Thames Tideway Tunnel
Thames Water Utilities Limited

Thames Water

Application for Development Consent

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Air Management Plan

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Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

Air Management Plan

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List of abbreviations

CSO	combined sewer overflow
Defra	Department of Environment, Food and Rural Affairs
EA	Environment Agency
H_2S	hydrogen sulphide
NPS	national policy statement
OCU	odour control unit
ou_E/m^3	odour units per cubic metre of air
PEIR	preliminary environmental information report
SOM	site operating manual
STW	sewage treatment works
UWWTD	Urban Waste Water Treatment Directive

1 Executive summary

1.1.1 The Thames Tideway Tunnel project is one component of the improvement works to the wastewater system serving London so as to comply with the European *Urban Waste Water Treatment Directive* (UWWTD). The other components consist of enhancing the capacity of the Sewage Treatment Works (STW) at Beckton, Crossness, Mogden, Riverside, Longreach and the construction of the Lee Tunnel from Abbey Mills Pumping Station to Beckton STW.

1.1.2 The Thames Tideway Tunnel project is to run from Acton Storm Tanks in the west of London to link to the Lee Tunnel at Abbey Mills Pumping Station. It consists of 25km of 7.2m to 6.5m diameter tunnel with about 6km of 5m to 2.6m diameter connection tunnels which, along with the 7km long 7.2m diameter Lee Tunnel, forms the tunnel system.

1.1.3 The tunnel system is designed to capture flows from combined sewer overflows (CSOs) which, at times of rainfall, presently discharge wastewater to the River Thames about 50 times per year. The wastewater from the CSOs would be stored in the tunnel until there is capacity at Beckton STW where the wastewater would be pumped-out of the tunnel for treatment.

1.1.4 Under the various operational scenarios of the tunnel system the air displaced from the tunnels needs to be managed. These scenarios include; tunnel empty, tunnel filling with wastewater, tunnel storing wastewater and pump-out of wastewater.

1.1.5 This *Air Management Plan* describes the ventilation and air treatment systems which are to control the air released from and flowing into the tunnel under the operational scenarios and under all expected weather conditions. The plan demonstrates how the air management plant would operate to control and treat air exhausted from the tunnels such that any malodours are either not perceivable or negligible and within the Environment Agency standards.

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2 Introduction

2.1.1 The older areas of the London sewer system are combined sewers that carry foul flow and rainwater runoff. When it rains, the combined sewer system often becomes overloaded and excess sewage discharges from combined sewer overflows into the rivers Lee and Thames. CSOs are required to reduce the risk of sewer flooding, limit damaging surcharging of the sewer system and overloading of the Beckton and Crossness sewage treatment works.

2.1.2 The Environment Agency has determined that 36 of the 57 CSOs that discharge into the River Thames and River Lee are unacceptable and require control to meet the requirements of the *Urban Waste Water Treatment Directive* and to limit the pollution to the river and subsequent effects on human and ecological health of the river. The CSOs discharge approximately 50 times per year, with a combined discharge of about 39 million cubic metres in a typical year.

2.1.3 The overall London Tideway Improvements includes upgrades to five main sewage treatment works that discharge to the Thames Tideway and the construction of the Lee Tunnel from Abbey Mills to Beckton STW. The proposed Thames Tideway Tunnel project would complete the overall planned improvements and would consist of a main tunnel from Acton Storm Tanks to Abbey Mills. The main tunnel would connect to the Lee Tunnel at Abbey Mills. Combined sewage controlled by the tunnel system would be stored and transferred to Beckton STW for treatment before discharging to the River Thames.

2.1.4 The purpose of this *Air Management Plan* is to define how air from the proposed Thames Tideway Tunnel project is vented into and out of the tunnel system and how air releases are controlled and treated. It outlines operational and management procedures for controlling air movement and treatment to meet regulatory requirements so as to limit the extent of nuisance odours and significant loss of amenity. The plan covers the Thames Tideway Tunnel project from Acton Storm Tanks to Abbey Mills (including the change to the operation of facilities being built by the Lee Tunnel). A separate odour management plan exists for the Abbey Mills Pumping Station (Thames Water, 2008)[1] and Beckton Sewage Treatment Works (Thames Water, 2008)[2].

2.1.5 This *Air Management Plan* particularly focuses on the 24 shafts at the 22 sites where air can enter into and exhaust from the system. Of the 24 shafts, six consist of active ventilation plant with extraction fans and air treatment while 17 locations have passive filtration systems and one shaft is linked to the active ventilation plant at Abbey Mills Pumping Station.

2.1.6 It should be emphasised that the evaluations undertaken to design facilities outlined in this plan are based on conservative input parameters and produce a robust and reliable system, with low risk of nuisance odours and low risk of significant loss of amenity.

2.1.7 The format for the document, in general, follows that of previous management plans (Thames Water, 2008[3], 2010[4] and 2010[5]) related to odour control for other Thames Water sites, but as the Thames Tideway Tunnel project has intermittent and variable operations at multiple sites, some deviation from previous reporting is required.

2.1.8 Environmental health officers at the 14 London boroughs potentially affected by the Thames Tideway Tunnel project have been consulted, the feedback from which is reflected in the *Air Management Plan*.

3 Site information

3.1 Site locations

3.1.1 There are to be 24 shafts at 22 sites at which air would be managed[i]. The locations are listed in Table 3.1 and shown on Plate 3.1. The Lee Tunnel project would construct three shafts, all of which would have active air treatment plants. These plants are included in the overall air management plan for the CSO control system.

3.2 Site receptors

3.2.1 The *National Policy Statement for Waste Water* (NPS) (Defra, 2012)[6] suggests that an odour impact assessment is undertaken. This is to assess the potential for odorous releases and the proposed mitigation measures. It indicates that odour impact should be assessed based on appropriate standards which include the Environment Agency methodology (described below).

3.2.2 The Environment Agency *H4 odour management guidance (Appendix 3)* (EA, 2011)[7] provides odour standards for modelling exposure. The benchmark level for the most offensive odours at the site boundary is taken to be 1.5 odour units per cubic metre (ou_E/m^3)[ii] as an hourly average concentration level which is not to be exceeded for 98 percent of the time in a typical year. This benchmark is the highest standard and is adopted by the Thames Tideway Tunnel project. The standard is applied at sensitive receptors and consideration is given to the impacts and effects of odour on surrounding land uses outside the boundary of the facility. The standard is intended for continually operating sewage facilities and not specifically for intermittent conditions, such as from CSO control schemes. The application of this standard therefore provides a high level of protection from odours that might give rise to a significant loss of amenity or cause a nuisance from the intermittently operating Thames Tideway Tunnel project.

3.2.3 The type of receptor determines the sensitivity to odour[iii], with residential properties, hospitals and schools being classed as sensitive receptors and other sensitive land uses being commercial premises, recreational facilities and open spaces. Consideration of receptors should include any major new developments expected to come forward in the vicinity of the sites in future years. With most sites being close to the river, permanent moorings are also included as residential receptors.

[i] Connection Shaft and Overflow Shaft are both on the Beckton STW site

[ii] A concentration of odour of 1 OU_E/m^3 is when half the panel of evaluators can detect the odour under laboratory conditions

[iii] Sensitive receptors are defined in the NPS for Waste Water paragraph 4.3.16 and Environment Agency H1 Environmental Risk Assessment Annex F

Table 3.1 Site information

CSO ID	Location ID[iv]	Site location	Address (nearest road)
CS01X	1	Acton Storm Tanks	Canham Road
CS04X	2	Hammersmith Pumping Station	Chancellor's Road
CS05X	3	Barn Elms	Horne Way
CS06X	4	Putney Embankment Foreshore	Lower Richmond Road
CS07A	5	Dormay Street	Dormay Street
CS07B	6	King George's Park	Buckhold Road
No CSO	7	Carnwath Road Riverside	Carnwath Road
CS09X	8	Falconbrook Pumping Station	York Road
CS10X	9	Cremorne Wharf Depot	Lots Road
CS14X	10	Chelsea Embankment Foreshore	Chelsea Embankment
No CSO	11	Kirtling Street	Kirtling Street
CS16X CS17X	12	Heathwall Pumping Station[v]	Nine Elms Lane
CS19X CS20X	13	Albert Embankment Foreshore[vi]	Albert Embankment
CS22X	14	Victoria Embankment Foreshore	Victoria Embankment
CS27X	15	Blackfriars Bridge Foreshore	Victoria Embankment/ Blackfriars Underpass
No CSO	17	Chambers Wharf	Chambers Street
CS29X	21	King Edward Memorial Park Foreshore	The Highway
CS31X	18	Earl Pumping Station	Croft Street
CS32X	19	Deptford Church Street	Deptford Church Street
CS33X	20	Greenwich Pumping Station	Greenwich High Road
CS35X	23	Abbey Mills Pumping Station[vii]	Lee Tunnel – Abbey Lane
No CSO	24	Beckton STW Connection Shaft	Lee Tunnel – Beckton STW
Tideway CSO	24	Beckton STW Overflow Shaft	Lee Tunnel – Beckton STW

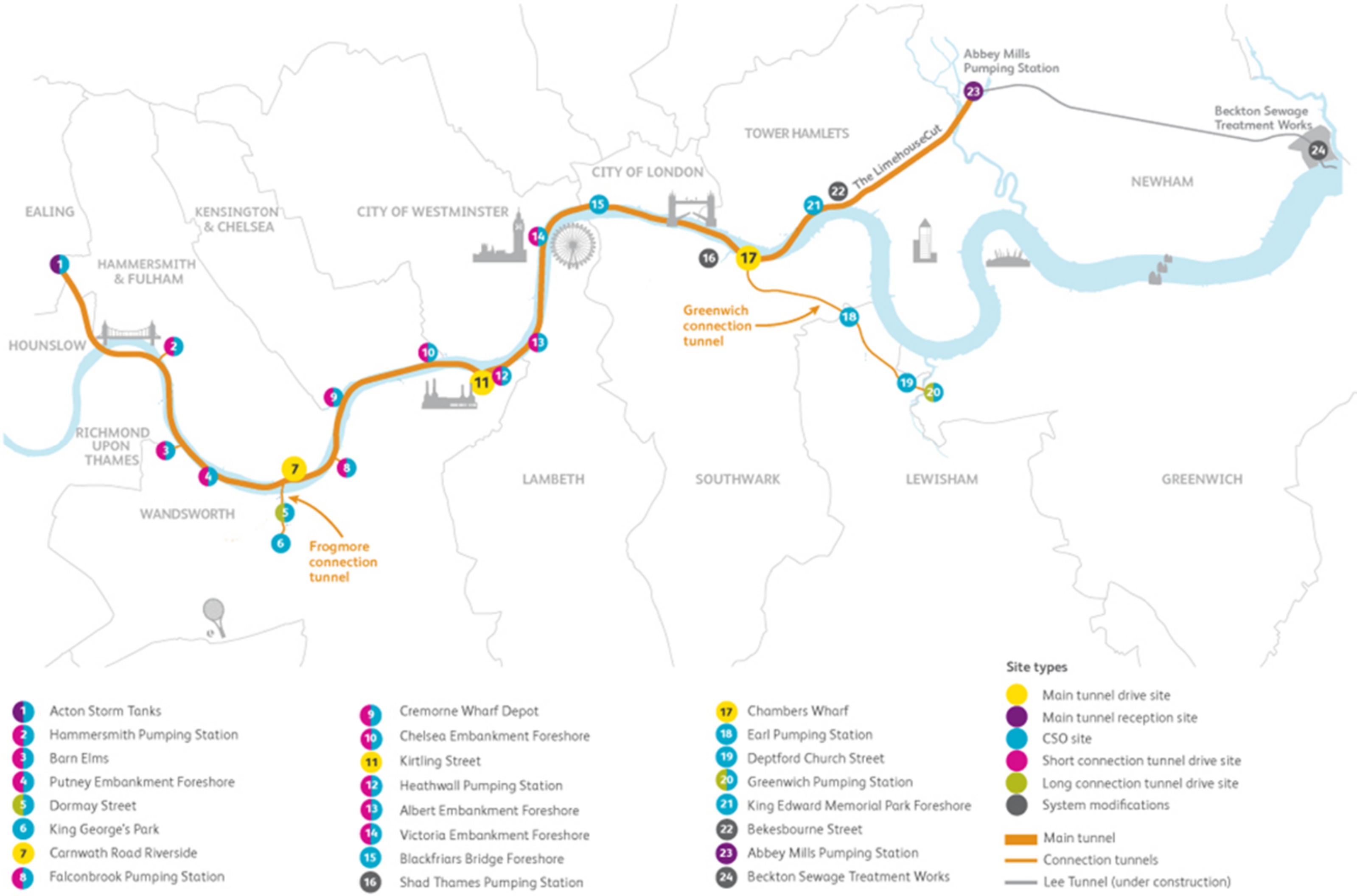
[iv] Location shown on Plate 3.2.1

[v] Includes Heathwall Pumping Station and South West Storm Relief sewer

[vi] Includes Clapham and Brixton Storm Relief sewers

[vii] There are two shafts at Abbey Mills Pumping Station

Plate 3.1 Thames Tideway Tunnel project sites



3.3 Overview of air management processes

3.3.1 Air in the tunnel would normally be managed by the creation of a small, negative pressure relative to atmospheric by fans at the active control ventilation and air treatment plant at shafts towards the upstream and downstream ends of the tunnel system. It is proposed that the three facilities constructed as part of the Lee Tunnel project would continue in use and three new active control plants would be built as part of the Thames Tideway Tunnel project. Air exhausted from these active control plants would pass through and be treated by odour control units (OCUs).

3.3.2 Overall, there are to be 24 shafts at 22 sites. This includes two shafts at Abbey Mills sharing one active air management system and two shafts each with active air management facilities at Beckton STW. At Heathwall Pumping Station there is to be a small shallow shaft associated with the pumping station interception structure; this would have a small diameter shallow depth connection tunnel to the main shaft which would also capture the South West Storm Relief sewer and would link to the Thames Tideway Tunnel project. The small shaft capturing the Heathwall Pumping Station discharge is to have a tank breather unit (a small stack with a carbon filter which treats all released air), whilst the main shaft is to have a passive filter.

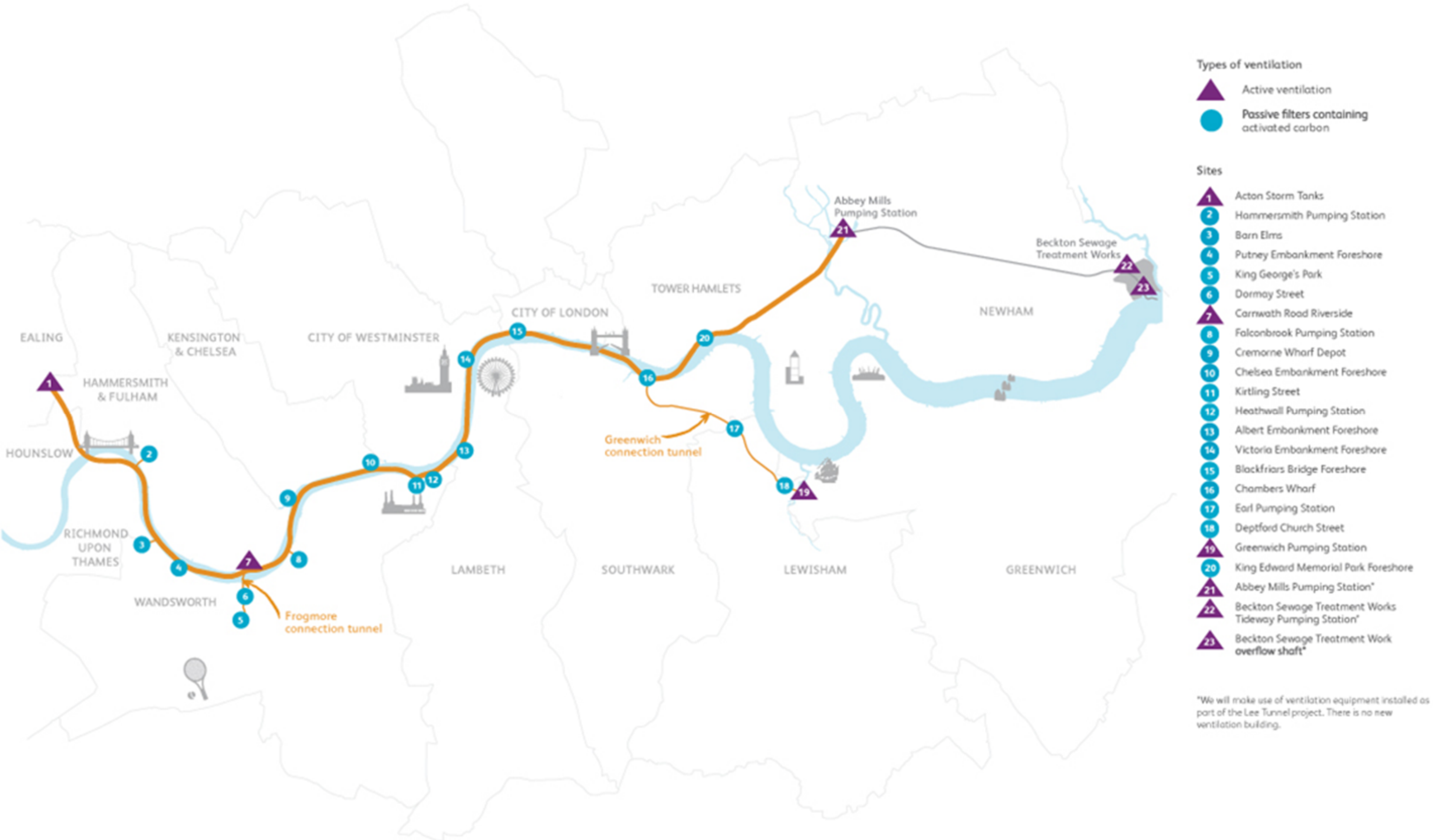
3.3.3 All 22 sites are to have either active or passive control air treatment plants:

a. Active control would be through forced air plants where extraction fans draw air from the tunnel and pass it through carbon filter OCUs for treatment before release. There would be active control plants at six locations: Acton Storm Tanks, Carnwath Road Riverside, Greenwich Pumping Station, Abbey Mills Pumping Station, Beckton STW Connection Shaft and Beckton STW Overflow Shaft, the latter three being provided under the Lee Tunnel project. When the tunnel system is empty, continuous extraction and treatment of tunnel air is to be at Carnwath Road Riverside and from both shafts at Abbey Mills. This is to maintain the negative pressure relative to atmospheric within the tunnel thereby preventing air releases at sites other than these extraction sites and to allow fresh air to enter the tunnel at preferential air intake locations. These preferential air intakes are to be at: Acton Storm Tanks, King George’s Park, Blackfriars Bridge Foreshore, Greenwich Pumping Station and the Overflow Shaft at Beckton STW.

b. There are to be 17 sites with passive plants which would treat the limited amount of air that could be displaced whenever the tunnel fills and drowns the particular shaft. Passive sites are also locations for nominal air inflow. Both air inflow and exhaust would be controlled by the natural pressure loss through the carbon filters.

3.3.4 The locations of the active control plant and passive plant are shown in Plate 3.2.

Plate 3.2 Location of active ventilation and passive filters



Notes:
1) Heathwall Pumping Station includes a small interception structure shaft with a tank breather unit and a main shaft to capture the flow from the South West Storm Relief sewer
2) Abbey Mills includes two shafts; one for the Lee Tunnel and one for the Thames Tideway Tunnel project.

3.3.5 The active plant sites are to have ventilation columns generally set at 15m above ground level to ensure adequate dispersion. Since bypass air would also be released at the ventilation column (see para. 3.3.11) a 15m column is required to provide the necessary dispersion.

3.3.6 At passive sites, all released air would be treated by passing through the carbon filters. The height of the ventilation columns is set so as to comply with hazardous zoning requirements, in accordance with Thames Water standards (Thames, 2009)[8]. At most sites, the extent of the hazardous zone is 2m from the emission point. Allowing a further 2m headroom, the minimum height of the ventilation column is set at 4m. This zone allows for the dispersion and dilution of potentially explosive or toxic gases. The arrangement of ventilation structures and above-ground facilities has been architecturally designed to limit any visual impact while maintaining the air management function.

3.3.7 The type of ventilation structure at each site and the expected hours of treated air exhausted during a typical year are shown in Table 3.2.

3.3.8 This shows that the active ventilation facilities at Abbey Mills and Carnwath Road Riverside are to operate continuously in order to provide the required tunnel ventilation throughout the full year, whilst the active plant at Acton Storm Tanks, Greenwich and in Beckton STW would only operate for, on average, about 15% of the time during a typical year when the tunnel is capturing or storing CSO wastewater.

3.3.9 At each active ventilation facility the noise emanating from the fans and air ducts would be controlled by acoustic attenuators and acoustic enclosures such that the noise level at receptors is below the limits set by BS4142[viii] and the planning policy guidance for each particular London Borough.

3.3.10 The passive filters would operate infrequently for on average about 20 hours spread out over a typical year with those at the eastern end of the tunnel system operating more frequently (up to about 50 hours) whilst those at the western end operating less frequently (about ten hours).

3.3.11 Under unusually high air release rates resulting from air displaced during large storms filling the tunnel, which exceed the capacity of the active ventilation facility, a weighted bypass damper would open to allow air to circumvent the active ventilation facilities. This protects the fans and OCUs from high air flows. Under these conditions, air would be released through a bypass vent, which is nominally combined with the OCU vents as one structure. It would not be practical to size the active ventilation facilities to cater for the infrequent and short duration peak air exhaust rate. To treat these peak events (occurring on average for 0.3% of the time during the typical year) the plant at Carnwath Road Riverside would need to be four times as big and at Acton Storm Tanks twice as big. This would have a detrimental impact in terms of the increased footprint required to house the upsized air treatment facilities at these sites. The proposed capacity of the facilities meets the Environment Agency standard with a safety margin of about five; thus is the most practical size.

[viii] BS4142 1997 – Method for rating industrial noise affecting mixed residential and industrial areas.

Table 3.2 Site ventilation structure types and expected hours of air exhaust emissions for the typical year

Site location	Ventilation structure and air treatment type	No. of hours of air exhaust (typical year)	No. of hours of untreated exhaust (typical year)	% time treated
Acton Storm Tanks	Active,-3 vents (2 OCUs/ 1 bypass)	1138	9 (5 separate release events)	99.9%
Hammersmith Pumping Station	Passive,-Low level vent	7	0	100%
Barn Elms	Passive,-Low level vent	9	0	100%
Putney Embankment Foreshore	Passive,-Vent column	12	0	100%
Dormay Street	Passive,-Low level vent	10	0	100%
King George's Park	Passive,-Vent column	11	0	100%
Carnwath Road Riverside	Active,-3 vents (2 OCUs/ 1 bypass)	Full year treated ventilation	23 (17 separate release events)	99.7%
Falconbrook Pumping Station	Passive,-Vent column	13	0	100%
Cremorne Wharf Depot	Passive,-2 vent columns	13	0	100%
Chelsea Embankment Foreshore	Passive,-2 vent columns	13	0	100%
Kirtling Street	Passive,-Low level vent	16	0	100%
Heathwall Pumping Station[ix]	Tank breather unit for interception works shaft	2	0	100%
Heathwall Pumping Station (SWSR)[x]	Passive,-Vent column	19	0	100%
Albert Embankment Foreshore	Passive,-2 vent columns	22	0	100%
Victoria Embankment Foreshore	Passive,-2 vent columns	19	0	100%
Blackfriars Bridge Foreshore	Passive,-5 vent columns	23	0	100%
Chambers Wharf	Passive,-3 vent columns	39	0	100%
King Edward Memorial Park Foreshore	Passive,-2 vent columns	48	0	100%
Earl Pumping Station	Passive,-Low level vent	25	0	100%
Deptford Church Street	Passive,-4 vent columns	21	0	100%
Greenwich Pumping Station	Active,-2 vents in wall	1,050	0	100%
Thames Tideway Tunnel Shaft (Abbey Mills)	Duct to Shaft F 1 bypass column	12	12 (12 separate release events)	99.9%
Included as part of the Lee Tunnel project:				
Abbey Mills Lee Tunnel (Shaft F)	Active,-4 vents (3 OCUs/ 1 bypass)	Full year treated ventilation	12 (12 separate release events)	99.9%
Beckton STW Connection Shaft	Active,-2 vents (1 OCU/ 1 bypass)	1574	32 (26 separate release events)	99.6%
Beckton STW Overflow Shaft	Active,-2 vents (1 OCU/ 1 bypass)	1166	30 (26 separate release events)	99.7%

[ix] A tank breather carbon filter is to be installed at the Heathwall Pumping Station interception structure shaft
[x] SWSR is the South West Storm Relief sewer at Heathwall Pumping Station

3.3.12 During a CSO event, the tunnel would follow a cycle of:

a. filling with combined sewage: The main tunnel is estimated to fill completely four times in a typical year. The system would receive flow and fill, or partially fill, for about 2,050 hours[xi] in a typical year

b. temporary storage of the combined sewage: Simulations indicate that the average event storage time would be 13 hours, with the longest storage duration in the typical year of about 49 hours

c. emptying the stored combined sewage by pumping to the Beckton STW for treatment.

3.3.13 Each part of this CSO control cycle has different air management requirements:

a. For about 70–75% of the time the tunnel would be empty and the active plants at Carnwath Road Riverside and Abbey Mills would operate at a low rate to exchange the air in the tunnel system at least once per day. Air would be exhausted at these two sites, with primary air intake at Acton Storm Tanks, King George’s Park, Blackfriars Bridge Foreshore, Greenwich Pumping Station and the Overflow Shaft at Beckton STW.

b. During tunnel filling, the extraction fans at the active treatment facilities would increase to maximum until the shaft at the facility is submerged by the rising wastewater. The extraction fans would then reduce to a minimum rate. This is based on the detection of the wastewater level at each shaft. At passive filter sites air is driven through the carbon filter by the rising wastewater in the shaft. Shafts at the downstream, eastern end of the tunnel would be drowned out more frequently (about 25 to 50 hours during the typical year), compared with shafts at the western end (about five to 15 hours during the typical year).

c. When the tunnel is storing or emptying, air inlet structures and passive filters would allow air inflow. When shafts become open to the tunnel headspace the system reverts to the empty tunnel ventilation scenario.

3.3.14 Under very extreme conditions (about once every 15 years), generally associated with rapid tunnel filling, air displacement rates can exceed the design airflow rate of the air management facilities and bypass vents. This high pressure air would be released via a pressure relief structure with weighted dampers and exhausted to the atmosphere for a short time, estimated to be less than ten minutes. This pressure relief is incorporated into the design of all shafts, including active and passive sites.

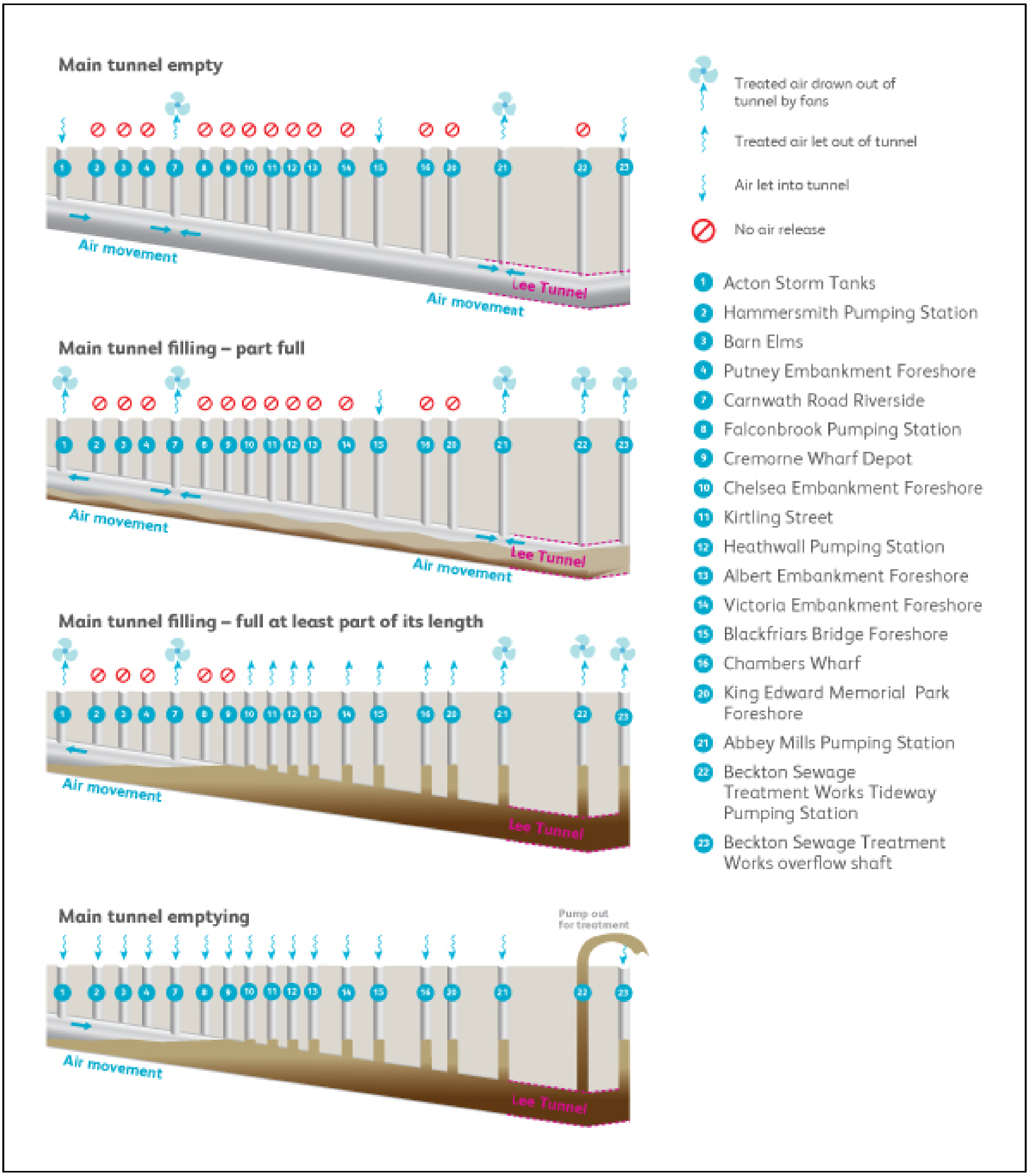
3.3.15 At locations with passive odour treatment, air intake and air release would be regulated by the pressure difference across the carbon filter. No air is released until rising wastewater during tunnel filling seals the shaft and the pressure rises within the shaft to push the air through the filter.

[xi] Based on 850 hours of inflow and 1,200 hours of pump-out.

3.3.16 As a further precaution against possible adverse air releases, small diameter vent columns similar to existing vent columns on the sewer network are included in the design of the interception chambers. These air vents would generally allow air inflow but occasionally may release air when wastewater is flowing into the particular shaft while the wastewater in the shaft is rising forcing air back to the interception chamber. This would result in short duration air releases at about half the sites as short-term discrete events lasting on average for a total of about ten hours in a typical year. Under such infrequent circumstances, the vent columns would also allow the interception chamber to vent whenever wastewater is diverted to the river.

3.3.17 Plate 3.3 provides schematic diagrams of how the air management system works in different tunnel filling scenarios.

Plate 3.3 Air management system operation



3.4 Odour sources

3.4.1 Air would be released from the system at the 22 sites (24 shafts) identified above. On average for 99.7% of the time at active ventilation sites, this would be treated air and therefore would not be odorous. For rare occasions, associated with heavy rain, a portion of air releases would bypass treatment and vent to the atmosphere. This air would be released at high level (15m above ground level), where dispersion and dilution is better. The effect of rain is accounted for in the assessment of the dispersion parameters. The quality of the air released would be similar to the air quality that is associated with the current CSO discharges and would not cause odour nuisance or significant loss of amenity.

3.4.2 Also associated with sewage is the generation of hydrogen sulphide (H_2S, a rotten egg smell). Both odour and H_2S generation is based on the amount of odour-forming constituents in combined sewage. Other constituents of odour emanating from sewage are described in Table 3.3.

Table 3.3 Typical odorous compounds

Odorous compound	Odour type	Recognition ppm
Amines	Fishy	4.7
Ammonia	Ammoniacal	37
Diamines	Decayed fish	Not available
H2S	Rotten eggs	0.0005
Mercaptans (methyl/ethyl)	Decayed cabbage	0.001
Mercaptans (butyl/crotyl)	Skunk	0.001
Organic sulphides	Rotten cabbage	0.001
Skatole	Faecal matter	0.019

3.4.3 Since the H_2S concentration in the air is measurable by probes, whereas odour is not, H_2S is used as the surrogate gas for determining the level of odour. Following a sampling programme throughout London, the relationship between the H_2S concentration and the odour level has been derived and is applied in assessing the odour in the air exhausted from the tunnel.

3.4.4 Air movement out of and into the tunnel is a function of how the tunnel system fills and empties and how air is therefore displaced. With simulation of air displacement and the quality of that air based on the H_2S generated, estimates of air exhaust rates and the concentration of odours can be produced. These rates and quality of release are based on conservative input parameters to meet a design objective of a robust and reliable system, with low risk of a significant loss of amenity or nuisance odours.

3.4.5 The *National Policy Statement for Waste Water* advises that the Environment Agency methodology is consulted. This methodology sets an impact exposure standard to be applied at sensitive receptors such as housing, hospitals and schools of $1.5ou_E/m^3$ for the 98th percentile of hourly average concentrations at the site boundary, unless the nearest sensitive receptor is some distance away. The odour concentrations at ground level and at elevations beyond the site boundary at each site have been modelled in relation to the 98th percentile of hourly odour concentrations in a year and also the concentrations at buildings where people could be exposed. These modelling results are presented in Volumes 4 to 27 Section 4.6 of the *Environmental Statement*.

3.4.6 Two sites would operate continuously extracting air from the tunnel allowing fresh air inflow to ensure good air quality within the tunnel. The extracted air would be treated and as shown by the dispersion modelling results presented in the *Environmental Statement*, would meet the air quality requirements with there being no significant risk of nuisance odours or significant loss of amenity associated with the Thames Tideway Tunnel project. All of the sites would achieve the 98th percentile odour criterion.

3.4.7 The continuous extraction and treatment of air at the two sites creates the low pressure within the tunnel with respect to atmospheric pressure, thereby preventing the unwanted release of air at other sites. It reduces the potential for slime to develop on the tunnel walls. The slime contains anaerobic bacteria which would cause the generation of odours when the tunnel next fills with wastewater. In between storm events sediment may settle in the tunnel invert and may cause odours. Maintaining a continuous extraction of air would capture and treat any such odours.

4 Critical plant operation, maintenance and monitoring procedures

4.1 Identification of critical plant – risk assessment

4.1.1 As part of the design process, a detailed risk assessment has been undertaken for each of the locations where air could leave or enter the tunnel system. The risk assessment applies the predicted concentrations derived from the dispersion modelling. The assessment utilises the data of wastewater quality (particularly the concentration of sulphides) collected at 18 existing CSO locations throughout the catchment from 2009 to 2012. The air displaced at each shaft is determined from an air movement model applying data from the hydraulic inflows during a typical year. The quality of the air is derived from the concentration of sulphides which give rise to the generation of H_2S within the tunnel before air treatment at the carbon filters. The rate of the air released and H_2S concentration after air treatment is applied to the dispersion modelling which uses the dispersive weather conditions for the same hourly data during a typical year at each location. This modelling has been used to inform the design of air management facilities and to formulate the risk assessment.

4.1.2 The standard risk assessment is designed specifically for sewage treatment works and, as such, is not directly applicable to the Thames Tideway Tunnel project which is an infrequently operating conveyance and storage system for diluted combined effluent. The risk assessment is therefore undertaken for the tunnel system in different modes of the ventilation facilities. These modes are taken as the normal operating condition, an abnormal event and an emergency event. A level of severity and the likelihood of odour nuisance are assessed.

4.1.3 The normal operating mode considers that all the ventilation plant operates as shown on Plate 3.3. A score is assigned to the severity (0 – 5) of odour. For this mode the level of severity is taken as the actual 98th percentile concentration as derived from the odour dispersion model for each site. This is taken to be a linear variation to the nearest whole number with 0 equivalent to a 98th percentile of 0ou_E/m^3 and 5 equivalent to the 1.5ou_E/m^3 limiting criterion used to assess compliance with the odour standard. A score is assigned to the likelihood (0 – 5) that the odour would cause a nuisance, from 0 for no nuisance to 5 for significant nuisance. An odour nuisance is taken to be an odour event that interferes with a person's enjoyment of their property or of an amenity such as an open space. For the normal operating mode the 98th percentile levels of odour are likely to occur during the typical year but these levels would be lower than 1ou_E/m^3 and therefore unlikely to be detected[xii].

[xii] 1ou_E/m^3 is taken as the level of odour which is detected by 50% of people under laboratory conditions; in open air there is a low risk of detection.

4.1.4 As such, the likelihood of nuisance is taken as to be low and a score of 1 is applied. The severity of odour is multiplied by the likelihood of nuisance to give an ‘odour emission risk’ score for each site. The possible score ranges between 0 (zero risk) and 25 (maximum risk).

4.1.5 Table 4.1 gives the results for the normal operating mode from which the maximum ‘odour emission risk’ is 1, hence low when compared with the maximum possible risk.

4.1.6 An abnormal event would be an event out of the ordinary that is not expected to occur throughout the duration of a typical year. Such an event could consider that both of the key ventilation facilities at Abbey Mills and Carnwath Road Riverside are not available. Under the tunnel empty scenario these two facilities would normally be operating continuously as shown on Plate 3.3 and explained in Section 3.3. Should this plant be unavailable the remaining operating plant at the Beckton Overflow Shaft and Connection Shaft and Acton Storm Tanks can extract sufficient air to maintain the negative pressure relative to atmospheric and can provide the minimum one air change per day throughout the tunnel system. Under this abnormal event, when the tunnel system is filling the ventilation facilities at the Beckton Overflow Shaft and Connection Shaft would become locked-out as the tunnel fills from the eastern end. In this case most of the active air treatment for the main tunnel would be at the only available facility at Acton Storm Tanks. The active plant at Greenwich Pumping Station can provide limited air treatment until it is locked-off from the main tunnel by rising wastewater at Chambers Wharf. The peak air release at Acton Storm Tanks would exceed the treatment capacity more frequently than under the normal operating mode, thus the number of hours of untreated air bypass would increase. Table 3.2 shows that under the normal operating mode, bypass events would be infrequent at Acton Storm Tanks (about nine hours per annum) and 99.9% of the emissions are treated. Under this abnormal mode bypasses would increase to about 80 hours per annum and treated air releases would reduce to 99.0%. At Acton Storm Tanks the 98th percentile odour level is estimated to rise to about 0.8ou_E/m^3 giving a severity score of about 3 for this abnormal event. The likelihood of nuisance is estimated to give an even score of about 3 giving an odour emission risk score of 9. At all other sites the ‘odour emission risk’ would remain as given in Table 4.1.

4.1.7 An emergency event could be depicted as a complete failure of all the ventilation facilities throughout the tunnel system. Each of the six active ventilation facilities has duty and stand-by extraction fans and a complete failure of all the ventilation plant is unlikely unless there is a city wide power outage. Even under such an onerous condition a proportion of air displaced from the tunnel during a filling event would pass through the passive filters. The active ventilation plant would also behave as passive filters. An ‘odour emission risk’ for this emergency condition is not predictable and hence is not evaluated.

4.1.8 Representative receptors that could be affected by air release are taken to be receptors at ground level immediately outside the boundary fence of a facility within a Thames Water compound or at 5m from the emission point when within public land.

4.1.9 The need for operational mitigation and communication with potential receptors is identified on the basis of the 'odour emission risk' scores identified for each site.

Table 4.1 Normal operation risk assessment

Site location	Severity(1)	Likelihood of nuisance(2)	Odour emission risk
Acton Storm Tanks	1	1	1
Hammersmith Pumping Station	0	1	0
Barn Elms	0	1	0
Putney Embankment Foreshore	0	1	0
Dormay Street	0	1	0
King George's Park	0	1	0
Carnwath Road Riverside	1	1	1
Falconbrook Pumping Station	0	1	0
Cremorne Wharf Depot	0	1	0
Chelsea Embankment Foreshore	0	1	0
Kirtling Street	0	1	0
Heathwall Pumping Station	0	1	0
Albert Embankment Foreshore	0	1	0
Victoria Embankment Foreshore	0	1	0
Blackfriars Bridge Foreshore	0	1	0
Chambers Wharf	0	1	0
King Edward Memorial Park Foreshore	0	1	0
Earl Pumping Station	0	1	0
Deptford Church Street	0	1	0
Greenwich Pumping Station	1	1	1
Abbey Mills Pumping Station	1	1	1

Notes:

(1) The severity score is taken as a linear variation of the modelled 98th percentile odour level to the nearest whole number from 0 for 0ou$_E$/m^3 to 5 for 1.5ou$_E$/m^3, the latter being the Environment Agency compliance standard for offensive odours.

(2) The score for the odour causing a nuisance is from 0 for no nuisance to 5 for significant nuisance. The likelihood of the 98th percentile odour level causing a nuisance is taken as low; hence a score of 1 is applied.

4.2 Operational baseline control measures

4.2.1 As part of Thames Water's Best Operating Practice a Site Operating Manual (SOM) would be prepared for each site. The SOM would identify the operational procedures to be followed in order to maintain and operate plant to Thames Water's standards, which include housekeeping procedures to ensure that the generation of odour is minimised.

The operation of the odour control equipment would form part of the SOM along with other operating practices for the site including the operation and control of components such as flow, depth and gas monitors, ventilation plant, dampers and penstocks. Relevant data included in the SOM can be made available to the relevant local authority on request.

4.2.2 The main air management, odour control and abatement practices for the Thames Tideway Tunnel project are the passive and active ventilation systems and odour control units, as described in Section 3.3.

4.2.3 For passive systems the plant would self-operate through the pressures which develop in the shaft. As such the operational procedures include inspection and maintenance of dampers and gas monitors and recording the H_2S concentrations before and after the passive filter.

4.2.4 The operation of the active ventilation systems would be automatically controlled by the detection of wastewater levels in the tunnel system. The operational procedures are to inspect and maintain dampers, fans and carbon filters and monitoring H_2S concentrations.

4.3 Performance checks

4.3.1 The following routine monitoring procedures for the odour control system would be used:

a. Quarterly assessment of odour abatement performance at each location in terms of H_2S generation and capture. The performance would be assessed based on data logged records of H_2S concentration before and after treatment. These records would be analysed to determine how the system is performing and used to determine if any remedial action is required. It is proposed that record inspection and analysis would be conducted for at least three years after start of operation.

b. Should records indicate good performance at passive filter sites, which operate infrequently (on average less than 20 hours per year, see para. 3.3.7), the inspection and analysis would be discontinued. Carbon media replacement at such passive filters would be determined by sampling the media or on a regular cycle.

c. At all active sites there would be continuous recording of H_2S levels in air extracted from the tunnel (see Section 4.5 below). It is proposed that H_2S monitoring would be maintained for at least three years after start of operation and, if records indicate good performance, such H_2S monitoring would continue at a reduced frequency as required to determine when carbon is depleted.

Good performance is deemed to occur when actual measured emission levels are modelled and show that the 98th percentile does not exceed $1.5ou_E/m^3$ at receptors.

d. Quarterly inspection of the active odour control units to confirm proper operation. Any actions necessary to maintain the performance of the units and the required frequency of media replacement would be implemented through the maintenance system developed for the project (see Section 4.4 below).

4.4 Maintenance and inspection of plant and processes

Routine

4.4.1 In addition to the routine operational tasks, planned preventative and defect maintenance of all plant would be carried out. Maintenance requirements would be documented in the SOM and preventative maintenance or defect repairs records would be captured in the Thames Water system. Relevant details can be made available to the relevant local authority on request.

4.4.2 An inspection and maintenance regime would be established for the new ventilation and odour control systems to be installed as part of the project. The ventilation and odour control units at each site would receive the following inspection, as a minimum:

a. Check of duty/standby fans and motors once every three months.

b. Check on residual lifetime of OCU media once every three months.

c. Retention of critical spares for each OCU (required spares to be confirmed with the supplier).

4.4.3 The condition of the media in the OCU would be monitored by performance checks (see Section 4.3) and by additional testing, as required. The life of the carbon filters would depend upon the H_2S loading of the tunnel air, the capacity of the filter and the volume of tunnel air that the carbon filter treats. The expected life of the filter at each site assuming the release rates of a typical year has been calculated to be greater than three years and, for passive filters, up to ten years. A three year cycle of replacement is, however, assumed.

4.4.4 The active ventilation plant sites within Thames Water compounds would be visited on at least a weekly basis as a matter of course. Active ventilation plant sites and the passive filter sites would be visited quarterly for general inspection and maintenance.

Fault reporting

4.4.5 Faults identified in the routine inspections would be reported to the Air Management System Manager, who would determine the severity of the fault and the appropriate response time, in accordance with the ‘odour risk assessment.’

4.4.6 Faults affecting the normal operation mode (para. 4.1.3) would be rectified within 48 hours, whilst faults associated with the abnormal mode would be rectified within one week depending on the availability of spare parts.

Emergency

4.4.7 For an emergency condition, 24 hour maintenance cover would be available, and under control and discretion of the Air Management System Manager. Less urgent repairs are assessed for criticality and dealt with during normal working hours.

4.4.8 An emergency would involve the complete failure of all the ventilation facilities throughout the tunnel system.

4.4.9 With regard to emergency fault/breakdown and incident response procedures, responses to failures of the ventilation sites would be covered in the Disaster Recovery Plan documents to be prepared for each site, which cover scenarios including:

a. failure of control: failure of telemetry, sensor, or control systems

b. electrical failure: failure of grid supply

c. prolonged non-access to site due to event at site or local to the site (eg, bomb scare, fire, flood or emergency services controlled incident).

4.5 Monitoring

4.5.1 The active odour control plant would have sufficient instrumentation and telemetry to allow any faults to be detected remotely at a central operations control station. Signals which would be recorded include:

a. logging of carbon unit hours of operation

b. pressure loss across the carbon unit

c. probes logging the H_2S levels in the inlet and exhaust air

d. fail/healthy signal for the fan motors

e. status of the fan motors and operational hours

f. position indication of the pressure relief dampers

g. alarms for unauthorised access.

4.5.2 Alarms would be in place to indicate a ‘fault’ to one of the components of the air management system. This fault indication would then be further interrogated to determine which component is at fault.

4.5.3 This monitoring would be undertaken continuously. The data is required for scheduling maintenance and replacement works.

4.6 Operator training

4.6.1 All technicians/operators involved in maintenance and monitoring would receive training in the odour control systems appropriate to their grade. All records of staff training would be held on a central training database.

4.7 Record keeping

4.7.1 Records of OCU monitoring, maintenance and media replacement would be kept at a central location and, when appropriate, for operation and maintenance on site at active control sites. Such records would be made available to the relevant local authority on request but without obligation.

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5 Public communications

5.1 Public complaints process

5.1.1 It is envisaged that the public would contact either their local authority or Thames Water Customer Service at the Customer Centre. Details of the different communication routes are summarised in Plate 5.1. Members of the public are encouraged to communicate via the Customer Services to ensure all contacts are recorded and followed up.

5.1.2 All locally received complaints would be redirected or forwarded to Customer Service and be logged on the Thames Water Complaint Database by the Customer Service Gate Keeping Team.

5.1.3 The Customer Service Gate Keeping Team would pass complaints deemed to be related to the tunnel system to a team provisionally named the Thames Water Tunnel Team. This team would investigate the complaint to assess the validity and severity of the complaint. Where the complaint is deemed to be minor or not related to the tunnel system an assessment is made without a field visit. Otherwise a field visit would be instigated and, where there is an odour issue which is out-with the compliance standards, mitigation works would be carried-out. In all instances the Thames Water Tunnel Team report back to the Customer Service Gate Keeping Team who would issue a response to the complainant. The Customer Services Gate Keeping Team would record the response and any works carried-out on the Complaint Database. Relevant information would be passed to the local authority on request.

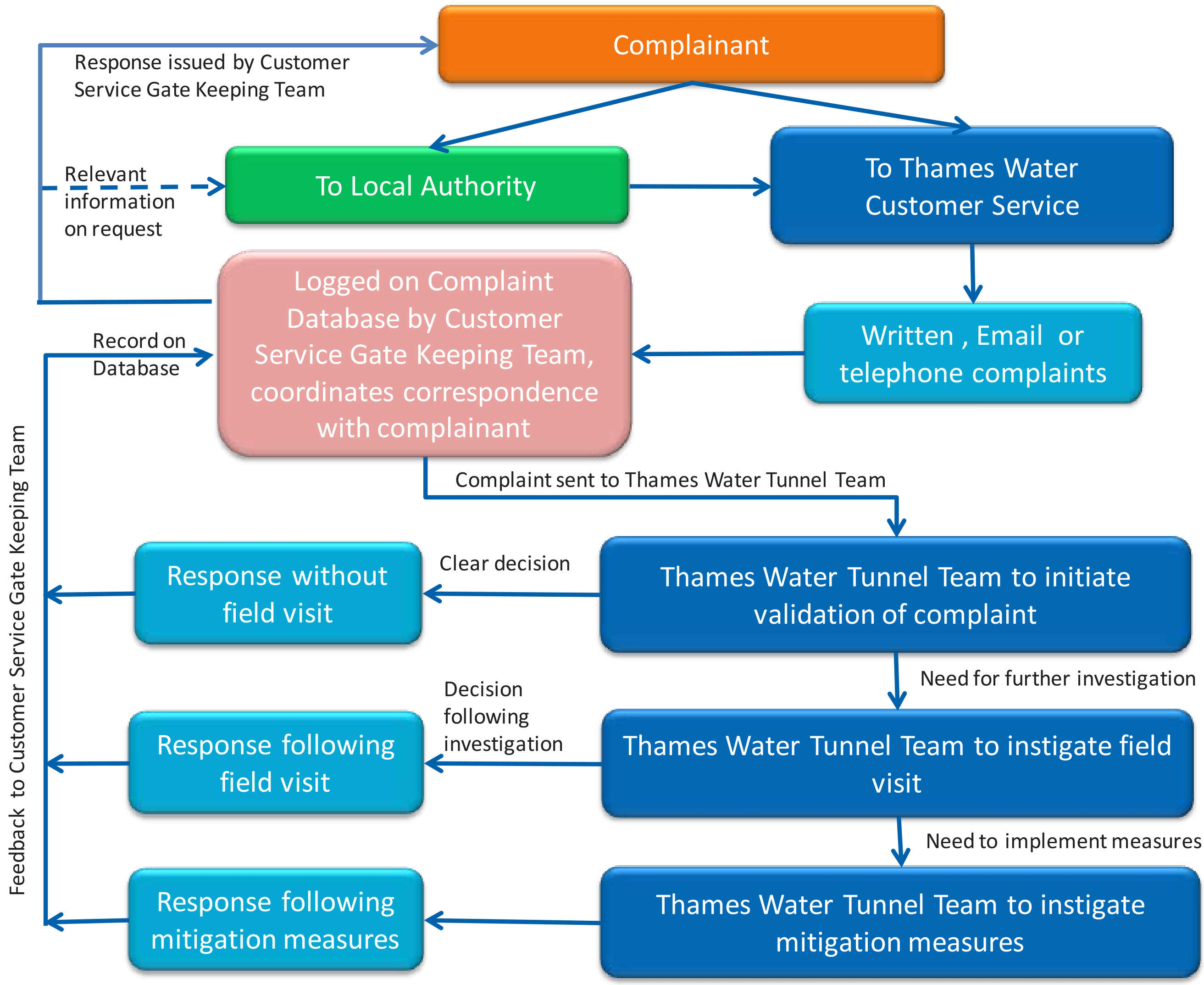
5.2 Complaint validation

5.2.1 Complaints received would be checked and validated by Thames Water within ten days of the receipt of the complaint. This may be done with reference to site inspection, visit to the complainant, site activities and weather conditions. The H_2S readings at the particular site can be interrogated.

5.2.2 All contacts would be recorded by Thames Water on the Complaint Database.

5.2.3 Statutory bodies can request Thames Water to provide the details of the validation process and subsequent mitigation with respect to any particular complaint and Thames Water can provide relevant data on request.

Plate 5.1 Complaints structure flow chart[xiii]



[xiii] The complaints structure flow chart has been prepared with assistance from Thames Water, but it is acknowledged that this complaints structure will have evolved by the time the Thames Tideway Tunnel project is constructed.

Glossary

Active	Fan driven air management facility
Passive	Air management filters without fans

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References

[1] Thames Water, *Abbey Mills Pumping Station Odour Management Plan* Version 1.0, (December 2008).

[2] Thames Water, *Beckton Sewage Treatment Works Odour Management Plan* Version 1.1, (November 2008).

[3] Thames Water, *See citation above.*

[4] Thames Water, *Odour Management Plan for Beckton STW Enhance Digestion*, (July 2010).

[5] Thames Water, *Olympic Park Blackwater Treatment Plant Odour Management Plan*, (July 2011).

[6] Defra, *National Policy Statement for Waste Water*, (March 2012).

[7] Environment Agency, *H4 Odour Management, how to comply with your environmental permit*, (March 2011).

[8] Thames Water, *Standard Practice Document E04: Zoning of Hazardous Areas*, Issue 4.0, (May 2009).

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