SILVERTOWN TUNNEL

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1. Overview

1.1. Introduction

The Silvertown Tunnel (STT) scheme involves the construction of a twin bore road tunnel providing a new connection between the A102 Blackwall Tunnel Approach on the Greenwich Peninsula (Royal Borough of Greenwich) and the Tidal Basin roundabout junction on the A1020 Lower Lea Crossing / Silvertown Way (London Borough of Newham). The project was formally granted planning permission through a Development Consent Order (DCO) issued by the Department of Transport in May 2018. STT will be approximately 1.4km long and able to accommodate large vehicles including double-decker buses. It will include a dedicated bus, coach and goods vehicle lane, enabling TfL to provide additional cross-river bus routes. The scheme also includes the introduction of free-flow user charging on both the Blackwall Tunnel (northern portal located in London Borough of Tower Hamlets) and the new Silvertown Tunnel.

Transport for London (TfL) have entered into a Project Agreement with the Project Company Riverlinx (Project Co) who are responsible for the detailed design, construction, financing and maintenance of the tunnel and supporting infrastructure. A 5 year period of design and construction will be followed by a further 25 years of operation and maintenance. The Project Co has appointed Riverlinx CJV as the Design and Construction (D&C) Contractor responsible for undertaking the detailed design and construction of the STT scheme all in accordance with the constraints and parameters of the Development Consent Order (DCO), TfL specifications and other commitments made by TfL to stakeholders. Riverlinx CJV is a joint venture formed between Ferrovial Agroman (UK) Ltd, BAM Nuttall and SK Engineering and Construction Co Ltd.

1.2. Purpose

The purpose of the Groundwater Monitoring and Verification (GMVP) is to detail how Riverlinx CJV will set out groundwater monitoring and reporting criteria during preconstruction, construction and post-construction. The GMVP will be updated for each stage and may include additional revisions as further understanding of groundwater behaviour in the area is understood through the design and construction phases of STT. The early versions of the GMVP will be centred on the pre-construction period where the focus is on interpreting baseline conditions set against the emerging design and construction proposals for STT. Riverlinx CJV will consult with and seek approval from the Environment Agency for the GMVP as required under the DCO.

A Groundwater Monitoring Strategy was developed to support the Environmental Statement as part of the DCO application. It provides an overarching framework for groundwater monitoring in order to assess the potential impact on groundwater resources as a result of the project. The focus was to assess the potential impacts on groundwater quality and quantity within the Upper, Intermediate and Lower Aquifers across Greenwich and Silvertown as a result of construction (including any dewatering activities). This includes measures to monitor the following:

- baseline groundwater quality and quantity conditions prior to construction;
- changes in groundwater quality and levels as a result of dewatering and the effectiveness of mitigation measures to counter these effects;
- changes to the local hydrogeological regime as a result of construction and the effects on neighbouring structures and associated potential contaminant transport;
- the effects of long-term changes in groundwater pressures and the design of the tunnels and structures to accommodate these changes;
- potential for mobilisation of contaminants already present in groundwater by the creation of alternative pathways, using sentinel monitoring boreholes to assess the impacts;
- early identification of trends towards derogation of pumping rights. Such monitoring would also inform mitigation actions that would need to be taken in the event of derogation; and
- potential increased turbidity in groundwater due to the physical action of tunnelling construction within the Lower Aquifer and subsequent migration with the prevailing groundwater flow.

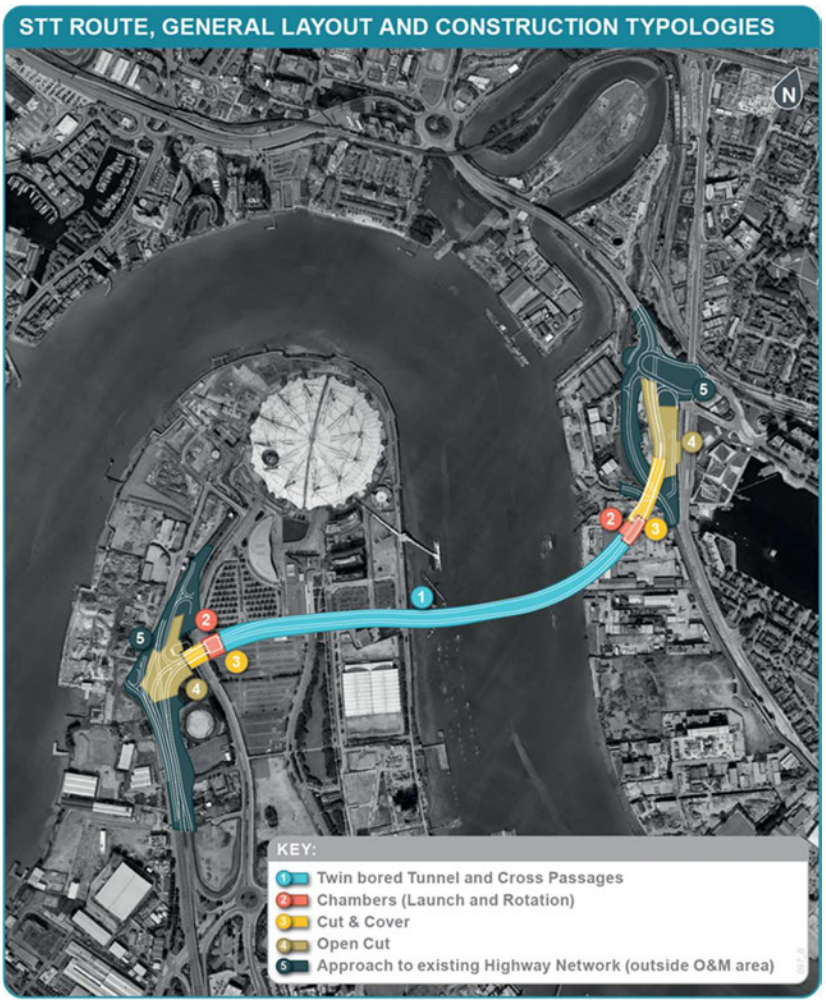
This document sets out a strategy to monitor groundwater during the life cycle of the STT. Following the development and implementation of baseline groundwater monitoring, the data will be used to inform the following:

- detailed tunnel design and subsequent dewatering requirements (if required);
- site specific preliminary groundwater risk assessments and detailed groundwater risk assessments (if required);
- development of alert and trigger levels for construction;
- the update of the GMVP; and
- a Groundwater Control Strategy.

1.3. Project Details

Figure 1 below shows the STT route, general layout, and construction typologies. The tunnel will cause changes to the existing road network on both sides of the River Thames. On the south side of the river, the following changes to the A102 Blackwall Tunnel approach will be needed; widening the A102 Blackwell Tunnel approach to create space for STT approach lanes, building a new flyover for the southbound traffic from the Blackwall Tunnel to cross above the Silvertown Tunnel approach lanes and introducing new signage to direct traffic. On the north side of the river, the following changes will occur; modification of the existing Tidal Basin Roundabout to connect the STT approach roads with Dock Road, realigning the Dock Road so that it links with the modified roundabout and introducing new pedestrian and cycle facilities within the modified roundabout.

Figure 1 STT General Layout



2. Planning

2.1. Objectives

Based on the source-pathway-receptor linkage model, monitoring of groundwater is proposed to enable the following:

Baseline:

- collection of a groundwater level dataset to be used as a baseline such that an assessment can be completed as to whether or not the tunnel has significantly impacted groundwater flow during construction and operation;
- collection of a groundwater quality dataset to establish baseline groundwater quality, identify trends and determine trigger levels, where possible;
- assessment of risk of mobilisation and migration of pre-existing contaminants affecting the groundwater (i.e. if source-pathway-receptor linkages exist);
- direct the placement of sentinel monitoring boreholes to be utilised during construction to ensure that mobilisation of contaminants is not adversely affecting identified receptors; and
- enable the development of site specific alert and trigger levels and the development of a contingency plan.

Construction and Post Construction Phases:

- Collection of groundwater level dataset during both phases, to establish whether groundwater levels have been affected by dewatering and tunnel seepages.
- Collection of groundwater quality samples during both phases, to establish whether:
  - mobilisation and migration of contaminants has taken place; and
  - significant changes in water quality as a result of dewatering and tunnel seepages have occurred.
- To ensure alert and trigger levels are not exceeded and if they are that the contingency plan is activated.

2.2. Code of Construction Practice Requirements

Riverlinx CJV, in developing the final construction methodology will consider suitable control methods to manage groundwater ingress and dewatering. Riverlinx CJV will seek to ensure good practice is employed to establish ground and groundwater conditions, including verifying the presence of geotechnical hazards such as scour features in the vicinity of the scheme alignment, and that the most appropriate groundwater exclusion or management method is adopted to minimise risks. Riverlinx CJV will control the abstraction of potentially contaminated water from excavations through the adoption of mitigation measures as outlined in the Environment Agency's PPG5. To prevent additional land and groundwater contamination Riverlinx CJV will adhere to the EA Pollution Prevention Guidelines, including (but not be limited to) the following pollution prevention measures:

- Silt pollution potentially produced when working in surface water will be minimised by keeping water out of work areas, using appropriate isolation techniques or through operation of special excavation plant. Any water generated from such activities will be disposed of by following guidance set out in the Environment Agency's document PPG5 – Works and maintenance in or near water;
- Surplus waste slurry / water produced during tunnel construction will likely require filtration prior to its disposal, because of the anticipated quality. Where necessary, a permit and licence will be obtained;
- Polymers used for operation of the tunnel boring machine (TBM) will be bio-degradable and non-hazardous to the water environment. Agreement with the Environment Agency will be sought prior to their use and any licences obtained (where necessary). Discharges which contain polymers will be tested to show that they are bio-degradable and low risk to the water environment;
- Provision of wheel washing facilities and defined clean down areas for vehicles and equipment;
- Regular cleaning of site access points;
- Defined areas for loading / unloading of plant and materials;
- Defined areas for the storage of plant and materials used during construction;
- Production of and adherence to an emergency spill response plan (as part of the Emergency Plan developed in consultation with the Environment Agency), and ready availability of associated equipment and materials;
- Groundwater and dewatering control measures;
- Sediment control measures (compliant with the Site Waste Management Plan); and
- Methods for the removal and reinstatement of obstructions (e.g. piles).

Riverlinx CJV will apply for any permits and licences that may be needed for excavation and dewatering purposes. These are outlined below:

- Environmental Permit - a Discharge Licence (e.g. for discharge of excavation water into a watercourse, should waste water meet the Environmental Quality Standards (EQS) for discharge);
- Environmental Permit - a Mobile Treatment Plant Licence (e.g. for treatment of contaminated soils or contaminated groundwater prior to disposal);
- Transfer Licence – a licence to pump more than 20 m/d of groundwater as part of dewatering operations.

2.3. Scope of Groundwater Monitoring

The groundwater monitoring programme will be initiated ahead of construction to enable collection of baseline data and will incorporate historic groundwater monitoring points in the area of the scheme to determine the baseline. The data obtained will be used to quantify any potential impacts produced by the scheme. The construction phase groundwater monitoring regime will be designed following an assessment of the baseline data and be set against the detailed design of the scheme and proposed construction methodologies. This construction phase monitoring data will be compared against the baseline data and agreed alert and trigger levels in the event of an identified risk starting to materialise.

The monitoring regimes for each phase, baseline, construction and post-construction, of the scheme are to be described in this Plan and be updated at appropriate intervals ahead of the next phase. The Plan and relevant regime will be also be updated in for changes to the anticipated impacts on groundwater levels or groundwater quality as a result of any variations in design or construction or site conceptual model. The post construction monitoring will depend on the extent of the impact the development has on the groundwater environment. This will be identified through an assessment of the baseline and construction monitoring data and the associated detailed design. Post construction monitoring will be undertaken until groundwater elevations and groundwater quality stabilise.

2.4. Roles and Responsibilities

The Riverlinx CJV Project Director is responsible for the implementation of the GVMP during the design and construction of STT. Many members of the Riverlinx CJV also have responsibility for elements of groundwater monitoring appropriate to their function, experience and seniority. The Riverlinx CJV Environmental Manager will lead on groundwater monitoring and act as the key advisor on all related matters including compliance with this Plan. The Environmental Manager will be supported by water specialists to lead on technical matters. Water specialists shall meet the minimum qualifications and experience described in Table 1 below;

Table 1 CJV Environmental Specialists Competency

Environmental specialism	Specialist's minimum qualifications and experience
Hydrology, groundwater and surface water	A full member of the Charted Institution for Water and Environmental Management or equivalent with a minimum of 3 years relevant post qualification experience.
Water quality	A full member of the Charted Institution for Water and Environmental Management or a Chartered Chemist and member of the Royal Society of Chemistry or equivalent with at least three years' experience.

Table 2 provides details of the personnel working on the project with specific responsibilities in relation to groundwater monitoring.

Table 2 CJV GMVP Roles and Responsibilities

Role Title	Responsibilities
Project Director	• Provide adequate environmental resources and support to effectively deliver the requirements of this Plan
Environmental Manager	• Develop and implement the GMVP • Identify and maintain compliance with the requirements and principles of the GMVP • Assist lead auditors in auditing the GMVP • Identify, develop and provide environmental training as required specific to the GMVP • Approve method statements and consider GMVP requirements • Advise and instruct construction teams in the event of incidents and complaints • Liaise/meet with external stakeholders
Environmental Advisors	• Inspections on compliance with the GMVP requirements • Brief GMVP requirements to relevant teams • Advise and guide project team in the implementation of groundwater protection practices • Identify ideas for improvement to environmental manager for consideration • Report best practice across the project • Assist in incident investigations and reporting • Encourage near miss reporting and identify trends
Water Specialists	• Provide technical support on surface/groundwater issues in respect of the design and construction phases • Advise on effective reporting and monitoring regime for the baseline, construction and post construction phases
Section Manager	• Ensure the requirements of the GMVP are implemented on site • Ensure the requirements of the GMVP are integrated into all aspects of the works and detailed in method statements • Manage the investigation and response to complaints
Community Construction Liaison Manager	• Liaise with the local community regarding any complaint or query • Notify the Section Manager and environmental team of any complaints regarding groundwater • Manage investigations into the complaints and provide the main point of contact with the helpline
All Personnel	• Carry out the works in accordance with agreed methods and briefings • Report anything that deviates from agreed processes • Report all incidents and examples of best practice to section managers • Attend environmental training

2.5. Training and Awareness

The Riverlinx CJV Environmental Team will provide training to staff and operatives at all levels (and, when appropriate, to others involved in or affected by work activities) to achieve and maintain a high standard of environmental awareness and risk control. Riverlinx CJV will work collaboratively to develop the GMVP and embed the requirements into the programme. The established practices will be briefed to all those who work for or on behalf of Riverlinx CJV in order to best achieve compliance with the Plan. Environmental information on groundwater will be displayed in offices and site cabins to increase awareness of specific matters. Such information will include details on the groundwater monitoring locations, dewatering plans and groundwater protection measures.

All those working for Riverlinx CJV or on behalf of Riverlinx CJV shall undertake an induction that includes an introduction to the key aspects of environmental management on the project including information on the GMVP. In

addition, all Riverlinx CJV personnel will undertake the bespoke Environmental Awareness training session that will introduce personnel to the management of site environment risks relevant to STT and provide practical guidance for specific topics including groundwater monitoring and protection. The Environmental Team, the Water Specialists and the Riverlinx CJV construction team will deliver groundwater protection themed toolbox talks to site and office teams making use of best practice materials from parent companies and organisations such as CIRIA.

2.6. Communication

The Riverlinx CJV Environmental Manager, Consents Manager and members of the Environmental Team will meet the Environment Agency as required to discuss groundwater monitoring matters including the contents of the GMVP. Riverlinx CJV will consult the Environment Agency before making formal submissions to ensure all comments can be addressed and incorporated as applicable. Meetings and consultations with other interested parties will be arranged as necessary. Sections 6 and 7 below go in to greater detail on how the CJV will report groundwater matters and interface with the Environment Agency through the construction period including alert levels and trigger levels, emergency measures and reporting. The Riverlinx CJV Community Relations representative will maintain dialogue with local communities and associations by various means including the Helpdesk. Should groundwater issues arise due to construction activities, Riverlinx CJV will report details to the Environment Agency. The Riverlinx CJV Environmental Manager will participate in monthly Environmental Review Meetings with Project Co and TfL counterparts to review progress during construction including compliance against the GMVP.

3. Groundwater Control Summary

3.1. Overview of hydrogeology

The hydrogeological model of the site and the scheme design information informs the baseline groundwater quality monitoring strategy. The ground conditions relevant to groundwater control are;

- Upper Aquifer: River Terrace Deposits (RTD) (Secondary A aquifer)
- Upper Aquitard: London Clay Formation
- Intermediate Aquifer: Harwich Formation, Lambeth Group Laminated Beds (Secondary A aquifer)
- Lower Aquitard: Lambeth Group (Lower Shelly Beds, and in some locations clays within the underlying Lower Mottled Beds)
- Lower Aquifer: Lambeth Group (Upnor Formation and in some locations sands within the overlying Lower Mottled Beds), Thanet Sand Formation (Secondary A aquifer) and Chalk Group (Principal aquifer).

The following sections describe the groundwater control measures for each element of Silvertown Tunnel

3.2. Portals and approach structures

The portals and approach structures on both sides of the river will be constructed within areas enclosed by vertical cut-off walls penetrating down to the Upper Aquitard. Groundwater control in the RTD will comprise pumping to remove the water trapped within the structure, above the Upper Aquitard. There will be no significant longer-term abstraction from the RTD; there should be negligible impact on groundwater levels in the RTD external to the cut-off walls due to groundwater control pumping. The deeper sections of the approach structures, including TBM launch and recovery structures will require some pressure relief pumping from the Intermediate Aquifer. It is anticipated that the distance of influence due to depressurisation pumping will be less than 500m in the Intermediate Aquifer.

3.3. Tunnelling Works

The two main tunnel drives are to be constructed using an earth pressure balance (EPB) TBM boring through the Upper Aquitard and Intermediate Aquifer and this is not expected to significantly influence the groundwater levels. By this method the TBM applies a counter pressure to the face to stabilise the ground and balance groundwater pressures. There will be no significant groundwater abstraction, and there should be negligible impact on groundwater levels due to groundwater control during tunnelling.

3.4. Cross Passages

There are also 7 mined cross passages connecting the two main tunnels along the route; these will be excavated using Sprayed Concrete Lining (SCL) techniques, which involves a sequence of short rounds of open excavation, followed by the application of sprayed concrete support. The ground conditions encountered by the cross passages are variable but all are expected to encounter water-bearing cohesionless soils in some areas. Some form of groundwater control will therefore be needed during construction of these for safe excavation. Based on the geotechnical information available it is marginal whether or not a grouting/groundwater depressurisation scheme would be feasible in some of these soils and therefore further investigation is proposed to establish this, but it may be that artificial ground freezing is needed for some of the cross passages.

Should dewatering be adopted for the cross passages, this is expected to be mainly within the Intermediate Aquifer, with the exception of one cross passage which is within the Upper Aquifer. However, given the close proximity of the invert of some cross passages to the Lower Aquifer it is envisaged that local depressurisation of this aquifer may be needed at some locations. These requirements will be assessed as the design develops. If a grouting/groundwater depressurisation scheme is chosen for the cross passage ground treatment, then it will be necessary to monitor the groundwater levels locally during excavation, to ensure that adequate drawdown is achieved and maintained to allow safe excavation. The existing monitoring wells are not located sufficiently close to the cross passages to provide the necessary reassurance during construction. When new monitoring wells were chosen for the additional site investigation work (see Section 5), one of the considerations was ensuring that they are suitably located to allow them to be useful for construction monitoring also. This requires them to be as close

as possible to the cross passages, without risking a clash between the wells and the cross passage itself, or any grouting tubes/freezing pipes that may be needed. However, a single monitoring well for each cross passage will not be sufficient for construction; it is envisaged that additional monitoring wells will be installed, either from the surface or from in-tunnel (surface installations are unlikely to be practicable for the cross passages below the river). If artificial ground freezing is adopted, then the wells may not be needed during construction.

3.5. Silvertown Launch and Reception Chamber

The TBM drive is to launch from the Silvertown portal, proceed to the rotation chamber at Greenwich from where it will be relaunched, and return to Silvertown. At Silvertown, the face of the TBM is predominantly within the London Clay Formation (Upper Aquitard), however the tunnel crown is very close to/intersects the River Terrace Deposits (Upper Aquifer) close to the launch and reception chambers. Consequently, as the TBM breaks into or out of these chambers, there is a risk of flooding. For the TBM launch, a sealing detail in the headwall of the launch chamber headwall is to be adopted to prevent water ingress to the launch chamber, and so no impact to the external groundwater regime is envisaged. This is not the case for the TBM reception however. It is envisaged that a small cofferdam will be formed of soft piles, to enable localised dewatering of the RTDs at and above the tunnel crown, before the TBM breaks in through the chamber headwall. The cofferdam solution has been chosen to minimise the impact on the surrounding groundwater regime. Monitoring will be needed within the cofferdam to confirm that the required drawdown has been achieved before break-in.

3.6. Greenwich Rotation Chamber

As it approaches the Greenwich rotation chamber the upper part of the tunnel face is entirely within the River Terrace Deposits (Upper Aquifer). The lower part of the tunnel face is mainly within the London Clay Formation (Upper Aquitard), but potentially the invert could encounter the sandy Harwich Formation (Intermediate Aquifer) below this. Consequently, there is a risk of water ingress to the rotation chamber during launch and reception of the TBM. To stabilise the RTD at this location it is proposed to form a block of soft piles or jet-grouted soil in front of the rotation chamber, which will effectively exclude the groundwater in the Upper Aquifer. As at Silvertown, the launching arrangements include a sealing ring around the machine shield and so no further groundwater control measures are needed. But again a different technique will be used for the reception of the TBM. Although the soft piles or jet grouting will exclude the water in the Upper Aquifer, the sandy Harwich Formation (Intermediate Aquifer) at invert level could provide a water pathway into the rotation chamber. Localised deepening of any soft piles, or grouting and/depressurisation may be needed to mitigate this risk; if depressurisation is adopted then local monitoring may be needed to confirm its effectiveness before the TBM breaks into the chamber.

3.7. TBM Interventions

To date the only planned intervention (to obtain access to the TBM cutterhead for inspection and/or repair) known of is shortly after the launch at Silvertown; for this the current proposal envisages the TBM stopping within a block of soft piles, which will exclude groundwater. However as the scheme develops further interventions may be planned, and there may be a need during the works for unplanned interventions if any problems are encountered during tunnelling. Some localised dewatering may be required for these; the requirements and nature of this will be developed in due course.

3.8. Dewatering

Riverlinx CJV are currently developing the approach to dewatering for the construction of STT and shall implement suitable control methods to manage groundwater ingress and dewatering. Riverlinx CJV will liaise with the Environment Agency to determine the need for detailed assessment of dewatering impacts. The following objectives will be met:

- the project is compliant with Environmental Permitting Regulations (EPR) – Schedule 22 (England and Wales) 2010 with respect to dewatering;

- adequate protection of surface water and groundwater resources, in line with principles as set out under the Water Resources Act 2003 (required for abstraction licence applications);
- construction effects arising directly or indirectly from dewatering systems and from discharges to the water environment are mitigated; and
- movements of poor quality groundwater as a result of dewatering activities will be minimised.

The dewatering schemes are planned to discharge all dewatering water to the River Thames or to Thames Water sewer. It is not intended to discharge any dewatering water directly back to groundwater.

Riverlinx CJV will be responsible for obtaining all necessary licences and permits from the Environment Agency prior to any dewatering activitiy as required and for ensuring compliance with the conditions of all licences and permits granted by the Environment Agency. On the Greenwich Peninsula and, potentially at Silvertown, it is likely that water pumped from the ground via dewatering systems will require some form of treatment prior to discharge. An appropriate discharge point/s will be assessed prior to the commencement of dewatering and approval from appropriate statutory authorities will be obtained (i.e. the Environment Agency and/or Thames Water).

A Groundwater Control Plan will be developed. Its objectives will include mitigation of any negative environmental impacts arising directly or indirectly from dewatering systems and discharges to the water environment. The Groundwater Control Plan will be developed and submitted to the Environment Agency for approval as part of the GMVP, and will include:

- main discharge points;
- details of any dewatering well installations;
- details of monitoring network (surface and groundwater);
- details of equipment used;
- proposed construction sequence;
- licences and permits from the Environment Agency;
- prior authorisation from local sewerage provider; and
- outline of any pre-treatment required prior to discharge, approved by the Environment Agency/Thames Water.

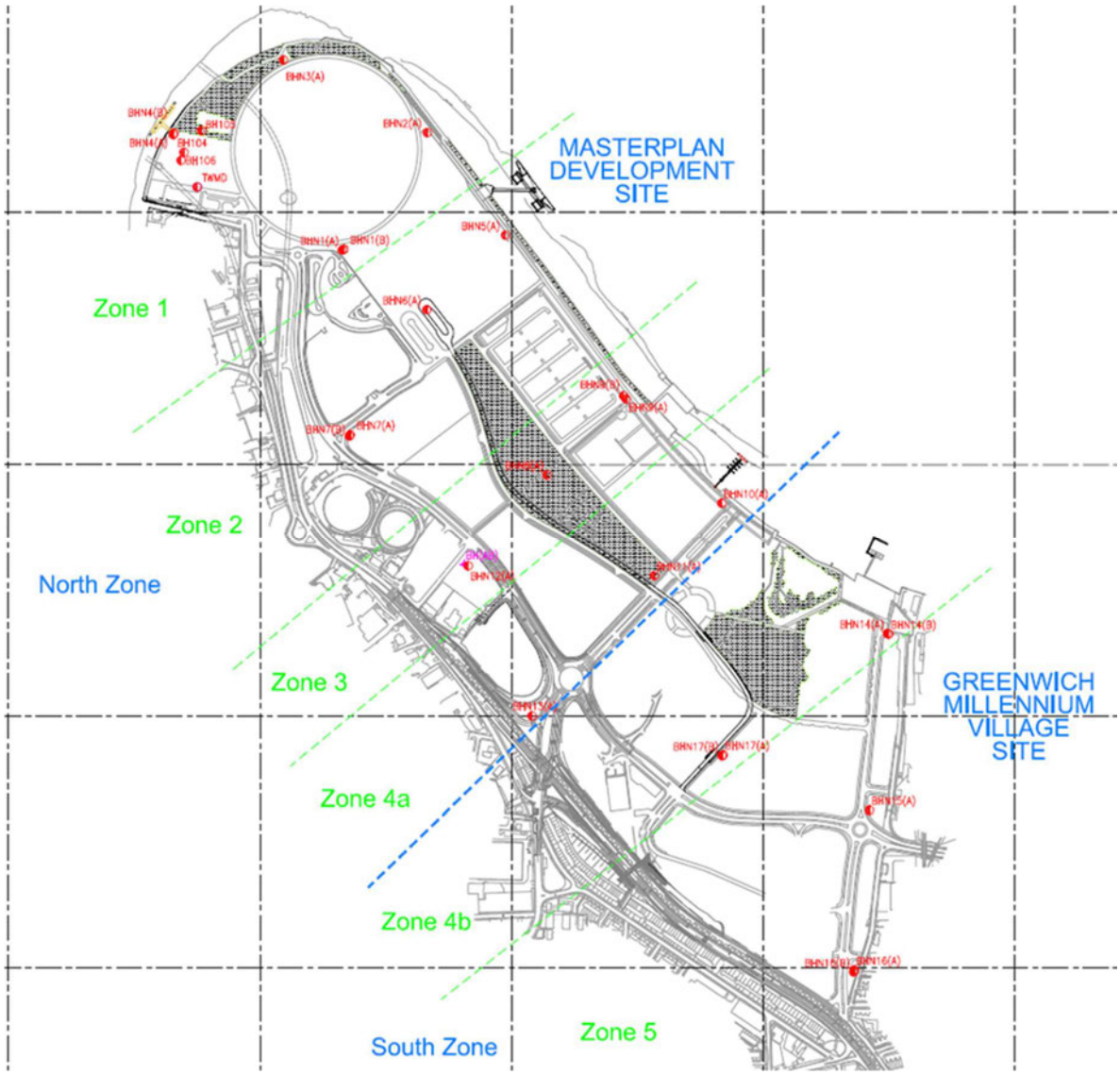
Riverlinx CJV will review and approve the site-specific groundwater control plans prior to submission to the Environment Agency for approval.

4. Baseline Setting

4.1. Groundwater Quality Baseline

On Greenwich Peninsula, groundwater monitoring has been undertaken by Atkins for English Partnerships, the HCA and most recently for the GLA, originally to satisfy a planning condition for the remediation of Greenwich Peninsula in the late 1990s. This long-term groundwater monitoring (LTGWM) has been carried out continually between 2001 and 2019, although the frequency and scope of the sampling and analysis has reduced with time, in agreement with the Environment Agency. The network of monitoring well locations were 20 in number, comprising 10 wells with response zones in the Chalk or Thanet Sand and 17 wells with response zones in the River Terrace Deposits (RTD) – there were dual installations at seven locations. The results of the monitoring are presented in a series of annual factual and interpretative reports issued by Atkins. The LTGWM network is shown on Figure 2.

Figure 2 Greenwich Peninsula LTGWM network (Silvertown Tunnel alignment in Zone 2)



Between 2001 and 2008 the water quality of the Chalk aquifer showed varying degrees of salinity, with electrical conductivity averaging 3,000µS/cm, but was of generally good quality with nitrate concentrations below the 50mg/l

drinking water standard. Organic and inorganic compounds were typically either below method detection limit or of low concentration, with the exception of the far north of the peninsula (more than 600m from the STT alignment) which has remained the focus of the annual groundwater monitoring programme since 2008. Only wells in the northern half of the peninsula have been included in the monitoring scope since that time (limited to Zone 1 and northern part of Zone 2). In summary, elevated concentrations of gasworks contaminants remain at the northern tip of the peninsula, in the area of the former Ordnance Jetty, where heavy hydrocarbon contamination exists at depth.

The RTD aquifer has been adversely impacted by the former uses, particularly at the northern end of the Peninsula. The water quality is poor and is influenced by tidal fluctuations, with the presence of organic and inorganic pollutants ubiquitous throughout the aquifer, including elevated concentrations of ammoniacal nitrogen.

4.2. Previous Groundwater Quality Monitoring For STT

Groundwater quality monitoring has been undertaken from boreholes installed to inform the design of the Silvertown Tunnel, during the following ground investigations:

- **Soil Engineering (2015), Report on a ground investigation for Silvertown Tunnel, Report No. SE-RRG-F-001, Version 3.00** – In April and May 2015, on Greenwich, chemical testing was undertaken on two samples of perched water in the Made Ground (EB3A (shallow)) and 10 samples from the RTD (EB3A (deep), G4, G5, G7, G8 (shallow), G10A). On Silvertown, chemical testing was undertaken on four samples of perched water in the Made Ground (EB5, G25A) and two samples from the RTD (G16).

- **Fugro (2018), Report on ground investigation without geotechnical evaluation, Silvertown Tunnel additional surveys, Reference: G180001U(03).** Between July and November 2018, on Greenwich, chemical testing was undertaken on nine samples from the RTD (GRW-BH025, BH033, BH035, BH028B, GPB-15B (shallow)) and 28 samples from the Harwich Formation (GPB-04, GPB-05, GPB-06, GRW-BH012B, GPB-13, GPB-15, GPB-16, GPB15B (deep)). On Silvertown, chemical testing was undertaken on two samples from the RTD (OP037C (shallow)) and 22 samples from the Harwich Formation (OP037C (deep), STB-26B, STB-30).

Continued groundwater monitoring and sampling from boreholes along the alignment of the Silvertown Tunnel has been undertaken from a network of monitoring standpipes between November 2018 and January 2020, as follows;

- On Greenwich chemical testing has been undertaken on 35 samples from the RTD (GPB-15B(shallow), GPB-19, GRW-BH025, BH027, BH032, BH033, BH035, BH005) and 31 samples from the Harwich Formation (GPB-04, GPB-05, GPB-06, GRW-BH012B, BH013, GPB-13, GPB-15B (deep), GPB-16).

- On Silvertown chemical testing has been undertaken on one sample of perched water in the Made Ground (STB-36), 28 samples from the RTD (STB-37B, SLV-BH012, SLV-BH015, SLV-BH018, STB-34, OP037C (shallow) and SLV-CP009) and 21 samples from the Harwich Formation (OP037C (deep), SLV-CP008, STB-26B, STB-30 and STB-33A).

4.3. Groundwater Quality Baseline Review for Greenwich

Perched Groundwater (Made Ground)

High levels of organic contamination typical of tar were recorded in perched groundwater in 2015 along the Silvertown Tunnel alignment (EB3A). Naphthalene, in particular, was recorded up to 384,000µ/l, which exceeds the aqueous solubility limit and confirms the presence of tarry product within perched groundwater. None of the LTGWM boreholes were installed within Made Ground.

Upper (RTD) Aquifer

Elevated concentrations of petroleum aromatic hydrocarbon fractions and PAH are measured in the RTD. High concentrations of ammonia (approximately 22mg/l) have consistently been measured in the Upper Aquifer (BHN1(A)) 300m to the north of the alignment; cyanide concentrations are approximately 0.5mg/l and monitoring indicates a

stabilised condition. The concentrations of these contaminants in Zones 3 and 4 are typically lower than in the north of the Peninsula, however similarly high concentrations of ammonia and cyanide are recorded. The concentrations of the determinands along the Silvertown Tunnel alignment are broadly consistent with the LTGWM. High levels of hydrocarbon contamination were recorded in 2015 (EB3A and G10) along the alignment, although the contamination recorded is probably not laterally extensive.

Intermediate (Harwich Formation) and Lower (basal sands and Chalk) Aquifers

Contamination in the Lower Aquifer is present at the northern tip of Greenwich Peninsula. The source and behaviour of the contamination has been modelled and assessed by Atkins, in consultation with the Environment Agency. High levels of contamination include total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylenes (BTEX) and polyaromatic hydrocarbon (PAH) species, associated with spillage from a former tar tank which has migrated to the Lower Aquifer via a local scour feature. Annual reporting of the contamination by Atkins suggests that the current condition is stable and consistent with parameters considered in earlier risk assessments. Monitoring standpipes in the Lower Aquifer (Chalk) (BHN4(B), BH104, BH105, BH106 and BH107) represent the worst impacted groundwater close to the scour feature which is more than 600m to the north of the STT alignment. BHN1(B) (Thanet Sand) is located is located approximately 300m to the north of the STT alignment. Monitoring indicates low concentrations of the COC, although high concentrations of ammonia are noted (up to approximately 20mg/l) which is widespread in groundwater on the Peninsula. Monitoring in BHN1(B) is similar to historical monitoring of the Lower Aquifer in Zone 3. LTGWM in the southern part of the Peninsula (Zone 3) ceased in 2008 on agreement with the Environment Agency, as groundwater contamination was considered to have stabilised. Concentrations of ammonia in BHN9(B) (Thanet Sand) were <15mg/l. Recent monitoring of the Intermediate Aquifer along the STT alignment is broadly consistent with the LTGWM of the Lower Aquifer in Zone 3. Ammonia was recorded in the range of 2mg/l to 14mg/l, and up to 30mg/l in the east of the Peninsular (TBM section). Locally cyanide was measured up to 0.4mg/l, and was typically <0.2mg/l, which is similar to levels recorded in BHN1(B) (Zone 1). Monitoring and testing of the Lower Aquifer has not been undertaken during the investigations for the STT, as no standpipe piezometers have been installed to that depth so far.

4.4. Groundwater Quality Baseline Review for Silvertown

Perched groundwater (Made Ground) and Upper (RTD) Aquifer

Recent groundwater monitoring of perched groundwater and the Upper Aquifer along the Silvertown Tunnel alignment at Silvertown indicates typically much lower levels of contamination when compared to Greenwich. The groundwater quality of the RTD was not heavily contaminated and was typical of concentrations anticipated in an urban setting and is indicative of mild levels of contamination only. High concentrations of arsenic (up to 208µg/l) have been recorded in the RTD in 2015 (G16), although lower concentrations (up to 71µg/l) were recorded in a nearby borehole (OP037C) in 2018 and 2019.

Intermediate (Harwich Formation) Aquifer

Generally, the concentrations of determinands recorded in the Intermediate Aquifer (Harwich Formation) are similar to, or lower than those recorded in the RTD, however locally elevated arsenic and slightly elevated concentrations of petroleum hydrocarbon fractions were recorded (south of the proposed TBM launch and retrieval chamber). Typically, ammonia has been measured <2mg/l, although locally up to 10mg/l (STB-30). Monitoring and testing of the Lower Aquifer has not been undertaken during the investigations for the STT, as no standpipes have been installed to that depth so far.

4.5. Groundwater Levels Baseline

An extensive programme of groundwater level monitoring has been carried out during the site investigations for the STT scheme, including monitoring associated with a series of pumping tests in the Intermediate Aquifer. Additional pumping tests are planned in 2020 to better inform the design of groundwater control measures needed for the cross passage construction, and these are focussed on the proposed locations of the cross passages. The pump tests will target the Intermediate Aquifer and the Upnor Formation of the Lower Aquifer that require treatment for the safe excavation of the cross passages. Five of the cross passages are onshore or nearshore, and for each of these a pumping test is proposed with one new monitoring well. Below the river, where access is more challenging,

two pumping tests, with one or two new monitoring wells. Where the existing groundwater monitoring installations are still functional these will be re-used during the additional site investigation to supplement the monitoring data obtained from the new wells.

Groundwater level monitoring to date indicates that groundwater levels are typically different in each aquifer. Furthermore, in the vicinity of the river, groundwater levels are tidally influenced in all aquifers. Groundwater levels in the Upper Aquifer are typically higher (in mAOD) than groundwater levels in the Intermediate Aquifer, which in turn are typically higher than in the Lower Aquifer. The presumption is that this is due to historic abstraction from the chalk in the Lower Aquifer.

- The Upper Aquifer has a maximum tidal range (peak to trough) of up to around 3 m. The mean groundwater level (i.e. the centre of the tidal cycle) is around 1.5 mAOD in the Silvertown area (north of the River) and -0.5 mAOD in Greenwich (south of the River).
- The Intermediate Aquifer has a maximum tidal range (peak to trough) of up to around 2 m. The mean groundwater level (i.e. the centre of the tidal cycle) is around -0.5 mAOD in the Silvertown area (north of the River) and -1.0 mAOD in Greenwich (south of the River).
- The Lower Aquifer has a maximum tidal range (peak to trough) of up to around 2 m. The mean groundwater level (i.e. the centre of the tidal cycle) is around -4.0 mAOD in the Silvertown area (north of the River) and -6.0 mAOD in Greenwich (south of the River).

4.6. Groundwater Abstractions

Current licensed abstractions within the vicinity of the Silvertown Tunnel alignment are shown on Appendix 1. On Greenwich Peninsula there are five groundwater abstractions with 1km of the Silvertown Tunnel alignment and two to the north of the River Thames at Silvertown. Of the seven abstractions, one pumps groundwater from the RTD for make up or top up water and six abstract groundwater from the Chalk for use as process water, for lake and pond throughflow, or for heat pumps. A summary of the active groundwater abstractions within 1km of the Silvertown Tunnel alignment is listed in Table 3. The closest potable water abstraction is from the Chalk for Britannia Hotels Ltd (TH/039/0039/077/R01) located approximately 1.7km to the west of the STT alignment.

Table 3 Active Groundwater Abstractions within 1km of Silvertown Tunnel

Reference	Source	Use	Start	Expiry	Max. quantities (m3)		Distance and direction from alignment
					Annual	Daily	
Greenwich							
28/39/44/0047/R01	Chalk	Process water	09/2004	03/2028	50,000	720	60m west
TH/039/004/013	Chalk	Heat pump	09/2013	03/2025	1,261,440	3,456	Borehole A 120m north
	Chalk	Heat pump	09/2013	03/2025			Borehole B 150m north
TH/039/0044/016	Chalk	Lake and pond throughflow	Unknown	Unknown	11,000	80	760m southeast
TH/039/0044/023	Chalk	Heat pump	Unknown	Unknown	275,940	756	700m south
Silvertown							
TH/037/0054/014/R01	Chalk	Heat pump	05/2013	Unknown	5,000	308	350m east
29/38/09/0162	RTD	Make up or top up water	07/1997	Unknown	30,000	146.4	600m northwest

4.7. Potential Contaminant Linkages

The potential sources of contamination are described and assessed in the ground contamination risk assessment reports prepared for the scheme (document reference ST150030-ARU-FAE-06-ZZ-ASM-EN-0001 for the Greenwich side and ST150030-ARU-FAE-17-ZZ-ASM-EN-0001 for the Silvertown side), which incorporates the agreed preliminary risk assessment (Environmental Statement) and assessment of several phases of ground investigation. Considering the design information and the sources of ground contamination, the potential plausible contaminant linkages for the scheme affecting groundwater are described for Greenwich and Silvertown in the following tables. Tables 4 and 5 have been reproduced from the Silvertown Tunnel ground contamination risk assessments for Greenwich and Silvertown.

Table 4 Controlled waters potential plausible contaminant linkages (Greenwich)

Potential Contaminant Linkage			Considerations
Source	**Pathway**	**Receptor**	
Ground contamination (soil / vapour / groundwater) from onsite sources: • Residual historical contamination from South Metropolitan Gasworks and associated rail land. • East Greenwich Landfill. • Contaminated perched water in the Made Ground. • Contaminated groundwater in the RTD. Residual offsite contamination on Greenwich Peninsula	Horizontal and vertical migration of contaminated liquids/groundwater within the Made Ground and River Terrace Deposits.	Groundwater in the superficial deposits (Alluvium and RTD) (Upper Secondary Aquifers).	Historical groundwater monitoring across the Greenwich Peninsula, including long term groundwater monitoring since 2002, confirms that there is widespread contamination in the area. The open cut will be enclosed by vertical cut-off walls penetrating down to the London Clay (Upper Aquitard). Groundwater control in the RTD will comprise pumping to remove the water trapped within the structure, above the Upper Aquitard. There should be negligible impact on groundwater levels in the RTD due to groundwater control pumping.
	Migration of contaminated liquids/groundwater into the Intermediate Aquifer through the creation of preferential pathways.	Groundwater in the Harwich (Intermediate Secondary Aquifer)	The introduction of the tunnel and piled foundations may create preferential pathways for contamination in the RTD to migrate to the Intermediate Aquifer (Secondary A aquifer). Some pressure relief pumping from the Intermediate Aquifer anticipated adjacent to the cut and cover and rotation chamber. It is anticipated that the distance of influence due to depressurisation pumping will be less than 500 m in the Intermediate Aquifer.
	Migration of contaminated liquids/groundwater into the Lower Aquifer through the creation of preferential pathways.	Groundwater in the Chalk (Lower Principal Aquifer)	The introduction of the tunnel may create preferential pathways for contamination in RTD to the Upnor Formation - Secondary A aquifer; the Upnor Formation is assumed to be hydraulically connected with deeper Thanet Sand and the Chalk (Principal Aquifer). No dewatering will occur from the Lower Aquifer.
	Lateral movement of contaminated groundwater to the River Thames.	River Thames	The RTD is known to be hydraulically connected to the River Thames. Dewatering of RTD will be undertaken in areas enclosed by groundwater cut off barriers and therefore should not affect potential plume migration within the RTD (external to the barriers) nor cause potential migration towards the Thames.

Table 5 Controlled waters potential plausible contaminant linkages (Silvertown)

Potential Contaminant Linkage			Considerations
Source	**Risk**	**Receptor**	
Ground contamination (soil / vapour / groundwater) from onsite sources: Residual historical contamination from former activities, such as chemical works and docklands warehouses Infilled ground (Royal Victoria Dock Western Entrance) Contaminated perched water in the Made Ground. Contaminated groundwater in the RTD Current activities such as aggregate manufacturing, waste recycling and a scrap metal yard	Horizontal and vertical migration of contaminated liquids/groundwater within the Made Ground and River Terrace Deposits.	Groundwater in the superficial deposits (Alluvium and RTD) (Upper Secondary Aquifers).	Significant contamination of groundwater has not been encountered at Silvertown. Ammoniacal nitrogen, metals and PAHs have been encountered which are indicative of the general background concentrations for the area. The open cut will be enclosed by vertical cut-off walls penetrating down to the London Clay (Upper Aquitard). Groundwater control in the RTD will comprise pumping to remove the water trapped within the structure, above the Upper Aquitard. There should be negligible impact on groundwater levels in the RTD due to groundwater control pumping.
	Migration of contaminated liquids/groundwater into the Intermediate Aquifer through the creation of preferential pathways.	Groundwater in the Harwich (Intermediate Secondary Aquifer)	The introduction of the tunnel and piled foundations may create preferential pathways for contamination in the RTD to migrate to the Intermediate Aquifer (Secondary A aquifer). Some pressure relief pumping from the Intermediate Aquifer anticipated in the area of the cut and cover and rotation chamber. It is anticipated that the distance of influence due to depressurisation pumping will be less than 500 m in the Intermediate Aquifer.
	Migration of contaminated liquids/groundwater into the Lower Aquifer through the creation of preferential pathways.	Groundwater in the Chalk (Lower Principal Aquifer)	The introduction of the tunnel may create preferential pathways for contamination into the Upnor Formation - Secondary A aquifer; the Upnor Formation is assumed to be hydraulically connected with deeper Thanet Sand and the Chalk (Principal Aquifer). No dewatering will occur from the Lower Aquifer.
	Lateral movement of contaminated groundwater to the River Thames.	River Thames	The RTD is known to be hydraulically connected to the River Thames. Dewatering of RTD will be undertaken in areas enclosed by groundwater cut off barriers and therefore should not affect potential plume migration within the RTD (external to the barriers) nor cause potential migration towards the Thames.

4.8. Assessment of Risk

If during detailed design it is identified there is a potential risk to receptors then a Groundwater Risk Assessment will be required to assess all source-pathway-receptors linkages, as explained in the Code of Construction Practice (COCP). If dewatering is required as part of the construction process a detailed qualitative risk assessment (DQRA) maybe required to assess the risks to controlled waters from dewatering. The Groundwater Risk Assessment / DQRA will inform the following:

- the requirement for further assessment of identified potential impacts to receptors through detailed risk assessments;
- further development / verification of appropriateness of alert and trigger levels;
- the development of the GMVP including the requirement for additional and/or more frequent monitoring relative to the baseline programme (including long term monitoring) based on the risk identified;
- additional groundwater monitoring requirement to be implemented during periods of dewatering;
- remedial groundwater treatment as mitigation shall be proposed where a detailed quantitative risk assessment identifies an unacceptable risk to receptors. The proposal shall include an options appraisal; and full details of the remedial works required and how they are to be undertaken.

The Groundwater Risk Assessment and the DQRA, if required, will be prepared in consultation with the Environment Agency, and submitted for information, following the completion of detailed design, the establishment of dewatering requirements and baseline monitoring. The outputs of the assessments will be included within future revisions to the GMVP which will be subject to approval by the Environment Agency.

5. Monitoring Network

5.1. Borehole Network

The boreholes listed in Appendix 2 (which include standpipe piezometers and vibrating wire piezometers (VWP)) are selected for ongoing groundwater quality and groundwater level monitoring to finalise the baseline prior to construction. The locations comprise existing and newly installed boreholes to provide a network of data taking into consideration the hydrogeological model and anticipated zone of influence of the construction activities. The use of existing boreholes is subject to condition surveys and this table will therefore be subject to revisions. Some of the wells established as part of pumping tests may be used for onward monitoring during the baseline phase and construction phase. The locations are shown in drawings in Appendix 3.

5.2. Monitoring frequency

It is proposed that baseline groundwater quality monitoring and sampling will be undertaken at monthly intervals for 4 months, to be commenced as soon as possible from existing standpipes and on completion of the new standpipe installations. This period will run from September 2020 to December 2020.

For all groundwater monitoring installations, groundwater levels readings shall be taken twice daily during site investigation works. Within all land-based piezometers <200m from the river, groundwater levels shall be recorded at an hourly frequency throughout the field work period to observe any tidal fluctuations. Following completion of the site investigation field work period, monitoring of the groundwater level installations is to continue for 4 months as part of the baseline work. On completion of the 4 months an assessment will be undertaken to ascertain whether a steady baseline can be determined. If further monitoring is required for this purpose, the baseline data collection period will continue.

5.3. Groundwater sampling and testing

The water quality boreholes are to be developed a minimum of one week prior to initial sampling round (new boreholes). This will allow identification of boreholes where recharge is an issue in advance of sampling. An amendment to the previous groundwater purging and sampling method is proposed, using micro-purge techniques and low flow sampling. Groundwater drawdown and flow rate will be controlled, and water quality parameters will be monitored. Sample collection will not occur until water quality samples have stabilized. Readings can be adjudged stable if variation is less than or equal to the values below.

- Turbidity 10%
- Dissolved Oxygen 10%
- Temperature 3%
- PH ±1 unit
- Oxidation/ Reduction ±10 millivolts
- Specific conductance 3%

The development and micro-purged groundwater will be stored onsite in dedicated IBCs for offsite disposal.

The field tests and measurements specified in Table 6 will be undertaken on groundwater samples obtained from standpipes during purging and sampling.

Table 6 Field Tests and Measurements

Test	Units	Detection Limit	Degree of Accuracy
pH	**pH units**	**0.1**	**±0.1**
Temperature	**°C**	**0.1**	**±0.1**
Dissolved oxygen	**mgO2/l**	**0.1**	**±0.1**

Electrical conductivity	**µS/cm**	**10**	**±2.0**
Redox potential	**mV**	**±1**	**±0.1**
Turbidity	**NTU**	**0.01**	**±0.5**

The sampling equipment and procedures will allow discrete depth sampling and cause minimum disturbance to the physical or chemical condition of the water. Groundwater samples shall be stored in accordance with BS 10175 and shall be sent for testing within 24 hours of sampling. Testing will be undertaken for the analytical suite listed in Table 7.

Table 7 Analytical Testing Suites

Determinand	Method detection level
SUITE F1 – Water samples general	
pH value	0.1 pH units
Hardness	2 mg/l
Arsenic	1 µg/l
Cadmium	0.5 µg/l
Chromium	5 µg/l
Copper	0.5 µg/l
Lead	1 µg/l
Mercury	0.05 µg/l
Nickel	1 µg/l
Selenium	1 µg/l
Zinc	1 µg/l
Antimony	1 µg/l
Beryllium	1 µg/l
Vanadium	1 µg/l
Ammoniacal nitrogen	0.02 mg/l
Ammonia	0.02 mg/l
Chloride	1 mg/l
Cyanide - total	5 µg /l
Phenols - total	10 µg/l
Dissolved organic carbon (DOC)	10 µg/l
Calcium	10 µg/l
Manganese	10 µg/l
Nitrate	
SUITE F2 – Water samples speciated TPH	
TPH CWG	10 µg/l
SUITE F3 – Water samples PAH and BTEX	
BTEX	1 µg/l
16 USEPA Polyaromatic Hydrocarbons	0.001 µg/l
SUITE F4 – Water samples VOC and SVOC	

Determinand	Method detection level
Volatile Organic compounds *including MTBE	1 µg/l
Semi-Volatile Organic compounds	1 µg/l
SUITE F7 – Water samples cyanide speciation	
Complex cyanide	5 µg/l
Cyanide - free	5 µg/l
Cyanide - thiocyanates	5 µg/l

5.4. Baseline Monitoring Report

A Baseline Monitoring Report will be produced incorporating the collected baseline groundwater level and water quality data from both the historic campaigns described in Section 4.2 above and the 2020 campaign and will outline a typical range for both groundwater levels and selected contaminants of concern (COC) for the site. The report will also include initial assessment and compliance criteria against which project impacts can be assessed as part of the GMVP. Baseline data, in conjunction with the detailed design, will also be used to select sentinel monitoring boreholes which will be used to monitor the potential movement of contamination and changes to elevations throughout the construction phase of the project. The initial criteria will be derived in consultation with the Environment Agency. A two-tier system of screening criteria shall be adopted; Alert Levels and Trigger Levels. Alert levels will be used on a day-to-day basis to draw the attention to the development of adverse trends in groundwater conditions. The alert levels will be treated primarily as an early warning system to enable appropriate investigative or corrective measures to be implemented so that the risk of breaching a compliance limit can be reduced and before impacts can cause harm to the environment or human health.

Comparison of measured water quality and elevations with trigger levels will be used to demonstrate compliance with agreed water quality standards and elevations. Trigger levels are to be agreed with the Environment Agency through approval of the GMVP.

For water quality, alert and trigger levels will not be derived for every water quality monitoring determinand. Instead, key indicator parameters will be identified using a risk-based approach that reflects the baseline water quality dataset, extent of dewatering required, discharge points and identified receptors. The indicator parameters will be agreed with the Environment Agency through the approval of the GMVP. The choice of indicator parameters will be reviewed annually for adequacy; any proposed changes must be approved by the Environment Agency prior to implementation.

Alert and trigger levels may be derived on a borehole-specific basis. The levels will be based on the baseline dataset and will take into account existing variability and trends. Statistical methods will be used, where possible, to derive appropriate alert and trigger levels. The alert and trigger levels, and associated procedures, will determine whether contingency plans need to be activated. The assessment process will involve evaluation of the significance of a departure from baseline conditions.

Sentinel monitoring boreholes (relatively distant from the STT alignment), which will provide an early warning to the mobilisation of contamination, will be selected following analysis of the baseline dataset and completion of the detailed design and subsequent scope of dewatering required. These monitoring boreholes will be a combination of already established monitoring locations and newly installed boreholes, depending on the specific scope of dewatering and availability of existing monitoring locations. The selected sentinel monitoring borehole details, justifications and associated alert and trigger levels will be submitted to the Environment Agency for review and approval in the GMVP. For new monitoring boreholes a dataset will need to be established prior to the commencement of construction of at least a minimum four rounds over four months to provide a reasonable baseline, however, this will depend on the scope of dewatering and will be subject to Environment Agency agreement. A one-off pre-construction groundwater Baseline Monitoring Report will be provided to the Environment Agency. The Baseline Monitoring Report which will be completed prior to the start of construction, will contain the following:

- relevant historical and current groundwater level and quality data;
- interpretation of data;
- trends in key water quality parameters;
- appropriate alert and trigger levels defined at this stage; and
- an outline of sentinel boreholes selected for the project to monitor the movement / migration of contamination.

5.5. Monitoring

Future revisions of the GMVP will include a protocol and schedule for regular inspection and maintenance of monitoring locations. This will include procedures for the repair and replacement of monitoring locations as required. Each new or repaired monitoring point will be designed, constructed, supervised and certified in accordance with normal engineering construction quality assurance (CQA) procedures. These procedures will adhere with the procedures contained with the Greenwich Peninsula Environmental Method Statement (GEMS). An up-to-date register of all monitoring points will be incorporated within the GVMP and Annual Interpretative Report. Future revisions of the GMVP will present details regarding the groundwater monitoring methodology that will be implemented during the construction and post-construction phases for approval by the Environment Agency. Future revisions of the GMVP will also specify a process for managing any required changes in monitoring methods, procedures or protocols over the life of the project taking into account the need for reliable comparison of future monitoring results against the baseline dataset. Each plan will specify field protocols with respect to:

- monitoring network condition inspections;
- in situ groundwater measurement protocols:
  - manual measurements; and
  - data loggers.
- water sampling method(s) and protocols, including purging (where appropriate);
- field analysis protocols;
- sample handling protocols;
- sample containers and preservation;
  - sample labelling;
  - sample storage and transportation; and
- QA/QC protocols.

Methods used will ensure that the samples collected and measurements made are not be affected by contamination associated with surface run-off, contact with the sampling equipment or extraneous matter that may have entered the monitoring structure. Nor will they be affected by the products of reaction with materials used in the construction of the monitoring point, sampling equipment or containers. Each plan will specify laboratory analysis protocols with respect to:

- laboratory selection, including accreditation requirements (UKAS and MCERTS accredited);
- analytical suite (as per the project list at the time);
- analytical methods;
- detection limits; and
- QA/QC protocols.

5.6. Schedules

Future revisions of the GMVP shall present a detailed schedule for groundwater monitoring during construction, dewatering and post-construction phases of work once the initial baseline monitoring programme has been established. The monitoring schedule will ensure that identified risks to groundwater from construction activities are monitored such that potential moderate and large adverse effects are identified such that actions can be implemented to ensure the security of receptors. Riverlinx CJV are responsible for managing the groundwater monitoring data collected and will specify protocols for data management, including:

- data collection;
- data collation;
- data verification; and
- data storage.

Monitoring data will be checked for laboratory and scheduling inconsistencies within five working days of receipt. Riverlinx CJV will be responsible for keeping original monitoring records and submitting these on completion of construction. Water level and quality data will be stored in Excel-compatible formats. Riverlinx CJV will review the groundwater monitoring data collected prior to contract award and interpret the results to support development of the design and need for additional boreholes. Riverlinx CJV will undertake an ongoing review of the alert and trigger levels for adequacy during the construction period. When risks are re-evaluated or monitoring data reveal unexpected variations or trends, it may be necessary to review and occasionally change assessment or compliance criteria. However, any proposed changes to the alert and trigger levels used will be justified technically and may be implemented only after consultation and agreement with the Environment Agency.

6. Contingency Planning

6.1. Contingency Action Plan

A Contingency Action Plan will be developed to describe a phased contingency response process that will be implemented so that risks to the project and nearby receptors can be assessed and managed in the event of any breach of approved alert or trigger levels. Where risks are unacceptable, corrective or remediation measures will be initiated and a strategy to monitor their effectiveness will be determined within one working week of the trigger level exceedance being confirmed by the laboratory and in consultation with the Environment Agency. In all cases, the need for remediation should be balanced against the risk posed to groundwater receptors and the benefits gained by remediation. In complex cases, specialist advice should be taken, and remedial actions and their objectives agreed in consultation with the Environment Agency. The Contingency Action Plan shall specify the required timescales and parties responsible for implementing each action.

6.2. Assessment Criteria (Alert Levels)

Assessment criteria are intended to draw the attention of site management to the development of adverse trends in monitoring data or the breach of a specified alert level. The assessment process will involve the evaluation of the significance of a departure from baseline conditions. The assessment criteria should be treated primarily as an early warning system to enable appropriate investigative or corrective measures to be implemented, particularly where there is the potential for a compliance limit to be breached. Future revisions of the GMVP will specify the assessment criteria being applied, including the alert levels and the protocols for identifying adverse trends. If an alert level is breached on a single occasion the following actions will be taken:

- notify Site Management Team;
- repeat sampling/monitoring round if no routine sampling is planned within seven days; and
- report in next quarterly factual monitoring report.
- If an alert level is breached on three consecutive sampling/monitoring rounds or if the annual review process identifies significant adverse trends in four sampling/monitoring rounds, further assessment will be required as follows:
- characterise observed issues (desk-based data review), including:
  - parameter(s) involved;
  - magnitude of exceedance(s);
  - frequency of exceedance(s);
  - spatial pattern; and
  - temporal trends.
- review relevant site activities;
- review potential cause(s) for observed results;
- review monitoring plan for adequacy;
- undertake additional investigation or sampling/monitoring (if required) to better characterise issue; and
- identify likely cause(s) for observed results.

If the observed issue is considered to relate to the project the following actions will be taken by the Contractor:

- consult with regulator(s)/stakeholders (as appropriate);
- review significance of potential risks to receptors;
- implement mitigation measures (as appropriate) to try and halt or reverse adverse trends and/or manage risks for receptors; and
- carry out ongoing sampling/monitoring at an increased frequency and review to confirm effectiveness of measures implemented.

The assessment findings and actions will be reported in the next monitoring report.

6.3. Compliance Criteria (Trigger Levels)

If a trigger level is breached on a single occasion:

- notify Site Management Team in writing;
- undertake Assessment of Significance (desk-based data review):
  - parameter(s) involved;
  - magnitude of exceedance(s);
  - frequency of exceedance(s);
  - spatial pattern;
  - temporal trends; and
  - risks to nearby receptors.
- repeat sampling/monitoring round if no routine sampling/monitoring is planned within seven days; and
- prepare notification report and inform key stakeholders.

If a trigger level breach occurs on two consecutive sampling/monitoring rounds, is part of a significant adverse trend or is considered to indicate an immediate and significant risk to nearby receptors Riverlinx CJV will undertake the following additional actions:

- prepare a notification report and inform key stakeholders (e.g., Environment Agency, TfL), as soon as possible;
- notify other relevant stakeholders within one week as appropriate, e.g., other abstractors;
- review relevant activities occurring on site;
- review potential cause(s) for observed results;
- review existing monitoring plan for adequacy;
- undertake additional targeted sampling/monitoring or investigation (if required) to characterise the issue better; and
- identify likely cause(s) for observed results.

If the observed issue is considered to relate to the project:

- review significance of risks to nearby receptors;
- develop strategy within one week of the Trigger Level exceedance being confirmed by the laboratory, to
- mitigate and/or remediate issue(s) in consultation with key stakeholders;
- implement mitigation and/or remedial measures (as appropriate) to reduce risk of future breaches
- affecting project or nearby receptors; and
- ongoing sampling/monitoring and review to confirm effectiveness of measures implemented.

The assessment findings and actions will be reported in Notification Report as described in Section 7.2 to be submitted to SPV and the Environment Agency within a time frame approved by SPV and the Environment Agency.

6.4. Emergency Measures

Additional groundwater monitoring may be required in the event of a pollution incident accidentally occurring at or near the site. Riverlinx CJV will propose any such additional monitoring for the approval of the Environment Agency. The scope should be targeted to reflect the nature of the pollution incident and potential risks. This cannot be readily defined in advance of any incident occurring. Instead, the Contingency Action Plan will include a phased process by which the necessary scope of additional monitoring will be proposed in consultation with the Environment Agency following a pollution incident. In the event of a pollution incident, Riverlinx CJV will inform the Environment Agency as soon as practicably possible and complete the following actions:

- review significance of risks to nearby groundwater receptors;
- notify other relevant stakeholders within one week as appropriate, e.g., other nearby abstractors;
- review the existing GMVP for adequacy;
- design additional targeted sampling/monitoring or investigation (if required) to better characterise issue; consult with the Environment Agency and other stakeholders as appropriate;
- undertake additional targeted sampling/monitoring or investigation (if required) and review results;
- develop strategy to mitigate and/or remediate issue(s) in consultation with key stakeholders;
- implement mitigation and/or remedial measures (as appropriate) to reduce risk of future breaches affecting project or nearby receptors; and

- ongoing sampling/monitoring and review to confirm effectiveness of measures implemented.

The assessment findings and actions will be reported in Notification Report as described in Section 7.2 to be submitted to SPV and the Environment Agency within a time frame approved by SPV and the Environment Agency as part of the Contingency Action Plan.

6.5. Ground Settlement

Changes in groundwater levels could result in ground settlement, which might cause damage to nearby assets (e.g. buildings or utilities). All assets will be subject to initial assessments. The most vulnerable assets will subject to further detailed assessment which will incorporate soil-structure interaction.

An Instrumentation and Monitoring Plan will be developed which will include monitoring the movement of vulnerable assets. Trigger levels will be set for each asset, based on the anticipated movement of the assets, and consideration of the levels of movement at which damage becomes unacceptable. Appropriate responses at each trigger level will also be developed – which could involve mitigation measures (e.g. changes to construction methodology, or implementation of mitigation measures such as grouting, to minimize further movement). The trigger levels and responses for each asset will be agreed with the relevant asset owner.

Where dewatering is required for construction (see sections 3.2 - 3.8 of this report) it is likely to be localised and the impact of dewatering will be assessed and mitigated where appropriate as part of the design. Construction monitoring (over and above that described in the GVMP) will be needed to confirm that dewatering (in terms of levels achieved and zone of influence) is no worse than assumed in those assessments, and to determine whether or not any unexpectedly large ground movements are a consequence of lowering of groundwater levels. In a similar manner to the asset movement monitoring, trigger levels and responses will be developed in advance of the works, however in this case the monitoring will also be needed to confirm that conditions are safe for the works in progress at that time – for example ensuring sufficient drawdown is achieved and maintained to allow safe excavation of the cross passages or portals.

7. Reporting

7.1. Overview

Riverlinx CJV will report groundwater monitoring results during construction and these will be included within future versions of the GMVP. They will comprise:

- notification reports (if required);
- factual reports for each monitoring round; and
- interpretative reports (frequency to be agreed with the Environment Agency)

The monitoring reports shall be:

- submitted on time;
- quality assured; and
- collated and presented in a consistent format.

The templates for the monitoring reports will be developed in consultation with the Environment Agency.

7.2. Notification report

Notification reports will be used to disseminate information regarding breaches of Trigger Levels or pollution incidents. These reports will provide clear, concise information and carry a recommendation for action (or describe action taken). Notification reports will include:

- date and time of issue of report;
- name, position and contact information for person issuing report;
- date and time of monitoring surveys or observations that confirm the breach of a compliance limit, or an actual pollution incident;
- pollution incident recorded or compliance limit breached;
- details of any emergency contingency actions implemented; and
- an indication of the urgency of response needed from the Environment Agency.

In instances where assessment criteria or compliance limits are breached regularly and action is being implemented by the site operator (e.g. where remedial measures are underway or where the source of contamination to groundwater is being investigated), alternative ongoing reporting procedures will be agreed with the Environment Agency to avoid unnecessary duplication of notification reports.

7.3. Factual Report

Factual monitoring reports shall be prepared by Riverlinx CJV quarterly. Minimum factual monitoring report requirements are as follows:

- self-audit of compliance with monitoring plan requirements;
- groundwater level data in graphical form;
- key groundwater quality data to be displayed in graphical form;
- breaches of alert levels in tabular form;
- breaches of trigger levels in tabular forms;
- urgent actions;
- mitigation and/or remedial measures (if required) to manage groundwater-related risk to project or nearby receptors; and
- factual datasets (electronic).

7.4. Interpretative Report

Interpretative monitoring reports shall be prepared by Riverlinx CJV annually. Minimum Annual Interpretative report requirements are as follows:

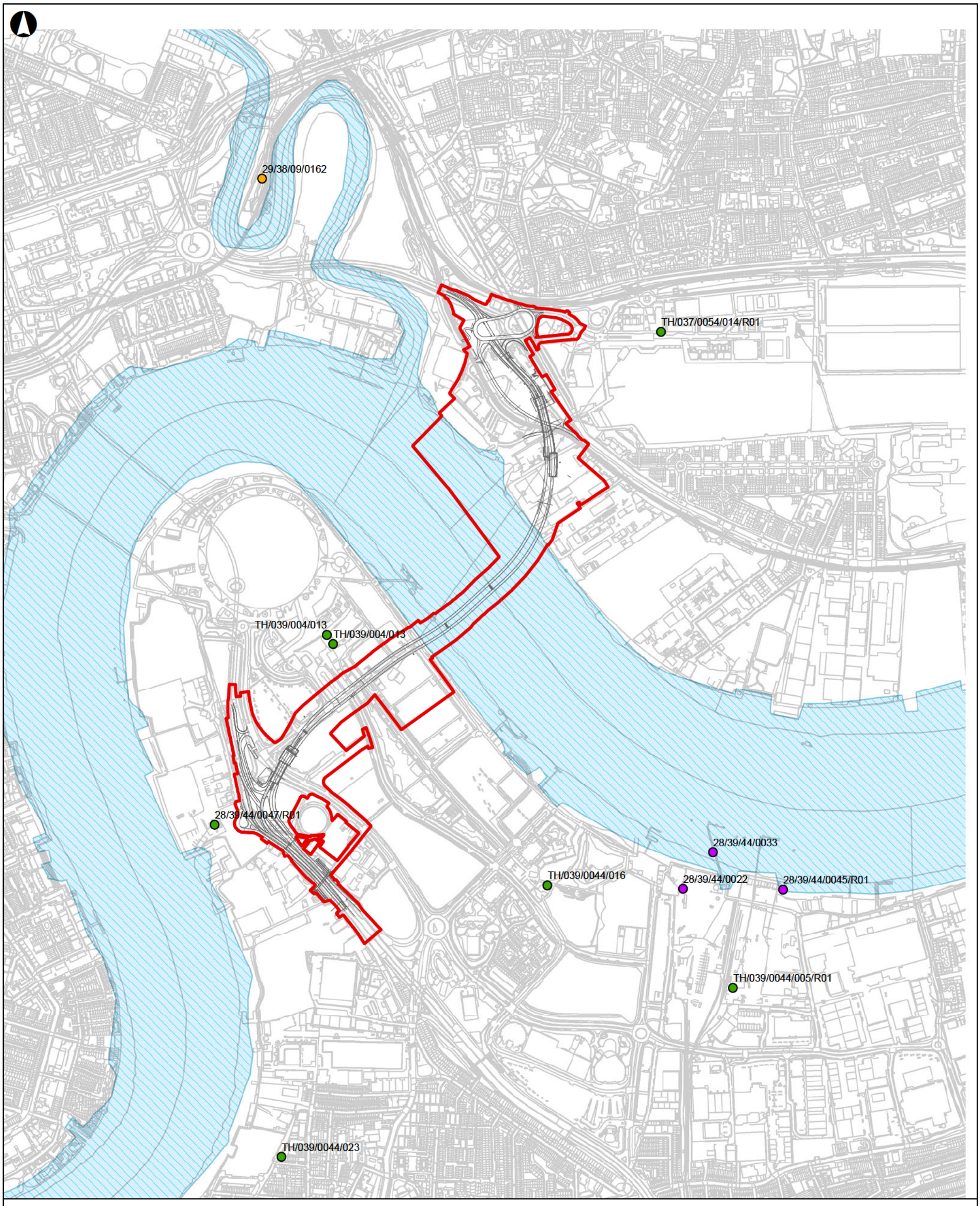
- self-audit of compliance with monitoring plan requirements;
- updated register of monitoring network;
- groundwater level data in graphical form;
- spatial contour plots of groundwater levels in Upper, Intermediate and Lower Aquifers;
- spatial plots of key COC in Upper, Intermediate and Lower Aquifer to an appropriate scale;
- groundwater quality data in graphical form for agreed indicator species
- breaches of Alert Levels in tabular form;
- breaches of Trigger Levels in tabular form;
- summary of QA/QC checks e.g. ionic balance calculations;
- review of Key groundwater issues and patterns (in context of existing conceptual model and baseline dataset);
- update or refinement of conceptual model (if appropriate);
- likely causes of significant groundwater issues;
- influence of site activities on groundwater;
- influence of off-site/third party activities on local and regional groundwater;
- assessment of risk to nearby receptors;
- identification of any data gap at the site;
- proposed modification to monitoring plan (if required);
- changes to monitoring network;
- changes to monitoring frequency;
- changes to sampling methodology;
- changes to analytical suite;
- proposed revision to alert and trigger levels (if appropriate);
- mitigation and/or remedial measures (if required) to manage groundwater-related risk to project or nearby receptors; and
- other proposed modifications to site activities to better manage risk to/from groundwater (if appropriate).

The annual reports will be submitted by Riverlinx CJV after monitoring year end which will be established within the Baseline Monitoring Report. The SPV approved draft final annual report shall be submitted to the Environment Agency within two months of monitoring year end. Following receipt of corrections and comments from the Environment Agency, the final report will be produced within one month of receipt of these comments.

Appendix 1 Live groundwater and surface water abstractions

A3

06/04/2020 15:50:46



Legend

Abstraction source

- Chalk
- RTD
- River Thames
- DCO bounday
- Silvertown Tunnel alignment

Issue	Date	By	Chkd	Appd
F1	2020-04-06	CN	JW	CB

ARUP

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Client
RiverLinx CJV

Job Title
Silvertown Tunnel

Metres
0 120 240 480

Live groundwater and surface water abstractions

Scale at A3
1:10,000

Job No	Drawing Status
255415	For Issue

Drawing No	Issue
Drawing 4	F1

MXD Location

Appendix 2 Baseline Groundwater Monitoring Network

Borehole ID	Easting (m)	Northing (m)	Aquifer	Existing/Proposed	Groundwater Quality	Groundwater Elevation
BH-G-01	539339.20	179198.47	Intermediate	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-G-02	539299.69	179161.72	Intermediate	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-G-03	539274.27	179177.01	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-G-04	539287.80	179260.40	Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-G-05	539140.27	179319.17	Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-G-06	539146.27	179389.28	Upper, Intermediate & Lower	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-G-07	539117.57	179417.83	Intermediate	Proposed	Planned to be available for monitoring	N/A
BH-G-08	539130.60	179467.37	Upper	Proposed	N/A	Planned to be available for monitoring
BH-G-09	539175.41	179457.63	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-G-10	539144.53	179495.09	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-G-11	539186.86	179486.71	Upper & Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-G-GWEnv03(B)	539449.43	179480.43	Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-G-GWEnv04	539461.95	179656.97	Lower	Proposed	Planned to be available for monitoring	N/A
BH-G-GWEnv07(A)	539295.25	179487.95	Upper	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-G-GWEnv07(B)	539295.25	179487.95	Intermediate	Proposed	Planned to be available for monitoring	N/A
BH-G-W01	539206.40	179519.42	Intermediate & Lower	Proposed	Planned to be available for monitoring	N/A
BH-G-W02	539194.98	179575.15	Intermediate & Lower	Proposed	N/A	N/A
BH-G-W03	539229.75	179593.01	Upper, Intermediate & Lower	Proposed	Planned to be available for monitoring	N/A
BH-G-W04	539343.47	179677.66	Upper, Intermediate & Lower	Proposed	Planned to be available for monitoring	N/A
BH-G-W05	539463.34	179766.83	Upper, Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring

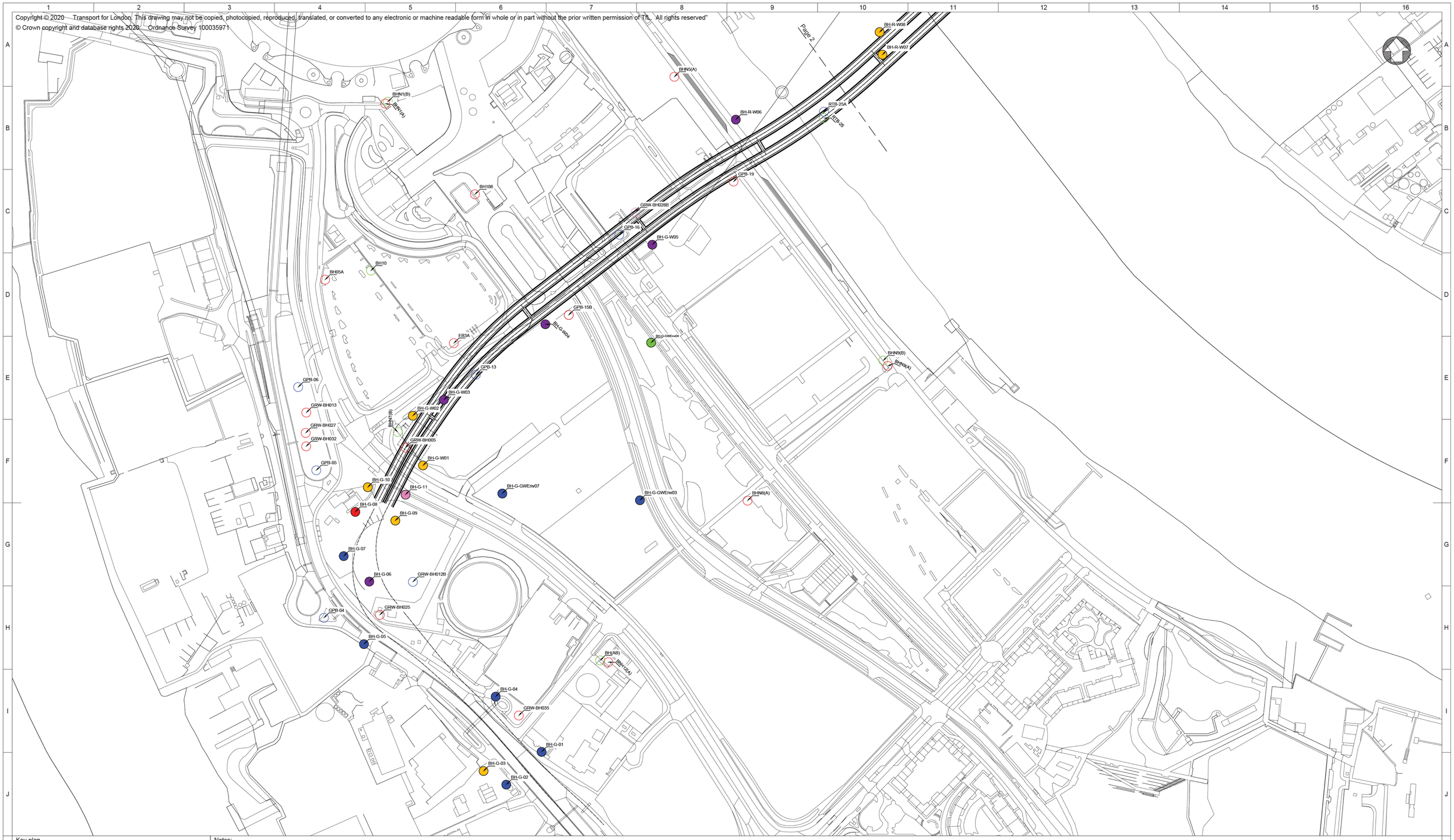
Borehole ID	Easting (m)	Northing (m)	Aquifer	Existing/Proposed	Groundwater Quality	Groundwater Elevation
BH-R-12	539836.46	180095.77	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-R-W06	539556.88	179906.98	Upper, Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-R-W07	539721.18	179979.78	Intermediate & Lower	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-R-W08	539718.00	180005.02	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-S-13	539934.66	180337.66	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-S-14	539916.79	180423.56	Intermediate & Lower	Proposed	Planned to be available for monitoring	N/A
BH-S-15	539949.80	180442.69	Intermediate & Lower	Proposed	Planned to be available for monitoring	N/A
BH-S-16	539894.05	180487.37	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-S-17	539925.64	180547.95	Intermediate & Lower	Proposed	N/A	Planned to be available for monitoring
BH-S-18	539893.18	180536.08	Upper & Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-S-19	539871.50	180581.02	Upper	Proposed	Planned to be available for monitoring	N/A
BH-S-20	539903.86	180601.39	Intermediate & Lower	Proposed	Planned to be available for monitoring	N/A
BH-S-21	539891.26	180615.28	Upper & Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-S-22	539857.99	180655.36	Upper	Proposed	N/A	Planned to be available for monitoring
BH-S-GWEnv01	539795.00	180632.00	Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-S-GWEnv02	539810.51	180411.61	Lower	Proposed	N/A	Planned to be available for monitoring
BH-S-GWEnv03	540013.00	180273.00	Lower	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-S-GWEnv04(A)	540099.00	180070.00	Upper	Proposed	Planned to be available for monitoring	Planned to be available for monitoring
BH-S-GWEnv04(B)	540099.00	180070.00	Intermediate	Proposed	Planned to be available for monitoring	N/A
BH-S-GWEnv06(A)	540265.00	180238.00	Upper	Proposed	Planned to be available for monitoring	N/A
BH-S-GWEnv06(B)	540265.00	180238.00	Intermediate	Proposed	Planned to be available for monitoring	Planned to be available for monitoring

Borehole ID	Easting (m)	Northing (m)	Aquifer	Existing/Proposed	Groundwater Quality	Groundwater Elevation
BH-S-GWEnv07(A)	539669.00	180502.00	Upper	Proposed	N/A	Planned to be available for monitoring
BH-S-GWEnv07(B)	539669.00	180502.00	Intermediate	Proposed	Planned to be available for monitoring	N/A
BH-S-GWEnv08(A)	539974.00	180685.00	Upper	Proposed	Planned to be available for monitoring	N/A
BH-S-GWEnv08(B)	539974.00	180685.00	Intermediate	Proposed	N/A	Planned to be available for monitoring
BH-S-GWEnv09	539803.69	180755.70	Intermediate	Proposed	Planned to be available for monitoring	N/A
BH-S-W09	539913.35	180228.33	Upper & Intermediate	Proposed	N/A	
BH-S-W10	539932.68	180319.69	Upper & Intermediate	Proposed	N/A	Planned to be available for monitoring
BH(AB)	539405.00	179301.00	Lower	Existing	N/A	Available for monitoring (subject to condition survey)
BH05A	539096.73	179727.64	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
BH10	539148.07	179737.79	Lower	Existing	N/A	Available for monitoring (subject to condition survey)
BH108	539264.59	179823.24	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
BHN1(A)	539164.00	179925.00	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
BHN1(B)	539167.00	179927.00	Lower	Existing	Available for monitoring (subject to condition survey)	N/A
BHN5(A)	539488.00	179955.00	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
BHN7(A)	539179.00	179560.00	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
BHN7(B)	539178.00	179557.00	Lower	Existing	N/A	Available for monitoring (subject to condition survey)
BHN8(A)	539570.00	179480.00	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
BHN9(A)	539727.00	179631.00	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
BHN9(B)	539722.00	179637.00	Lower	Existing	Available for monitoring (subject to condition survey)	N/A
BNH12(A)	539414.00	179299.00	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
EB3A	539241.00	179656.50	Upper	Existing	Available for monitoring (subject to condition survey)	Available for monitoring (subject to condition survey)

Borehole ID	Easting (m)	Northing (m)	Aquifer	Existing/Proposed	Groundwater Quality	Groundwater Elevation
GPB-04	539095.40	179348.70	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GPB-05	539086.81	179514.00	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GPB-06	539066.50	179607.20	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GPB-13	539265.59	179621.11	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GPB-15B	539369.70	179688.10	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
GPB-15B	539369.70	179688.10	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GPB-16	539426.30	179778.00	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GPB-19	539554.28	179837.61	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
GRW-BH005	539186.81	179539.35	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
GRW-BH012B	539195.00	179389.00	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
GRW-BH013	539075.61	179578.67	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
GRW-BH025	539158.00	179352.00	Upper	Existing	Available for monitoring (subject to condition survey)	Available for monitoring (subject to condition survey)
GRW-BH027	539075.00	179555.90	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
GRW-BH028B	539444.58	179802.95	Upper & Intermediate	Existing	Available for monitoring (subject to condition survey)	N/A
GRW-BH032	539075.48	179540.84	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
GRW-BH035	539313.71	179239.25	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
NT BH01	539869.00	180301.00	Intermediate	Existing	Available for monitoring (subject to condition survey)	Available for monitoring (subject to condition survey)
OP-37C	539936.40	180302.10	Upper & Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)
RTB-24	539854.24	180165.05	Lower	Existing	N/A	Available for monitoring (subject to condition survey)
RTB-25	539655.56	179908.77	Lower	Existing	N/A	Available for monitoring (subject to condition survey)
RTB-25A	539655.59	179915.79	Intermediate	Existing	N/A	Available for monitoring (subject to condition survey)

Borehole ID	Easting (m)	Northing (m)	Aquifer	Existing/Proposed	Groundwater Quality	Groundwater Elevation
SLV-BH002	539951.35	180361.32	Intermediate & Lower	Existing	N/A	Available for monitoring (subject to condition survey)
SLV-BH011	539943.51	180382.95	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
SLV-BH012	539915.69	180570.45	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
SLV-BH015	539828.99	180629.02	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
SLV-BH018	539823.90	180714.10	Upper	Existing	N/A	Available for monitoring (subject to condition survey)
SLV-CP008	539881.70	180213.80	Intermediate	Existing	Available for monitoring (subject to condition survey)	Available for monitoring (subject to condition survey)
SLV-CP009	539909.40	180181.60	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
STB-26B	539892.15	180222.20	Intermediate	Existing	Available for monitoring (subject to condition survey)	N/A
STB-27	539927.00	180188.96	Upper, Intermediate & Lower	Existing	Available for monitoring (subject to condition survey)	N/A
STB-30	539964.50	180375.50	Intermediate	Existing	Available for monitoring (subject to condition survey)	N/A
STB-32	539951.07	180410.76	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
STB-33A	539923.28	180489.56	Intermediate	Existing	Available for monitoring (subject to condition survey)	N/A
STB-34	539894.60	180553.90	Upper	Existing	Available for monitoring (subject to condition survey)	N/A
STB-37B	539679.90	180802.50	Upper	Existing	Available for monitoring (subject to condition survey)	N/A

Appendix 3 Baseline Groundwater Monitoring Network Drawing



Key plan

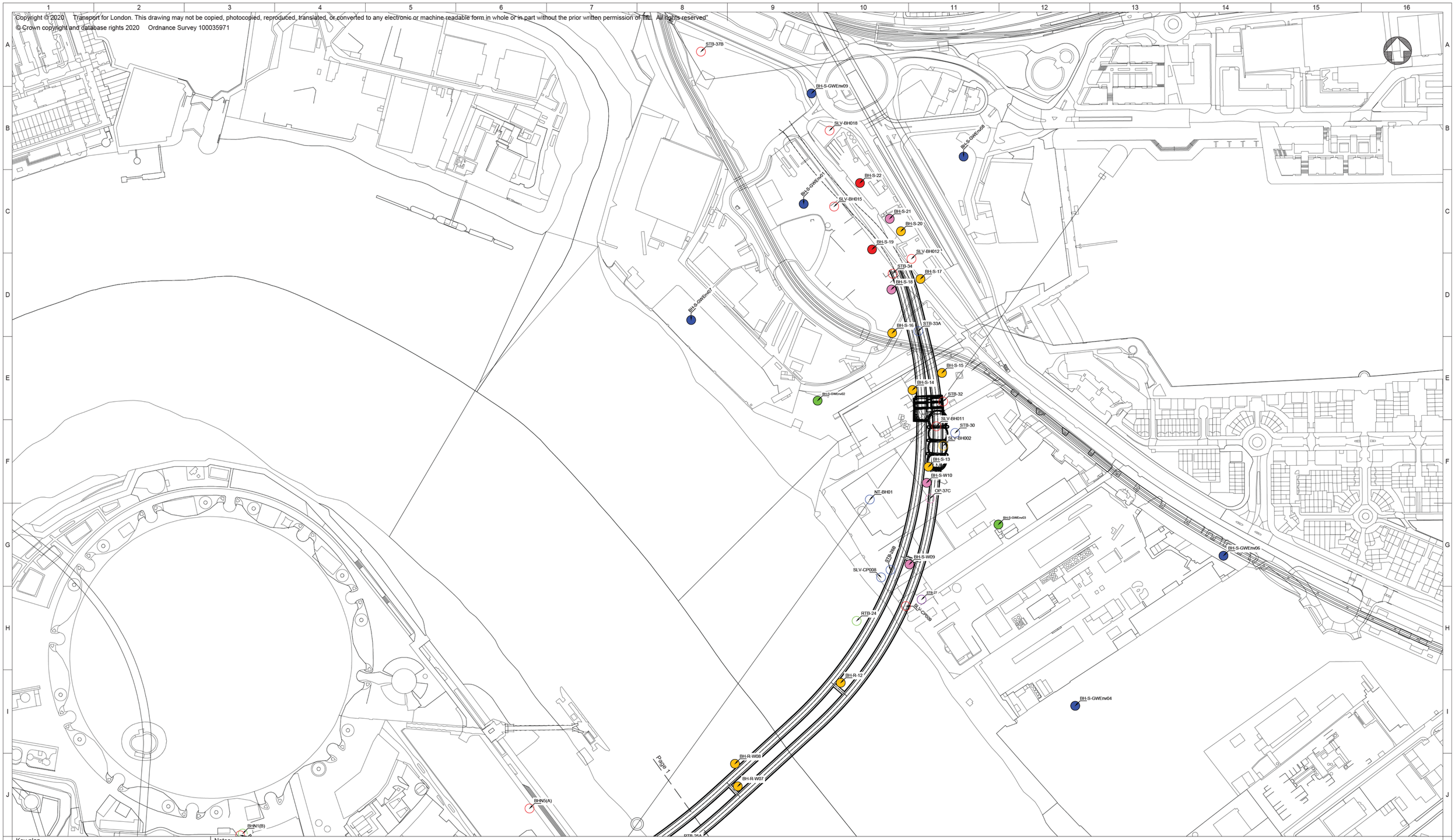
Notes:

Existing Monitoring Points

- Lower
- Intermediate
- Intermediate / Lower
- Upper / Intermediate
- Upper / Intermediate / Lower
- Upper

Proposed Monitoring Points

- Lower
- Intermediate
- Intermediate / Lower
- Upper / Intermediate
- Upper / Intermediate / Lower
- Upper



Key plan

Notes:

Existing Monitoring Points	Proposed Monitoring Points
Lower	Lower
Intermediate	Intermediate
Intermediate / Lower	Intermediate / Lower
Upper / Intermediate	Upper / Intermediate
Upper / Intermediate / Lower	Upper / Intermediate / Lower
Upper	Upper