with a risk critical situation.

A Safety Officer can be any role, but the complexity of the task, size of the incident and scope of responsibility must be considered by the Incident Commander when determining the supervisory level required.

Safety Officers must wear nationally recognised identification to indicate they are undertaking the 'Safety Officer' role.

Fire and Rescue Authorities must ensure that training and other measures (such as aide-memoires) are in place and available to support those staff liable to undertake this role.

Traffic and machinery movement

Precautions must be in place to manage vehicles and machinery movements that could affect Fire and Rescue Authority operations or pose a risk to personnel. These may include:

- Traffic management systems including road/rail closure, fending off procedures. In multi-bore tunnels consideration will need to be given to stopping traffic in unaffected bores as evacuation passages may lead to this route
- Shut down and isolation of machinery/automated systems
- Fire and rescue personnel must not enter a rail tunnel unless permission has been given by the Rail Incident Officer.

Electricity

- High-voltage cables will require isolation, bonding to earth and testing before they can be considered electrically safe
- Overhead line equipment must not be touched even when it is isolated and bonded to earth unless absolutely necessary
- Fire fighting operations must only commence when all high-voltage cables have been isolated, bonded to earth and tested. For railway operations a permit to work will be issued to the Rail Incident Officer, not the Fire and Rescue Authority Incident Commander.

Hazardous materials and stored items

- hazardous material identification must be carried out using established systems
- regulation of storage arrangements by relevant enforcing authorities.

Construction phase

- Electricity (see above)
- Hazardous materials – planning discussions must ensure that only essential materials are stored within the structure and/or tunnel boring machine. Lubricants and greases must be high flash point and kept to a minimum, and flammables must be kept in appropriate flame proof containers
- Fire and Rescue Authority Liaison Officers and appropriate enforcement authorities must ensure regular inspection of the site to ensure compliance with fire and safety requirements

- Specialist equipment needs to be specified and provided by the constructor to ensure that a safe intervention can be made
- Equipment for the transportation of personnel and equipment must be provided where applicable. The transportation of personnel must be an approved 'man rider' facility.

Structure

- the construction type, age and fire conditions must be established to help determine the risk of spalling and collapse
- specialist advice must be sought regarding the structural safety post-incident.

Complexity

- provision of specialist access equipment, for example track trolleys.
- well rehearsed (multi agency) evacuation procedures
- special fire fighting tactics may be required due to length of tunnel and inability to manually lay hose for long distances
- fixed installation systems, ventilation systems
- consider provision of additional lighting.

Physiological

- planning must guarantee full facilities for the Fire and Rescue Authority which must include water for firefighting, communications and safe havens
- intervention shafts provide closer access/egress to the scene of operations, however strict access control must be maintained
- increased breathing apparatus crew rotation to account for greater physiological demands due to temperature, humidity and travel distances.

Environmental

- control of ventilation systems to minimise the effects of smoke/combustion products on Fire and Rescue Authority operations
- consideration of prevailing wind conditions and the effects on smoke travel
- continuous air monitoring carried out where remote start up of breathing apparatus is required (frequency to be appropriate to level of assessed risk)
- consider the environmental impact of an incident on the community with particular regard to:
 - smoke pollution
 - water run off into surface water drainage sets
 - recycle fire fighting water.

Personal protective equipment

Fire and Rescue Authorities must ensure that any personal protective equipment provided is fit for purpose and meets all required safety standards. When choosing suitable protective garments, the standard of clothing worn beneath the specialist personal protective equipment must also be taken into account. Consideration must also be given to the selection of suitable sizes and gender specific requirements of personal protective equipment.

Personal protective equipment must also take account of the need for rescuers to be visible against the operational background including night working and for the Incident Commander and other managerial and functional roles (defined in the national incident command system) to be distinguishable.

All personnel must use appropriate levels of service provided personal protective equipment and respiratory protective equipment as determined by the safe system of work.

Post-incident

The following measures must be considered to help eliminate or remove risks after an incident, as appropriate to the nature and scale of the incident:

- Any safety events; personal injuries, exposure to hazardous substances or near-misses must be recorded, investigated and reported in line with legislative requirements such as *Reporting of Injuries Diseases and Dangerous Occurrence Regulations 1995*, etc
- Arrangements must be in place to either remove all contamination from personal protective equipment or to ensure it's safe and appropriate disposal and to check that it maintains the agreed levels of integrity and protection for the wearer throughout it's lifecycle
- As appropriate, occupational health support and surveillance follow up
- Conduct a de-brief to identify and record any "lessons learned" from the incident. De-briefs will range in complexity and formality, proportionate to the scale of the incident and in line with individual Fire and Rescue Authority's procedures
- Consider any changes required to safe systems of work, appliances or equipment in the light of any lessons learned from debriefs or from safety events
- Consider the need to review existing information held on a premises or location, or the need to add a new premises or location into future planning eg by adding to visit or inspection programme
- Staff must be supported and monitored to identify whether they are experiencing any adverse affects and to check whether they would benefit from accessing counselling and support services
- Consideration must be given to arranging for staff to make a contemporaneous written record of their actions. This information may be used to assist in any internal or external investigations or enquiries that follow any incident eg Coroner's Court, public enquiry, etc.

SECTION 2

Summary of Generic Risk Assessment 2.7

Rescues from tunnels and underground structures

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
1	Fire and Rescue Authority intervention	Traffic and machinery movements	Collision or entrapment	Fire and rescue personnel Public Other agencies	Road closure/fencing off procedures Shut down and isolation of machinery/automated equipment Restricted access.
2		Electricity	Electrocution	Fire and rescue personnel Public Other agencies	Isolation, bonding to earth and testing to ensure electrical safety Advice from internal and/or external specialists eg tactical advisors and utility company representatives.
3		Water	Drowning Biological agents Slips and falls	Fire and rescue personnel Public Other agencies	Water safety arrangements Universal hygiene procedures Appropriate personal protective equipment for example dry suits, personal floatation devices.
4		Hazardous materials/ stored items	Exposure to hazardous chemicals, chemical reaction to fire	Fire and rescue personnel Public Other agencies	Planning, regulation and awareness, identification procedures Provision of appropriate personal protective equipment, for example gas tight suits.

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
5		Construction phase	Restricted access/egress Electrical Fire loading of structure Mechanical hazards Environmental conditions	Fire and rescue personnel Public Other agencies	Close liaison between Fire and Rescue Authorities, enforcement authorities, constructor and owner/operator throughout construction.
6		Human behaviour	Unexpected or unpredictable behaviour from public during evacuation phase	Fire and rescue personnel Public Other agencies	Thorough searching of the tunnel and underground structure Training and awareness.
7		Structure	Concrete spalling/structural failure/sudden collapse Slips/trips	Fire and rescue personnel Public Other agencies	Identification of construction type, age, condition to determine risk of failure Specialist structural advice Emergency evacuation procedures.
8		Underfoot conditions	Loose materials on floor surface Slippery surfaces Obstructions and trip hazards	Fire and rescue personnel Public Other agencies	Scene lighting Training and awareness Personal protective equipment – protective footwear.
9		Restricted working space and access/egress	Manual handling/musculo-skeletal	Fire and rescue personnel Public Other agencies	Planning Training Firefighting personal protective equipment.

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
10		Complexity	Disorientation Loss of communication systems Travel distances Evacuation difficulties Difficulty applying correct tactics, media and resources	Fire and rescue personnel Public Other agencies	Well rehearsed multi agency emergency plans Planning Specialist access equipment Intervention shafts Fixed installations.
11		Physiological	Heat exhaustion Hypothermia Fatigue Restricted space working	Fire and rescue personnel Public Other agencies	Increased crew rotation Intervention shafts to minimise travel distances Planning Crew welfare and hydration.
12		Environmental	Irrespirable atmosphere Oxygen deficiency or enrichment	Fire and rescue personnel Public Other agencies	Breathing apparatus Air monitoring Emergency evacuation procedures.
13			Flooding/inundation	Fire and rescue personnel Public Other agencies	Planning to consider systems/supplies Specialist information/advice Weather reports Emergency evacuation procedures.

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
14			Heat, smoke, smoke travel Water pollution	Fire and rescue personnel Public Other agencies	Control of ventilation systems Knowledge of prevailing wind conditions Control of water run-off.
15			Darkness masking the presence of hazards	Fire and rescue personnel Public Other agencies	Scene/site lighting Training and awareness Firefighting personal protective equipment.
16			Weather/wind producing inclement conditions, items/objects being carried by the wind within the tunnel and underground structure Changing direction and/or intensity of fire	Fire and rescue personnel Public Other agencies	Specialist advice (for example the Met Office) Training and awareness Firefighting personal protective equipment (eye protection) Crew rotation and welfare arrangements Emergency evacuation procedures.
17			Noise	Fire and rescue personnel Public Other agencies	Limit exposure Crew rotation Provision of hearing protection Awareness Health monitoring.